FISHERY MANAGEMENT PLANS

- Fishery Management Plan (FMP) Update Memo
- FMP Update
- Annual FMP Review Memo
- Annual FMP Review
- Striped Bass FMP Decision Document
- Draft NC Estuarine Striped Bass FMP Amendment 2

ROY COOPER
Governor

ELIZABETH S. BISER
Secretary

KATHY B. RAWLS
Director

July 29, 2022

MEMORANDUM

TO: N.C. Marine Fisheries Commission

FROM: Corrin Flora, Fishery Management Plan Coordinator
Fisheries Management Section

SUBJECT: Fishery Management Plan Update and Schedule Review

Issue

Update the N.C. Marine Fisheries Commission on the status of North Carolina fishery management plans.

Action Needed

The commission is scheduled to **vote on adoption of the River Herring FMP Information Update**.

Overview

2021 Fishery Management Plan Review

The briefing materials include a separate publication entitled "2021 Fishery Management Plan Review." This document is a compilation of annual updates for each State, Federal, and Atlantic States Marine Fisheries Commission managed species where North Carolina is directly involved in the fishery management plan. 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. It is a useful resource for fishery management plan schedule recommendations as well as comprehensive research needs for all fishery management plans.

The 2021 Fishery Management Plan Review is a reference document on the latest status of fisheries occurring in North Carolina. It is organized into two primary sections: state-managed species and interstate-managed species. Interstate is further divided into species which do or do not directly use North Carolina surveys to produce indices. Indices are indirect measurements used to assess stocks in Fishery Management Plans.

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

- Fishery Management Plan History
- Management Unit
- Goal and Objectives

- Description of the Stock
- Description of the Fishery
- Monitoring Program Data (fishery-dependent and fishery-independent data)
- Research Needs
- Management Strategy; and
- Fishery Management Plan Schedule Recommendations.

Five-year Fishery Management Plan Review Schedule

Recommendations included in the state-managed species annual updates inform the draft “N.C. Fishery Management Plan Review Schedule (July 2022-June 2027)”. The schedule reflects the status of the individual plans regarding statutorily mandated plan reviews. Per N.C. General Statute 113-182.1(d), each plan shall be reviewed at least once every five years. The schedule will be forwarded to the Department of Environmental Quality Secretary for approval, per G.S. 113-182.1(d).

The Schedule includes the review of the River Herring FMP in 2022. The division requests the commission approve the 2021 FMP review to complete the scheduled review of the River Herring FMP. This document will serve as the 2022 River Herring FMP Information Update. The next review would be planned for 2027.

Annual Fishery Management Plan Update
Division of Marine Fisheries and Marine Fisheries Commission
July 30, 2022

Authority and Process

The Fisheries Reform Act of 1997 and its amendments established the requirement to create fishery management plans (FMPs) for all of North Carolina's commercially and recreationally significant species or fisheries. Plan contents are specified, advisory committees are required, and oversight by the Department of Environmental Quality (DEQ) secretary, Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources (AgNER), and legislative Fiscal Research Division are mandated.

Annually, the division reviews all State, Federal (Fishery Management councils), and Atlantic States Marine Fisheries Commission (ASMFC) managed FMPs where North Carolina is directly involved. Upon review, the annual State FMP Schedule is confirmed or revised.

Status of State FMPs

Review is underway for three of the 13 State FMPs: Estuarine Striped Bass, Spotted Seatrout, and Striped Mullet.

The division is continuing with progress of the **Estuarine Striped Bass FMP** Amendment 2, which is jointly developed with the Wildlife Resources Commission. Results from the 2020 peer-reviewed stock assessment indicates the Albemarle-Roanoke (A-R) stock is overfished and overfishing is occurring. No stock status is available for the Central Southern Management Area; however, a population model indicates the stock is depressed to a level where sustainability is unlikely. The November 2020 Revision to Amendment 1 immediately addressed overfishing concerns with the A-R stock while development of Amendment 2 is underway. Amendment 2 has been completed with the Marine Fisheries Commission (MFC) selecting preferred management at its May 2022 business meeting. The DEQ Secretary notified the AgNER and received comment. The MFC will now consider final adoption during its August 2022 business meeting.

The 2022 Stock Assessment for the **Striped Mullet FMP** was completed, and a peer review team recommended it suitable for management use. The terminal year was 2019. The stock assessment indicated overfishing was occurring and the stock is overfished. The division will hold a public scoping period to inform Amendment 2 from September 26-October 7, 2022. Public scoping aims to solicit input and possible management strategies regarding the striped mullet fishery from stakeholders. Ideas gained from the scoping period will be presented to the MFC at its November 2022 business meeting and commissioners will have the opportunity to provide further input. The division will then begin drafting the Striped Mullet FMP Amendment 2.

A stock assessment for the **Spotted Seatrout FMP** is underway. The terminal year includes data through February 2020. A peer review of the assessment will be held August 30–September 1, 2022. Once the stock assessment is completed a public scoping period will be held to inform the plan.

The **Hard Clam FMP** Amendment 2 and the **Eastern Oyster FMP** Amendment 4 were approved in February 2017. Due to limited data, stock assessments cannot be conducted; therefore, population size and the rate of removals are unknown. For the Hard Clam FMP, harvest fluctuates, often in response to changes in demand, improved harvesting methods, and polluted shellfish area closures. For the Oyster FMP, commercial landings from public bottom have been variable, and landings from private bottom have increased due to increased interest in aquaculture. Work is underway with N.C. State University and the Nature Conservancy to develop methodologies to survey eastern oysters. Review of both FMPs will begin in 2022.

The **Red Drum FMP** management continues to meet targets. The next review of the Red Drum FMP will begin in 2024. This will provide time for completion of the ASMFC red drum stock assessment, which will inform management. Stock conditions and management are monitored and reported through annual FMP updates.

The **Blue Crab FMP** Amendment 3 was approved in February 2020 to address the overfished status and end overfishing, indicated by the 2018 stock assessment. An update to the 2018 stock assessment will be completed in

2023. Amendment 3 provides adaptive management to address changes in stock status based on the stock assessment update. The next scheduled review of this plan will begin in 2025.

Bay scallop abundances have remained at historically low levels. Therefore, the MFC approved the 2020 annual FMP update to fulfill the scheduled review of the **Bay Scallop FMP**. Management strategies continue to be maintained as outlined in the State FMP. Stock conditions are monitored and reported through the annual FMP update. The next scheduled review of this plan will begin in 2025.

The **Kingfishes FMP** management has resulted in a stock that has met ongoing management targets. Therefore, the MFC approved the 2020 annual FMP update to fulfill the scheduled review of the Kingfishes FMP. Management strategies continue to be maintained as outlined in the State FMP. Stock conditions are monitored and reported through the annual FMP update. The next scheduled review of this plan will begin in 2025.

The **Shrimp FMP** Amendment 2 was adopted by the MFC at its February 2022 business meeting. Amendment 2 management has been implemented through proclamations. The division is continuing work on habitat and gear improvements. The next scheduled review of the plan will begin in 2027.

The **Southern Flounder FMP** Amendment 3 was adopted by the MFC at its May 2022 business meeting. Amendment 3 addresses long-term, comprehensive management for the flounder fishery. Amendment 3 management continues to be implemented through proclamation. The division is working in partnership with the other states on updating the stock assessment with current data. Adaptive management in Amendment 3 will allow flexibility in management based on results of the stock assessment update. The next scheduled review of the plan will begin in 2027.

The 2022 information update for the **North Carolina FMP for Interjurisdictional Fisheries** was adopted by the MFC at its May 2022 business meeting. The goal of the FMP for Interjurisdictional Fisheries is to adopt FMPs, consistent with law, approved by the federal Councils or the ASMFC by reference and implement corresponding fishery regulations in North Carolina to provide compliance or compatibility with approved FMPs and amendments, now and in the future. The next review of the plan is set for 2027.

The division recommends the 2022 Annual FMP Review fulfill the scheduled five-year review of the **River Herring FMP**. The 2017 Atlantic coast-wide stock assessment update indicated river herring remain depleted and at near historic lows on a coast-wide basis. All management strategies will be maintained as outlined in the State and ASMFC FMPs. The next scheduled review of the plan will begin in 2027.

ROY COOPER
Governor

ELIZABETH S. BISER
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KATHY B. RAWLS
Director

July 29, 2022

MEMORANDUM

TO: N.C. Marine Fisheries Commission

FROM: Lee Paramore, Biological Review Team Chair

SUBJECT: Fishery Management Plan Review

Issue
Memo is to inform the Marine Fisheries Commission of the 2021 Fishery Management Plan Review, released for August 2022.

Findings
- The Division of Marine Fisheries 2021 Fishery Management Plan Review summarizes available information by species stock to monitor North Carolina's fishery resources. It is available on the division website at https://deq.nc.gov/about/divisions/marine-fisheries/managing-fisheries/fishery-management-plans.
- The report provides information for each species stock based on data through 2021.
- To better inform the public on management responsibility, the report is organized by the 13 species or species groups managed solely by North Carolina then the 21 species or species groups managed by the Atlantic States Marine Fisheries Commission and Federal councils.
- For each species stock where a peer-reviewed stock assessment is available, assignment of stock status is based on the overfishing and overfished/depleted determination. For species stocks without overfished/overfishing determinations, information on abundance trends and management is provided.
- In 2020 and 2021, some sampling effort and surveys were impacted by restrictions implemented due to the COVID pandemic. Impacts are noted in each report.

Action Needed
For informational purposes only, no action is needed.

Overview
The annual Fishery Management Plan Review was released to the public through the division website on July 27, 2022. The review supports the division's effort to aid in public understanding of management for all commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources.

Highlights of this year's Fishery Management Plan review for state managed species include:

- **Estuarine Striped Bass** – A 2020 peer-reviewed, benchmark stock assessment indicated the Albemarle-Roanoke estuarine striped bass stock is overfished and overfishing is occurring. Adaptive management through Amendment 1 allowed immediate implementation of stricter harvest restrictions to address overfishing in the Albemarle Sound and Roanoke River Management Areas. The measures took effect January 1, 2021. Due to ongoing low juvenile recruitment, a stock assessment update is underway. No stock status is available for the Central Southern Management Area; however, a population model indicates the stock is depressed to a level where sustainability is unlikely. Amendment 2 to the N.C. Estuarine Striped Bass Fishery Management Plan, jointly developed with the N.C. Wildlife Resources Commission, is under review.
- **Shrimp** – The Shrimp Fishery Management Plan Amendment 2 work continued in 2021 and final approval for the plan was given in February 2022. The plan focuses on further reducing bycatch of non-target species and minimizing ecosystem impacts.
- **Blue Crab** – Amendment 3 to the Blue Crab Fishery Management Plan was approved in February 2020, and management measures were implemented to address the overfished and overfishing status of the stock based on results from the peer reviewed 2018 benchmark stock assessment. Blue crab landings have been below average in both 2020 and 2021, prompting the Division to move up a stock assessment update that had been planned for no sooner than 2023.
- **Southern Flounder** – In 2021, while Amendment 3 was being finalized, commercial and recreational seasons implemented through Southern Flounder Fishery Management Plan Amendment 2 continued but did not fully meet the reduction goal for the plan. The Southern Flounder Fishery Management Plan Amendment 3 was recently passed in May of 2022 providing more comprehensive and robust management strategies. These changes will be implemented in 2022 and include quotas and accountability measures to maintain a 72% harvest reduction across the fisheries.
- **Striped Mullet –** Work on this species in 2021 included the recently completed 2022 Stock Assessment of Striped Mullet in North Carolina. Results of the peer reviewed report indicate the stock is overfished and overfishing is occurring through the terminal year of 2019. A formal review of the plan is currently underway and will address the overfished and overfishing status for this stock.

North Carolina
Division of Marine Fisheries

2021 Fishery Management Plan Review

August 2022

INTRODUCTION

The Fishery Management Plan Review is a compilation of annual updates for each State, Federal, and Atlantic States Marine Fisheries Commission managed species where North Carolina is directly involved in the fishery management plan. 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 about the latest status of fisheries in North Carolina. The document is organized into two primary sections: State managed species and interjurisdictional managed species which are managed by either a Federal or Atlantic States Marine Fisheries Commission management plan. The latter section is further divided into species which do or do not directly use North Carolina surveys to produce indices. Indices are indirect measurements used to assess stocks in Fishery Management Plans.

There are 13 State Fishery Management Plans, 12 of which are updated annually in this document. The North Carolina Fishery Management Plan for Interjurisdictional Fisheries does not require annual updates. This plan adopts by reference, management measures appropriate for North Carolina contained in federal Council or Atlantic States Marine Fisheries Commission fishery management plans.

Management measures for interjurisdictional fisheries are implemented by the Marine Fisheries Commission and the Division of Marine Fisheries to provide compliance or consistency with the approved interjurisdictional 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 goal 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.

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Due to the COVID-19 pandemic, several sampling programs were disrupted in 2020 and portions of 2021. Specific effects are provided in each species update as needed.

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FISHERY MANAGEMENT PLAN UPDATE
BAY SCALLOP
AUGUST 2022

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	
Schedule Changes:	None	
Comprehensive Review:	July 2025	

The North Carolina 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. has established 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 N.C. Bay Scallop FMP 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:

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

DESCRIPTION OF THE STOCK

Biological Profile

Bay scallops are estuarine-dependent mollusks found in seagrass beds. Bay scallops are hermaphroditic (contain both sex cells) bivalves and mature and spawn in a year (Brousseau 2005). Their lifespan is approximately 12 to 26 months. In North Carolina, bay scallops spawn predominantly from August through January and again from 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 (Gutsell 1930; Peterson et al. 1989).

Stock Status

There are insufficient data to conduct a traditional stock assessment for bay scallop in North Carolina. Bay scallops 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 the red tide event of 1987. Bay scallops are vulnerable to overharvest because of these factors affecting their survival.

Fishery 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 fishery 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 bay scallop abundance from fishery independent sampling are evaluated annually. Standardized bay scallop population level indicators were first established as progressive triggers for opening the harvest season in Amendment 1 of the N.C. 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 data shows most samples 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 for four years (2009, 2010, 2013, and 2021) in specific regions, and at the lowest allowed harvest levels. Three of the four 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.

Stock Assessment

A stock assessment is not available for this species.

DESCRIPTION OF THE FISHERY

Current Regulations

The season can occur from the last Monday in January through April 1st and there is no minimum size limit for both the commercial and recreational fisheries. 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 an open harvest season for bay scallops in Core Sound in 2021 because abundance levels met the minimum threshold for opening the season. No other areas in the state had an open harvest season in 2021.

Commercial Fishery

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 bay scallops in Bogue and Back sounds and reduced recruitment of juvenile bay 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 bay 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 if the fishery should open 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). In 2019 and 2020 a small amount (less than 300 pounds of meat) was landed from commercial private leases (Figure 4). Despite an open harvest season in Core Sound in 2021, no commercial harvest was reported in the state (Figure 4).

Recreational Fishery

The state's recreational shellfish survey added a question about bay scallop harvest in 2016, but only one open season in 2021 has occurred since the question's introduction. There was no reported recreational harvest from the open season in 2021. 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. In Pamlico Sound, standardized sampling occurs using a one meter-square (m^2) quadrat, and in Core, Back, and Bogue sounds, and areas south of Bogue Sound, a bay scallop dredge is towed. 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. Bay scallops are collected with a rake or by hand for ten 1-m^2 samples within the station in Pamlico Sound. The PVC 1 m^2 quadrat is randomly placed 10 separate times within the area. Catch per unit effort (CPUE) is defined as the number of bay 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 bay scallop abundance at the given time of year. The natural log (ln) of the catch per unit effort (lnCPUE), measured as the number of bay scallops per minute (dredges) and number of bay 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 harvest openings in the past decade (Table 4; Figure 1). There was a significant increase in bay scallop abundance in Core Sound in 2020, resulting in an open harvest season at the 50% progressive trigger level (Table 1; Table 4). This increasing trend in Core Sound continued in 2021 with abundances exceeding the 50% harvest trigger. Back Sound also had a significant increase in abundance, although it failed to exceed any harvest trigger.

From 2017 to 2020 the opening trigger was calculated by performing a log transformation of the CPUE of bay scallops on a waterbody/regional basis after the CPUE was averaged. This was inconsistent with previous years in which the log transformation was performed on each sample before the average was calculated. This altered calculation method was stopped, and data was corrected so the lnCPUE for all years are now calculated using a log transformation at the sample level. This altered method used from 2017 to 2020 had negligible effects on reported abundances except for Core Sound in 2020, where the altered method lnCPUE indicated an opening should occur when in fact the correct lnCPUE showed abundance was below any opening trigger (Table 1; Table 4).

RESEARCH NEEDS

The list below is presented in order as it appears in Amendment 2 of the Bay Scallop FMP. 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:

High

- Develop better methods to quantify the population including the means to have more precise measures of spatial and temporal variability both within and between sound scales
- Identify viable stock enhancement techniques

Medium

- Continue to identify strategic coastal habitats that will enhance protection of bay scallops and accelerate mapping of all shell bottom in North Carolina
- Develop surveys of recruitment and spat settlement and identify critical areas for these
- Identify role water quality and nutrient loading has in failed recruitment and develop methods for improvement

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 lnCPUE level it was in 1984-1985 in the main harvest areas (Core, Bogue, and Back sounds; Table 1). 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 1984-1985 lnCPUE levels (Tables 2 and 3). The open season may 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.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

The 2020 FMP update served as the formal review of Amendment 2 to the North Carolina Bay Scallop FMP. All management strategies that have been in place will be maintained as outlined in the state FMP. Stock conditions will be monitored and reported through each subsequent annual

FMP update and the Marine Fisheries Commission will continue to receive the FMP review schedule annually. The next scheduled comprehensive review of this plan will begin in July 2025.

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TABLES

Table 1: Target and progressive triggers based on the lnCPUE (natural log of the number of bay scallops per 1-minute tow) for the October–December 1984–1985 period for Back, Bogue, and Core sounds. Target and progressive triggers for lnCPUE (natural log of the number of bay scallops per meter squared) in Pamlico Sound are 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 125%	-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 lnCPUE Jan 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 Thurs	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 Thurs	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 lnCPUE 1984–1985 (Oct–Dec) target indicators for Core, Bogue and Back sounds and the lnCPUE Jan 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 1 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	-2.02	0.75	-2.18	0.46	-2.30	0.00	-2.30	0.00
2019	-2.26	0.24	-2.06	0.16	-2.30	0.00	-2.05	0.11	-2.19	0.09
2020	-2.26	0.24	-0.07	0.49	-2.02	0.19	-1.96	0.14	-1.50	0.26
2021	-2.26	0.24	0.87	0.74	-0.18	0.92	-1.81	0.20	-1.84	0.31

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

Management Strategy	Implementation Status
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 sediments and identify the areas of greatest concern to focus water quality improvement efforts	Ongoing through CHPP implementation plan
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

Management Strategy	Implementation Status
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

Management Strategy	Implementation Status
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	
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

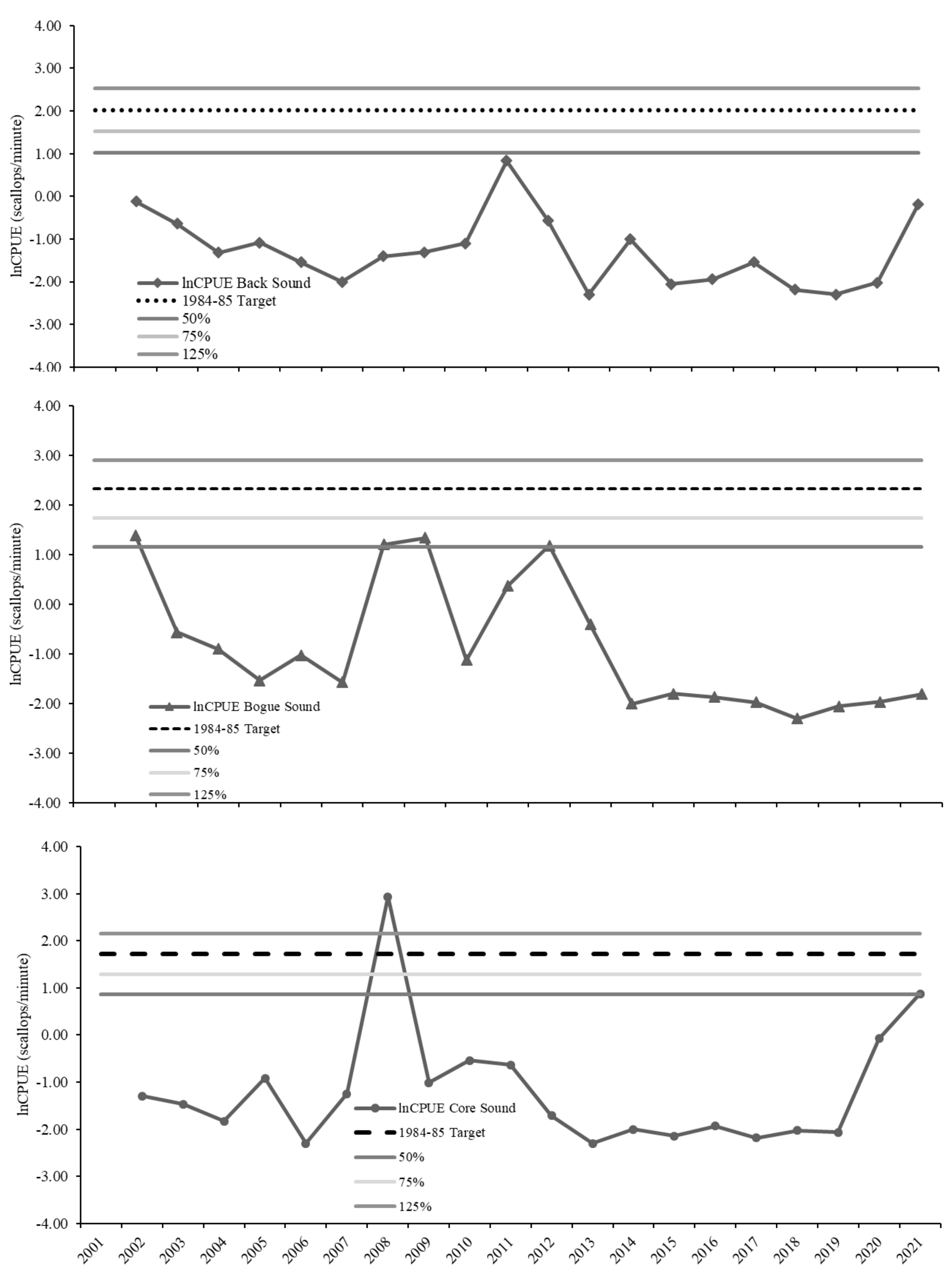

Figure 1. The mean number of bay scallops (lnCPUE; bay scallops/minute) for Back, Bogue, and Core sounds during the October-December sampling time-period and average lnCPUE (target) for the 1984–1985 period showing progressive triggers at 50, 75, and 125% of the target. Year indicates the sampling year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

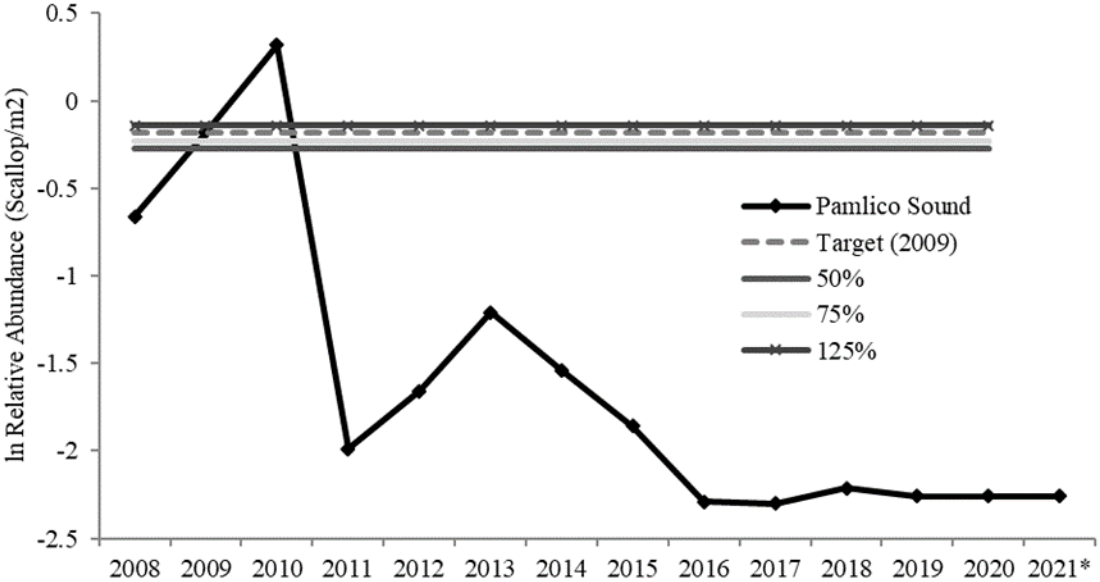

Figure 2. The mean number of bay scallops, lnCPUE (ln(bay scallops/m^2)), for Pamlico Sound during the January sampling time period and target for the January 2009 period showing progressive triggers at 50, 75, and 125% of the target. Year indicates the sampling year which is used to determine the harvest season for the same calendar year. *Sampling in 2021 was not conducted until March due to staffing issues and inclement weather.

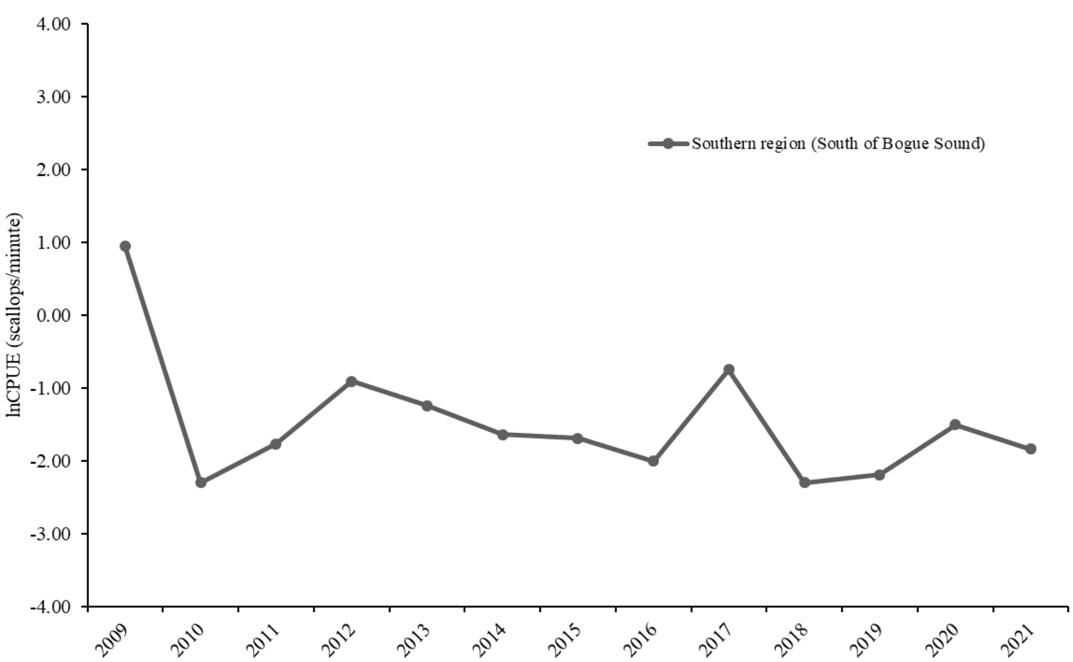

Figure 3. The mean number of bay scallops (lnCPUE) (bay scallops/minute) for areas south of Bogue Sound in October 2009–2020. Target opening estimates and progressive triggers are not defined for this region until sampling is expanded and a longer time series is established.

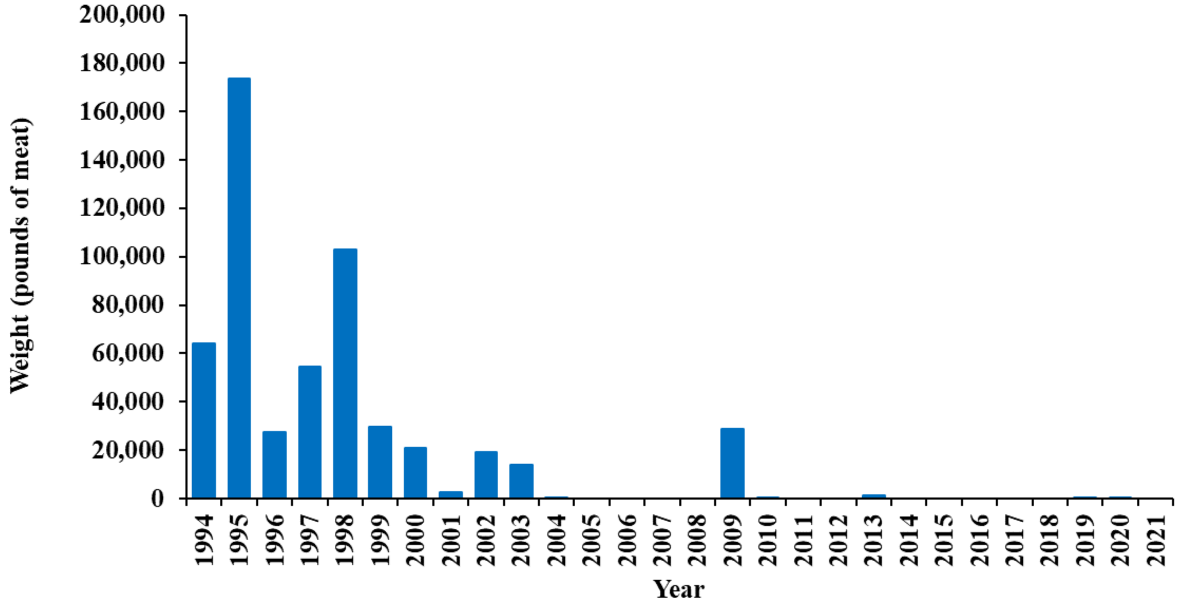

Figure 4. Bay scallop landings (pounds of meat) in North Carolina, 1994–2021. Landings occurred in 2010, 2013, 2019, and 2020 but are not evident in the figure due to the scale required to show the range of landings for the time series.

FISHERY MANAGEMENT PLAN UPDATE
BLUE CRAB
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	December 1998	
Amendments:	Amendment 1	December 2004
	Amendment 2	November 2013
	Amendment 3	February 2020
Revisions:	Revision to Amendment 2	May 2016
	Revision to Amendment 3	May 2020
Supplements:	None	
Information Updates:	None	
Schedule Changes:	August 2016	
Comprehensive Review:	2023	

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 March 1–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) prohibited the possession of white line peelers June 1–30, (6) changed the unattended pot rule from ten days to seven days, (7) prohibited 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) established 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) established 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) prohibited 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) extended the pot cleanup period by nine days, (5) changed the unattended pot rule from seven days to five days, (6) required a four-inch stretch mesh tail bag for crab trawls in western Pamlico Sound (including the Pamlico, Pungo, Bay, and Neuse rivers), (7) separated hard and peeler crab trawl landings on trip tickets, (8) modified channel net rule to incorporate limited blue crab bycatch provisions identical to those for shrimp trawls, (9) modified user conflict rule to resolve user conflicts on a regional basis, (10) allowed crab pots in all designated long haul areas in Hyde, Beaufort, and Pamlico counties, (11) modified the dates for designated crab pot areas from May 1–October 31 to June 1–November 30, (12) changed designated pot area boundary description to a standardized six foot depth contour in many areas, and (13) prohibited 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) repealed the spawner index trigger (and associated maximum size limits for mature female and peeler blue crabs) and replaced it with adaptive management framework based on the results of the annual Traffic Light Stock Assessment update, (2) opened long haul areas in the Pungo River to pots, (3) added Lower Broad Creek to non-pot areas in rule, (4) modified crab dredging rule to conform to current harvest management, (5) incorporated Pamlico Sound four-inch crab trawl line into rule, (6) redefined criteria for exempting escape rings in crab pots from the 1.5-inch pot mesh size to un-baited pots and pots baited with a male crab, (7) repealed proclamation authority that allowed for the exemption of escape ring requirement to allow harvest of peeler crabs, (8) adopted the 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) modified trawl nets rule to identify Pamlico, Back, and Core sounds as areas that can open to peeler trawling by proclamation, (10) modified rule to clearly state the intent of the exceptions, culling tolerance, and separation requirements for various crab categories, and (11) established proclamation authority to require terrapin excluders in crab pots and establish a framework for developing criteria and terrapin excluder specifications.

The NCMFC adaptive management strategy for blue crabs under Amendment 2 relied on the Traffic Light Stock Assessment to provide information on relative condition of the stock. The reference years (1987–2009) for assigning the signals in the Traffic Light Stock Assessment remained constant and the analysis was updated annually by July each year. The name of this analysis comes from assigning a color (red, yellow, or green) to categorize relative levels of different indicators for either a fish population or a fishery. The Traffic Light Stock Assessment effectively illustrates long term trends in the population.

Based on 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) April 1–April 30 each year; and include dark sponge crabs in the culling tolerance; (4) lower the culling tolerance from 10% to 5% 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 Comprehensive 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 begin the review immediately to assess the status of the blue crab stock and identify more comprehensive management strategies. Consequently, the review of the Blue Crab FMP for development of Amendment 3 began in August 2016. The stock assessment was completed and accepted for management use, and Amendment 3 was adopted by the NCMFC at their February 19, 2020, business meeting (NCDMF 2020a). The amendment retained measures implemented with the May 2016 Revision to the Blue Crab FMP and implemented several management changes including: 1) crab harvest and pot closure periods (January 1–31 north of the Highway 58 bridge to Emerald Isle and March 1-15 south of the Highway 58 bridge, 2), a 5-inch minimum size limit for mature female crabs statewide, 3) replacing the annual Traffic Light Stock Assessment update with an adaptive management framework based on an interim update of the 2018 benchmark assessment, 4) removal of all cull ring exempted areas, 5) revised the boundaries for crab spawning sanctuaries in Drum Inlet and Barden Inlet and established new crab spawning sanctuaries in Beaufort, Bogue, Bear, Browns, New River, Topsail, Rich, Mason, Masonboro, Carolina Beach, Cape Fear River, Shallotte, Lockwoods Folly, and Tubbs inlets with March 1–October 31 closure, 6) crab trawling prohibition in areas of the Pamlico, Pungo, and Neuse rivers where trawling for shrimp was prohibited, 7) crab bycatch allowance in oyster dredges reduced to 10% of the total weight of the combined oyster and crab catch or 100 pounds, whichever is less 8) adopted a framework to designate Diamondback Terrapin Management Areas, and 9) addressed water quality issues requiring partnering with other commissions and state agencies.

The Diamondback Terrapin Management Area (DTMA) framework in Amendment 3 contains the criteria required to identify areas of the state where terrapin excluder devices are required. Two DTMAs were established in May 2020 in Masonboro Sound and the lower Cape Fear River. This action, taken by the NCMFC, is documented in the May 2020 Revision to Amendment 3 to the N.C. Blue Crab FMP and implemented by Proclamation PT-1-2021 (NCDMF 2020b). These areas have documented terrapin populations and waterbody characteristics in which diamondback terrapins are susceptible to incidental capture. Beginning in March 2021, all pots in these areas are required to be modified with a North Carolina Division of Marine Fisheries (NCDMF) approved diamondback terrapin excluder device in each funnel March 1–October 31.

The Blue Crab FMP, Amendments, and Revisions are available on the NCDMF website at: https://deq.nc.gov/about/divisions/marine-fisheries/managing-fisheries/fishery-management-plans#state-managed-species

Management Unit

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

Goal and Objectives

The goal of Amendment 3 to the North Carolina Blue Crab FMP is to manage the blue crab fishery to achieve a self-sustaining population that provides sustainable harvest using science-based decision-making processes. The following objectives will be used to achieve this goal:

- Implement management strategies that maintain/restore the blue crab spawning stock with multiple cohorts and adequate abundance to prevent recruitment overfishing.
- Restore, enhance, and protect habitat and environmental quality necessary to maintain or increase growth, survival, and reproduction of the blue crab population.
- Use biological, environmental, habitat, fishery, social, and economic data needed to effectively monitor and manage the blue crab fishery and its ecosystem impacts.
- Promote stewardship of the resource through increased public awareness regarding the status and management of the blue crab fishery, including practices that minimize bycatch and discard mortality.

DESCRIPTION OF THE STOCK

Biological Profile

The blue crab is common to all North Carolina coastal waters but are most abundant in the Albemarle and Pamlico sounds and their tributaries. Blue crabs mature at approximately 12–18 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 rivers from late spring to early fall, and spawning occurs in high-salinity waters near ocean inlets from early summer to fall (Forward et al. 2003; Whitaker 2006). The first larval stage is carried offshore by ocean currents where several stages of development occur (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 (Binion-Rock 2018). 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 its shell and claws and a T-shaped apron on its underside. Female crabs are called "sooks" as adults and "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 its abdomen.

Stock Status

Results of the 2018 benchmark blue crab stock assessment (2016 terminal year) indicate the stock is overfished and overfishing is occurring (NCDMF 2018).

Stock Assessment

The 2018 benchmark 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 and several fishery-independent surveys (Program 100, Program 120, Program 195). Only hard crab landings were incorporated in the model, neither recreational nor 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 (Figure 1). Females had higher natural mortality estimates than males. The estimated fishing mortality remained high before 2007 and decreased by approximately 50% afterward (Figure 1).

The status of the blue crab stock was evaluated using biological reference points (BRPs) based on maximum sustainable yield (MSY). The MSY-based 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 (FMSY) was set to be the threshold for overfishing, and 0.75 FMSY was set to be the target fishing mortality. The spawner abundance at FMSY (SPMSY) and 0.75 FMSY were set to be the threshold and target for an overfished population, respectively. In the current stock assessment, the population is determined to be overfished if the average spawner abundance in 2016 falls below SPMSY and is determined to be undergoing overfishing if the average F in 2016 is above FMSY.

DESCRIPTION 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 NCDMF for the most current regulations.

<u>Definitions</u>

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, that 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 all hard blue crabs. It is unlawful to possess mature female hard crabs with a dark (brown or black) sponge from April 1 through April 30 statewide. Juvenile female hard crabs may not be harvested. 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 were 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. 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 of the NCDMF, may by proclamation, close the harvest of blue crabs and may impose any or all the following restrictions on the commercial and recreational harvest of blue crab: 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; Proclamation M-1-2021.

From January 1 to January 31, it is unlawful to possess blue crabs taken from all Coastal Fishing Waters of the state north and east of a line extending southeast from the Highway 58 Bridge to a point offshore at 34° 36.3292’N, 77° 2.5940’W to the North Carolina/Virginia state line. From March 1 to March 15, it is unlawful to possess blue crabs taken from all Coastal Fishing Waters of the state south and west of a line extending southeast from the Highway 58 Bridge to a point offshore at 34° 36.3292’N, 77° 2.5940’W to the North Carolina/South Carolina state line. Proclamation M-1-2021.

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; Proclamation M-12-2022] 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 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, 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, 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 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 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. 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 may be possessed. 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 where 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).

<u>Crab Pots</u>

- 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).
- From January 1 to January 31, it is unlawful to use crab pots in Coastal Fishing Waters of the state north and east of a line extending southeast from the Highway 58 Bridge to a point offshore at 34° 36.3292’N, 77° 2.5940’W to the North Carolina/Virginia state line. From March 1 to March 15, it is unlawful to use crab pots in Coastal Fishing Waters of the state

south and west of a line extending southeast from the Highway 58 Bridge to a point offshore at 34° 36.3292'N, 77° 2.5940'W to the North Carolina/South Carolina state line. Proclamation M-1-2021.

- 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 three unobstructed escape rings that are at least 2 and 5/16 inches inside diameter and two must be located in the opposite outside panels of the upper chamber of the pot and at least one must be located within one full mesh of the corner and one full mesh of the bottom of the divider in the upper chamber of the pot except: unbaited pots, pots baited with a male crab 15A NCAC 03J .0301(g); Proclamation M-1-2021.
- 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).

<u>Crab Dredging</u>

- It is unlawful to take blue crabs with dredges except incidental to lawful oyster dredging operations provided the weight of the crabs not exceed 10% of the total weight of the combined oyster and crab catch or 100 pounds, whichever is less. Proclamation M-1-2021

Diamondback Terrapin Management Areas

- For areas described in Proclamation PT-1-2021 including the Masonboro Island and Bald Head Island areas, from March 1 through October 31 it is unlawful to set or use crab pots without the correct use of Division of Marine Fisheries Approved Diamondback Terrapin Bycatch Reduction Devices. PT-1-2021.

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 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 Fishery

Since 1994, the North Carolina Trip Ticket Program (NCTTP) has collected data on the commercial harvest of blue crab. Commercial blue crab landings (hard, soft, and peeler crabs) averaged 36.6 million pounds for the period 1995–2016 (stock assessment years; Table 1). Generally, commercial blue crab landings have been lower since around 2012 and ranged from a high of 67.1 million pounds in 1996 to a low of 12.8 million pounds in 2021. Most blue crab landings are hard blue crabs. Landings for 2021 (12.8 million pounds) were 6% lower than 2020 and 60% lower than the 35-year average. Commercial blue crab landings have been below the stock assessment years' average since 2003 (Figure 2). Crab pots account for the majority of commercial blue crab landings (95.7% in 2021) followed by peeler pots (4.0% in 2021), crab trawls (0.2% in 2021), and other gears, including gill nets and shrimp trawls (0.1% in 2021; Figure 3). Most crabs landed in 2021 were hard crabs (94.0%), followed by peeler (4.2%) and soft (1.8%) crabs (Figure 4).

Recreational Fishery

A survey of Recreational Commercial Gear License (RCGL) holders conducted during 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% (116,797 pounds) of the total poundage (587,172 pounds) landed by RCGL holders. This survey was discontinued in 2009 due to lack of funding; meaning 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 using 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 generate recreational harvest estimates for blue crab. One weakness of the survey is that 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 2011–2021 (Figure 5; Table 1). Generally, recreational blue crab harvest estimates are 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. During 2011–2021, the average annual recreational harvest of blue crab was 82,178 blue crabs (approximately 27,393 pounds).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

The number of blue crab lengths obtained from fishery-dependent sources from 1995 through 2021 ranged from 7,698 in 2018 to 33,007 in 1995 (Table 2). Mean carapace width (CW) varied little and ranged from 5.6 inches to 5.9 inches. Minimum CW ranged from 1.2 inches to 3.9 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 ranging from 4.5 to 6.5 inches CW. The length composition and modal length of blue crab caught in the commercial fishery have varied little over time (Figure 6).

The annual length of 50% maturity is compared across the stock assessment years of 1995–2016 (113.4 mm CW [4.5 inches]). In 2021, the length of 50% maturity was 117.8 mm CW (4.6 inches) and was back above the mean for the stock assessment years after being below the mean in 2020 (Figure 7).

Fishery-Independent Monitoring

The blue crab stock assessment uses several fishery-independent indices for the recruit and fully recruited indices, including the Estuarine Trawl Survey (Program 120), the Pamlico Sound Survey (Program 195), and the Juvenile Anadromous Trawl Survey (Program 100). The base years used for the blue crab stock assessment were 1995–2016.

Recruit Abundance

The recruit indices use data from the Estuarine Trawl Survey and the Pamlico Sound Survey to monitor blue crab recruit abundance. Each index consists of blue crabs less than 127 mm CW (5.0 inches). Two indices are derived from Program 120: a male recruit index and a female recruit index (Figure 8). Four recruit indices are derived from Program 195: June indices by sex and September indices by sex (Figures 9 and 10).

Male recruit abundance in Program 120 has been below the stock assessment years' mean (4.5 crabs/tow) since 2012 when relative abundance was 5.5 crabs/tow (Figure 8A). Female recruit abundance has also been below the stock assessment years' mean (2.8 crabs/tow) since 2012 (3.3 crabs/tow) (Figure 8B). In 2020, recruit abundance fell to the lowest in the time series at 0.8 crabs/tow for male blue crabs and 0.4 crabs/tow for female blue crabs. In 2021, recruit abundance remained at the lowest levels for male blue crabs (0.8 crabs/tow) and only slightly increased for female blue crabs (0.5 crabs/tow).

Recruit abundance for Program 195 varies greatly from year to year. In June 2021, male recruit abundance fell to the lowest value in the time series at 4.9 crabs/tow and was below the stock assessment years' mean (24.1 crabs/tow) (Figure 9A). June 2021 female recruit abundance also fell to the lowest abundance in the time series at 3.9 crabs/tow and was below stock assessment years' mean (26.1 crabs/tow) (Figure 9B). In September 2021, male recruit abundance was the lowest in the time series at 0.2 crabs/tow, and female recruit abundance was also the lowest in the time series at 0.1 crabs/tow (Figure 10A and 10B). Both were below the stock assessment years' means (3.1 crabs/tow; 3.1 crabs/tow, respectively). However, the COVID pandemic impacted sampling in 2020 and 2021. In 2020, sampling was limited to 28 stations sampled in June and 35 stations sampled in September. A total of 35 stations were sampled in June 2021 and 32 stations were sampled in September 2021. Limited sampling likely impacted abundance indices calculated from Sound Survey data.

Fully Recruited Abundance

The adult indices include data from the Juvenile Anadromous Trawl Survey (Program 100) and the Pamlico Sound Survey (Program 195). Indices consist of blue crabs greater than or equal to 127 mm CW (5.0 inches). Four indices are derived from Program 100, a male fully recruited index and a female fully recruit index by season (summer and fall; Figures 11 and 12). Program 195 is also used to derive June fully recruited indices by sex and September fully recruited indices by sex (Figures 13 and 14).

In 2021, male fully recruited summer abundance in Program 100 was 0.8 crabs/tow which is below the stock assessment years' mean (1.3 crab/tow) and female fully recruited summer abundance was 0.4 crabs/tow which is below the stock assessment years' mean (0.5 crabs/tow) (Figures 11A and 11B). In 2021, male fully recruited fall abundance was 0.6 crabs/tow which is below the stock assessment years' mean (2.1 crabs/tow) and female fully recruited fall abundance was 0.3 crabs/tow, which is below the stock assessment years' mean (2.4 crabs/tow) (Figures 12A and 12B).

Program 195 fully recruited abundance does not vary in the same way as recruit abundance and is more variable in June compared to September for female blue crabs. In 2021, male fully recruited June abundance was 0.1 crabs/tow which is below the stock assessment years' mean (1.6 crabs/tow) and female fully recruited June abundance was 0.3 crabs per/tow which is lower than the stock assessment years' mean (3.2 crabs/tow) (Figures 13A and 13B). In 2021, male fully recruited September abundance was 0.01 crabs/tow which is below the stock assessment years' mean (1.6 crabs/tow) and the lowest male fully recruited abundance in the time series. In 2021, female fully recruited September abundance was 0.03 crabs/tow which is below the stock assessment years' mean (3.4 crabs/two) and the lowest female fully recruited abundance in the time series (Figures 14A and 14B). However, the COVID pandemic impacted sampling in 2020 and 2021. In 2020, sampling was limited to 28 stations sampled in June and 35 stations sampled in September. A total of 35 stations were sampled in June 2021 and 32 stations were sampled in September 2021. Limited sampling likely impacted abundance indices calculated from the Pamlico Sound Survey data.

RESEARCH NEEDS

Several research needs were identified in N.C. Blue Crab Fishery Management Plan Amendment 3; the bulleted list below outlines the specific needs and highlights the priority of each management and research need.

High

- Implement long-term monitoring of blue crab discards in other fisheries (e.g., gill net, trawl).
- Develop statewide fishery-independent survey(s) to monitor the abundance of all blue crab life stages.
- Expand time and area coverage of existing fishery-independent surveys.
- Better characterize the magnitude of recreational harvest.
- Develop better estimates of life-history parameters, especially growth and natural mortality.
- Explore alternative biological reference points.
- Research interaction rates of non-target species in the blue crab fishery and identify factors that may lead to interactions (e.g., migration patterns, habitat utilization).
- Identify biological characteristics of submerged aquatic vegetation beds of ecological value to blue crab and implement restoration and conservation measures.
- Research mature female migration routes and seasonal habitat use (e.g., inlets, staging areas).
- Research gear modifications to minimize interactions with non-target species (e.g., diamondback terrapin) in the blue crab fishery.
- Research the impacts of land use activities and shoreline clearing on water quality and the blue crab stock.
- Research the impact of endocrine disrupting chemicals on the various life stages of blue crabs and ways to reduce their introduction into estuarine waters, including discharge from wastewater treatment plants.

Medium

- Characterize the harvest and discard of blue crabs from crab shedding operations.
- Explore alternative model types.
- Research the impact of increased predator abundance on the blue crab stock.
- Identify key environmental factors that significantly impact North Carolina's blue crab stock and investigate assessment methods that can account for these environmental factors.
- Identify, map, and protect habitat of ecological value to blue crab (in particular juvenile habitat) and implement restoration and conservation measures.
- Assess the impact of inlet dredging activities on mature female blue crabs.
- Implement monitoring of hazardous events (e.g., hurricane, extreme hot or cold weather) affecting blue crab population dynamics and harvest.
- Research the extent, causes, and impacts of hypoxia and anoxia on blue crab behavior and population abundance in estuarine waters.

- Research the impact of invasive species (e.g., blue catfish) on the blue crab stock.

Low

- Investigate and support research on promising methods to age blue crabs.
- Evaluate the genetic stock structure of blue crabs within North Carolina and the magnitude of mixing between populations.
- Identify programs outside the NCDMF that collect data of potential use to the stock assessment of North Carolina's blue crabs.
- Research and identify key market forces and their effects on the blue crab industry.

MANAGEMENT STRATEGY

Program Amendment 3 adopted an adaptive management framework, replacing the traffic light assessment, based on the peer-reviewed and approved stock assessment model. Division staff will update the stock assessment at least once between full reviews of the FMP. If the stock is overfished and/or overfishing is occurring or it is not projected to meet sustainability requirements, management measures will be adjusted using the director's proclamation authority. If the stock is not overfished and overfishing is not occurring, management measures may be relaxed provided it will not jeopardize the sustainability of the blue crab stock. Any quantifiable management measure with the ability to achieve sustainable harvest (as defined in the stock assessment), either on its own or in combinations, may be considered. The director's proclamation authority for adaptive management is contingent on consultation with the Northern, Southern, and Shellfish/Crustacean advisory committees as well as approval by the NCMFC. Several management issues were explored in Amendment 3.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

Amendment 3 management measures were fully implemented as of January 1, 2021. An update to the 2018 benchmark stock assessment will begin in 2022. Results of the stock assessment update will be used to inform future management.

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TABLES

Table 1. Blue crab recreational harvest (number and weight) and releases (number; Recreational Mail Survey) and commercial harvest (weight; North Carolina Trip Ticket Program), 1987–2021. Recreational harvest weight is calculated using a standard conversion of 3 crabs per pound.

	Recreational			Commercial	
Year	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight 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	-	-	-	46,443,653	46,443,541
1996	-	-	-	67,080,200	67,080,200
1997	-	-	-	56,090,109	56,090,109
1998	-	-	-	62,076,170	62,076,171
1999	-	-	-	57,545,843	57,546,676
2000	-	-	-	40,638,384	40,638,384
2001	-	-	-	32,179,345	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	32,099,183	32,150,905
2016	72,645	82,781	24,215	25,460,121	25,491,033
2017	72,645	67,667	24,215	19,263,702	19,297,371
2018	47,766	57,024	15,922	17,013,532	17,028,276
2019	81,815	78,784	27,272	22,989,674	23,014,642
2020	78,646	78,742	26,215	13,549,083	13,575,299
2021	48,675	42,561	16,225	12,790,419	12,806,644
Mean	82,178	68,855	27,393	34,614,944	34,624,762

Table 2. Blue crab length (carapace width [CW], inches) data from commercial fish house samples, 1995–2020.

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	5.6	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	5.6	3.5	8.3	11,417
2003	5.8	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	5.6	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	5.9	3.7	8.7	17,910
2010	5.8	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	5.8	3.5	9.0	13,531
2017	5.8	3.6	8.1	9,978
2018	5.8	3.7	8.1	7,698
2019	5.7	3.9	8.4	11,779
2020	5.6	1.9	7.9	7,792
2021	5.7	3.3	7.8	10,204

FIGURES

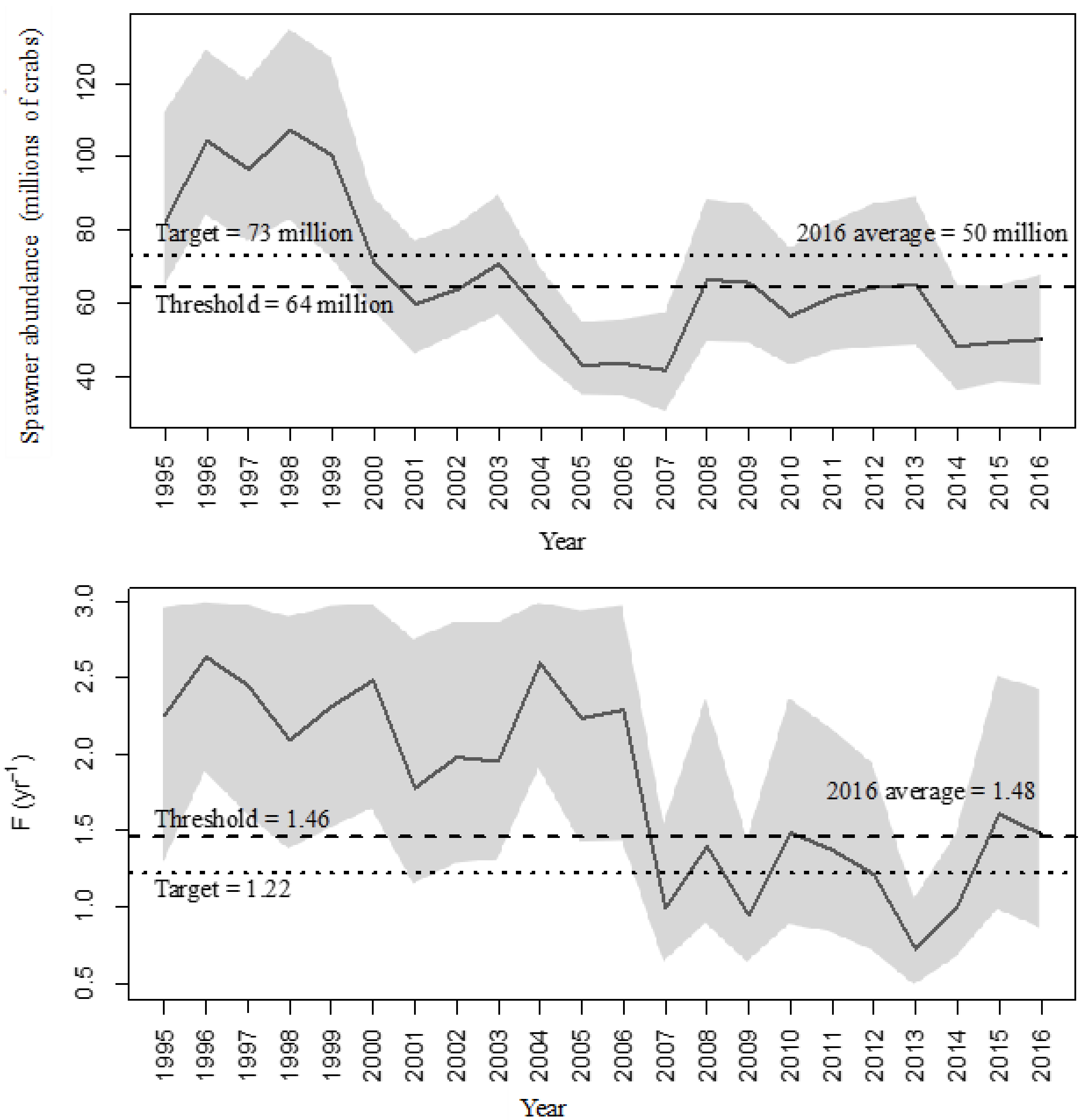


Figure 1. Estimated spawner abundance (mature female blue crabs; top) and fishing mortality (F; bottom) from the 2018 blue crab stock assessment (NCDMF 2018). The solid lines represent the posterior mean and the shaded area represents the 95% credible interval. The threshold and target values are the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

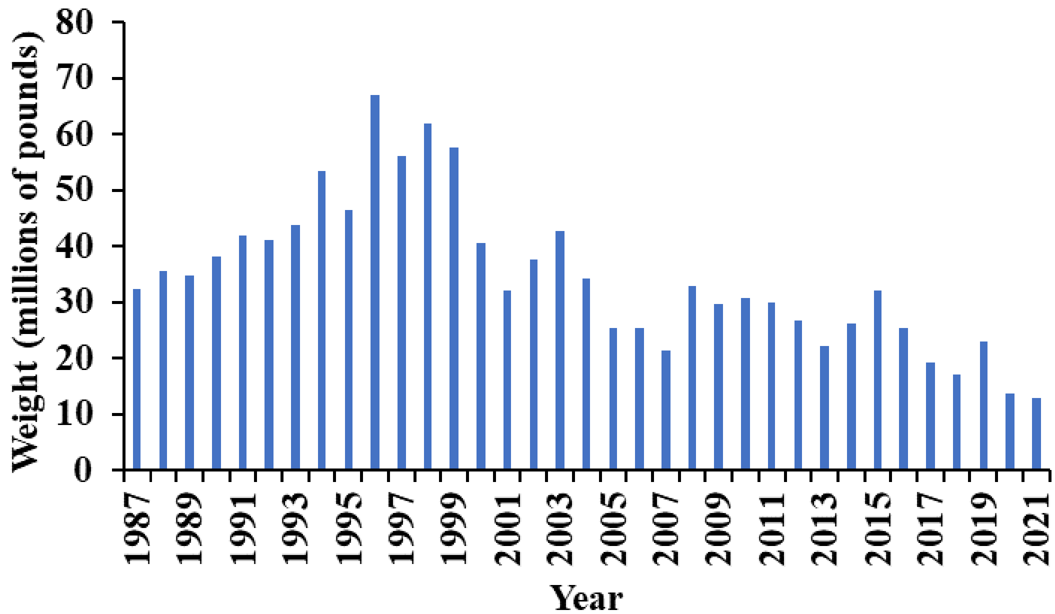


Figure 2. Annual blue crab commercial landings (North Carolina Trip Ticket Program), 1987–2021. Landings include hard, soft, and peeler crabs

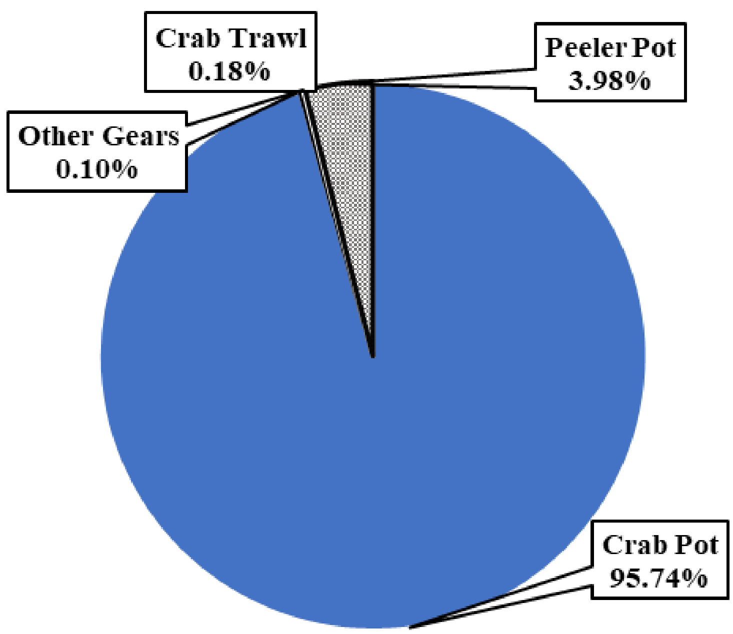


Figure 3. Commercial harvest (pounds) of blue crab by gear, 2021.

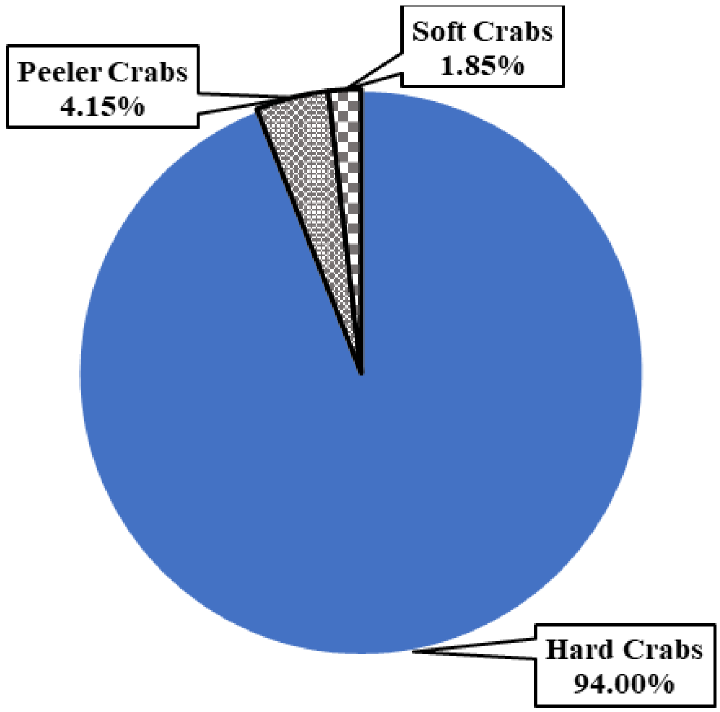


Figure 4. Commercial harvest (pounds) of blue crab by crab type, 2021.

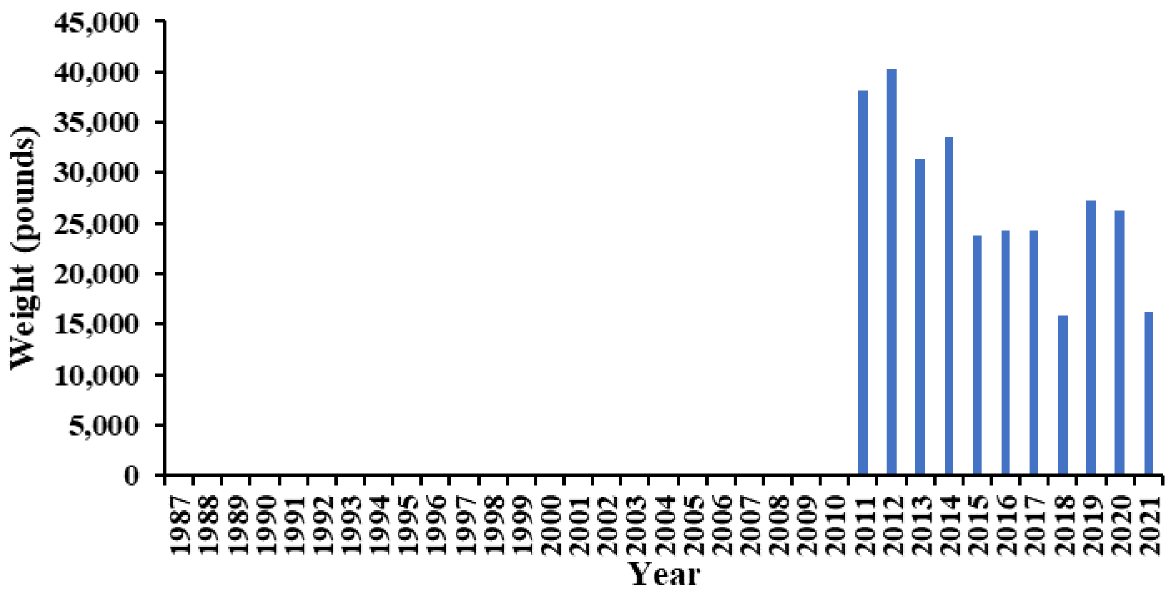


Figure 5. Annual blue crab recreational harvest, 1987–2021. Recreational mail survey began in October 2010 with the first full year of data available for 2011.

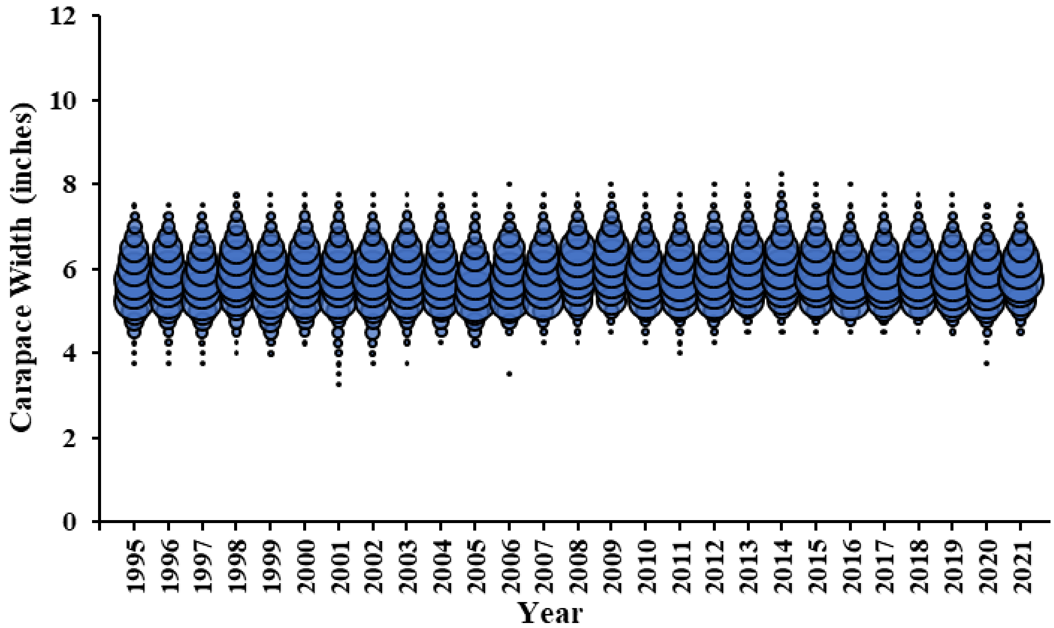


Figure 6. Commercial length frequency (carapace width, inches) of hard blue crab harvested, 1995–2021. Bubble represents the proportion of crabs at length.

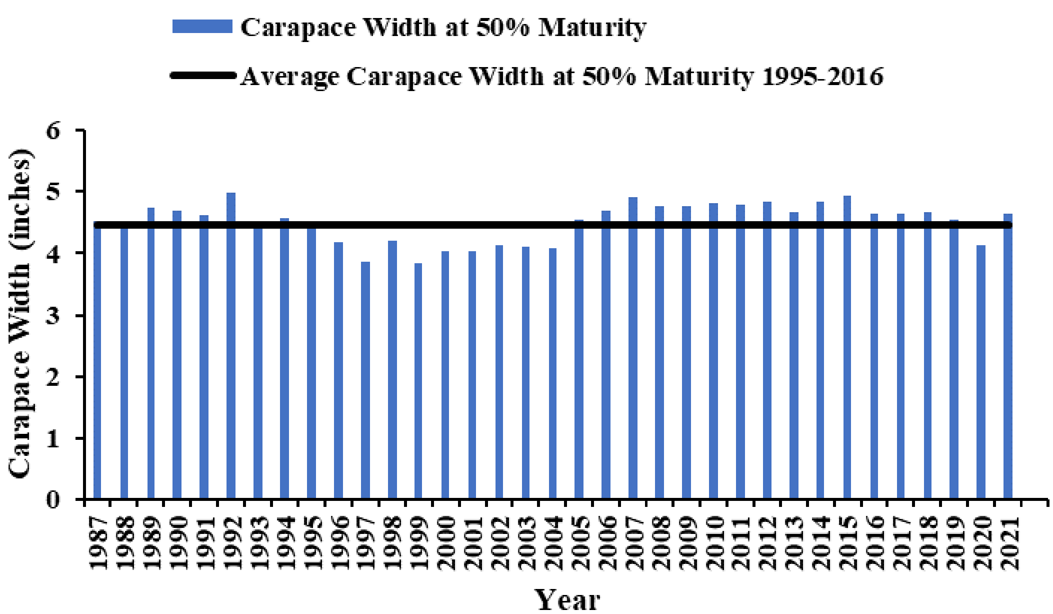
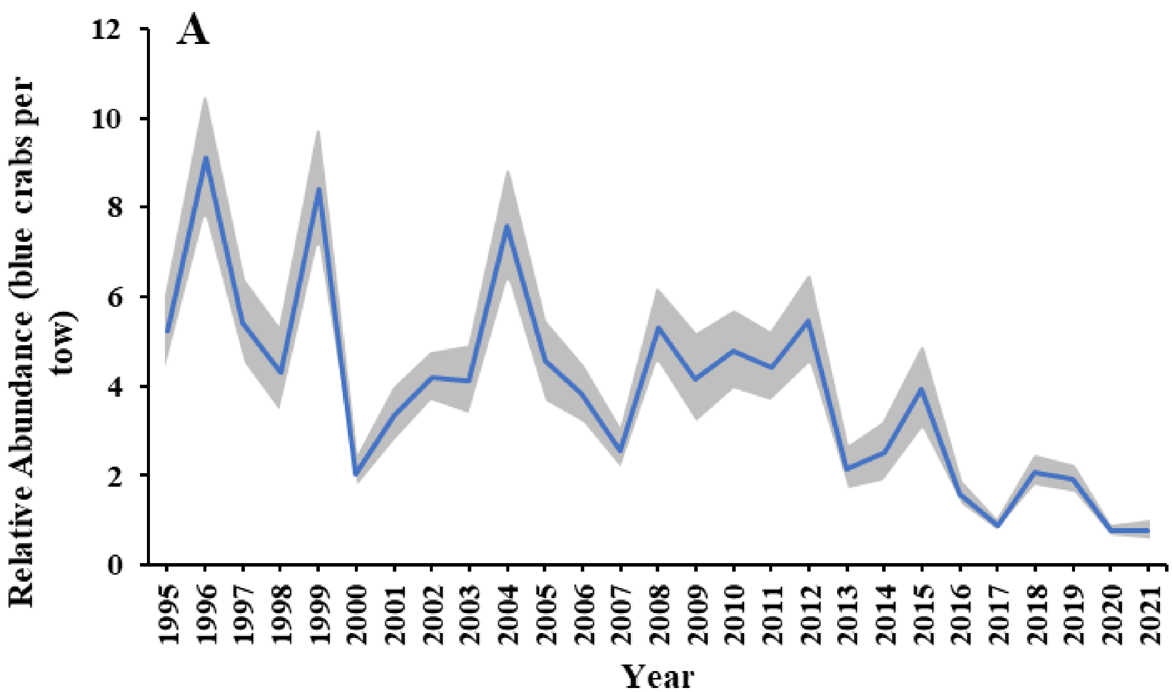


Figure 7. Length at 50% maturity for female blue crabs compared to stock assessment years, 1995–2016. Fishery-dependent and independent data were included in the analysis.



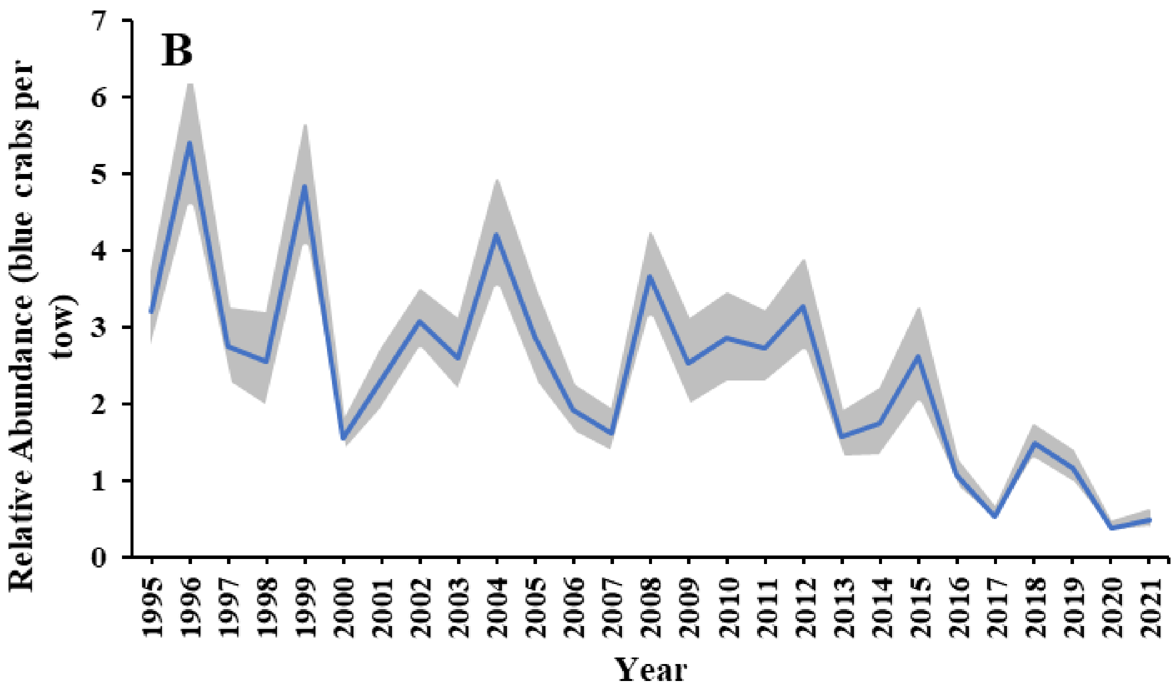
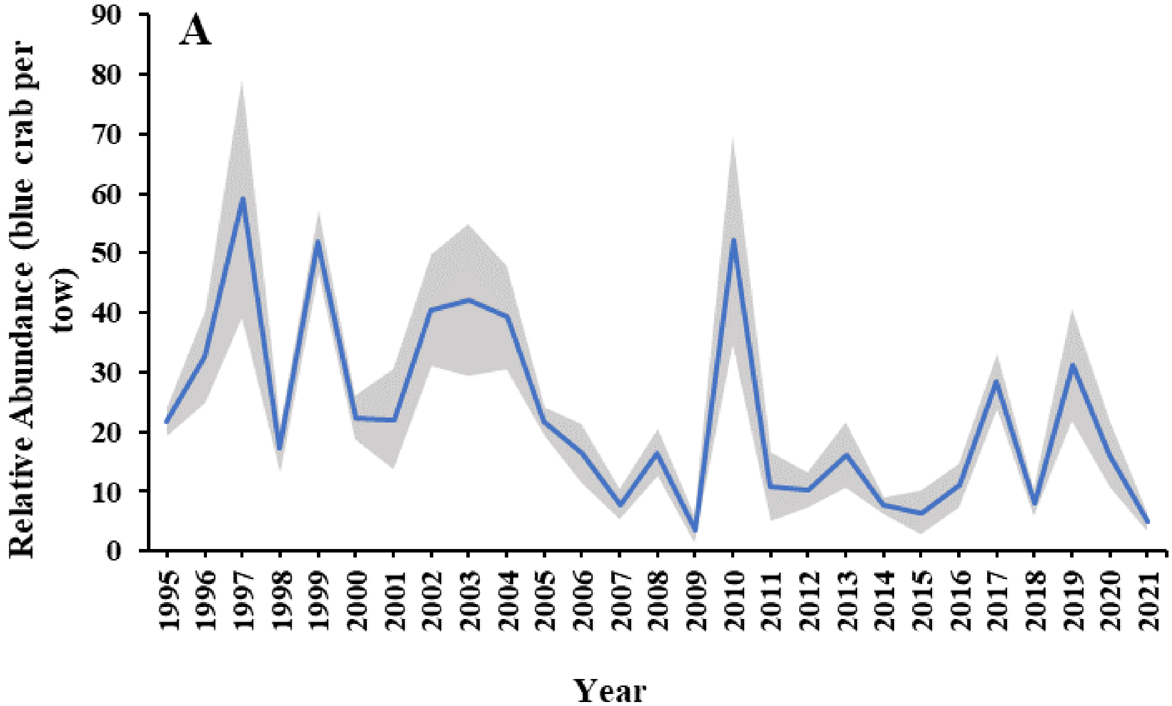


Figure 8. Nominal index (number of crabs per tow) of recruit crab relative abundance (<127 mm CW) captured in Program 120 in May and June by male (A) and female (B), 1995–2021.



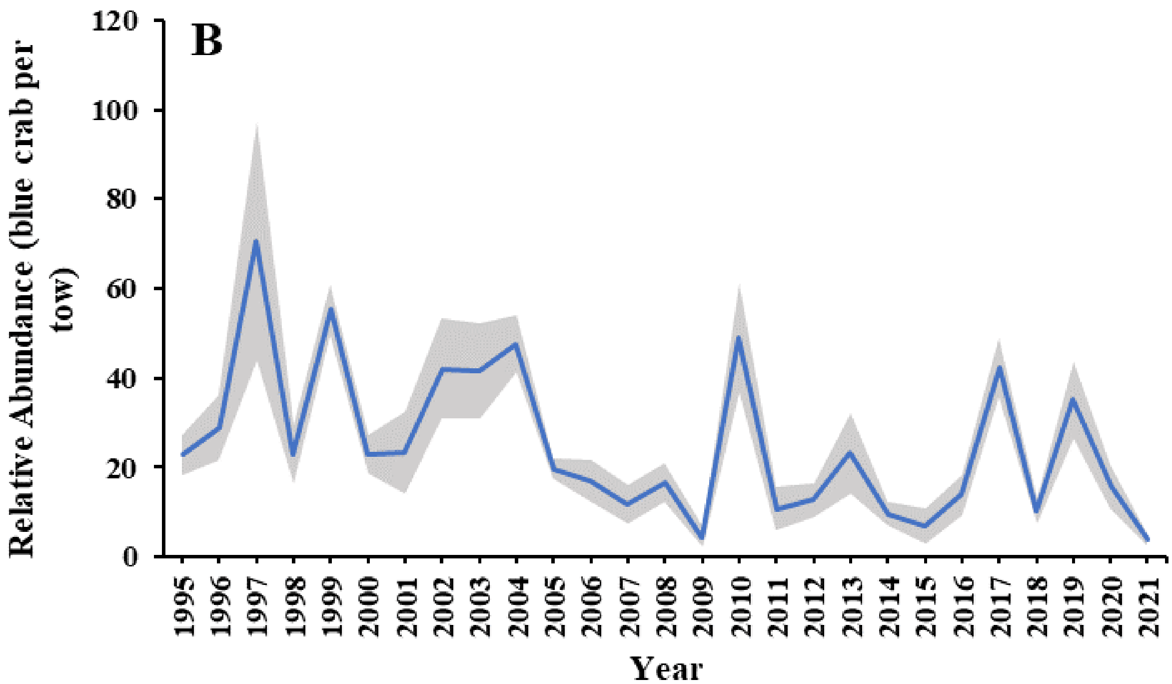


Figure 9. Nominal index (number of crabs per tow) of recruit crabs relative abundance (<127 mm, 5 inches, CW) captured in Program 195 by June male (A), June female (B), 1995–2021 for all strata combined. [Note: in 2020 and 2021 less than 54 stations were sampled]

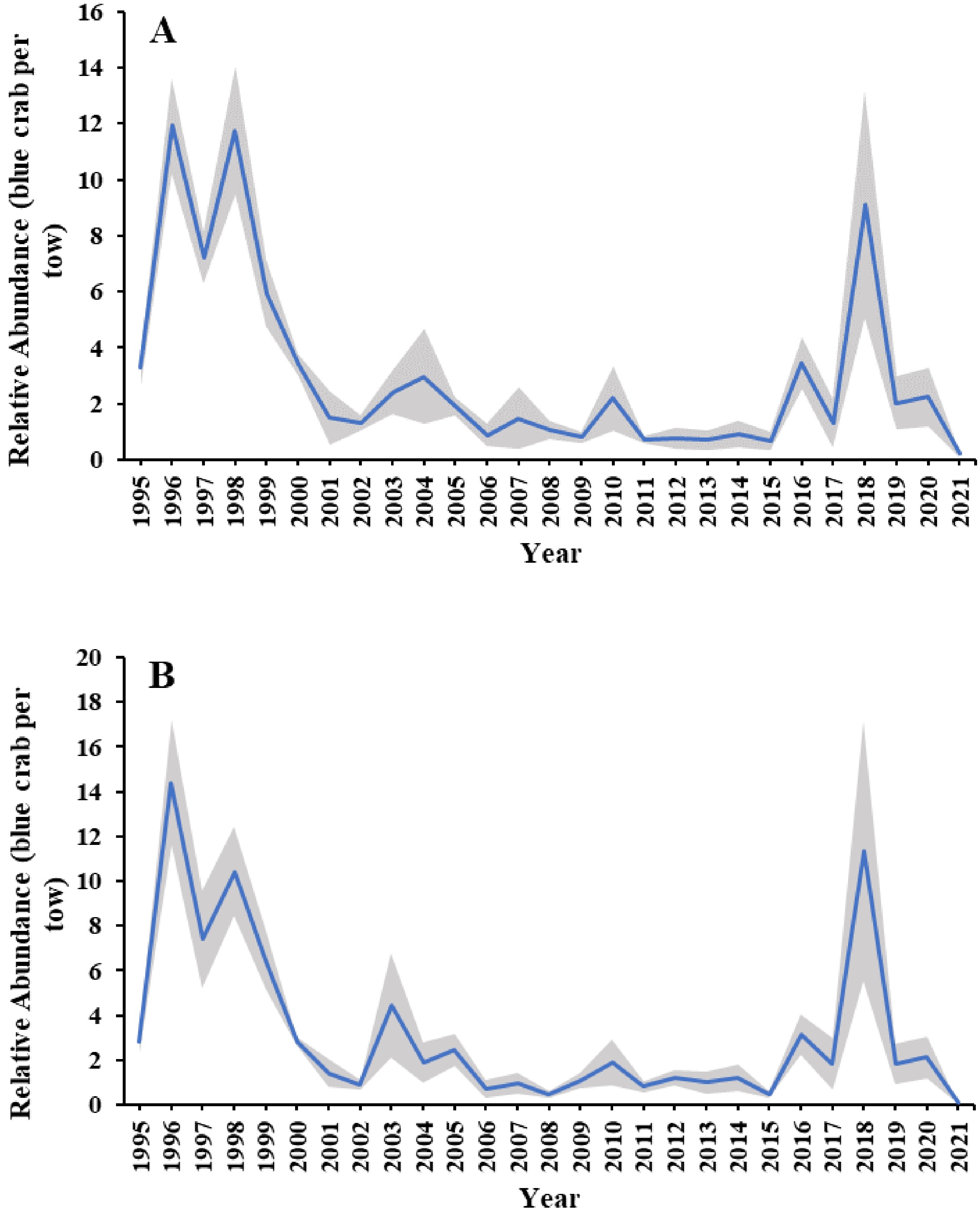


Figure 10. Nominal index (number of crabs per tow) of recruit crabs relative abundance (<127 mm, 5 inches, CW) captured in Program 195 by September male (A), September female (B), 1995–2021 for all strata combined. [Note: 2018 September sampling was conducted in October and in 2020 and 2021 less than 54 stations were sampled in both months]

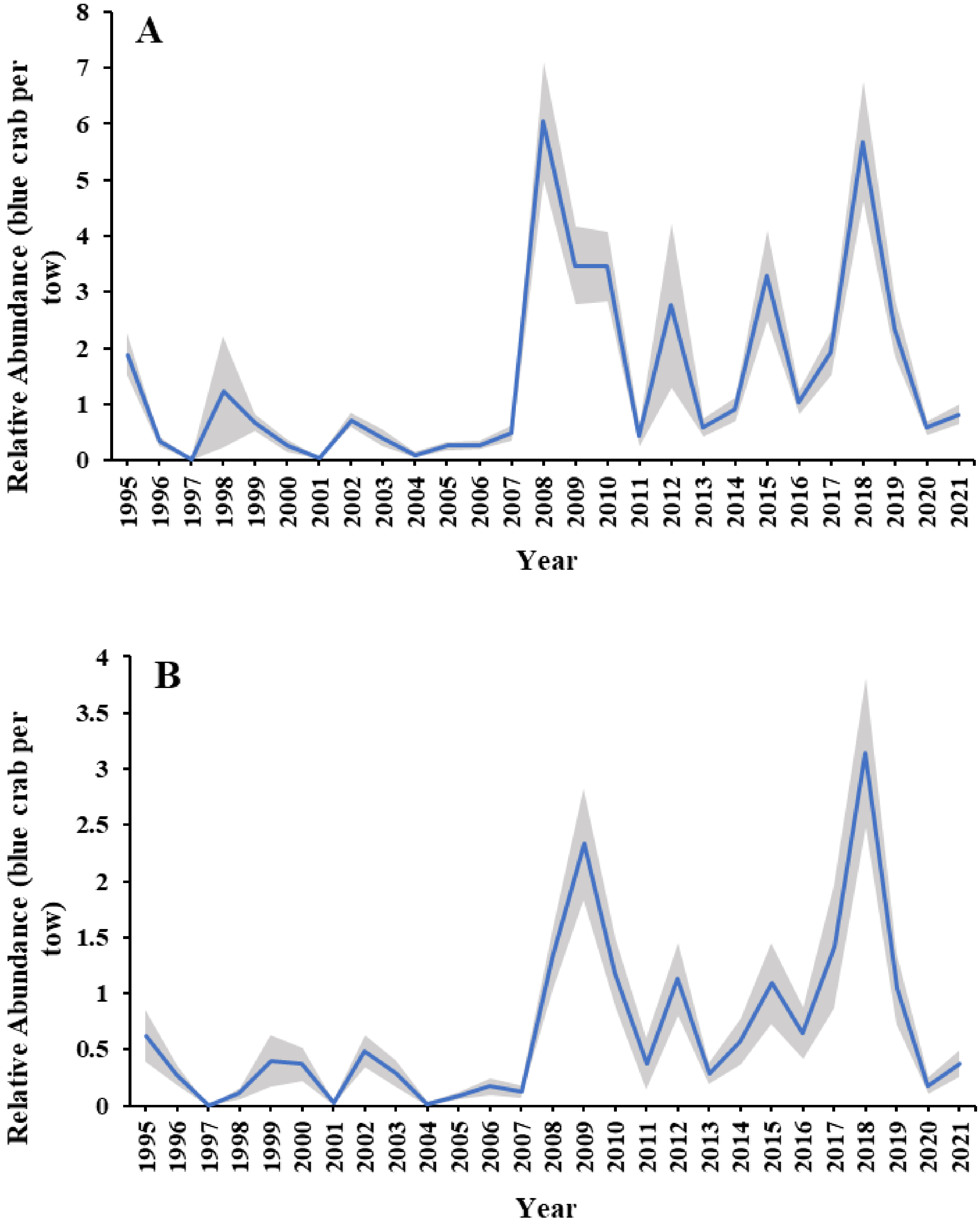
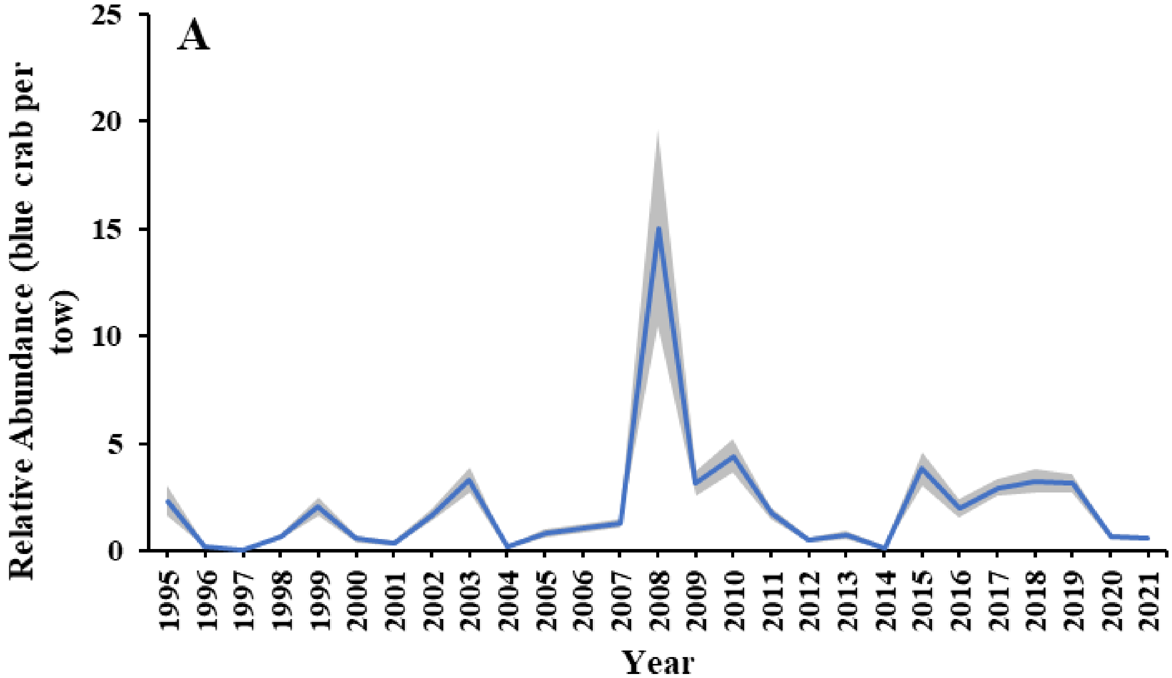


Figure 11. Nominal index (number of crabs per tow) of fully recruited crabs relative abundance (≥127 mm, 5 inches; CW) captured in Program 100 in summer for male (A) and female (B), 1995–2021.



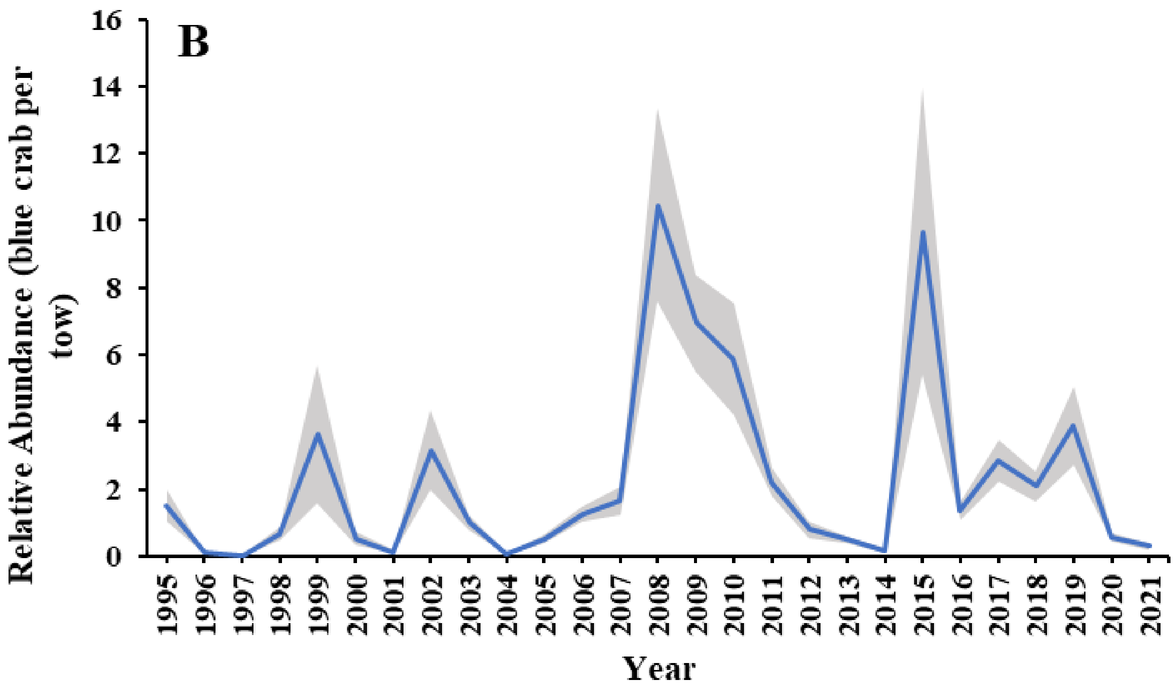
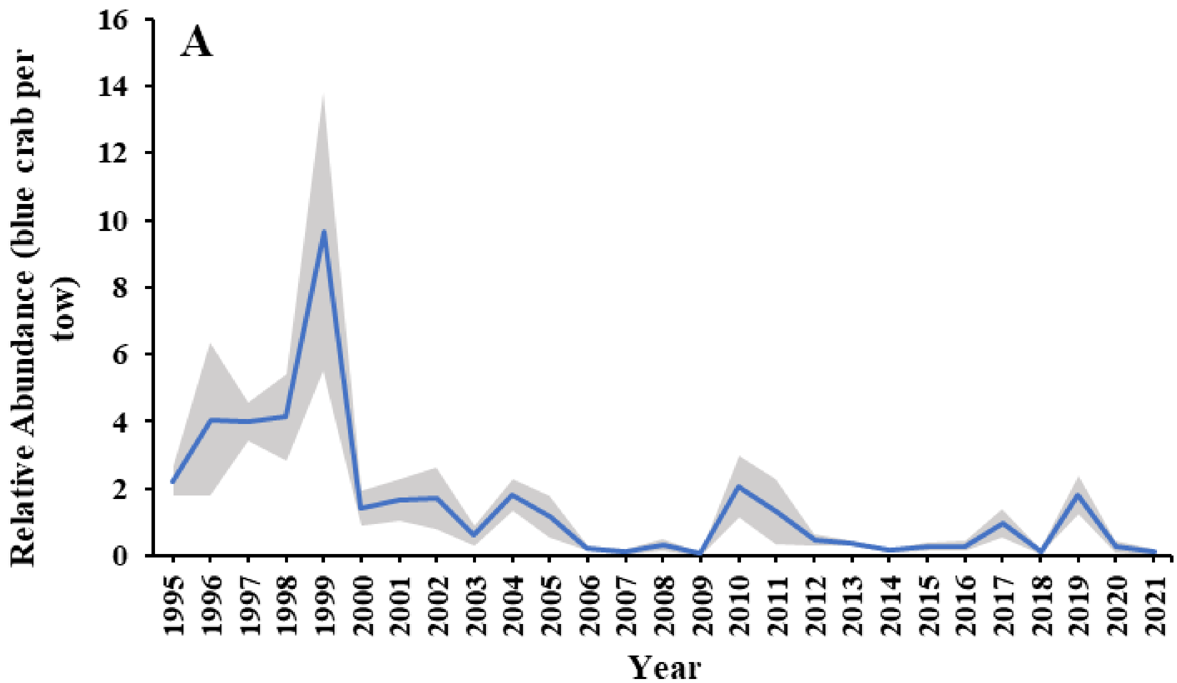


Figure 12. Nominal index (number of crabs per tow) of fully recruited crabs relative abundance (≥127 mm, 5 inches; CW) captured in Program 100 in fall for male (A) and female (B), 1995–2021.



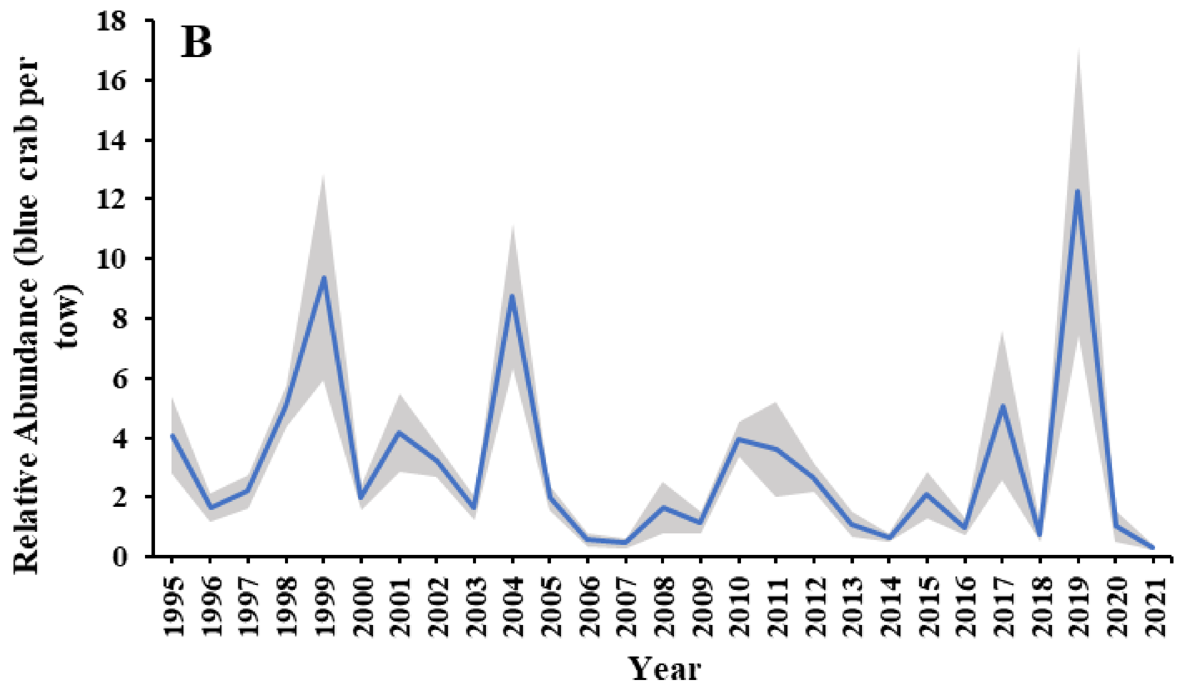


Figure 13. Nominal index (number of crabs per tow) of fully recruited crabs relative abundance (≥127 mm, 5 inches, CW) captured in Program 195 for June male (A) and female (B), 1995–2021 for all strata combined. [Note: in 2020 and 2021 less than 54 stations were sampled in both months]

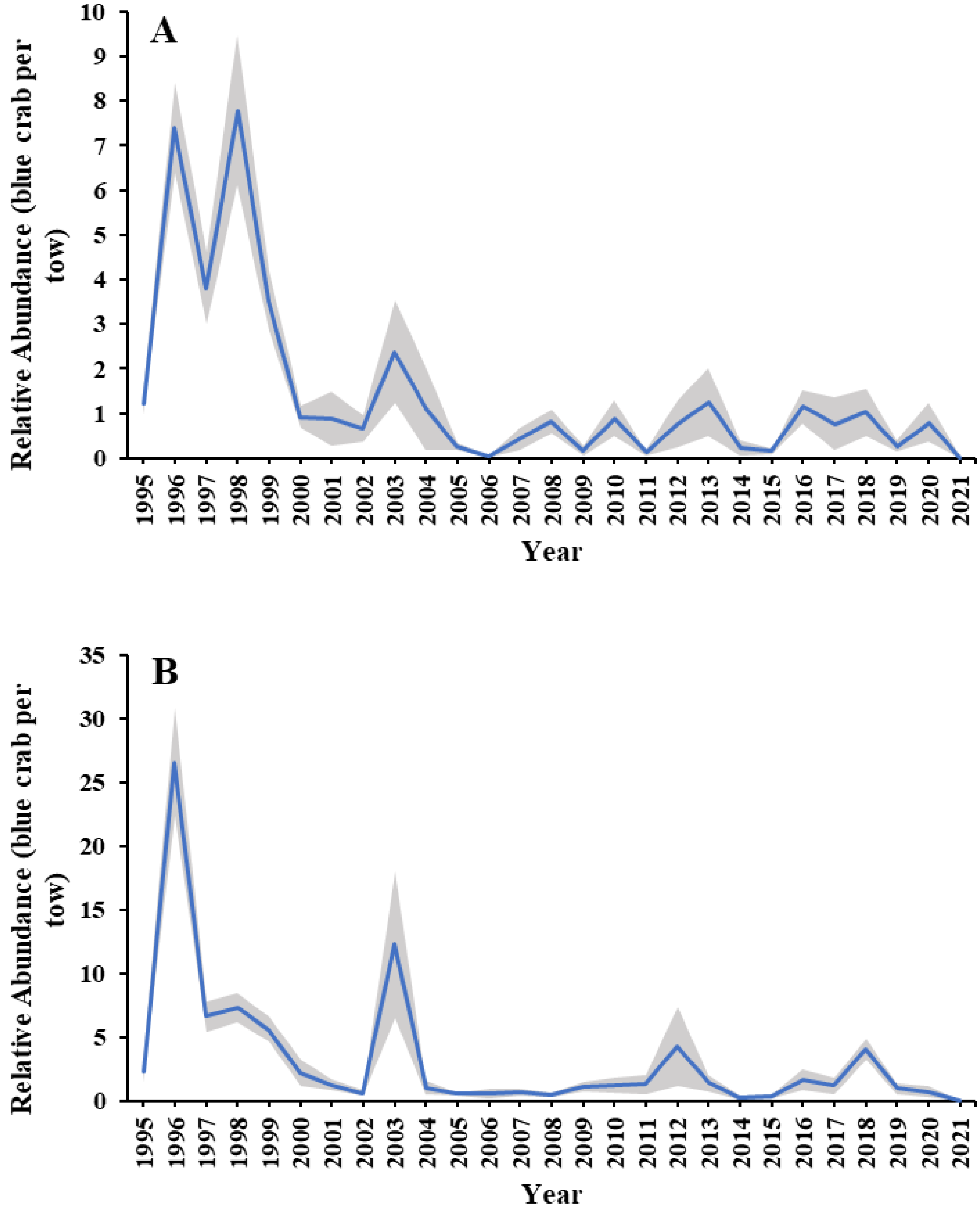


Figure 14. Nominal index (number of crabs per tow) of fully recruited crabs relative abundance (≥127 mm, 5 inches, CW) captured in Program 195 for September male (A) and female (B), 1995–2021 for all strata combined. [Note: 2018 September sampling was conducted in October and in 2020 and 2021 less than 54 stations were sampled in both months]

FISHERY MANAGEMENT PLAN UPDATE
EASTERN OYSTER
AUGUST 2022

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	
Schedule Changes:	None	
Comprehensive Review:	July 2022	

The original 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 Oyster FMP Amendment 1 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 Oyster FMP Amendment 2 included adopting a 15-bushel harvest limit in the 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 the Pamlico Sound to 20 bushels and created a monitoring system for determining when to close mechanical harvest in that area (NCDMF 2010). The Oyster FMP Amendment 3 created two seed oyster management areas in Onslow County (NCDMF 2014). Amendment 4 was adopted in February 2017 with selected management measures that included: 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 10 to five percent 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 (NCDMF 2017).

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 Amendment 4 to the North Carolina 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 (NCDMF 2017). To achieve this goal, it is recommended that the following objectives be met:

- Identify, restore, and protect oyster populations as important estuarine habitat.
- 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.
- 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.
- Consider the socioeconomic concerns of all oyster resource user groups, including market factors.
- 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.
- Identify and encourage research to improve understanding of oyster population ecology and dynamics, habitat restoration needs, and oyster aquaculture practices.
- Initiate, enhance, and continue studies to collect and analyze economic, social, and fisheries data needed to effectively monitor and manage the oyster resource.
- Promote public awareness regarding the ecological value of oysters and encourage public involvement in management and enhancement activities.

DESCRIPTION OF THE STOCK

Biological Profile

The eastern oyster 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, 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 < one percent 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 NCDMF biological sampling program. 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 also 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.

DESCRIPTION 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 five percent off public bottom based on management measures adopted in Amendment 4 of the Oyster FMP.

<u>Public Bottom</u>

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 nineteen times between the 1996-1997 and 2021-2022 seasons.

The daily hand harvest limit for oysters in the 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 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 onboard the vessel (NCDMF 2017). Hand harvesters with the Standard Commercial Fishing License (SCFL) could continue landing the higher daily harvest limits in all areas.

The mechanical harvest season for oysters in 2021-2022 was opened November 15, 2021, and was restricted to deeper portions of the sounds, rivers, and bays north of the 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 2021-2022 season (November 15 – 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 remaining 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 the 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 for the season on December 13, 2021, in the Northern Dare and Northern Hyde management areas. The Pamlico River and Neuse River management areas were closed to mechanical harvest for the season on February 14, 2022 (Table 1; Figure 1).

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 five percent culling tolerance, which is only 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 Fishery

Landings in the North Carolina oyster fishery are impacted by 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 percent 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 (Ray and Chandler 1955; Haskin et al. 1966; Ford and Figueras 1988; Ford and Tripp 1996). 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).

Throughout the 1990s, NCDMF sampling indicated that Dermo infections were on the rise in southern estuaries however, moderate and high Dermo infection levels during late summer 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 the 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 the 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 the 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 and 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 the 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 every year since 2017 (Figure 2). Hand harvest landings exceeded the mechanical landings from public bottom in 2012, 2013, and 2015 to 2021 (Figure 3). 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 SCFL. 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 2019, due to hurricane impacts to subtidal oyster populations in mechanical harvest area, commercial landings by hand harvest were over 30 times higher than mechanical harvest landings off public bottom (Figure 3).

Mechanical Harvest Fishery Off Public Bottom

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 the 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 during the 2011-2012 season (Figure 3). Regular sampling of oyster sizes to fulfill the requirements of Amendment 4 to the 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 the 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 County 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 outside of Northern Hyde area.

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 five percent following the adoption of Amendment 4. 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 (dissolved oxygen < 2-3 mg/L) or anoxic (dissolved oxygen = 0 mg/L) 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 University researchers 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).

In September 2019, a decline in water quality from Hurricane Dorian negatively impacted the already reduced subtidal oyster populations in Pamlico Sound. All mechanical harvest management areas were below than 26% legal management trigger during pre-season sampling in 2019. The percentage of legal oysters in both Neuse River and Dare County management areas was lower in the 2019-2020 pre-season sampling than it was at the close of the 2018-2019 mechanical season, showing the deep-water oyster mortality that occurred in these areas from the storm event. Following the protocol established in Amendment 4 of the Oyster FMP, the mechanical harvest season was opened on November 18, 2019, and closed on November 29, 2019, for all areas except Northern Hyde County, which closed January 6, 2020. While open to mechanical harvest, the small amount of effort and landings occurred in the shallow water bays where oyster populations were not as significantly reduced by the storm events of 2018-2019 season. Mechanical landings for 2019 were the lowest reported during the last 25 years (Figure 3).

Pre-season sampling in the deep-water areas in both the Neuse and Pamlico Management Areas showed very low percentages of legal oyster prior to the start of the 2020-2021 mechanical harvest season, and these areas both tripped the management trigger twice and closed to mechanical harvest on December 14, 2020. The bays in the Pamlico Management area maintained relatively high legal percentages for the entire possible six-week season, and harvesters reported harvesting a full limit before noon, even up to the last few days of the possible season. Legal percent in the Northern Dare management area remained above the trigger threshold for a relatively long time when compared to the previous three oyster seasons and remained open to mechanical harvest until February 14, 2021.

The Northern Hyde and Dare Management areas started the 2021-2022 mechanical harvest season below the management trigger and were closed to mechanical harvest on December 13, 2021, after the management trigger was tripped during first in-season trigger sampling event. Abundance and size of oysters in the deep-water areas of the Neuse and Pamlico River Management areas continued to be very low. Mechanical harvest in these two Management Areas was supported by oysters found in the bays during the six-week season.

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 Oyster FMP in 2008, the NCMFC adopted the strategy to promote a more habitat friendly fishery by increasing the hand harvest limits to match dredging limits in the bay areas of the Pamlico Sound (NCDMF 2008). Amendment 2 put in place a 15 bushel per day hand/mechanical harvest limit per commercial fishing operation in the 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 the 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 SCFL. 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 Oyster FMP (NCDMF 2017). 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 five percent of the total area open to harvest of shellfish 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 the harvest of shellfish. 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.

<u>Permanent and Temporary Shellfish Closures</u>

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/100 mL [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 2011 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 the harvest of shellfish, 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.

Throughout the North Carolina coast, 2018 was a record year for precipitation, with the landfall of Hurricane Florence contributing greatly to the total rainfall 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 78% of the total oyster landings in 2021 (Figure 2).

As of 2020, the shellfish lease program had 381 leases, with 29 bottom lease and 25 water column amendment applications during the year. Currently, shellfish leases take up about 2,070 acres of bottom (O. Mulvey-McFerron; Lease Program Coordinator, NCDMF; June 2021).

Recreational Fishery

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.

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

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 recently deceased oysters (known as “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 2021-2022 mechanical harvest season trigger sampling revealed percent legal levels lower than the trigger threshold prior to the start of the mechanical harvest season in both the Neuse River, Northern Hyde, and Northern Dare mechanical harvest management areas (Table 1; Figure 1).

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, but overall showing a declining trend for the past 10 years (Figure 4). The 2018 and 2019 indices were the lowest and below the 10-year average (annual average number of spat across all sampling sites) (Figure 4). Sampling was conducted in 2021; however, data is pending further review and entry into the biological database.

RESEARCH NEEDS

The specific research recommendations from Amendment 4 to the North Carolina Oyster FMP (NCDMF 2017). The list below outlines the specific needs and highlights the priority and status of each. 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.

High

- Support all proposed implementation actions under the priority habitat issue on sedimentation in the CHPP — Ongoing through the CHPP
- Improve the reliability for estimating recreational shellfish harvest — Ongoing
- Survey commercial shellfish license holders without a record of landings to estimate oyster harvest from this group —Needed
- Develop regional juvenile and adult abundance indices (fisheries-independent) — Pilot study in progress with The Nature Conservancy and N.C. State University)
- Determine alternative substrates for reef development and monitoring of intertidal and subtidal reefs (cost-benefit analysis for reefs and cultch planting) —Ongoing
- Quantify the impact of current fishing practices on oyster habitat suitability in North Carolina —Needed
- Develop a program to monitor oyster reef height, area, and condition — Ongoing
- Estimate longevity and yield of oysters on cultch planting sites — Needed
- Develop methods to monitor abundance of the oyster population — Pilot study in progress with the Nature Conservancy and N.C. State University

Medium

- Complete socioeconomic surveys of recreational oyster harvesters — Needed
- Support collaborative research to track bacterial sources more efficiently for land-based protection and restoration efforts — Ongoing
- Quantify the relationship between water quality parameters and the cumulative effect of shoreline development units (e.g., docks, bulkhead sections) — Needed
- Develop peer reviewed, standardized monitoring metrics and methodologies for oyster restoration and stock status assessments — Needed

Low

- Continue to complete socioeconomic surveys of commercial oyster fishermen — Needed
- Identify number and size of sanctuaries needed — Ongoing
- Identification of larval settlement cues which influence recruitment to restored reefs (i.e., sound, light, current, etc.) — Ongoing
- Further studies on the effects of dredge weight and size on habitat disturbance and oyster catches —Needed
- Estimate oyster mortality associated with relay — Needed

MANAGEMENT STRATEGY

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

Amendment 4 was adopted in February 2017 and associated rule changes became effective May 1, 2017. The selected management strategies adopted by the NCMFC in Amendment 4 of the Eastern Oyster FMP can be found in Table 3.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

The division recommends maintaining the current timing of the scheduled review in 2022.

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TABLES

Table 1. Percentage of legal-sized oysters and status (denoted by color) by management area for the 2021–2022 season in the mechanical oyster fishery trigger sampling program.

	Status as of Week							
Management Area	11/8/2021	11/22/2021	12/6/2021	12/20/2021	1/3/2022	1/10/2022	1/24/2022	2/7/2022
Neuse River	23.5%		37.5%			0.0%	0.0%	
Pamlico River	43.2%		49.2%			0.8%	1.8%	
N. Hyde	17.9%		25.2%			18.6%		
N. Dare	24.2%		20.6%			21.4%		

Color Codes

(green)	Open
(yellow)	Less than 26% Trigger Tripped Once: Open
(red)	Two Cosecutive Less than 26% Triggers Tripped: Closed
(orange)	One 26% or Greater Trigger Tripped: Closed

Table 2. Classification of shellfish waters in acreage, 2011–2021 (Source: NCDMF Shellfish Sanitation and Recreational Water Quality Section).

	Open Area		Closed Area		
Year	Approved	Conditionally Approved Open	Conditionally Approved Closed	Restricted	Prohibited
2011	1,734,938	43,054	12,552		428,414
2012	1,732,888	44,599	12,708		428,835
2013	1,733,069	44,649	11,834		429,531
2014	1,733,155	44,261	11,827		429,796
2015*	1,418,373	43,849	11,739		745,169
2016	1,416,960	44,785	12,008		745,597
2017	1,414,709	44,425	12,209		747,759
2018**	1,414,525	44,122	11,859	18,933	729,761
2019	1,415,007	43,216	12,721	20,260	730,550
2020	1,416,683	43,085	9,919	18,117	736,128
2021	1,459,163	42,801	9,917	18,168	736,690

** 314,710 acres administratively closed on 2/4/15 due to budget cuts and office closures.*
*** First year "Restricted" waters were differentiated from "Prohibited" waters.*

Table 3. Summary of the N.C. Marine Fisheries Commission management strategies and their implementation status for Amendment 4 of the Oyster Fishery Management Plan 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 five percent 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 percent 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

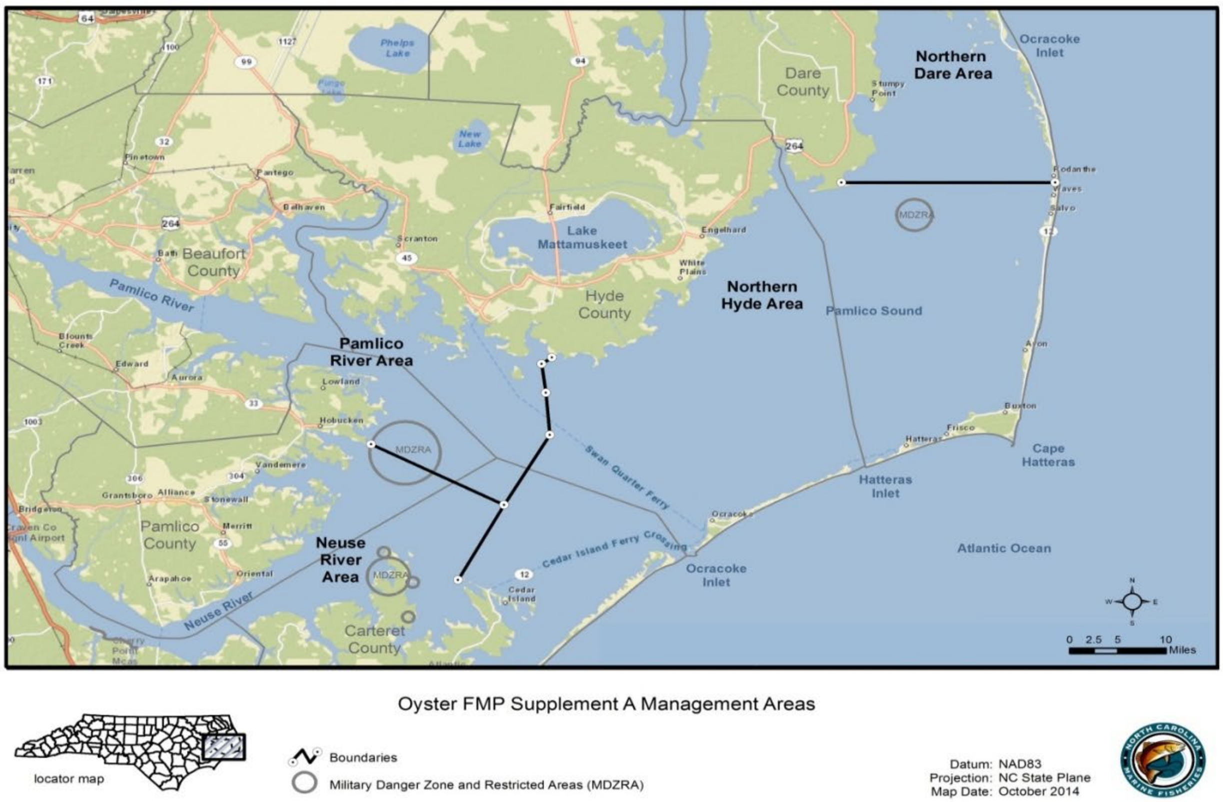

Figure 1. Mechanical harvest management areas from Amendment 4 of the Oyster Fishery Management Plan.

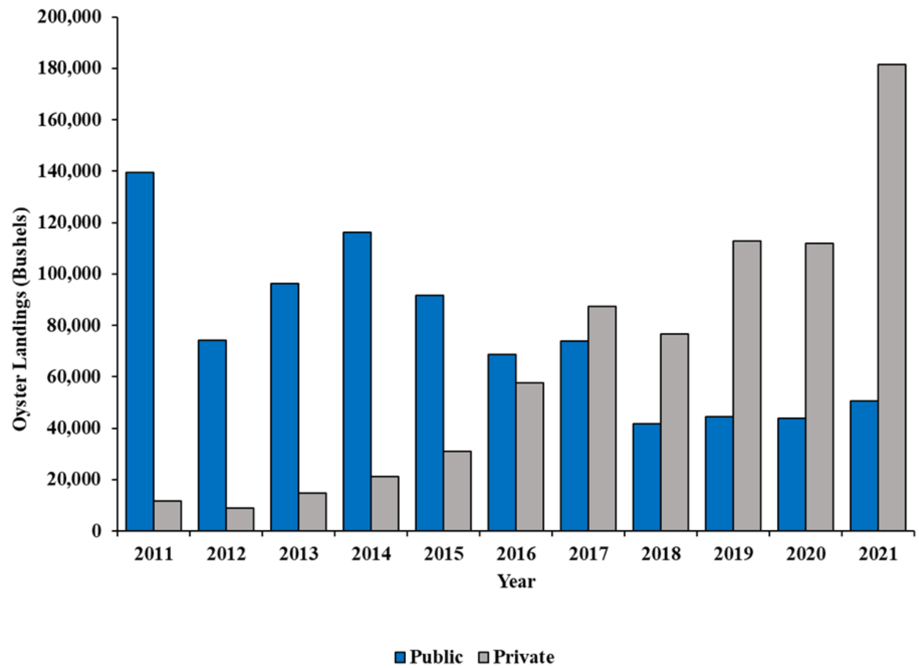

Figure 2. Annual commercial oyster landings (bushels) separated by private and public bottom in North Carolina, 2011–2021 (Source: NCDMF Trip Ticket Program).

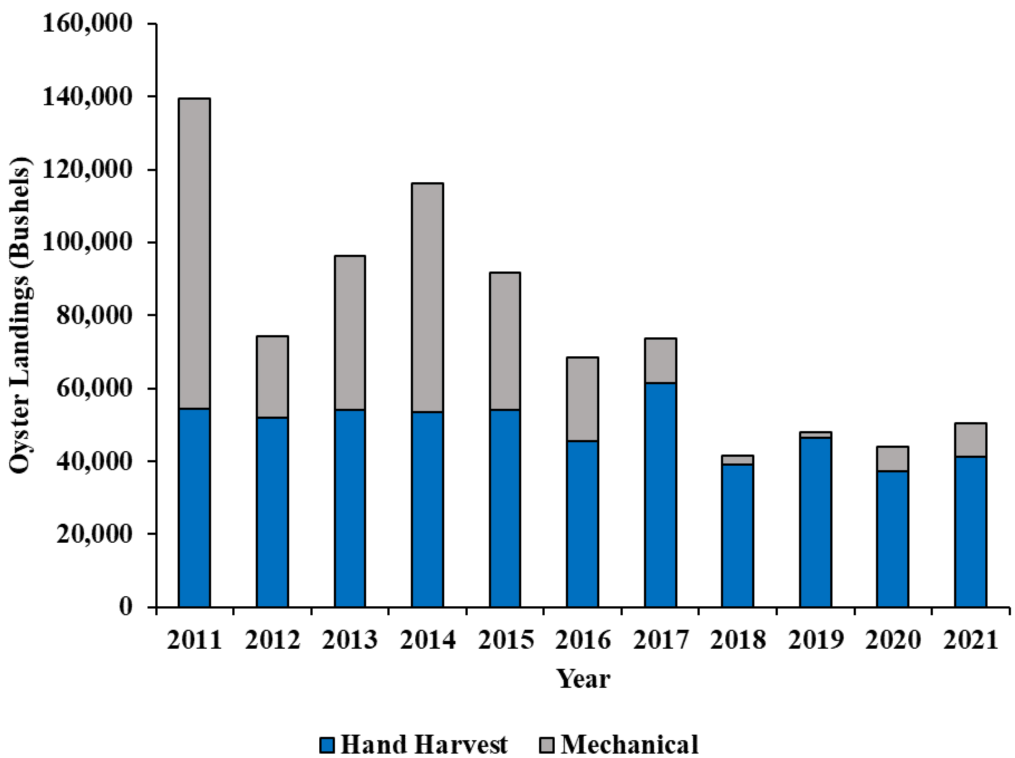

Figure 3. Annual commercial oyster landings (bushels) from public bottom separated by mechanical and hand harvest methods 2011–2021 (Source: NCDMF Trip Ticket Program).

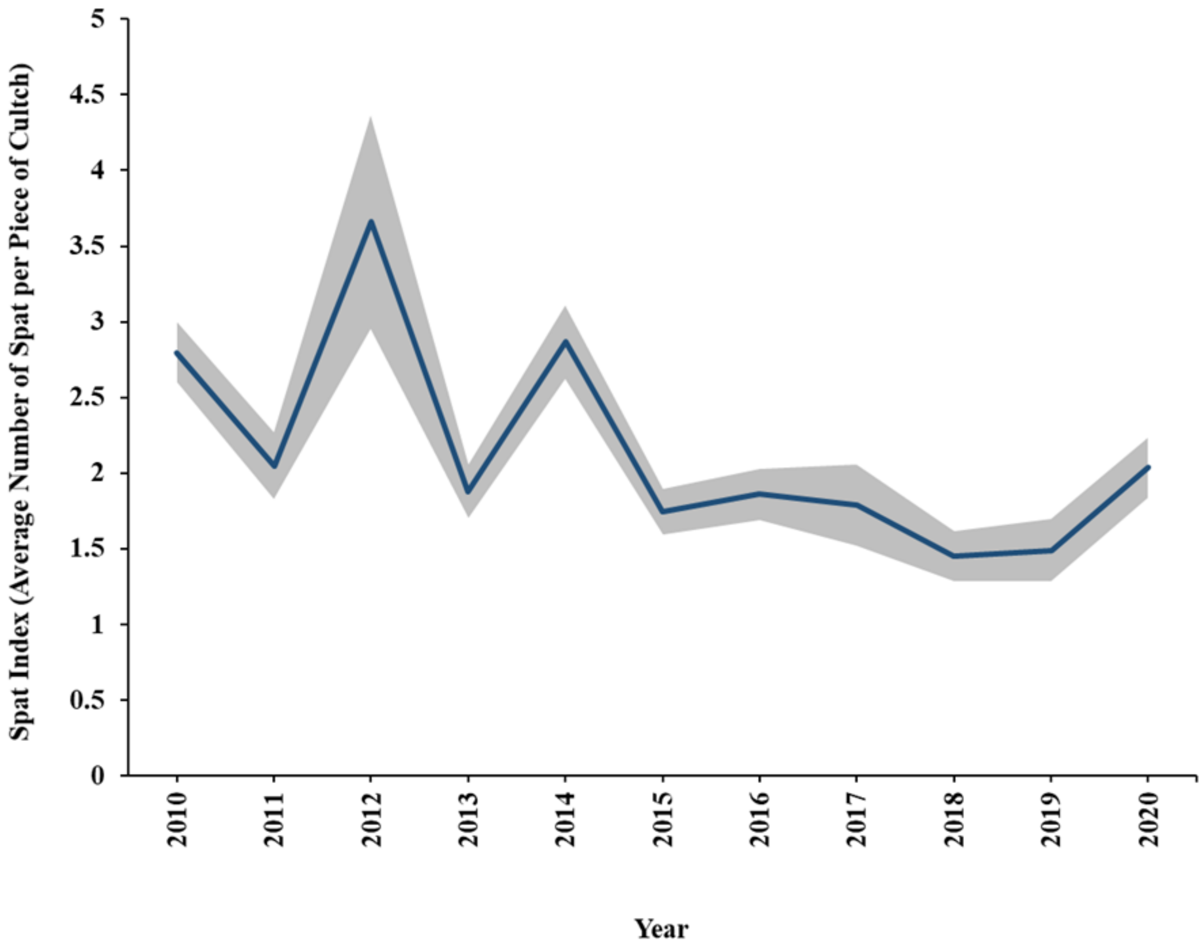

Figure 4. The annual average number of oyster spat across all sampling sites with standard error shaded in gray, 2010–2020 (Source: NCDMF Habitat and Enhancement Section). Shaded area represents + one standard error. Data from 2021 pending review and entry.

FISHERY MANAGEMENT PLAN UPDATE
ESTUARINE STRIPED BASS
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	January 1994 May 2004	
Amendments:	Amendment 1 Amendment 2	May 2013 In Progress
Revisions:	Revision to Amendment 1 Revision to Amendment 1	November 2014 November 2020
Supplements:	Supplement A	February 2019
Information Updates:	None	
Schedule Changes:	August 2016	
Comprehensive Review:	Review started in 2017; Amendment 2 is currently in development	

Estuarine striped bass (*Morone saxatilis*) in North Carolina are managed under Amendment 1 to the N.C. Estuarine Striped Bass FMP, its subsequent revisions, and Supplement A. It is a joint plan between the North Carolina Marine Fisheries Commission (NCMFC) and the North Carolina Wildlife Resources Commission (NCWRC). The Striped Bass FMP, Revisions, Amendments, and Supplement A (NCDMF 1994, 2004, 2013, 2014, 2019, and 2020) are available on the NCDMF website at: https://deq.nc.gov/about/divisions/marine-fisheries/managing-fisheries/fishery-management-plans#state-managed-species

The NCMFC and the 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 November 1993 and was targeted at the continued recovery of the A-R stock, which was at historically low levels of abundance and experiencing chronic spawning failures (Laney et. al. 1993). The comprehensive plan addressed the management of all estuarine striped bass stocks in the state, satisfying a 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 North Carolina Estuarine Striped Bass FMP approved in May 2004 was the first FMP developed under the criteria and standards of the 1997 Fisheries Reform Act (NCDMF 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.

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 7 to the Interstate FMP for Atlantic Striped Bass.

In response to the 2013 benchmark A-R striped bass stock assessment that indicated fishing mortality was above the target, the NCMFC approved a Revision to Amendment 1 in November 2014 (NCDMF 2014). The November 2014 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 November 2014 Revision maintained the 25,00-pound commercial TAL for the CSMA, 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 November 2014 Revision utilizes TAL instead of total allowable catch (TAC). The term TAC does 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 TAL.

In August 2016, the NCMFC approved a change to the FMP review schedule so 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 stocked fish and minimal natural recruitment in the CSMA systems. Review of the plan began in 2017 and development of Amendment 2 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 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 NCWRC 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 anchored 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.

The most recent A-R striped bass benchmark stock assessment (Lee et al. 2020) was completed and approved for management use in 2020. The assessment indicated the resource is overfished and is experiencing overfishing (Lee et al. 2020). In response to the overfished and overfishing stock status, the NCMFC approved a Revision to Amendment 1 in November 2020 (NCDMF 2020). The November 2020 Revision to Amendment 1 to the North Carolina Estuarine Striped Bass Fishery Management Plan reduced the striped bass TAL from 275,000 pounds to 51,216 pounds in the Albemarle Sound and Roanoke River Management Areas to remain in compliance with Amendment 1 to the North Carolina Estuarine Striped Bass Fishery Management Plan (FMP) and the Atlantic States Marine Fisheries Commission (ASMFC) Addendum IV to Amendment 6 to the Interstate FMP for Atlantic Striped Bass. The new TAL was effective January 1, 2021.

The CSMA Estuarine Striped Bass Stocks report (Mathes et al. 2020), completed in 2020, is a collection of (1) all data that have been collected, (2) all management effort, and (3) all major analyses that have been completed for CSMA stocks to serve as an aid in development of Amendment 2. No stock status determination was performed, and no biological reference points were generated for CSMA striped bass stocks.

NCDMF and NCWRC staffs continue to work collaboratively in development of Amendment 2 to the N.C. 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 striped bass 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 7 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:

- Identify and describe population attributes, including age structure, necessary to achieve sustainable harvest.

- Restore, improve, and protect striped bass habitat and environmental quality consistent with the Coastal Habitat Protection Plan (CHPP) to increase growth, survival, and reproduction.
- Manage the fishery in a manner that considers biological, social, and economic factors.
- 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.
- 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.
- Develop management measures, including regulations that consider the needs of all user groups and provide sustainable harvest.
- Promote practices that minimize bycatch and discard mortality in recreational and commercial fisheries.

DESCRIPTION OF THE STOCK

Biological Profile

Striped bass 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. 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 at age 4, while females in the Tar-Pamlico and Neuse rivers are 50% mature at 2.7 years and 98% mature by age 3 (Knight 2015). The length at 50% maturity 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 ranges from 223,110 eggs for Age-3 females to 3,273,206 eggs for Age-10 females (Knight 2015). Fertilized eggs drift with downstream currents and need 1.5 to 3 days to hatch and then continue to develop through the larval stage for several more days, eventually arriving at 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 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 the A-R stock occurs when water temperature 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. Natural reproduction and successful juvenile recruitment occur infrequently and at low levels in the Tar-Pamlico, Neuse and Cape Fear rivers. The CSMA stocks are supported by continuous stocking efforts as evidenced by stocked fish comprising nearly 100% of the striped bass 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. The oldest observed striped bass in the A-R stock was 31 years. The oldest observed striped bass within the CSMA were 7 years in the Cape Fear River and 12 years in the Tar-Pamlico and Neuse rivers. The largest striped bass on record are several 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 populations in the CSMA are considered to have a primarily endemic riverine life history, having limited or no adult oceanic migration (Setzler et al. 1980; Rulifson et al. 1982a; Callihan 2012).

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 Atlantic menhaden, herrings and shads are very important prey items, but they will also readily eat spot, mullet, Atlantic croaker, American eel, and various invertebrates like blue crab.

Stock Status: A-R Stock

The most recent assessment of the A-R striped bass stock was completed in 2020, utilizing data from 1991–2017. Results from the 2020 A-R striped bass benchmark stock assessment indicate the stock is overfished and overfishing is occurring (Lee et. al 2020). The estimate of *F* in the terminal year of the assessment (2017) was 0.27, above the $F_{35\%SPR\ Threshold}$ of 0.18 (Figure 1) and the estimate of SSB was 78,576 pounds, below the $SSB_{35\%SPR\ Threshold}$ of 267,390 pounds (Figure 2). Estimates of *F* have been above the $F_{35\%SPR\ Threshold}$ in 24 out of the 27 years of the time period of the assessment (Figure 1). Female SSB has declined steadily from a high of 587,516 pounds in 2000 to a low of 45,418 pounds in 2013. Female SSB increased through 2015 to 167,053 pounds and has declined since (Figure 2). Results of the assessment also show a period of strong recruitment (as measured by the number of age-0 fish coming into the stock each year) from 1993 to 2000, then a period of much lower recruitment from 2001 to 2017, which has contributed to the decline in SSB since 2003. Average recruitment during 1993–2000 was 1,127,646 age-0 fish per year while average recruitment for years 2001–2017 was 428,796 age-0 fish per year (Figure 2).

Several years of poor recruitment occurred during 2001–2004 at a time when SSB was at high levels, indicating factors other than abundance of SSB may be contributing to poor spawning success in some years. Appropriate river flow during the spawning period has long been recognized as an important factor in spawning success for A-R striped bass (Hassler et. al 1981; Rulifson and Manooch 1990). Low to moderate flows have been identified as favorable to strong year-class production while high flows (10,000 cubic feet per second or greater) are unfavorable to the formation of strong year classes. The peer reviewers of the 2020 benchmark assessment recognized the importance of river flow on recruitment and noted declining recruitment in the time series does not appear to result solely from reduced abundance due to harvest (Lee et. al 2020).

Stock Assessment: A-R Stock

Stock Synthesis text version 3.30 (Methot 2000, 2012; Methot and Wetzel 2013) was used to model the striped bass stock and to calculate reference points (Lee et al. 2020). 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. The model was peer reviewed and approved for use in management by an outside panel of experts and the ASMFC Atlantic Striped Bass Management Board. The NCDMF also approved it for management use.

DESCRIPTION OF THE FISHERY: ASMA/RRMA

Annual spawning success of striped bass 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/RRMA

Harvest in the ASMA commercial sector in 2021 was limited by an annual TAL of 25,608 pounds. 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. Harvest in the newly developing strike net fishery for blue catfish has also increased in recent years. 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. Dependent on available quota, a fall harvest season can be opened from October 1 through December 31 and a spring harvest season can be opened 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 of all small mesh (< 5-inch stretched mesh) gill nets during May–November 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 by the ASMA recreational sector in 2021 was limited by an annual TAL of 12,804 pounds. The recreational sector also has an 18-inch total length minimum size limit and a one 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.

Commercial harvest in the RRMA is prohibited. The RRMA recreational sector also had a TAL of 12,804 pounds in 2021. Due to the reduced TAL, the 2021 harvest season for striped bass in the RRMA was open April 10–April 16, and April 24–April 30, 2021. There is an 18-inch total length minimum size limit and a no possession slot where fish between 22- and 27-inches TL may not be possessed. There was a one 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 April 1–June 30.

Commercial Fishery: ASMA

Commercial landings in the ASMA have been controlled by an annual TAL since 1991 (Table 1). Due to gill net mesh regulations and minimum size limits in place, most harvest consists of fish 4–6 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 declined, commercial landings no longer reached the annual TAL, even with increases in the number of harvest days and daily possession limits. During 2005–2009 landings steadily declined and averaged about 150,000 pounds, even though gill net trips remained steady during that period (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 sustainability parameters being exceeded in the American Shad Sustainable Fishery Plan. Most landings traditionally have come during the American shad season. Length frequency distribution in 2021 is presented in Figure 4. Length at age for all commercial samples collected 1972–2021 are presented in Figure 5. Commercial length frequencies are represented in 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 18–24 inches TL dominate the fishery.

Recreational Fishery: ASMA/RRMA

The recreational sector's landings in the ASMA are dominated by fish aged 3 to 5. 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. (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 was decreased to two fish per person per day in January 2016 and further to one fish in January 2021. Recreational harvest during 1991–2021 has averaged 43,708 pounds in the ASMA. 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 21,247 fish (Table 2). Length frequency distribution in 2021 is presented in Figure 4. ASMA recreational length frequencies for 1996–2021 are presented in 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-yearclasses with a slight uptick in landings for 2019 and 2020 from the previous several years (2016–2019). Landings were substantially lower in 2021 than previous years as a result of a reduced TAL.

The recreational sector's landings in the RRMA are dominated by fish aged 3 to 5 due to a no possession rule of fish 22–27 inches TL 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 1991 through 2019 has averaged 66,189 pounds 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 discards from 2011 through 2021 in the RRMA have averaged 83,286 fish (Table 2).

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; 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 2021 is presented in Figure 4. RRMA recreational length frequencies for 2005–2021 are presented in Figure 8. Since 2005 abundance of older fish in the recreational creel survey has decreased.

MONITORING PROGRAM DATA: A-R STOCK

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 87.8% of the harvest in the ASMA (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 2021 was 21.6 inches (Table 3).

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 during 2005–2021 was 20 inches total length for the ASMA and RRMA (Tables 4 and 5). Age data from the dependent and independent surveys in the ASMA are presented in Table 6. The minimum and maximum age for the independent and dependent surveys are 1 and 17 years respectively with an average age of 5.

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 July–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; 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 2016 the stock saw improved annual spawning success, with above average JAI values in 2011, 2014, and 2015, with one year (2013) below the spawning failure threshold. However, the JAI values for 2018, 2019, 2020, and 2021 were 0.4, 1.18, 0.20, and 0.7 respectively and are below the spawning failure threshold of 1.33 (ASMFC 2010) (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 (Program 135). The survey utilizes a stratified random sampling design, employing mesh sizes from 2½-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. No index of abundance is available for the spring survey in 2020 and 2021 or the winter survey in 2021. Sampling in 2020 was suspended due to COVID-19 restrictions and Atlantic sturgeon protected species interactions but resumed in the fall of 2021.

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 4–6-year-old abundance. The trend in abundance of 4–6-year-old 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 4–6-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 (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 during 2001–2010. In 2019 the abundance of 4–6-year-old fish was below average in the fall/winter portion of the survey and increased in the spring. The 2020 fall/winter portion of the survey showed a continued increase in numbers of 4–6-year-old fish (Figure 11). This is due to the above average 2014- and 2015-yearclasses reaching the 4–6-year-old range in 2021. Expectations are the abundance of 4–6-year-old fish will decline over the next few years because of the repeated spawning failures the stock has experienced since 2018 (Figure 10).

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 4–6 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 2017 of 50 fish per hour (Figure 12). The abundance of fish in 2021 (140 fish per hour) was the highest since 2015 but below the time series average of 192 fish per hour. 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. In 2018 no age 9+ fish were captured. In 2021 the survey caught 0.72 fish per hour which was the highest rate since 2016 but well below the time series average of 3.97 fish per hour (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 a 31-year-old fish based on a tag returned by an angler in 2019 in the Roanoke River. When the survey started in 1990 fish older than seven were rarely observed in the survey. Age 9+ fish abundance has decreased in recent years and for years 2016–2021 is similar to the abundance levels seen in the early 90's.

RESEARCH NEEDS: A-R STOCK

The research recommendations listed below (in no particular order) are intended to improve future assessments of the A-R striped bass stock. The bulleted items outline the specific issue and are organized by priority ranking.

High

- Improve estimates of discard mortality rates and discard losses from the ASMA commercial gill-net fisheries (ongoing through observer program)
- Collect data to estimate catch-and-release discard losses in the ASMA recreational fishery during the closed harvest season
- Investigate relationship between river flow and striped bass recruitment for consideration of input into future stock assessment models

Medium

- Transition to an assessment that is based on ages derived from otoliths
- Improve estimates of catch-and-release discard losses in the RRMA recreational fishery during the closed harvest season
- Incorporate tagging data directly into the statistical catch-at-age model
- Improve the collection of length and age data to characterize commercial and recreational discards
- Explore the direct input of empirical weight-at-age data into the stock assessment model in lieu of depending on the estimated growth relationships

Low

- Re-evaluate catch-and-release mortality rates from the ASMA and RRMA recreational fisheries incorporating different hook types and angling methods at various water temperatures (e.g., live bait, artificial bait, and fly fishing)
- Investigate the potential impact of blue catfish on the A-R striped bass population (e.g., habitat, predation, forage)

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 (Table 7). Striped bass fisheries in the Atlantic Ocean of North Carolina are managed under ASMFC's Amendment 7 to the Interstate FMP for Atlantic Striped Bass. 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. The 2020 A-R striped bass stock assessment indicated that the A-R striped bass stock is overfished with overfishing occurring in the terminal year (2017). Adaptive management measures within Amendment 1 to the Striped Bass FMP required a reduction in TAL to reduce fishing mortality (F) to the target level. This reduction was implemented through a revision to Amendment 1 which reduced the TAL from 275,000 to 51,216 pounds starting in January of 2021 (NCDMF 2020). 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 recruitment failure trigger. If the JAI is below 75 % of all values from a fixed time series 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. The JAI values for 2018, 2019, 2020, and 2021 were 0.4, 1.18, 0.20, and 0.7 respectively and are below the spawning failure threshold of 1.33 indicating that the recruitment failure trigger has been met (ASMFC 2010). Amendment 2 to the N.C. Estuarine Striped Bass Fishery Management Plan is being jointly developed with the Wildlife Resources Commission.

Stock Status: CSMA Stocks

There is no stock status determination for the CSMA stocks in the Tar-Pamlico, Neuse, and Cape Fear rivers. No formal peer-reviewed stock assessments have been conducted for CSMA striped bass.

A demographic matrix model was developed to evaluate different stocking and management measures for striped bass in all three CSMA river systems. Results from the matrix model indicate that striped bass populations in the CSMA are depressed to an extent that sustainability is unlikely at any level of fishing mortality, and it also provides evidence that natural recruitment is the primary limiting factor influencing Tar-Pamlico and Neuse River stocks and if stocking was stopped the populations would decline (Mathes et al. 2020). The demographic matrix model does not provide population abundance or mortality estimates. A tagging model was developed to estimate striped bass abundance in the Cape Fear River. Tagging model results showed a consistent decline in abundance estimates for striped bass (2012–2018), and that abundance in 2018 was reduced to less than 20% of the abundance in 2012, even with a total no-possession provision for striped bass in place in the Cape Fear River since 2008.

Stock Assessment: CSMA Stocks

A stock assessment is not available for this species.

DESCRIPTION OF THE FISHERY: CSMA

Current Regulations: CSMA

Commercial and recreational harvest in the CSMA is prohibited. 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. The NCWRC hook-and-line closure proclamation had the effect of suspending rules 15A NCAC 10C .0107 (l) and 10C .0314 (g), and Supplement A actions 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). 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 Fishery: CSMA

Due to the no possession measure approved in Supplement A, the commercial striped bass fishery was closed in 2019 while Amendment 2 is developed. During 1994–2018 commercial landings in the CSMA were constrained by an annual TAL of 25,000 pounds. Landings closely follow the annual TAL, except for 2008 when less than half of the TAL was landed. From 2004 through 2018 striped bass commercial landings in the CSMA averaged 24,179 pounds and ranged from a low of 10,115 pounds in 2008 to a high of 32,479 pounds in 2004 (Table 7, Figure 14A). Most commercial landings come from the Tar-Pamlico and Pungo rivers and the Neuse and Bay rivers, with the remainder coming from the Pamlico Sound. From 2004 to 2018, there was only a spring harvest season, opening March 1 each year and closing when the TAL was reached.

Recreational Fishery: CSMA

The NCDMF started collecting recreational striped bass data in the major rivers of the CSMA in 2004. In 2013, due to comparatively low recreational striped bass catch in the Cape Fear River, creel survey methodology was adjusted for American and hickory shad to become the target species. Due to the recreational no possession measure approved as part of Supplement A in February 2019, there was minimal recreational harvest in 2019 (959 pounds) until the recreational season closed in March 2019, with the no recreational possession measure continuing through 2021. Recreational landings fluctuated during 2004–2018, ranging from lows in 2008 and 2009 to a high of 26,973 pounds in 2017 (Table 7; Figure 14B).

Since 2011, harvest in the Tar-Pamlico and Neuse rivers has fluctuated little, 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 7). Harvest on the Pungo River has remained consistent at a relatively low level compared to fluctuations in the Tar-Pamlico and Neuse rivers. In 2016 and 2017 the number of trips and hours spent targeting striped bass in the CSMA increased although there was a moderate decline observed in 2018 (Table 8).

Although the recreational striped bass season in the CSMA was closed in March of 2019, data collection characterizing fishing effort and release dispositions have continued. Within the CSMA there is a significant catch-and-release fishery and releases during the last ten years have averaged 48,842 fish annually (Table 8; Figure 15). Undersized discards peaked in 2017 mainly due to the large number of undersized striped bass available in the Tar-Pamlico River system. In 2021, the number of under sized discards was 24,825, which was slightly above the past three-year average (2018–2020; 23,562 fish). In 2021, discards of legal sized striped bass returned to more normal levels (n=9,822), after a high of 26,501 in 2017. Fish released that were within the slot limit, have fluctuated since 2004 and have ranged from lows in 2004, 2006, and 2007 of zero fish to a high of 6,779 fish in 2016 (Table 8). In 2021, there were approximately 3,912 discarded striped bass that were within the slot limit. CSMA recreational length frequencies are presented in Figure 16. In 2018, the modal length of striped bass in the recreational harvest from the Tar-Pamlico/Pungo rivers was 18 inches with few fish over 22 inches harvested, and the modal length from the Neuse River was 19 inches with few fish over 20 inches harvested (Figure 17).

MONITORING PROGRAM DATA: CSMA STOCKS

Fishery-Dependent Monitoring: CSMA

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 and in the CSMA since March 2019. From 2004 to 2018, length data from the commercial harvest shows that on average striped bass harvested in the Neuse and Bay rivers are slightly larger than fish harvested in the Pamlico and Pungo rivers (Table 9). Additionally, maximum lengths are generally larger in the Neuse and Bay rivers compared to the Pamlico and Pungo rivers.

In 2018, the modal length of CSMA striped bass in the commercial harvest from the Tar-Pamlico/Pungo rivers was 20 inches with few fish over 25 inches harvested and, in the Neuse/Bay rivers striped bass modal length was 23 inches with few fish over 27 inches harvested (Figure 17). CSMA commercial length frequencies are represented in Figure 18 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.

From 2004 to 2018, 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, however, only 27 striped bass were measured in 2019 that averaged 20 inches and ranged in length from 16 to 26 inches due to the season closure in March 2019 (Table 10).

Fishery-Independent Monitoring: CSMA

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 Tar-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 in May 2018. Precision of the relative abundance estimates appear to be good for most strata, months, and years, with some exceptions. Overall, the percent frequency of occurrence is lower and PSE values are typically higher in the deep stratum; thus, only the shallow stratum was used in the relative abundance calculation. The months of April and October–November are used in index calculation because striped bass are most available to the survey during these months. The Pamlico Sound data were not used due to low catch numbers and concerns about stock assignment. Pungo River data were also excluded due to mixed stock concerns. In the Cape Fear River, although striped bass catch rates were very low, data were used to calculate relative abundance. New River data were not used to calculate relative abundance because striped bass were seldom captured there. Limited abundance data is available for striped bass from the Fishery Independent Gill Net Survey (Program 915) for 2021. Sampling in 2020 was suspended due to COVID-19 restrictions and protected species interactions and was not resumed until the fall of 2021. Over the past fourteen years (2004–2021), striped bass relative abundance has been higher in the Tar-Pamlico and Neuse rivers when compared to the Cape Fear River and New rivers (Table 11). Since 2004, striped bass relative abundance in the Tar-Pamlico and Neuse rivers ranged from 2 to 9 fish per sample, whereas relative abundance in the Cape Fear and New rivers ranged from 0 to 0.14 fish per sample (Table 11). In 2021, striped bass relative abundance in the Tar-Pamlico River (0.92 fish per set) was well below the time series average of 4.4 striped bass per set (Table 11; Figure 19). However, the low relative abundance value is likely a result of only including two months of data in the analysis (October–November). From July to December, a total of 277 striped bass were captured in shallow water gillnet sets, and only 79 were captured in shallow water sets during October–November and included in calculations of relative abundance. In the Neuse River, striped bass relative abundance was 4.25 fish per set, which was above the time series average of 3.6 striped bass per set (Table 11; Figure 20). In 2021, relative abundance in the Cape Fear River (0.03 fish per set) was near the time series average of 0.45 striped bass per set (Table 11; Figure 21). Length frequencies from P915 are represented in Figure 22. Length frequency distributions are variable between years but generally range 10–25 inches TL, however in 2016–2017 in the Tar-Pamlico/Pungo River and 2015–2017 in the Neuse River 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 2018 and 2019, there were larger fish in the Tar-Pamlico/Pungo and Neuse rivers that could represent growth and perpetuation of the two year classes of striped bass. Length frequency distributions are not provided for the Cape Fear and New rivers due to low numbers of striped bass captured in the fishery independent gill net survey. Samples collected from P915 on the Tar-Pamlico and Neuse rivers show most striped bass were captured in the upper and middle portions of the rivers.

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 Tar-Pamlico, Neuse, Cape Fear, and Northeast Cape Fear rivers. The survey employs seines (June–July) and trawls (July–October) to monitor the status of the striped bass stocks in North Carolina and to assess the effectiveness of management measures aimed at promoting natural reproduction within the CSMA. From 2017 to 2021 young-of-year sampling in the Central Southern Management Area (CSMA) has captured very few individuals. In the Northeast Cape Fear River, 24 juvenile striped bass were captured in in 2018, four in 2019, and one in 2020. In 2021, the first two juvenile striped bass were captured on the Tar-Pamlico River, whereas sampling on the Neuse River and Cape Fear River system has not capture any juvenile striped bass.

Age data from are presented in Table 12 and Figure 23; from 2004 to 2021, a total of 2,372 otolith samples were collected and from 2016 to 2021, 1,375 genetic samples were collected to provide striped bass ages (Table 12). Figure 23 shows an increasing trend of size at length with a maximum age of 12 years old. Limited age data was collected in 2019 from the recreational creel survey (n=15) and no commercial samples were collected. Otolith age data from 2021 are considered preliminary, and genetic ages for 2020 and 2021are not currently available.

RESEARCH NEEDS: CSMA

The research recommendations listed below are intended to improve future assessments of the CSMA striped bass stocks. The bulleted items outline the specific issue and are organized by priority ranking.

High

- Acquire life history information: maturity, fecundity, size and weight at age, egg, and larval survival (ongoing through CRFL funded projects and NCDMF P930 data collection; see Knight, 2015 for recent work on maturation and fecundity in the Neuse and Tar-Pamlico rivers)
- Conduct delayed mortality studies for recreational and commercial gear during all seasons factoring in relationships between salinity, dissolved oxygen, and water temperature
- Develop better estimates of life-history parameters, especially growth and factors influencing rates of natural mortality for all striped bass life stages (growth is ongoing through NCDMF P930 data collection; for natural mortality, see recent publications Bradley 2016 and Bradley et al. 2018b)

Medium

- Determine factors impacting survivability of stocked fish in each system (Bradley et al. 2018b)
- Implement a random component to NCDMF program 100 juvenile sampling in the CSMA
- Conduct a power analysis to determine minimum sample sizes needed for determining the representative age structure

Low

- Determine if contaminants are present in striped bass habitats and identify those that are potentially detrimental to various life history stages (ongoing through N.C. 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)
- 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
- Evaluate factors influencing catchability of striped bass, particularly larger striped bass, in electrofishing surveys conducted on the spawning grounds

- Obtain improved commercial discard estimates from the estuarine gill-net fisheries (i.e., anchored, runaround, and strike gill nets) in the CSMA systems to better characterize harvest and discards
- Investigate factors influencing mixing rates between A-R and CSMA striped bass stocks
- Identify water quality parameters that impact spawning, hatching, and survival of striped bass in CSMA systems
- Develop a consistent ageing approach across agency sampling programs
- Continue PIT tagging striped bass in the Cape Fear River and expand PIT tagging to the Tar-Pamlico and Neuse rivers to estimates of spawning population size
- Investigate factors influencing rates of natural mortality for all striped bass life stages in the CSMA systems

MANAGEMENT STRATEGY: CSMA STOCKS

Estuarine striped bass in North Carolina are managed under Amendment 1 to the North Carolina Estuarine Striped Bass FMP and subsequent revisions and supplement. Due to concerns about the high percentage of stocked fish and minimal natural recruitment in the CSMA systems, the comprehensive review of the Estuarine Striped Bass FMP began in July 2017 instead of as originally scheduled in 2018. Since adoption of 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. The need for continued conservation management efforts is 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 suggest 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 measure provides additional protection for non-hatchery fish until Amendment 2 to the North Carolina Estuarine Striped Bass FMP is adopted. The stocks were evaluated using a matrix model for the Tar-Pamlico and Neuse rivers and a tagging model for the Cape Fear River. This evaluation will inform recovery metrics for the CSMA stocks in Amendment 2.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

The comprehensive FMP review is underway, and the division is continuing joint development of Amendment 2 with the NCWRC.

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TABLES

Table 1. ASMA and RRMA recreational harvest (number of fish landed and weight in pounds) and releases (number of fish) and ASMA commercial harvest (weight in pounds) of striped bass from North Carolina, 1990–2021.

	ASMA Recreational			RRMA Recreational			ASMA Commercial	
Year	Numbers Landed	Numbers Released	Weight Landed (lb)	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1990	-	-	-	-	-	-	103,757	103,757
1991	14,395	23,540	35,344	26,934	-	72,529	108,555	216,428
1992	10,542	19,981	30,758	13,372	-	36,016	100,641	167,415
1993	11,404	13,241	36,049	14,325	-	45,145	109,570	190,764
1994	8,591	-	30,217	8,284	-	28,089	102,471	160,777
1995	7,343	-	30,564	7,471	-	28,883	87,920	147,367
1996	7,433	-	29,186	8,367	15,230	28,178	90,213	147,577
1997	6,901	30,771	26,581	9,364	20,437	29,997	96,210	152,788
1998	19,566	91,888	64,580	23,109	87,679	73,541	124,032	262,153
1999	16,967	40,321	61,338	22,479	50,161	72,967	163,010	297,315
2000	38,085	78,941	116,158	38,206	93,148	120,091	214,223	450,472
2001	40,127	61,418	118,506	35,231	71,003	112,805	220,462	451,773
2002	27,896	51,555	92,649	36,422	55,775	112,698	223,108	428,455
2003	15,124	25,281	51,794	11,157	38,256	39,170	266,539	357,503
2004	28,004	41,041	97,097	26,506	187,331	90,191	273,814	461,102
2005	17,954	21,220	63,477	34,122	89,550	107,530	232,808	403,815
2006	10,711	9,455	35,997	25,355	40,805	84,521	186,555	307,073
2007	7,143	13,599	26,633	19,306	40,879	62,492	171,828	260,953
2008	10,048	36,975	31,628	10,541	141,646	32,725	74,979	139,332
2009	12,069	40,563	37,313	23,248	135,964	69,581	95,879	202,773
2010	3,504	16,200	11,470	22,445	77,882	72,037	200,003	283,510
2011	13,341	21,572	42,536	22,102	80,828	71,561	136,378	250,475
2012	22,345	24,971	71,456	28,847	40,772	88,271	115,698	275,425
2013	4,299	16,381	14,897	7,718	49,148	25,197	68,409	108,503
2014	5,529	23,086	16,867	11,058	93,471	33,717	71,055	121,639
2015	23,240	49,534	70,008	20,031	78,401	58,962	114,596	243,566
2016	4,794	10,352	14,487	21,260	34,753	65,218	123,216	202,921
2017	4,214	24,659	15,480	9,899	68,693	32,569	76,059	124,108
2018	3,465	25,639	11,762	8,741	121,969	26,796	116,144	154,702
2019	8,502	34,968	29,005	16,582	117,550	53,379	136,820	219,204
2020*	6,849	50,009	22,951	20,376	54,622	27,243	124,385	174,579
2021	2,258	7,782	8,258	7,795	57,188	27,546	27,930	63,734
Mean	13,409	32,303	43,708	19,053	74,736	66,189	136,165	235,064

*Due to Covid restrictions, the creel surveys during the spring of 2020 were cut short. Creel estimate for the spring ASMA survey is for the period January 1–March 27, 2020. Creel estimate for the spring RRMA survey is for the period March 1 to March 18, 2020 with data imputed for April based on harvest in April 2015 and 2016...

Table 2. Recreational striped bass effort, harvest, and discards from the ASMA and RRMA (2011–2021).

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									
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	9,057	34,764	3,465	11,763	281	21,388	3,970	N/A	25,639
2019	19,864	61,645	8,502	34,968	2,301	34,452	1,625	N/A	38,378
2020#	20,559	84,584	6,849	22,951	32,805	15,256	1,947	N/A	50,009
2021	8,080	29,174	2,258	8,258	689	5,684	1,408	N/A	7,782
Total	127,197	664,892	101,864	327,551	37,305	232,587	18,597	0	288,492
RRMA									
2011	27,311	122,876	22,102	71,561	Disposition of discards not available for all years.				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
2019	20,633	99,259	16,582	53,379					117,550
2020†	26,648	131,565	20,376	27,243					54,622
2021	12,976	69,281	7,795	27,546					57,188
Total	219,659	1,068,695	159,567	500,811					916,148

* Estimates of discards not available for the post-harvest season period.
# Creel estimate for the spring survey is for the period January 1–March 27, 2020.
† Creel estimate for the spring survey is for the period March 1 to March 18, 2020 with data imputed for April based on harvest in April 2015 and 2016.

Table 3. Striped bass total length (inches) data from commercial fish house sampling from the Albemarle Sound Management Area (ASMA), NC, 2005–2021.

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
2019	20	17	40	566
2020	22	17	40	191
2021	22	19	28	165

Table 4. Striped bass total length (inches) data from recreational landings from the Albemarle Sound Management Area (ASMA), NC, 2005–2021.

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
2019	18	17	27	555
2020	20	16	30	683
2021	21	17	28	290

Table 5. Striped bass total length (inches) data from recreational landings from the Roanoke River Management Area (RRMA), NC, 2005–2021.

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
2019	20	17	30	1,032
2020	19	18	24	155
2021	20	18	40	630

Table 6. Striped bass age data from dependent (commercial) and independent (independent gill net survey) surveys from the ASMA, NC, 2005–2021.

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
2019	5	1	14	482
2020	5	1	11	301
2021	5	4	9	120

Table 7. Recreational harvest (number of fish landed and weight in pounds) and releases (number of fish) and commercial harvest (weight in pounds) of CSMA striped bass from North Carolina, 1994–2021.

Year	Recreational			Commercial	
	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1994				19,858	19,858
1995				14,325	14,325
1996				33,250	33,250
1997				28,520	28,520
1998				25,973	25,973
1999				33,959	33,959
2000				31,048	31,048
2001				24,705	24,705
2002				37,585	37,585
2003				41,384	41,384
2004	6,141	13,557	22,958	32,479	55,437
2005	3,832	16,854	14,965	27,132	42,097
2006	2,481	14,895	7,352	21,149	28,501
2007	3,597	23,527	10,794	25,008	35,802
2008	843	17,966	2,990	10,115	13,105
2009	895	6,965	3,061	24,847	27,908
2010	1,757	7,990	5,537	23,888	29,425
2011	2,728	24,188	9,474	28,054	37,528
2012	3,922	43,313	15,240	22,725	37,964
2013	5,467	32,816	19,537	28,597	48,134
2014	3,301	30,209	13,368	25,245	38,613
2015	3,934	31,353	14,269	27,336	41,605
2016	6,697	75,461	25,260	23,041	48,301
2017	7,334	131,129	26,973	23,018	49,991
2018	3,371	49,122	10,884	20,057	30,941
2019	959	36,080	3,562	0	3,562
2020	0	19,420	0	0	0
2021	0	38,559	0	0	0
Mean	3,181	34,078	11,457	23,332	30,697

Table 8. Recreational striped bass effort, harvest, and discards from the CSMA (2004–2021). In the CSMA, there was a limited recreational harvest season in 2019 prior to closing (January 1–March 19, 2019). The recreational season remained closed in 2021.

					Striped Bass Discards				
Year	Striped Bass Fishing (Angler Trips)	Striped Bass Effort (Angler Hours)	Number Harvested	Pounds Harvested	Number Over-Creel	Number Under-Sized	Number Legal-Sized	Number Slot-Sized	Total Discards
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
2011	12,606	51,540	2,728	9,474	9	16,659	5,397	2,123	24,188
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
2019*	8,820	40,580	959	3,562	924	24,857	7,817	2,481	37,039
2020**	2,846	13,272	0	0	0	10,439	7,575	1,406	19,420
2021**	15,628	60,424	0	0	0	24,825	9,822	3,912	38,559
Total	248,266	1,076,721	57,259	206,224	8,503	440,623	134,429	29,850	614,636

* Limited harvest season (Jan 1–March 19, 2020)
** Closed harvest season

Table 9. Mean, minimum, and maximum length of striped bass (total length – inches) and number collected from the commercial harvest, 2000–2021.

	Tar-Pamlico/Pungo rivers				Neuse/Bay rivers			
	Length (inches)				Length (inches)			
Year	Mean	Min	Max	N	Mean	Min	Max	N
2000	23	20	35	126	25	22	31	5
2001	23	21	26	116	25	23	31	12
2002	24	19	39	96	25	19	29	31
2003	23	18	37	173	24	19	37	19
2004	24	20	42	131	25	19	37	74
2005	23	20	37	127	24	20	36	70
2006	22	18	37	119	24	19	36	144
2007	22	19	33	112	22	19	27	63
2008	22	18	43	84	23	19	44	39
2009	22	19	31	99	22	18	31	85
2010	22	19	26	194	23	19	32	263
2011	23	18	27	284	23	19	42	195
2012	24	15	30	254	24	19	29	96
2013	25	18	40	225	25	18	39	301
2014	22	18	39	52	24	20	38	56
2015	24	19	40	97	24	19	44	97
2016	24	17	29	257	23	19	28	78
2017	24	19	31	151	24	19	50	97
2018	23	19	32	76	24	18	38	163
2019	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-
2021	-	-	-	-	-	-	-	-

Table 10. Mean, minimum and maximum length of striped bass (total length – inches) and number collected from the recreational harvest, 2004–2021 (includes striped bass and hybrid striped bass). There was a limited recreational season in 2019 (Jan 1-March 19) and the season remained closed in 2021.

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
2019	20	17	26	27
2020	-	-	-	-
2021	-	-	-	-

Table 11. Relative abundance of striped bass (number of individuals per sample), total number of striped bass collected, and the number of gill net samples (N) in the Tar-Pamlico and Neuse rivers (April, and October-November, shallow water sets (2004–2021), and in the Cape Fear and New rivers (February–December, all sets; 2008–2021) The Percent Standard Error (PSE) represents a measure of precision. No sampling occurred in 2020 and limited sampling occurred in 2021 (July–December).

	Tar-Pamlico River				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	3.94	71	18	24	2.83	68	24	44	-	-	-	-
2005	4.61	83	18	17	3.75	90	24	42	-	-	-	-
2006	4.06	73	18	41	2.33	56	24	25	-	-	-	-
2007	3.56	64	18	49	2.83	68	24	28	-	-	-	-
2008	4.61	83	18	37	3.21	77	24	44	0.04	3	84	100
2009	2.78	50	18	36	2.13	51	24	41	0.03	3	119	67
2010	5.67	102	18	26	6.25	150	24	39	0.01	1	120	100
2011	7.72	139	18	32	4.75	114	24	30	0.04	4	120	50
2012	3.28	59	18	39	2.25	54	24	36	0.03	3	120	67
2013	3.22	58	18	36	2.54	61	24	31	0.02	2	120	50
2014	4.56	82	18	20	6.75	162	24	28	0	0	120	-
2015	2.67	48	18	33	5.33	128	24	27	0.14	15	120	36
2016	2.44	44	18	27	2.04	49	24	24	0.11	12	120	45
2017	2.44	44	18	29	3.21	77	24	24	0.08	9	120	50
2018	9.00	162	18	29	3.75	90	24	31	0.03	3	113	67
2019	5.06	91	18	33	4.21	101	24	32	0.01	1	120	100
2020	-	-	-	-	-	-	-	-	-	-	-	-
2021	0.92	11	12	43	4.25	68	16	38	0.03	3	88	67

Table 12. CSMA striped bass otolith and genetic age data from fishery dependent (commercial and recreational creel survey) and independent (independent gill net survey) surveys, 2004–2021. Otolith age data from 2021 are considered preliminary, and genetic ages for 2020 and 2021are not currently available.

	Modal Age		Minimum Age		Maximum Age		Total Number Aged	
Year	Otolith	Genetic	Otolith	Genetic	Otolith	Genetic	Otolith	Genetic
2004	3	-	1	-	11	-	50	-
2005	2	-	1	-	9	-	78	-
2006	3	-	1	-	9	-	111	-
2007	3	-	1	-	9	-	86	-
2008	3	-	1	-	8	-	103	-
2009	4	-	1	-	6	-	37	-
2010	5	-	1	-	9	-	154	-
2011	3	-	2	-	6	-	56	-
2012	3	-	1	-	7	-	205	-
2013	3	-	1	-	8	-	156	-
2014	3	-	1	-	11	-	172	-
2015	3	-	1	-	9	-	113	-
2016	2	3	1	2	8	6	38	323
2017	2	4	1	1	9	7	98	247
2018	3	4	1	1	12	8	109	201
2019	4	3	1	1	11	9	307	183
2020	5	-	1	-	9	-	147	-
2021	3	-	1	-	10	-	352	-

FIGURES

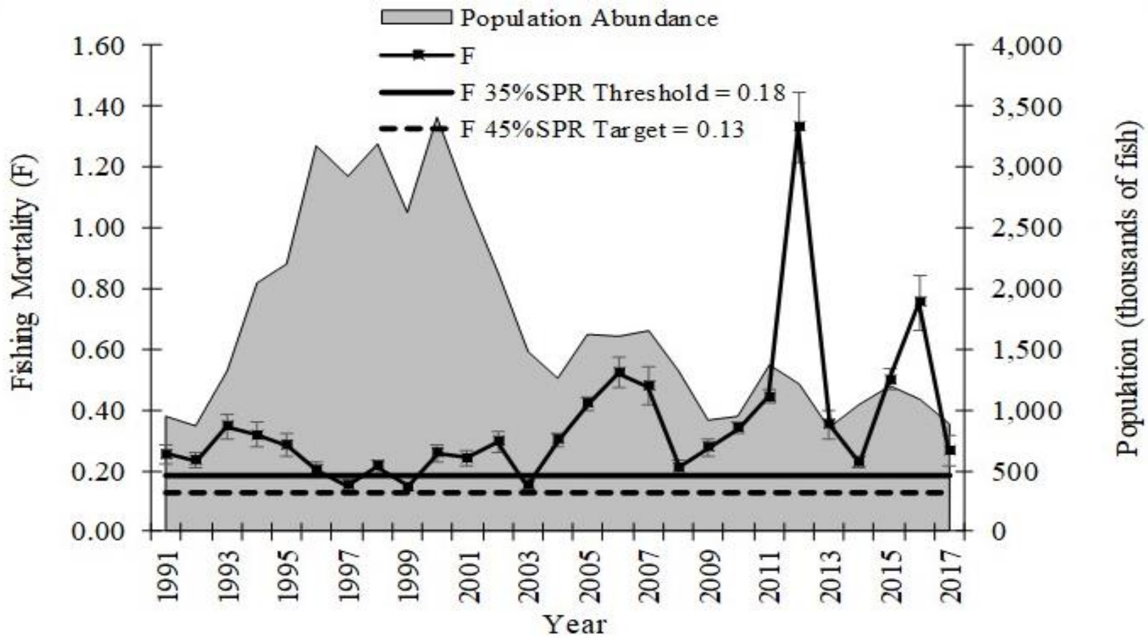

Figure 1. Estimates of fishing mortality (*F*) and population abundance for the Albemarle-Roanoke striped bass stock, 1991–2017. Error bars represent ± two standard errors. Source: Lee et al. 2020.

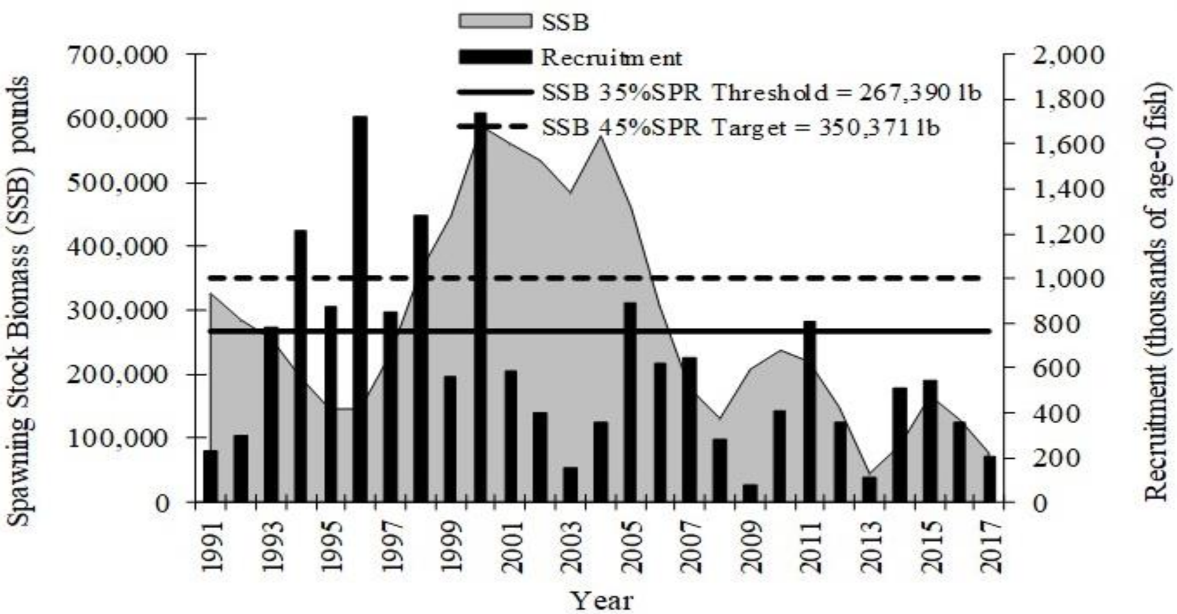

Figure 2. Estimates of spawning stock biomass (SSB) and recruitment of age-0 fish coming into the population each year for the Albemarle-Roanoke striped bass stock, 1991–2017. Source: Lee et al. 2020

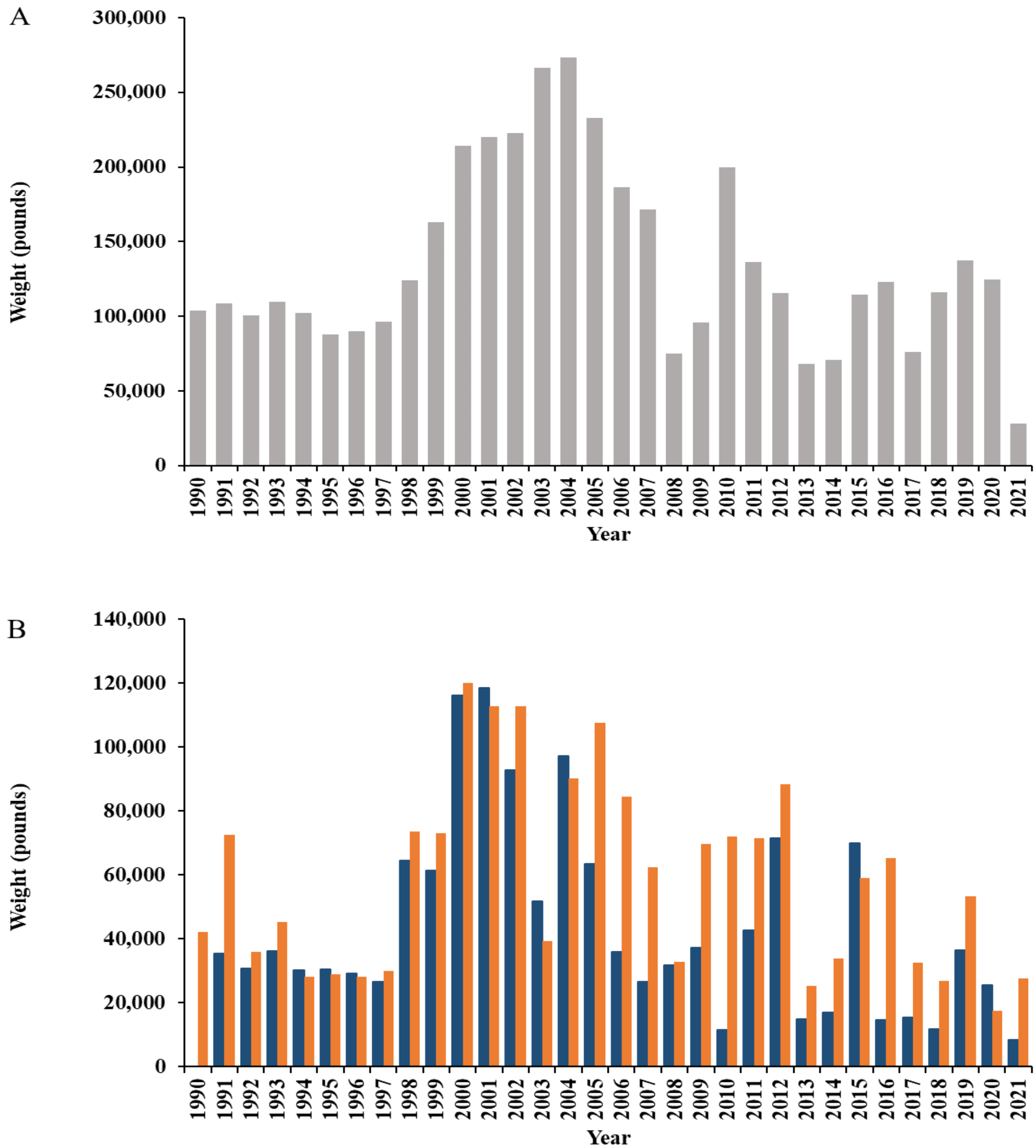

Figure 3. ASMA commercial (A), ASMA recreational, and RRMA recreational (B) striped bass landings in pounds, NC, 1990–2021. RRMA 2020 recreational landings are for March only. ASMA 2020 landings are from January–March.

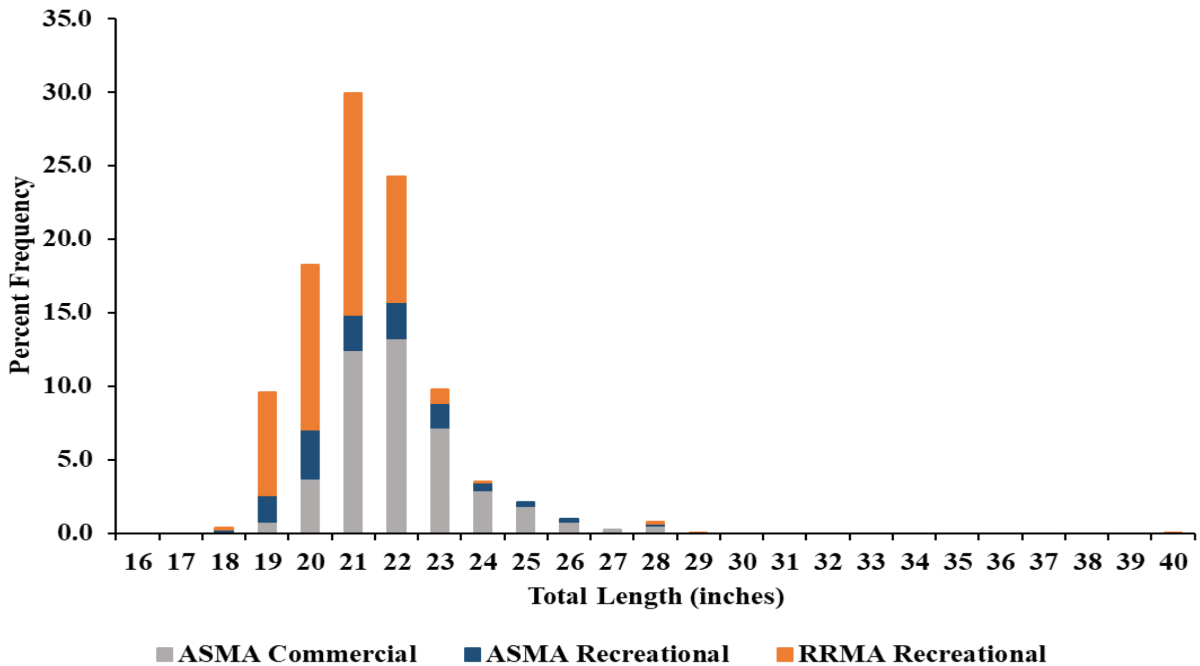

Figure 4. ASMA commercial and recreational length frequency distribution from striped bass harvested in 2021.

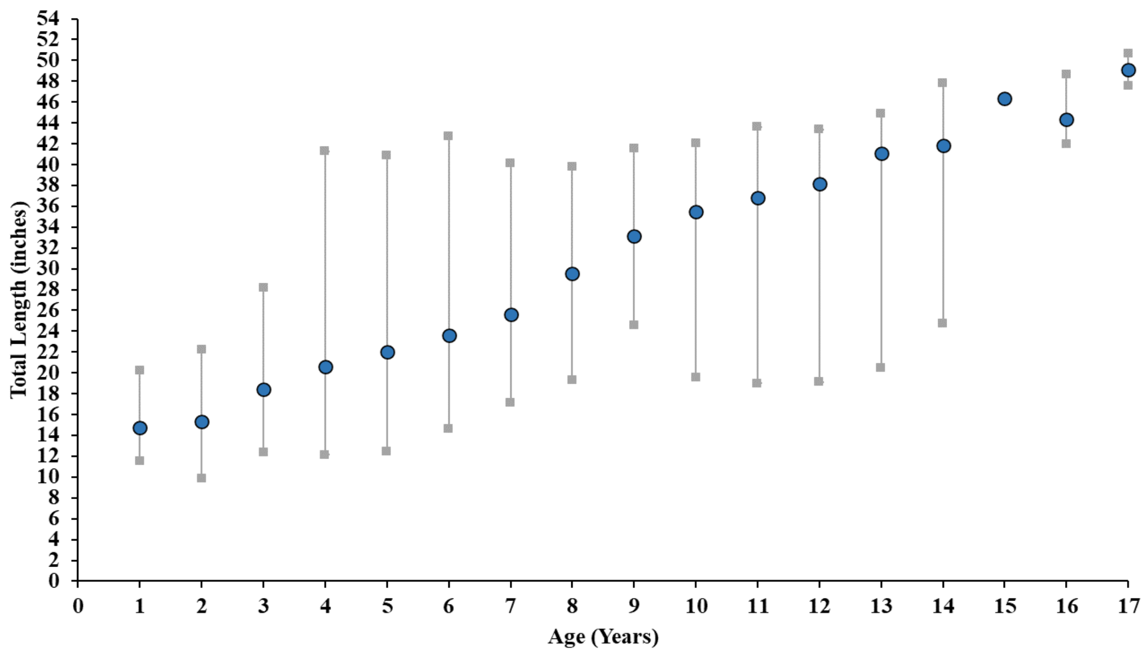

Figure 5. Striped bass length at age based on all commercial samples, 1972–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

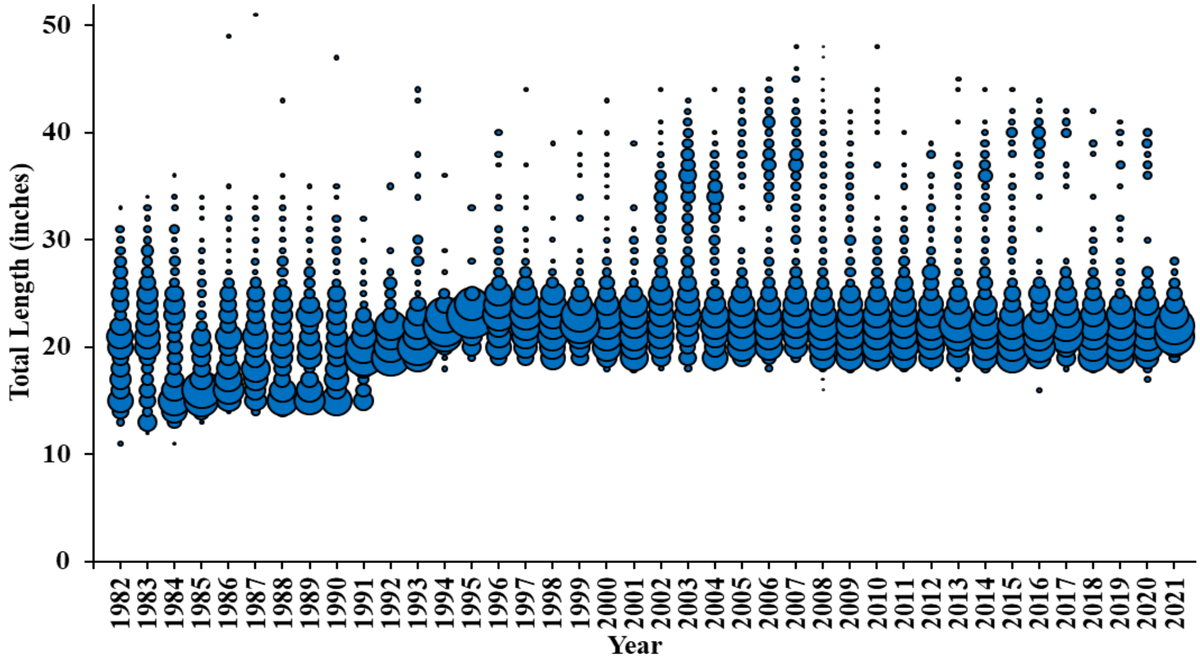

Figure 6. Commercial length frequency (total length, inches) of striped bass harvested in the ASMA, NC, 1982–2021. Bubble size represents the proportion of fish at length.

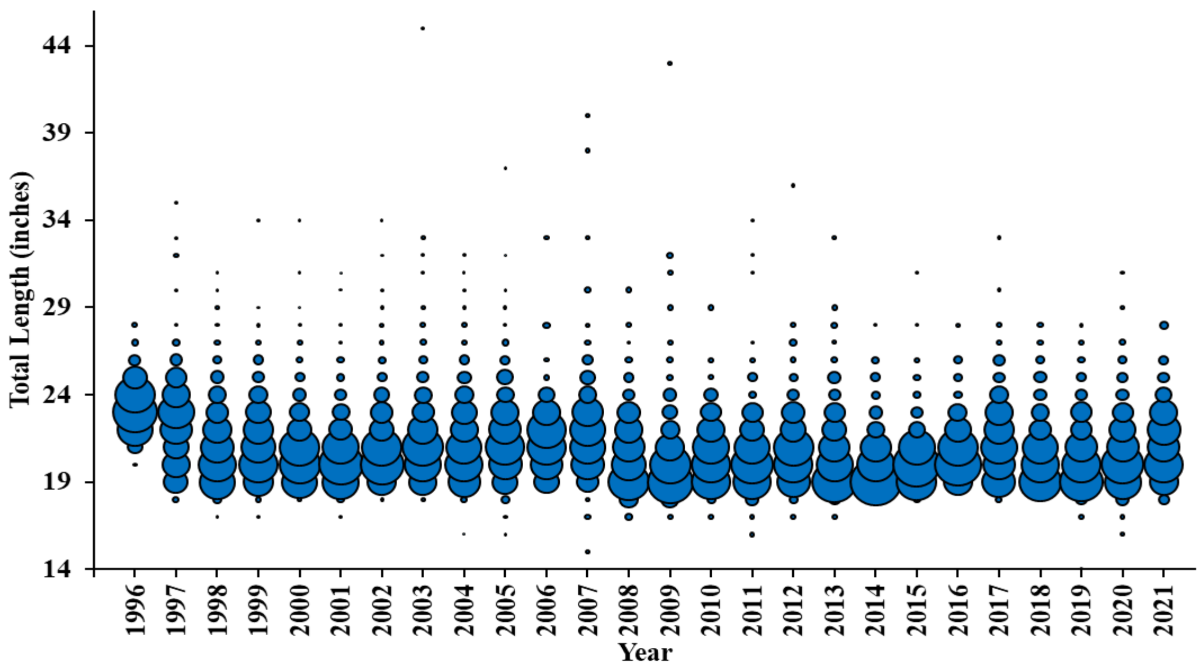

Figure 7. Recreational length frequency (total length, inches) of striped bass harvested in the ASMA, NC, 1996–2021. Bubble size represents the proportion of fish at length.

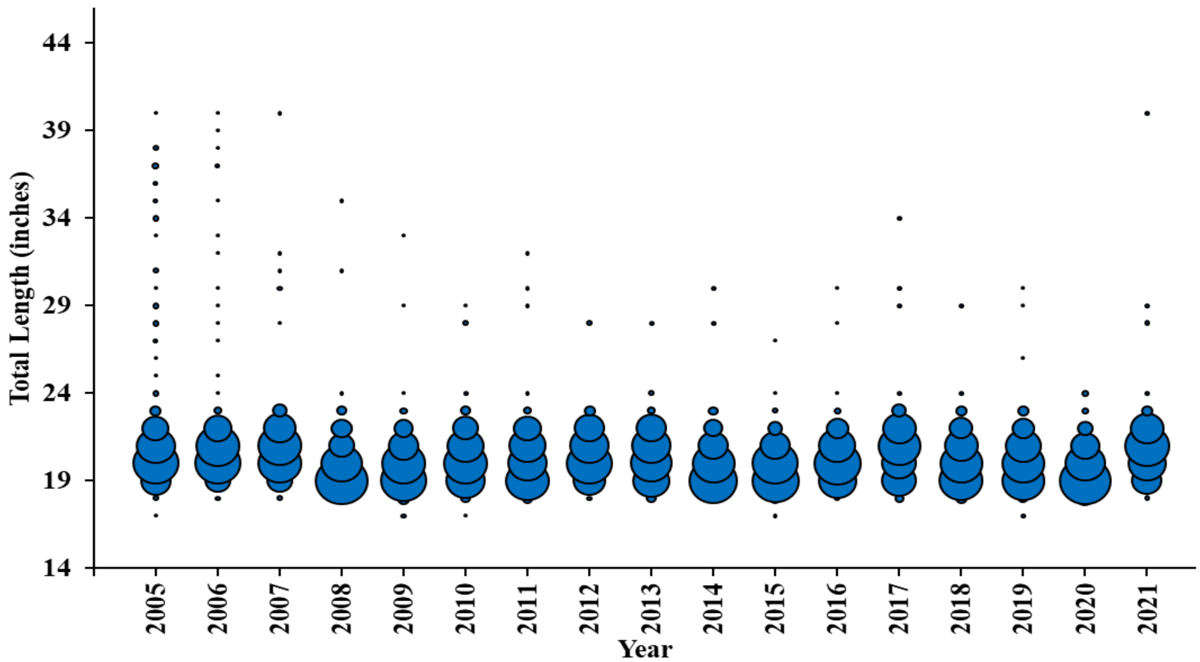

Figure 8. Recreational length frequency (total length, inches) of striped bass harvested in the RRMA, NC, 2005–2021. Bubble size represents the proportion of fish at length.

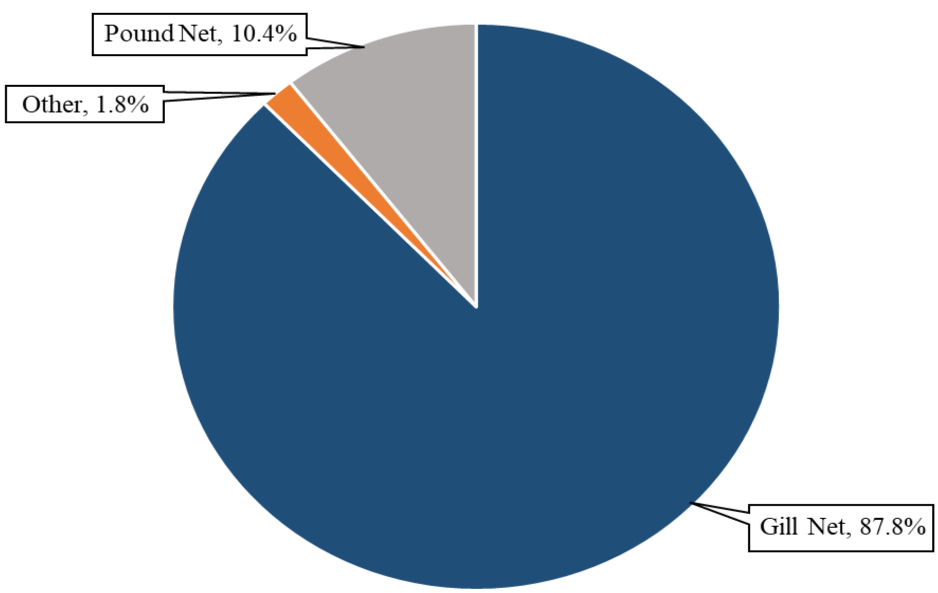

Figure 9. Commercial striped bass landings broken out by major gears in the ASMA, NC, 1994–2021.

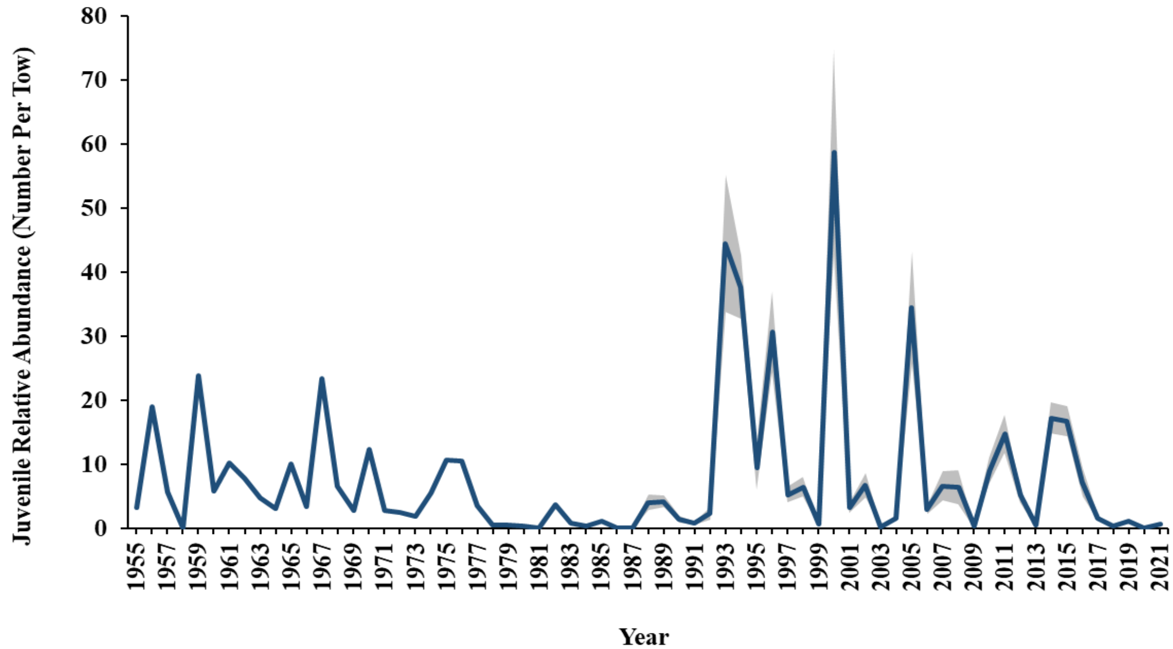

Figure 10. Juvenile abundance index (JAI) of Albemarle-Roanoke striped bass from the NCDMF juvenile trawl survey, western Albemarle Sound, NC, 1955–2021.

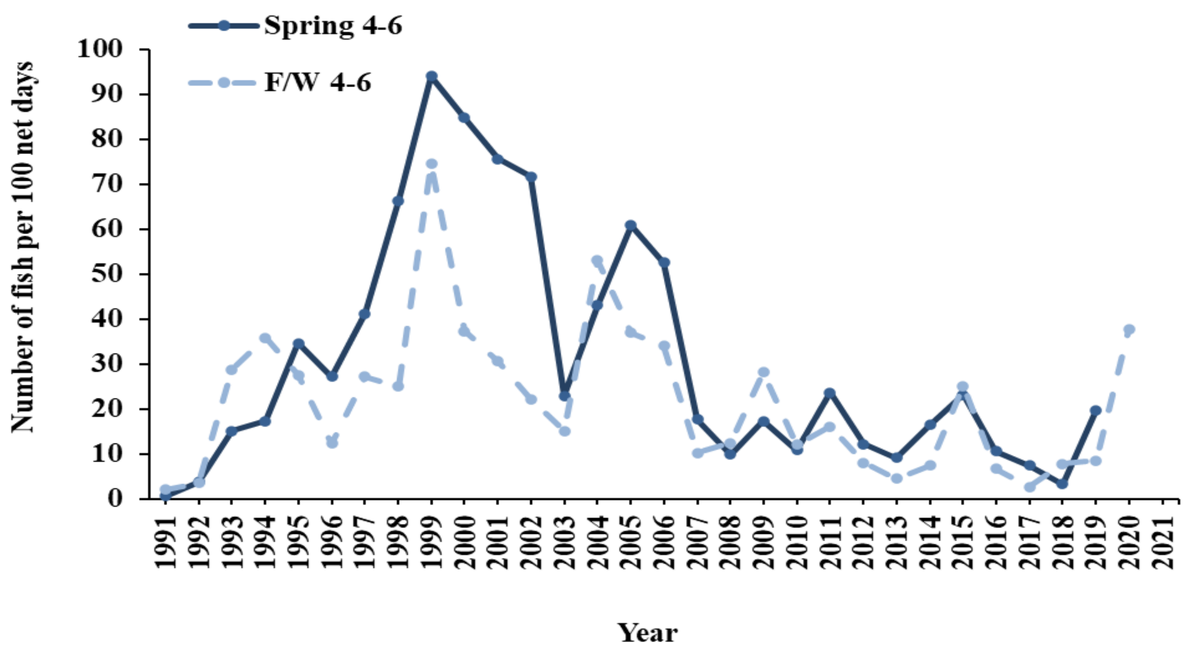

Figure 11. Relative abundance of age 4–6 Albemarle-Roanoke striped bass from the NCDMF fall/winter and spring independent gill net surveys, Albemarle Sound area, NC, 1991–2021.

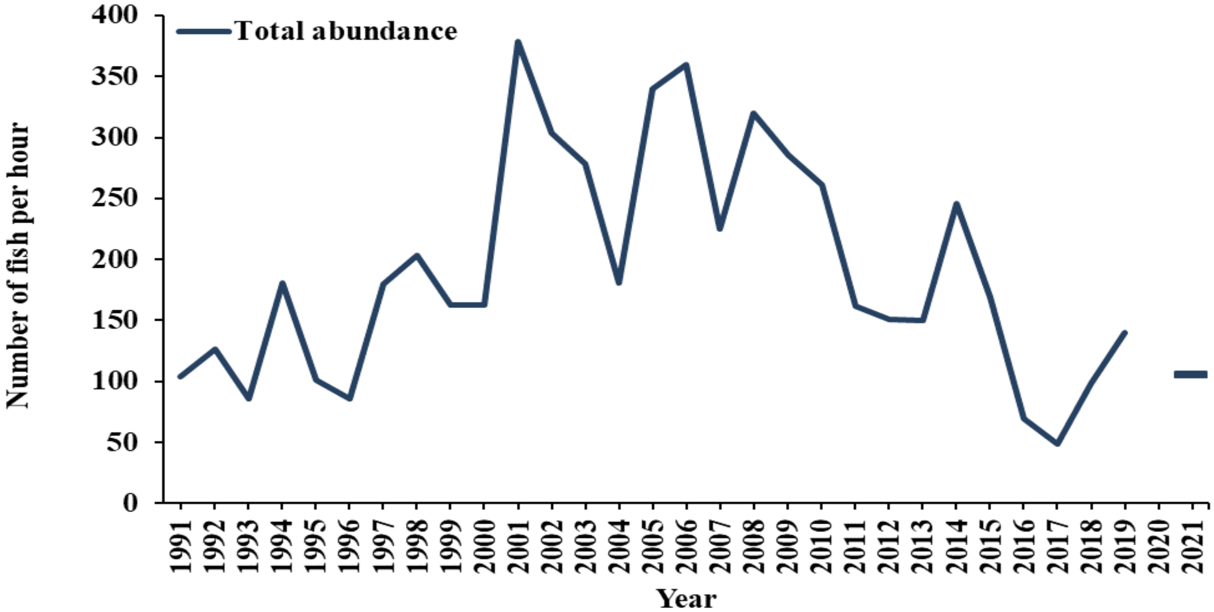

Figure 12. Relative abundance of Albemarle-Roanoke striped bass from the NCWRC spawning grounds electrofishing survey, Roanoke River at Weldon, NC, 1991–2021.

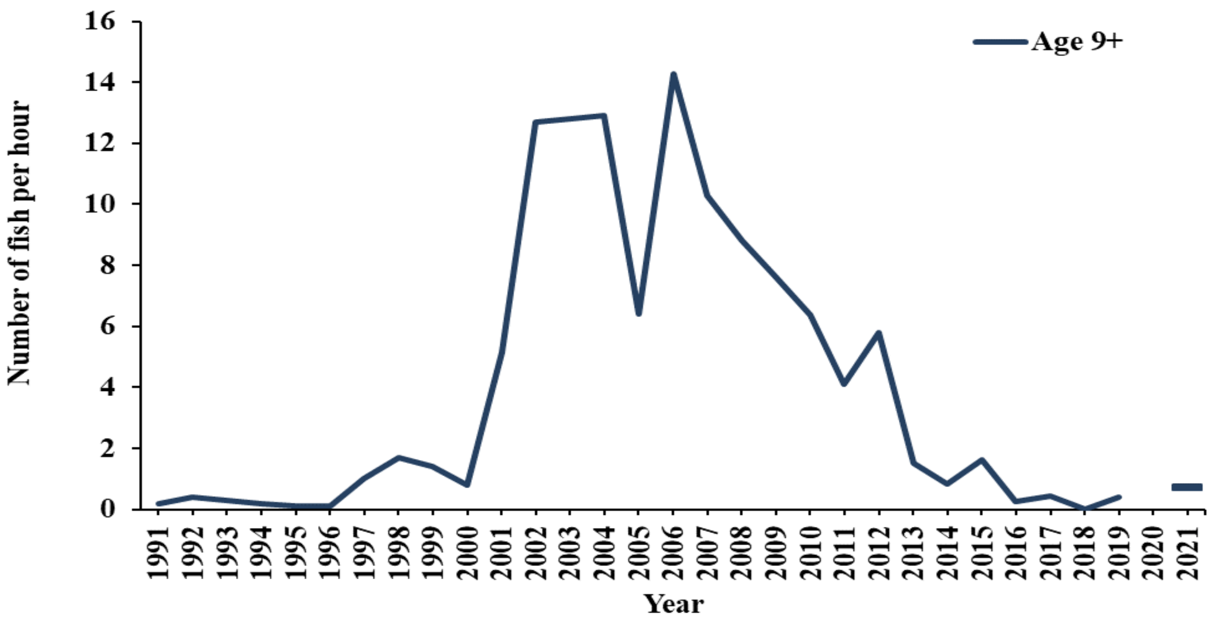

Figure 13. Relative abundance of age 9+ Albemarle-Roanoke striped bass from the NCWRC spawning grounds electrofishing survey, Roanoke River at Weldon, NC, 1991–2021.

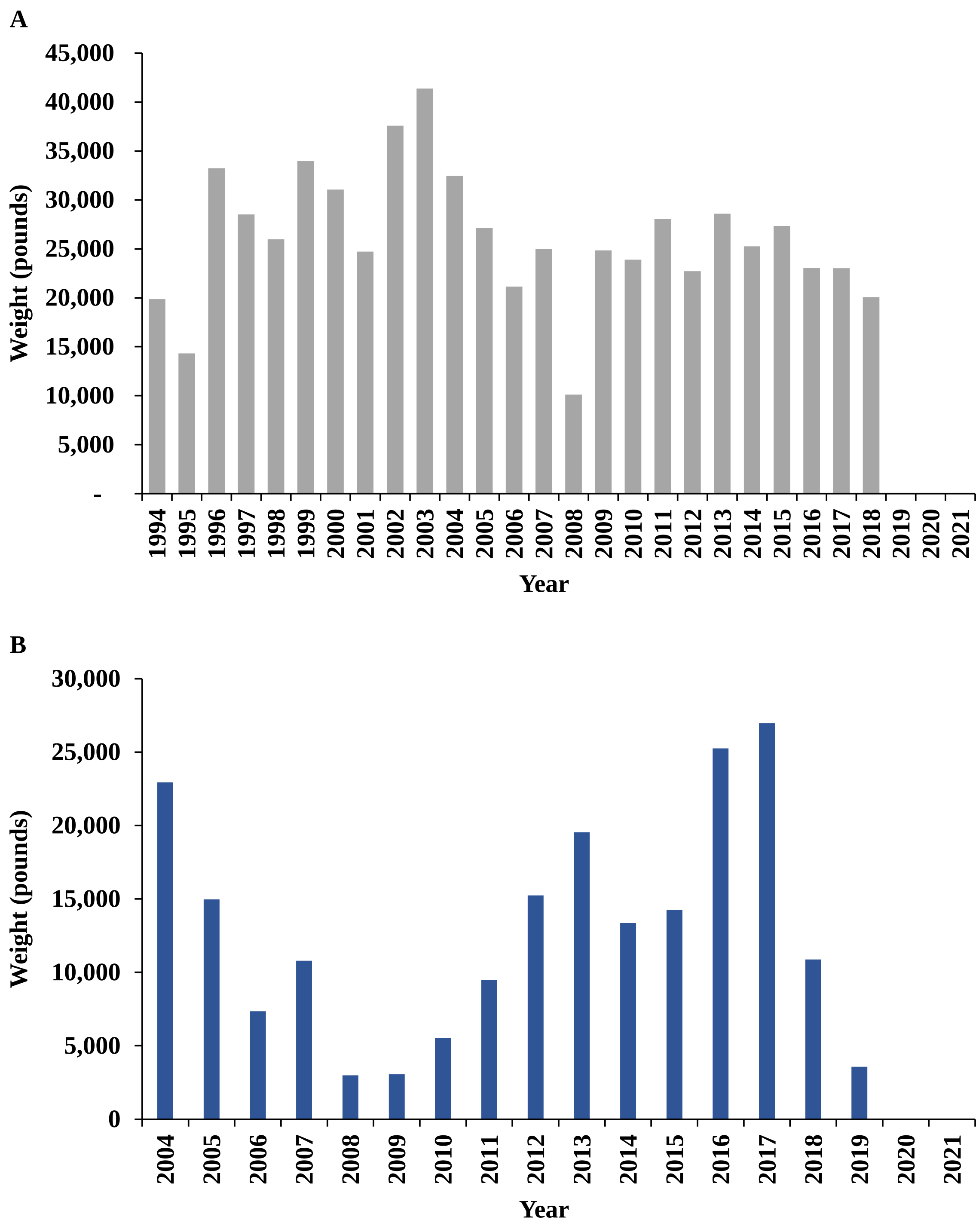

Figure 14. Annual commercial landings (pounds) reported through the North Carolina Trip Ticket Program, 1994-2021 (A), and recreational landings (pounds) estimated from the CSMA Recreational Creel Survey, 2004–2021. There was no commercial season and a limited recreational season in 2019, lasting from January 1 to March 19, 2019. Commercial and recreational seasons remained closed in 2021.

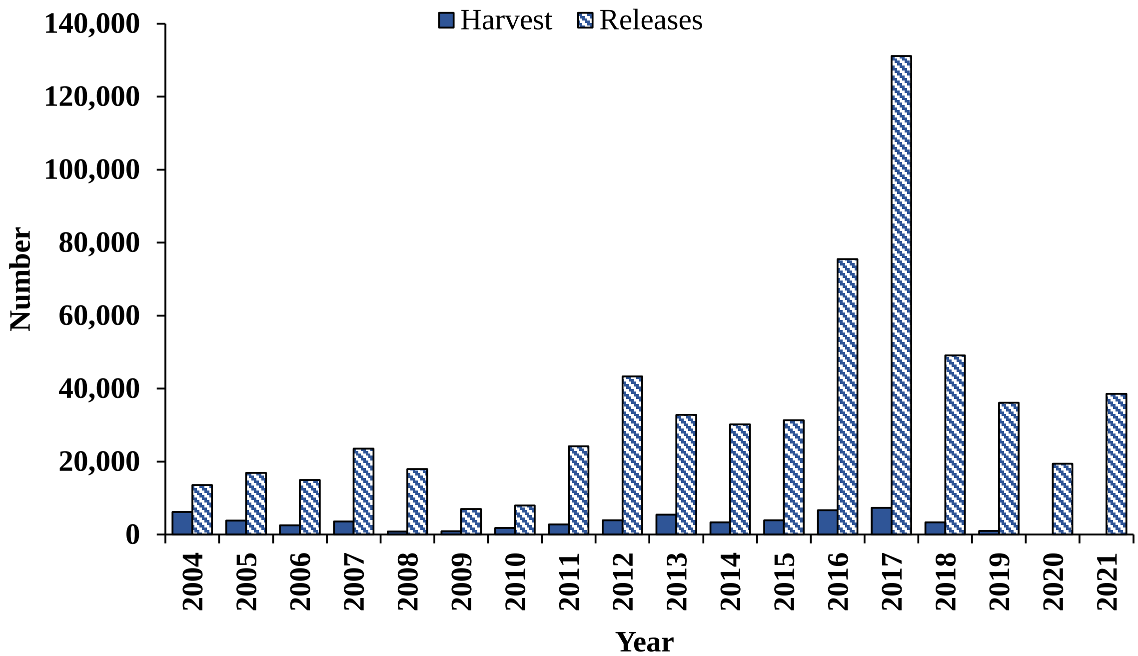

Figure 15. Annual recreational catch (harvested and/or released) of striped bass in the CSMA, 2004–2021. There was a limited recreational harvest season in 2019 prior to the closure, lasting from Jan 1 to Mar 19, 2019. The harvest season remained closed in 2021.

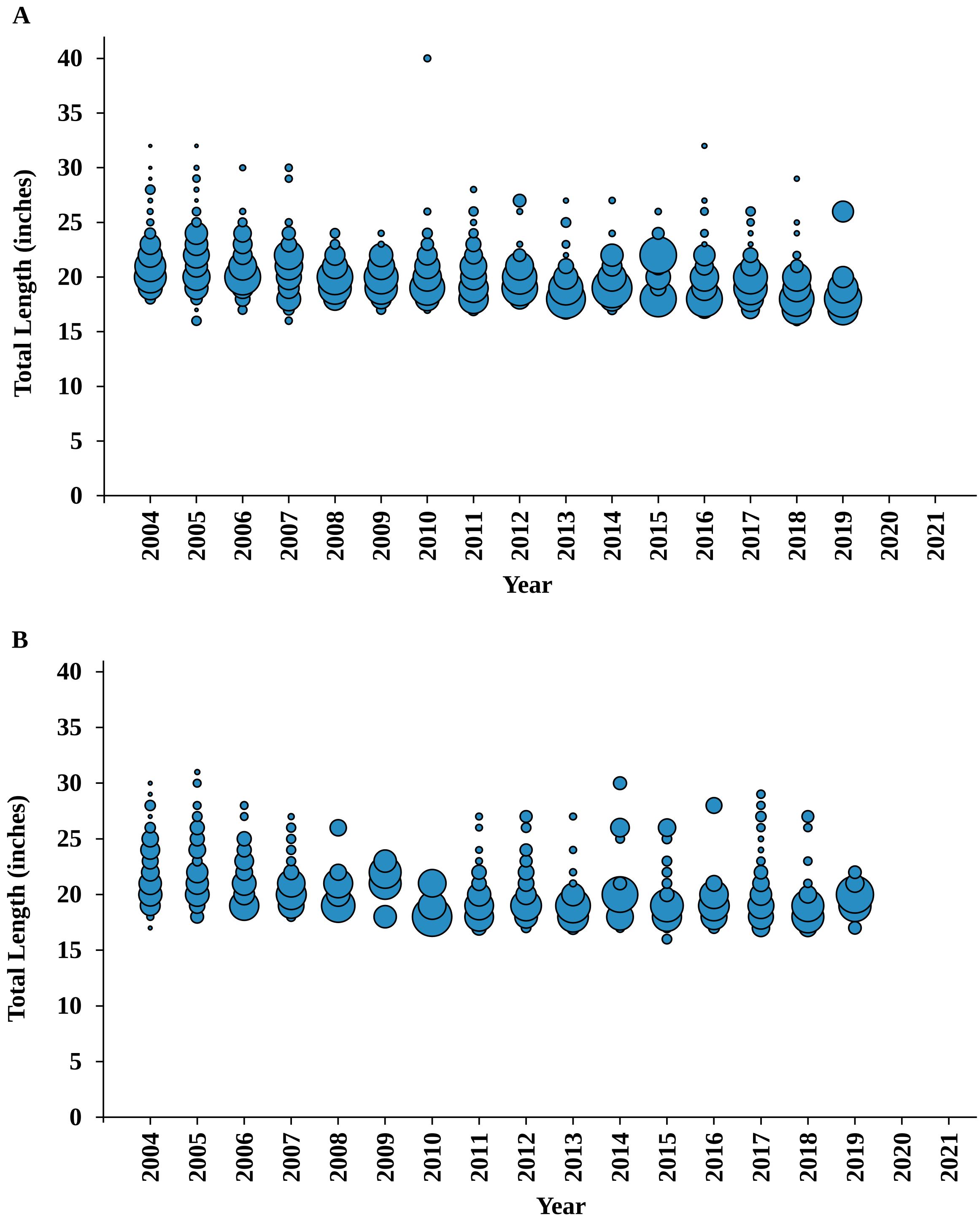

Figure 16. Recreational length frequency of CSMA striped bass harvested in the Tar-Pamlico/Pungo rivers (A), and the Neuse River (B), 2004–2021. Bubble size represents the proportion of fish at length. There was a limited recreational season in 2019 prior to the closure, lasting from Jan 1 to Mar 19, 2019. The recreational season remained closed in 2021.

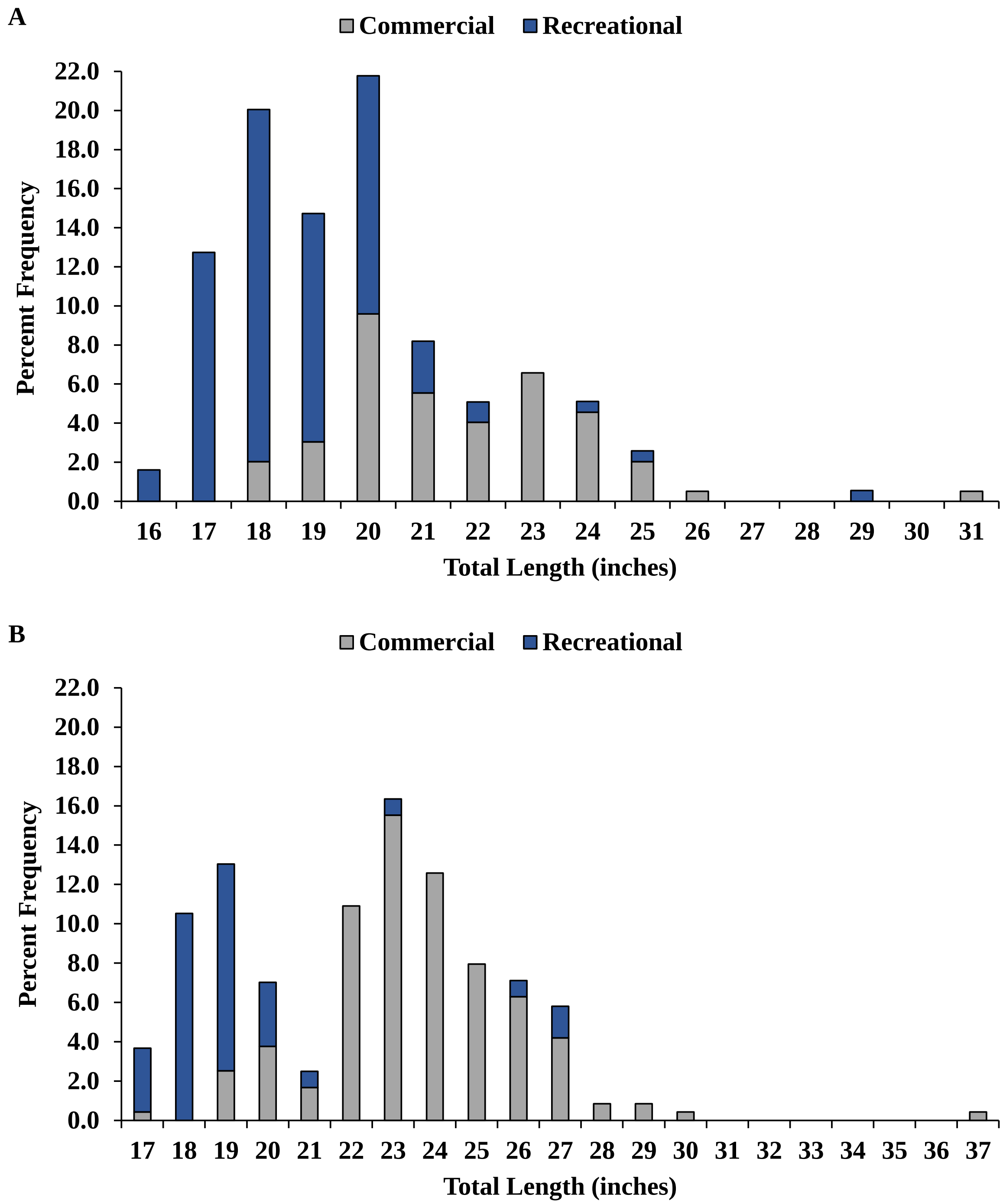

Figure 17. Commercial and recreational length frequency distributions from CSMA striped bass harvested in 2018 from the Tar-Pamlico/Pungo rivers (A) and the Neuse/Bay rivers (B).

A

B

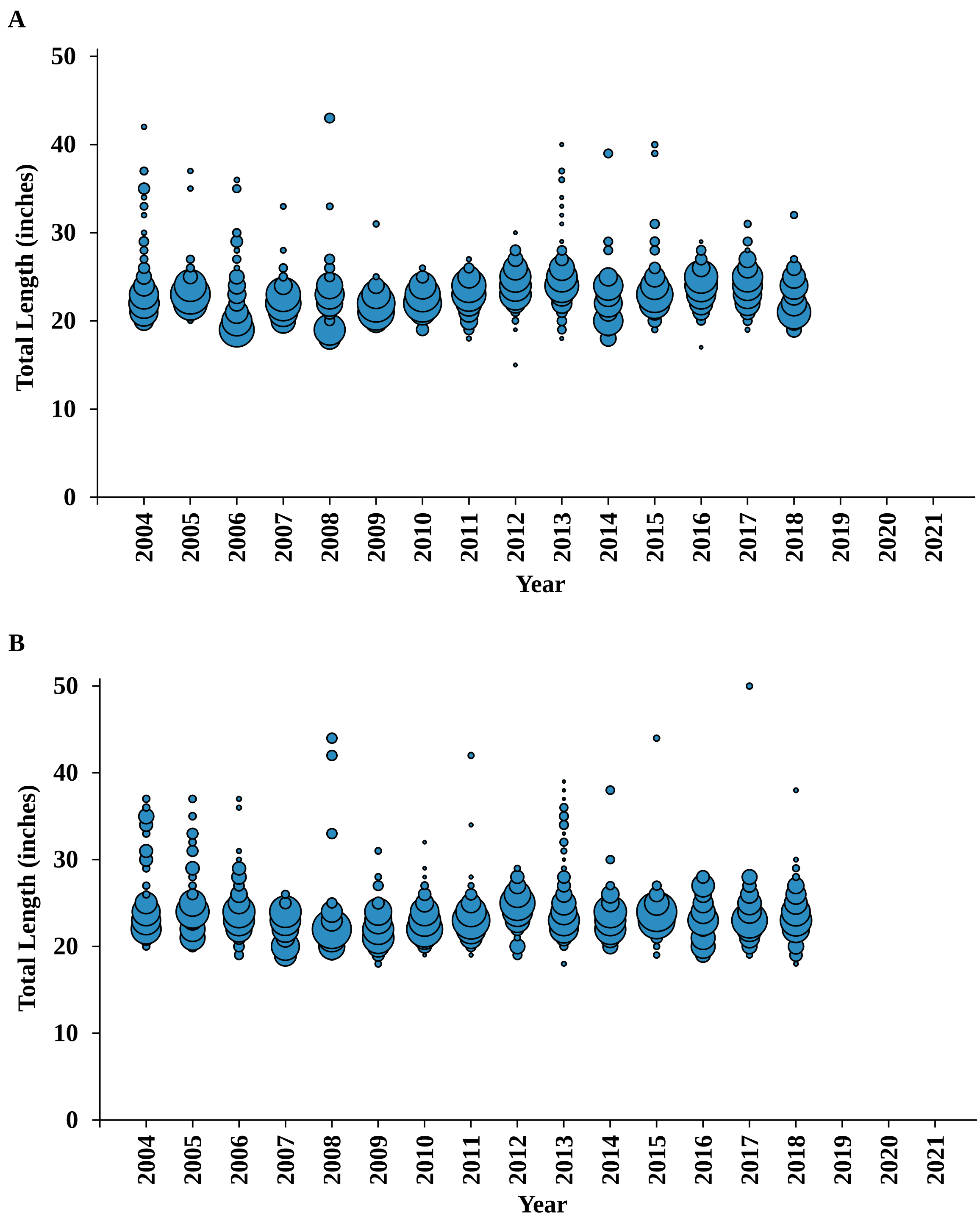

Figure 18. Commercial length frequency of CSMA striped bass landed in the Tar-Pamlico/Pungo rivers (A), and the Neuse/Bay rivers (B) from 2004–2021. Bubble size represents the proportion of fish at length. The commercial season remained closed in 2021.

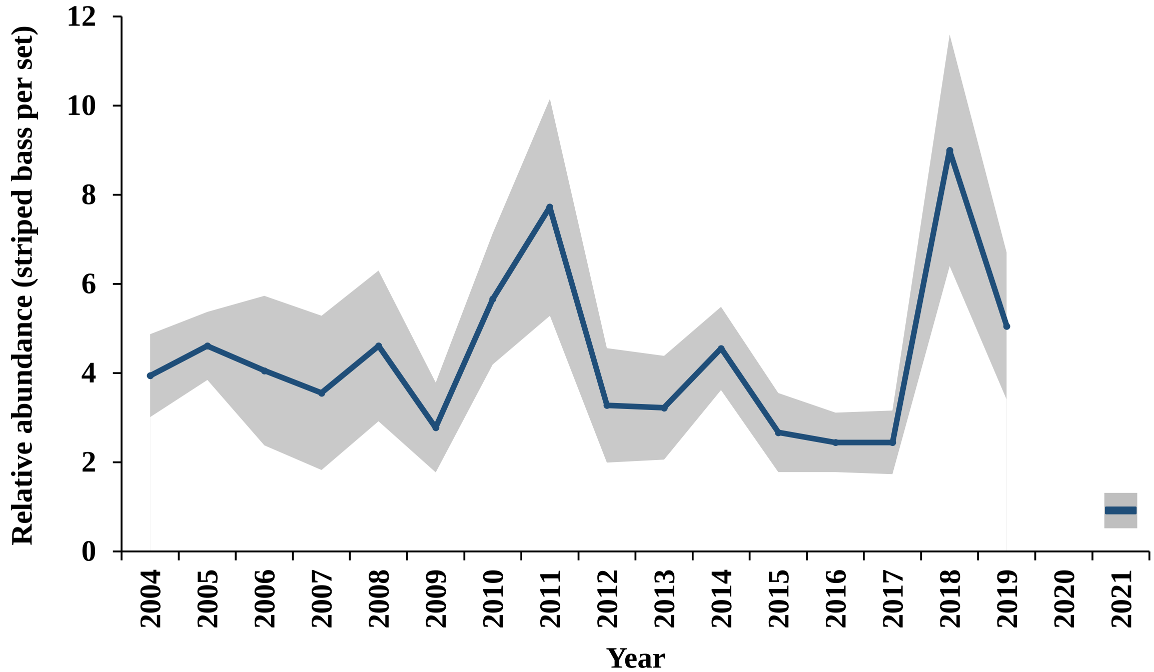

Figure 19. Annual index of adult striped bass relative abundance from the Fisheries Independent Gill Net Survey (P915) in the Tar-Pamlico River during April, and October-November, in shallow water sets, 2004–2021. No sampling occurred in 2020 and limited sampling occurred in 2021 (July–December). Error bars represent ± 1 standard error.

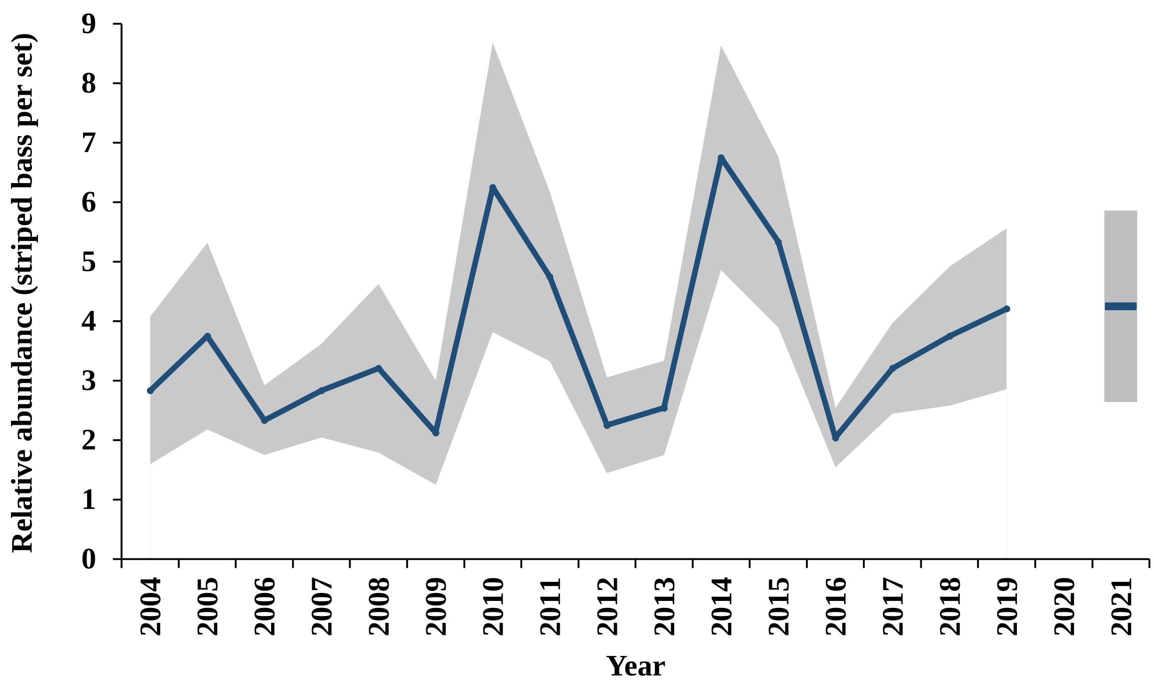

Figure 20. Annual index of adult striped bass relative abundance in the Fisheries Independent Gill Net Survey (P915) in the Neuse River during April, and October-November, in shallow water sets, 2004–2021. No sampling occurred in 2020 and limited sampling occurred in 2021 (July–December). Error bars represent ± 1 standard error.

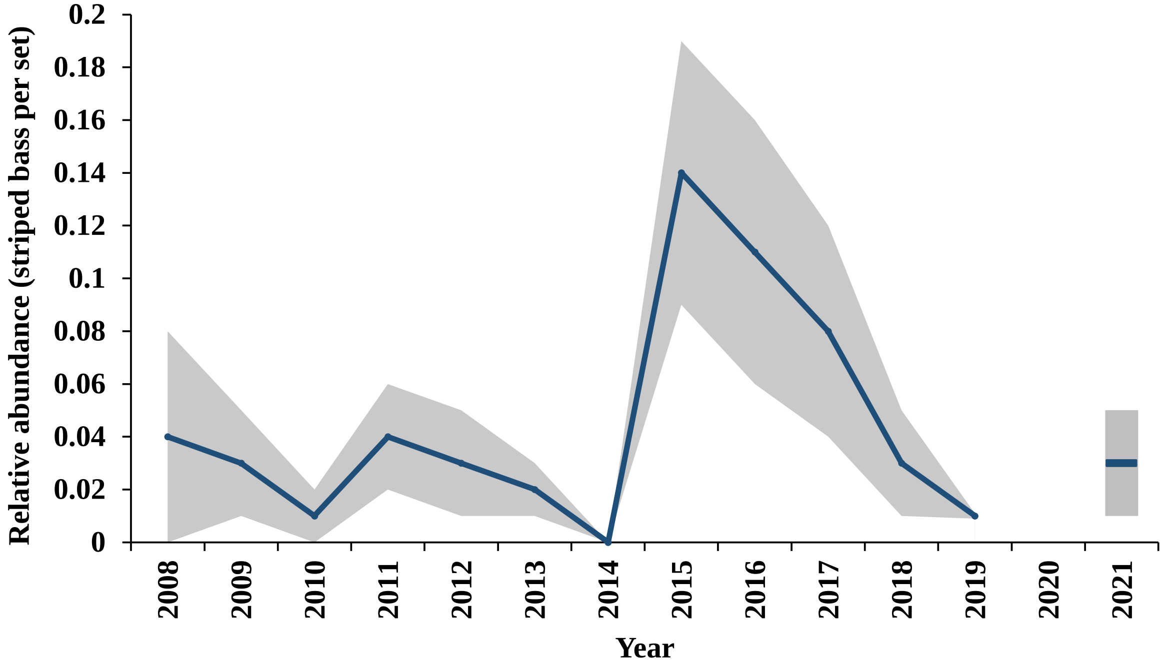

Figure 21. Annual index of adult striped bass relative abundance in the Fisheries Independent Gill Net Survey (P915) in the Cape Fear and New rivers, 2008–2021. No sampling occurred in 2020 and limited sampling occurred in 2021 (July–December). Error bars represent ± 1 standard error.

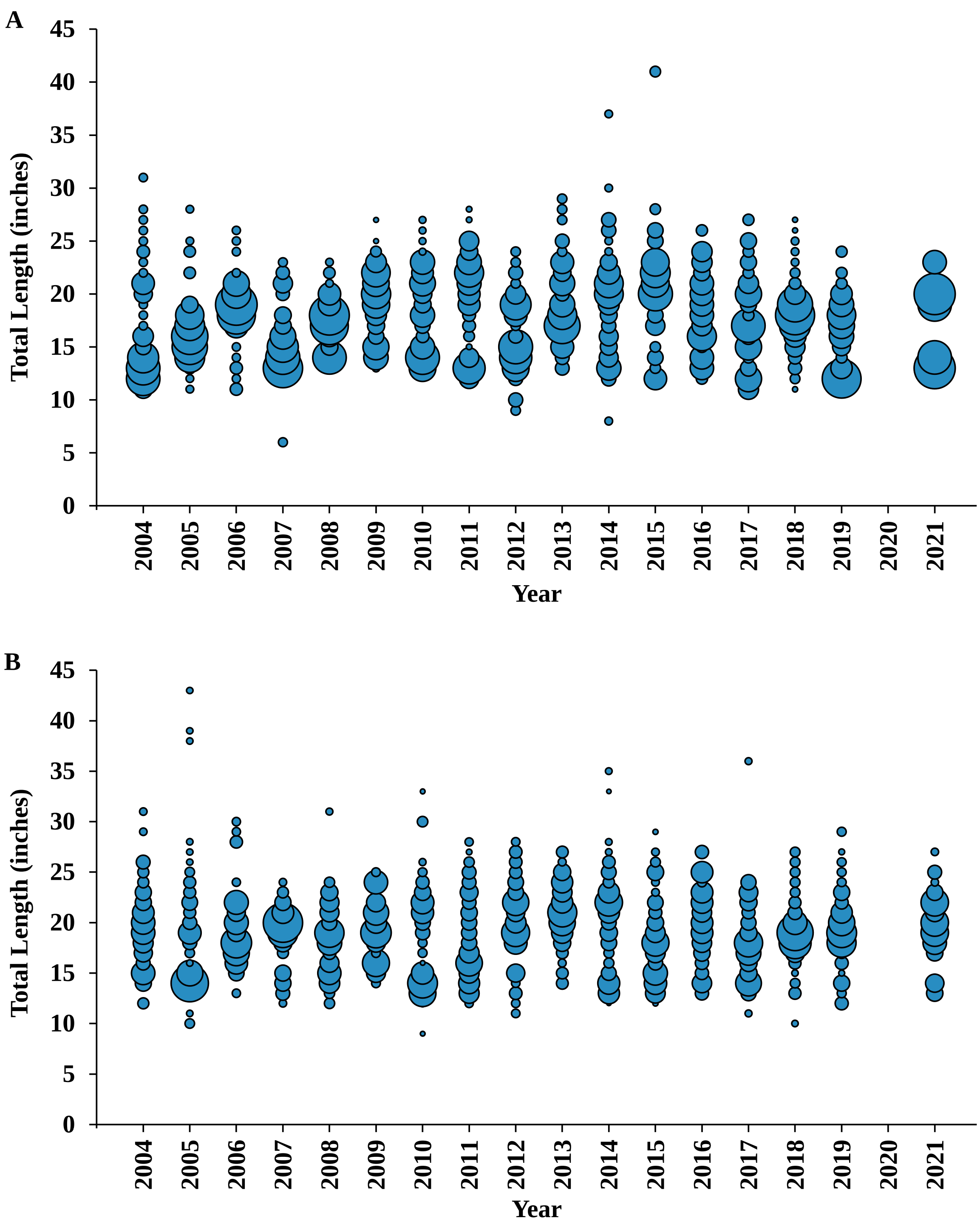

Figure 22. Length frequency of striped bass captured in the Fisheries Independent Gill Net Survey (P915) in the Tar-Pamlico River (A), and the Neuse River (B) during April, and October-November, in shallow water sets (2004–2021). No sampling occurred in 2020 and limited sampling occurred in 2021 (July–December). Bubble size represents the proportion of fish at length.

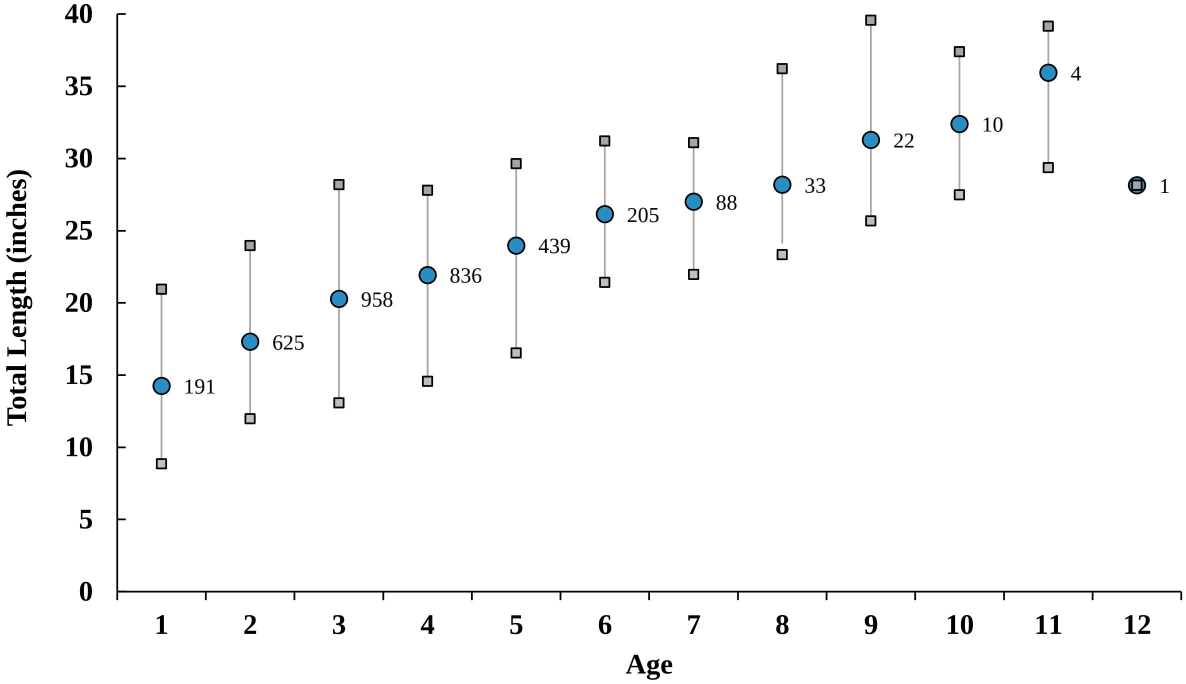

Figure 23. CSMA striped bass length at age based on otolith and genetic age samples collected, 2004–2021. Blue circles represent the mean size at a given age with the number of samples. The grey squares represent the minimum and maximum observed size for each age. Otolith age data from 2021 are considered preliminary, genetic ages from 2020 and 2021 are not currently available.

FISHERY MANAGEMENT PLAN UPDATE
HARD CLAM
AUGUST 2022

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	
Schedule Changes:	None	
Comprehensive Review:	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 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:

- 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.
- Identify, develop, and promote research to improve the understanding of hard clam biology, ecology, population dynamics, and aquaculture practices.
- Initiate, enhance, and continue studies to collect and analyze economic, social, and fisheries data needed to effectively monitor and manage the hard clam fishery.
- Identify, develop, and promote efficient hard clam harvesting practices while protecting habitat.
- Promote the protection, restoration, and enhancement of habitats and water quality so that the production of hard clams is optimized.
- Consider the socioeconomic concerns of all hard clam resource user groups, including market factors.
- Promote public awareness regarding the status and management of the North Carolina hard clam stock.

DESCRIPTION OF THE STOCK

Biological Profile

Hard clams are mostly estuarine-dependent, filter-feeding shellfish found in sandy and vegetated bottoms from Prince Edward Island, Canada to the Yucatan Peninsula, Mexico (Eversole et al. 1987). Spawning occurs from May through November when water temperatures are between 68 degrees and 86 degrees Fahrenheit (Loosanoff and Davis 1950). 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 shell length of about 1.3 inches, and the timing is therefore dependent on the rate of growth (Eversole et al. 1987). 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.

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.

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.

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.

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

A stock assessment is not available for this species.

DESCRIPTION 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.

<u>Public Bottom</u>

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 of submerged aquatic vegetation or in an established bed of saltwater cordgrass.

The public mechanical hard clam harvest season can occur from December 1 through March 31 and is opened by proclamation in specific locations. The mechanical harvest season usually begins the second Monday in December and extends through the week of March 31st. Harvest is allowed 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 include 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 were 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. A 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 area 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 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 Fishery

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 came 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.

Seventeen 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 periods. Hard clams are a live product and must go to market relatively quickly after harvest. Competition with hard clams grown in private culture from other states is 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 1994-2021 was 23.0 million clams (Figure 1). Annual landings in 2021 were the second lowest in the 27-year period at 4.3 million clams. This continuation of the low levels seen in 2020 is likely a extension of the effects of the COVID-19 pandemic on the markets. 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 from 1994-2001.

Hand Harvest Fishery

Hand harvest is a year-round fishery and has average landings of 18.1 million clams a year (1994-2020; 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 second lowest level of 3.7 million clams in 2021 (Figure 2; NCDMF 2017).

Mechanical Harvest Fishery

Hard clam landings from mechanical methods have averaged 4.1 million clams each fishing year (1994-2021; 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. Since 1994, roughly 35% of all private culture operations harvested only clams (NCDMF 2017).

Private enterprise has provided roughly 13.9% of the total commercial hard clam harvest in North Carolina between 1994 and 2021 (Figure 3). The annual average hard clam landings from 1994 to 2021 from private production were 2.8 million clams. In 2021, harvest from private culture was 0.75 million clams, the third lowest in the 25-year time series.

Recreational Fishery

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 been declining since 2013 (Figure 4). In 2021 recreational harvest was roughly one quarter of that in 2020 and only 16% of the time series average. This significant decrease from previous years was likely a continuation of the effects of the COVID-19 pandemic.

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.

During 2021, fishery-dependent sampling was impacted for the first half of the year due to the COVID-19 pandemic.

The number of hard clam shell lengths from fishery dependent sources from 1999 through 2021 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, 2018, and 2019, 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 from the commercial fishery (Table 3).

The modal shell length of hard clams caught in the commercial fishery decreased from 1.75 inches in 2020 to 1.5 inches in 2021 (Figure 5).

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 has been ongoing since 2007 (Table 4). 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 in August 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 relative abundance, or number of clams per station, has ranged annually from 0.1 clams per station in 2020 to 1.27 clams per station in 2009 (Table 4). No trend is apparent from this sampling and new fishery-independent programs for monitoring relative abundance of hard clams are being considered by the division (Figure 6).

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:

High

- Develop hard clam sampling methodology to monitor regional adult abundance
- Map and characterize hard clam habitat use by bottom type
- Develop a survey to better quantify recreational harvest

Medium

- Determine natural mortality estimates
- Survey commercial shellfish license holders without a record of landings to estimate hard clam harvest from this group

MANAGEMENT STRATEGY

There are no management triggers or methods to track stock abundance, fishing mortality, or recruitment between benchmark reviews of the 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 effective 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 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 hard clams on a vessel, during transport to a dealer, or storage on a dock from June through September.

See Table 5 for NCFMC selected management options under Amendment 2.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

The division recommends maintaining the current timing of the scheduled comprehensive review in 2022.

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TABLES

Table 1: Current daily mechanical hard clam harvest limits by water body. Season can 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	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, 2010–2021. * denotes partial year of sampling

Year	Number Trips	Clam Harvest	Catch Rate
2010*	528	8,731	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
2019	5,088	114,042	22.4
2020	6,557	62,164	9.5
2021	1,765	15,471	8.8

Table 3. Observed annual mean, minimum and maximum shell length (inches) of hard clams measured from commercial catches at the dealer, 1999–2021.

Year	Mean Shell Length	Min Shell Length	Max Shell Length	Total Number Measured
1999	1.5	0.9	3.0	3,999
2000	1.4	0.9	2.8	2,137
2001	1.5	0.9	3.1	3,265
2002	1.4	0.9	2.2	1,900
2003	1.4	0.8	2.2	836
2004	1.5	0.9	2.2	1,212
2005	1.5	1.1	3.2	304
2006	1.5	1.0	2.9	1,540
2007	1.5	1.0	2.5	1,405
2008	1.6	0.9	2.6	1,383
2009	1.5	1.0	2.7	1,859
2010	1.5	0.9	2.5	5,358
2011	1.5	0.8	2.6	10,670
2012	1.4	0.9	2.5	5,851
2013	1.5	0.8	2.6	4,750
2014	1.4	0.9	2.6	7,444
2015	1.4	0.8	2.6	6,216
2016	1.4	0.9	2.4	6,454
2017	1.6	0.9	2.6	3,420
2018	1.6	1.0	2.5	1,946
2019	1.6	0.9	2.6	1,786
2020	1.5	0.9	2.3	684
2021	1.5	0.7	2.2	646

Table 4. Fishery independent hard clam sampling (Program 640) annual estimates of relative abundance (number of clams per station) and their standard deviations, 2007–2021 for Core Sound.

Year	Total number of stations	Number of stations with zero catch	Number of clams	Relative Abundance (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
2019	30	23	9	0.30	0.13
2020	30	27	3	0.10	0.31
2021	30	27	6	0.20	0.76

Table 5. Summary of NCMFC 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
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

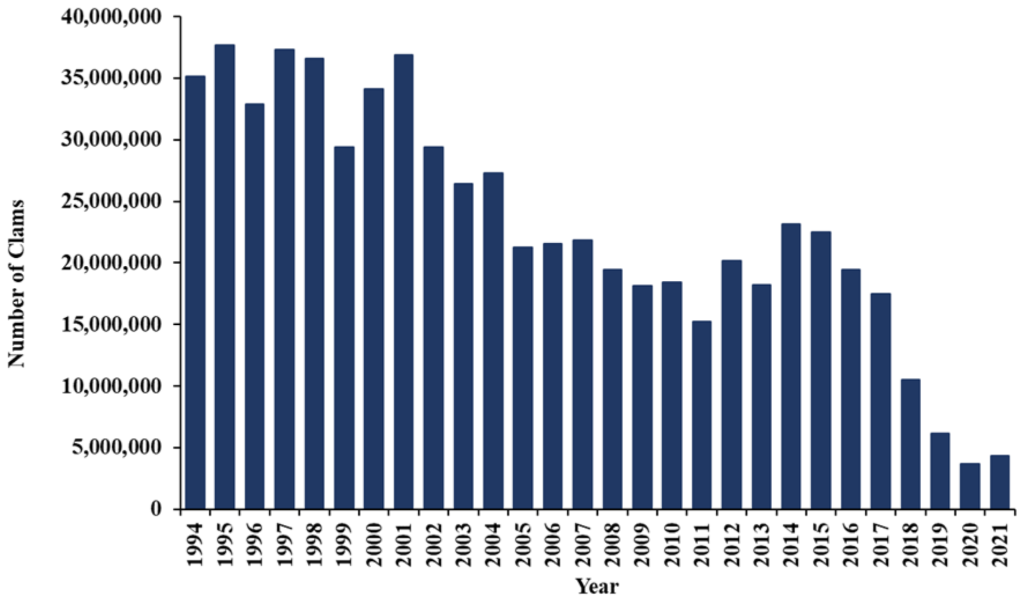

Figure 1. Annual commercial (1994–2021) hard clam landings (number of clams) from private and public bottom in North Carolina.

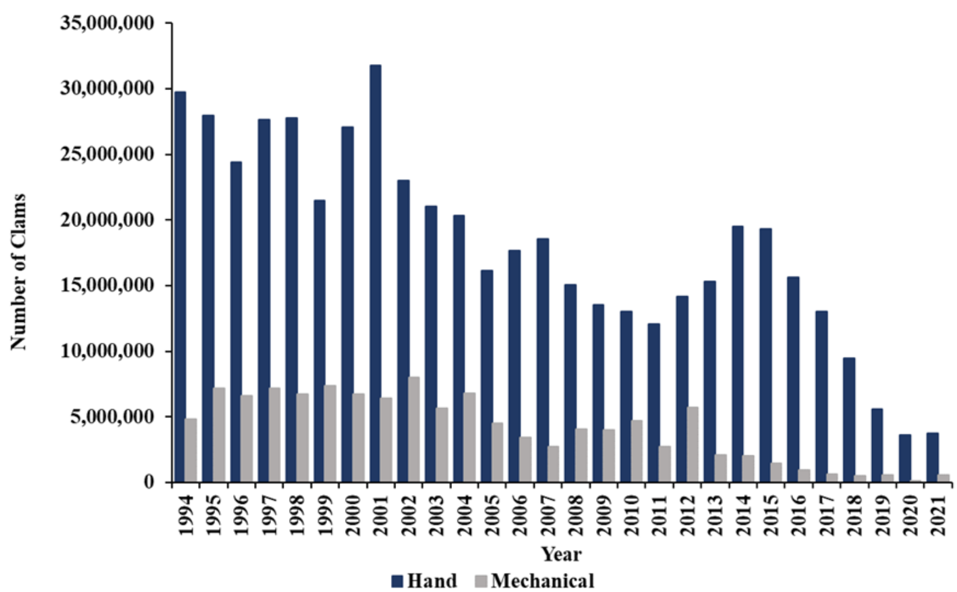

Figure 2. Annual hard clam landings (Number of clams) from hand and mechanical harvest in North Carolina, 1994–2021.

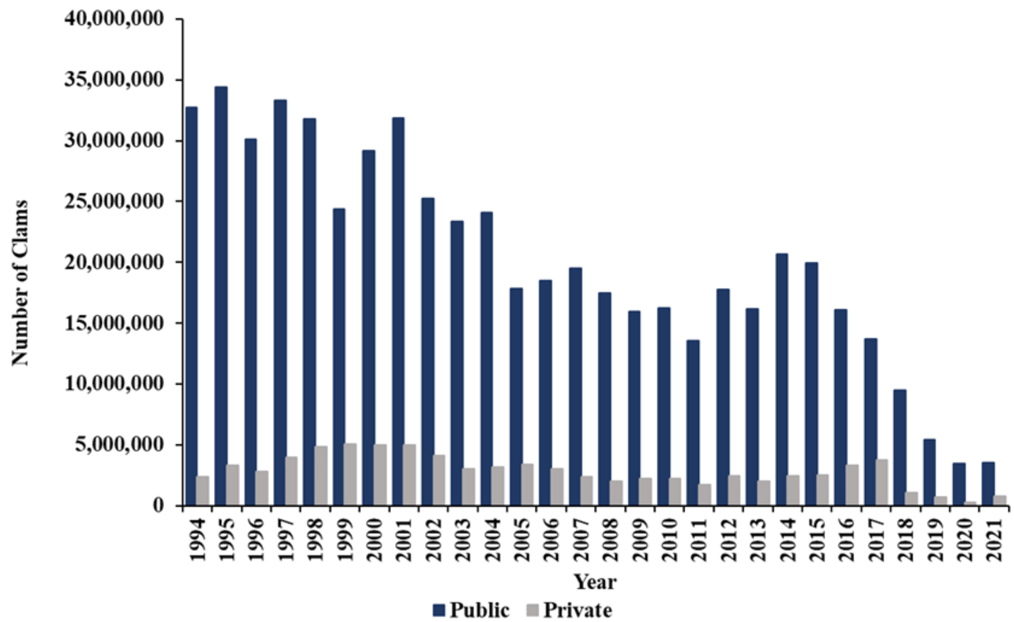

Figure 3. Annual hard clam landings (Number of clams) from private and public bottom, 1994–2021.

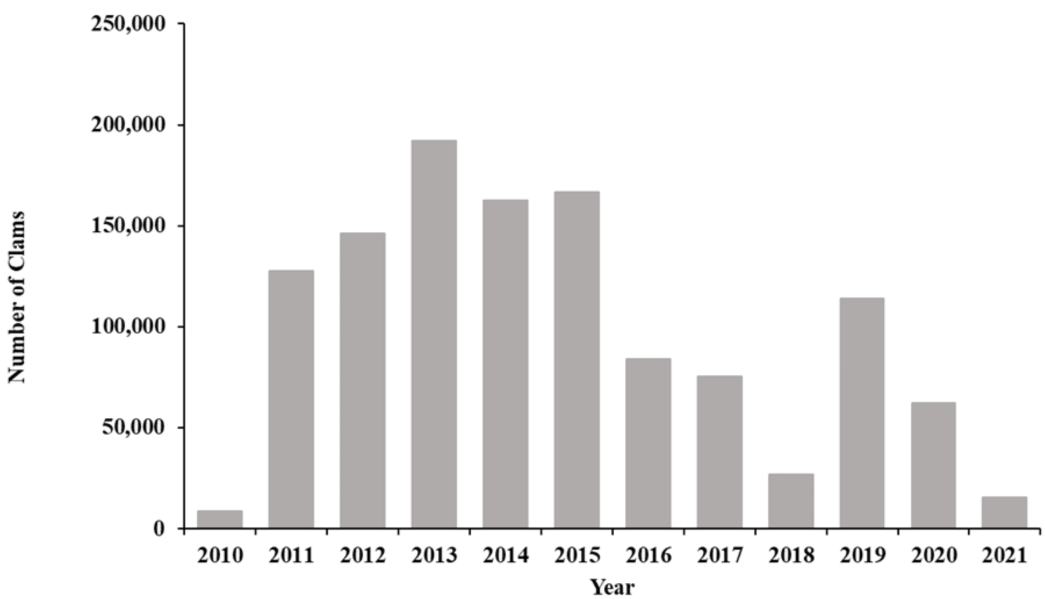

Figure 4. Annual recreational (2010–2021) hard clam landings (number of clams) in North Carolina. Data from 2010 represent a partial year of sampling.

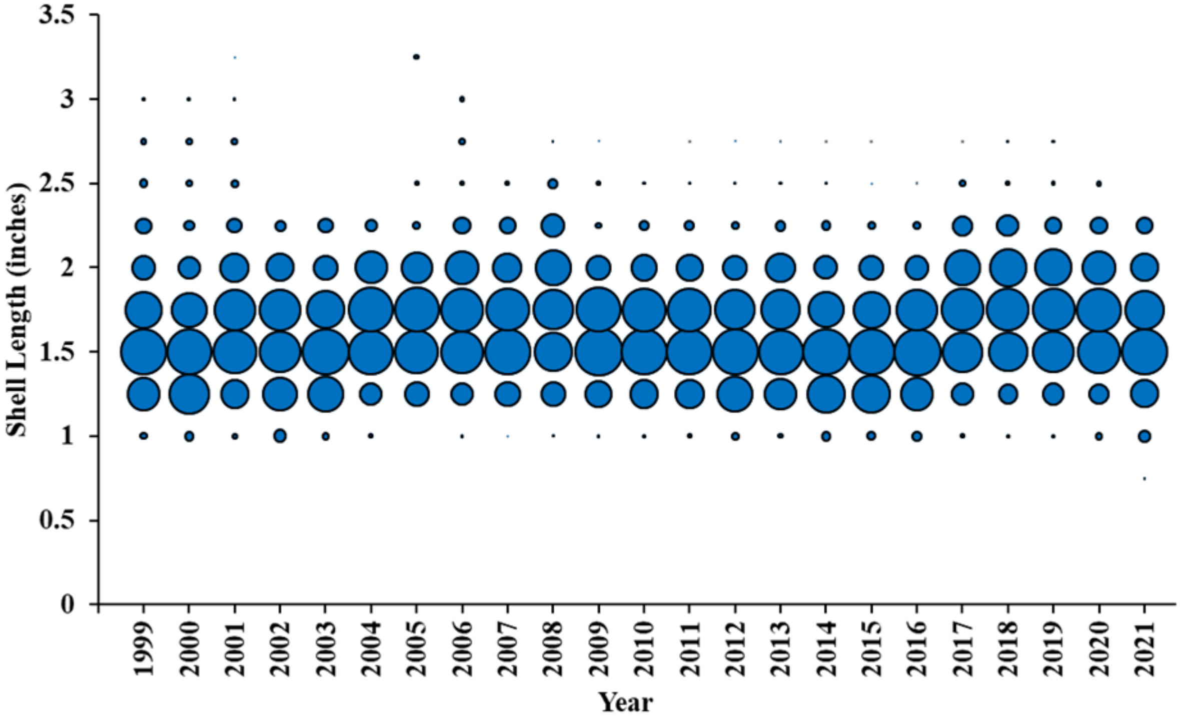

Figure 5. Length frequency (shell length, inches) of hard clams harvested from 1999–2021. Bubble represents the proportion of clams at length.

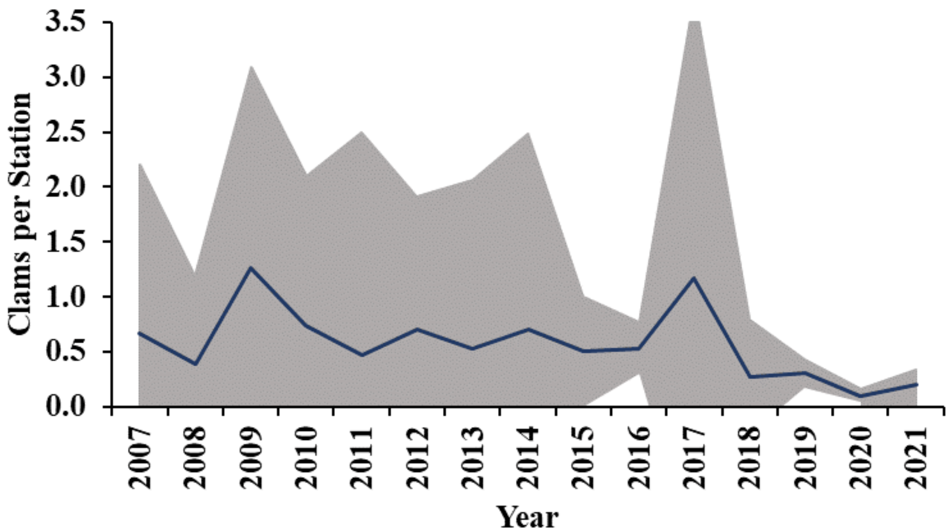

Figure 6. Annual catch per unit effort (Number of clams per stations) of hard clams in Core Sound from fishery independent sampling (Program 640), 2007–2021. Solid black line represents time-series average. Shaded area represents standard error.

FISHERY MANAGEMENT PLAN UPDATE
KINGFISHES
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	November 2007
Amendments:	None
Revisions:	None
Supplements:	None
Information Updates:	December 2015 August 2020
Schedule Changes:	None
Comprehensive Review:	2025

The original 2007 North Carolina Kingfish Fishery Management Plan (FMP) developed management strategies that ensure a long-term sustainable harvest for recreational and commercial fisheries in 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 N.C. Kingfish FMP in November 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 the 2015 Information Update. The annual FMP Update in 2020 served as the formal review of the N.C. Kingfish FMP. The next review will begin in July 2025.

Management Unit

The N.C. Kingfish FMP includes the kingfishes in all coastal fishing waters of North Carolina. The fishery includes three species: southern kingfish (*Menticirrhus americanus)*, gulf kingfish (*M. littoralis)*, and northern kingfish (*M. saxatlis*). 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. For this reason, a state-specific stock assessment cannot be conducted, and a regional stock assessment approach is recommended as the most appropriate mechanism for determining stock status and the long-term viability of these stocks (NCDMF 2007).

Goal and Objectives

The goal of the 2007 N.C. Kingfish FMP was to determine the health of the stocks and ensure the long-term sustainability of the kingfish stocks in North Carolina (NCDMF 2007). To achieve this goal, it is recommended that the following objectives be met:

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

DESCRIPTION OF THE STOCK

Biological Profile

Three species of kingfishes occur in North Carolina: southern, gulf, and northern. 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 stocks of kingfish are unassessed, thus overfishing/overfished status cannot be determined. Only three of the seven triggers were able to be updated with 2021 data due to the impacts from the COVID-19 pandemic and staffing issues with the division’s survey vessel. One of the three updated triggers tripped in 2021. Only two of the triggers were able to be updated with 2020 data due to impacts from the COVID-19 pandemic. One of the two updated triggers tripped in 2020. However, results from the 2019 trend analysis suggested there were 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 stocks in North Carolina (NCDMF 2007). During the review of the 2007 N.C. Kingfishes 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 the 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 based on southern kingfish use fishery independent indices of relative abundance for young-of-year (YOY), adult fish, the proportion of catch greater than size at 50% maturity (L50), and a relative fishing mortality index. Young-of-year fish includes new fish that enter the population that year. The L50 is the length at which 50% of the adult population is sexually mature and ready to spawn.

A quantitative stock assessment is not available for kingfishes 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 kingfishes 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, kingfishes management in North Carolina continues to fall solely within the framework of the state FMP process.

DESCRIPTION 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 kingfishes in any other fisheries.

Commercial Fishery

Commercial landings for kingfishes include southern, northern, and gulf kingfishes combined. Landings have fluctuated historically but have been increasing since 2019. In 2021, landings (808,049 lb) increased 26 percent from 2020 (640,759 lb; Table 1; Figure 1). The average landings from 2012 to 2021 was 727,530 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 Fishery

Recreational landings of kingfishes are estimated from the Marine Recreational Information Program (MRIP). Recreational estimates across all years have been updated and are now based on the new Fishing Effort Survey-based calibrated estimates. For more information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational landings for kingfishes include southern, northern, and gulf kingfishes. Total recreational landings fluctuate but have been generally increasing since 2007. The low landings year in 2018 was likely due to impacts from Hurricane Florence. In 2021, recreational landings (5,676,092 lb) increasing 127% from 2020 (2,505,507 lb; Table 1; Figure 1). Recreational landings in 2021 were the highest on record (previous high was 3,425,201 lb in 2014). Most kingfishes are landed from the ocean and 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 by anglers fishing from private vessels. Recreational harvest of kingfishes is seasonal with most fish harvested during the spring and the fall, and lowest during the summer.

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 kingfishes have varied by year throughout the time series, averaging 238 citations (Figure 2). The number of awarded citations in 2021 (120 citations) decreased from the previous year (611 citations), which was the highest number of citations on record. The decrease in 2021 may be partially due to the increase in weight required to qualify for a citation from one and one-half pounds to two pounds on beginning May 1, 2021.

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 North Carolina. A total of 29,533 kingfishes were measured from 2012 to 2021 (25,278 southern, 2,489 northern and 1,766 gulf; Table 2; Figure 10). Mean total length for southern kingfish ranged from 11.4 to 12.0 inches, with a minimum of 6.5 inches and a maximum of 24.8 inches. Mean length for northern kingfish ranged from 12.2 to 13.9 inches, with a minimum of 7.8 inches and a maximum of 18.6 inches. Mean length for gulf kingfish ranged from 12.0 to 13.1 inches with a minimum of 8.1 inches and a maximum of 18.3 inches. The length composition and modal length of kingfish caught in the commercial fishery has been stable since 2003 (Figure 12).

Recreational lengths are collected as part of MRIP by recreational port agents. A total of 5,674 kingfishes were measured from 2012 to 2021 (4,279 southern, 145 northern and 1,350 gulf; Table 3). Mean fork 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 15.1 inches. Mean length for gulf kingfish ranged from 10.4 to 12.2 inches, with a minimum of 6.0 inches and a maximum of 17.2 inches. Most of the recreational catch consists of kingfishes from 8 to 12 inches (Figure 13).

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 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 kingfishes 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 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 2021 (Figure 3; Table 5).

During 2020, sampling was impacted during June and September due to the COVID pandemic. Not all stations were able to be sampled as only day trips were permitted. In June, only 32 of the 51 stations were sampled, and in September, only 25 of the 51 stations were sampled. Thus, the relative abundance indices from this year should be viewed with caution.

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). 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 4; Table 5). 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 5; Table 5). The survey did not occur in 2020 or 2021, due to COVID.

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. Gill net sets are determined using a random stratified survey design, based on area and water depth. The L50 management trigger is based on a conservative proportion of adults in the population. This is the length at which 50 percent of the population is mature. For southern kingfish, this is 8.25 inches (210 mm) in total length. One of the data sources for this management trigger comes from the Independent Gill Net Survey (Program 915) and has been stable over the time series, ranging from 0.947% to 1.00% (Figure 6).

During 2020 no index of abundance is available for southern kingfish from the fishery-independent assessment (Program 915). Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021.

Table 4 summarizes the age data for kingfishes (southern, northern, and gulf), collected from 2012 through 2021. 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 ranged from 0 to 5 years old. Gulf kingfish ages ranged from 0 to 7 years old. The modal age has ranged from 1 to 4 years for southern, gulf, and northern kingfishes.

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:

High

- Conduct a coast-wide stock assessment of southern kingfish along the Atlantic Coast including estimation of biological reference points for sustainable harvest. — No Action
- Validate YOY and adult indices used in trend analysis. — 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. — No Action
- Collect observer data from commercial fishing operations to estimate at-sea species composition of the catch, discard rates, and lengths. — 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. — Steps have been taken to improve sampling in recreational fisheries, including a carcass collection program

- Develop tagging study to estimate natural and fishing mortality, to investigate stock structure, and to understand movement patterns. — No Action
- Collect histological data to develop maturity schedule with priority to southern kingfish. — NCDMF currently collecting histology samples in order to validate and update maturity schedules
- Conduct an age validation study with priority to southern kingfish. — No Action

Medium

- Improve dependent commercial data collection of more sample sizes for life history information. — 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. — No Action
- Continue bycatch reduction device studies in the shrimp trawl fishery to decrease bycatch. — Ongoing research through NCDMF and various federal agencies
- Conduct study to estimate fecundity with priority to southern kingfish. — No Action
- Conduct study to identify spawning areas with priority for southern kingfish. — No Action

Low

- Determine stock structure using genetics of kingfishes along North Carolina and the Atlantic Coast. — Grant approved for UNCW and NCDMF to use genetic markers to delineate the population structure
- Sample inlets and river plumes to determine the importance of these areas for kingfishes and other estuarine-dependent species. — 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. — 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. — 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. — NCDMF conducted a study of CRFL holders in 2009/2010
- Update information on the participants in the recreational kingfish fishery. — Socioeconomic study was conducted by NCDMF on piers)

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 southern kingfish stock in North Carolina (NCDMF 2007; Table 6). 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. Southern kingfish is designated as the indicator species for this assemblage. 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 L50 management trigger is based on a conservative proportion of adults in the population. This is the length at which 50 percent of the population is mature. For southern kingfish, this is 8.25 inches (210 mm) in total 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 harvest (commercial landings plus recreational harvest) divided by a fisheries-independent index of relative abundance. Here, harvest (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 the majority of harvest occurs in the spring.

The southern kingfish management triggers are summarized as follows:

<u>Biological Monitoring</u>

Proportion of adults ≥ length at 50 percent maturity (L50) for NCDMF Program 195 June (Figure 7)

Proportion of adults > L50 for NCDMF Program 915 (Figure 6)

Proportion of adults ≥ L50 for SEAMAP-SA Coastal Survey summer (Figure 8)

- If the proportion of adults ≥ L50 falls below 2/3 of the average proportion of adults ≥ L50 for the time series (through 2013), 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 3)

SEAMAP-SA Coastal Survey summer index of adult relative abundance (Figure 4)

SEAMAP-SA Coastal Survey fall index of YOY relative abundance (Figure 5)

- If a fisheries-independent survey falls below 2/3 of the average abundance for the time series (through 2013), then the trigger will be considered tripped.

Other

Relative fishing mortality rate (F) (Figure 9)

- If relative F rises above the average +1/3 of relative F for the time series (through 2013), 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. Only three of the triggers were able to be updated with 2021 data due to the impacts from the COVID-19 pandemic and staffing issues with the division's survey vessel. One of the three updated triggers tripped in 2021. Only two of the triggers were able to be updated with 2020 data due to impacts from COVID-19 pandemic. One of the two updated triggers tripped in 2020. In 2019, one management trigger was activated (the YOY index from the fall portion of SEAMAP Survey) and below the management trigger threshold.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

The management program currently in place for kingfishes has resulted in a stock that has met ongoing management targets. All management strategies in place will be maintained as outlined in the state FMP. Stock conditions will be monitored and reported through each subsequent annual FMP update and the NCMFC will continue to receive the FMP review schedule annually. The next scheduled review of this plan will begin in July 2025.

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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 kingfishes from North Carolina for the period 1987–2021.

Year	Recreational			Commercial	
	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1987	1,857,068	260,871	992,633	959,928	1,952,561
1988	2,890,243	437,608	901,222	503,949	1,405,171
1989	694,996	232,077	354,489	562,424	916,913
1990	2,185,356	794,834	1,045,318	738,612	1,783,930
1991	2,556,003	797,605	1,342,855	864,651	2,207,506
1992	2,101,326	622,123	1,205,802	851,708	2,057,510
1993	1,713,370	363,653	970,140	1,194,224	2,164,364
1994	1,905,437	704,638	932,088	620,841	1,552,929
1995	1,566,976	887,357	877,355	1,058,785	1,936,140
1996	1,594,185	604,856	824,301	528,260	1,352,561
1997	1,377,757	315,294	764,540	872,888	1,637,428
1998	887,493	542,905	543,575	399,313	942,888
1999	1,434,966	879,223	789,732	607,465	1,397,197
2000	2,650,504	1,943,897	1,747,843	551,940	2,299,783
2001	2,425,319	1,059,193	1,374,961	489,743	1,864,704
2002	1,640,675	968,687	987,857	619,737	1,607,594
2003	1,480,769	1,920,446	962,157	652,636	1,614,792
2004	2,638,463	2,528,681	1,656,167	567,659	2,223,826
2005	1,796,386	1,814,579	961,919	296,263	1,258,182
2006	2,649,617	2,509,056	1,476,769	559,440	2,036,209
2007	2,277,856	2,408,418	1,397,901	817,588	2,215,489
2008	2,783,237	2,344,633	1,480,223	921,120	2,401,343
2009	3,785,900	4,711,527	2,070,355	721,924	2,792,279
2010	3,745,586	4,465,523	2,213,702	886,841	3,100,543
2011	2,345,068	2,631,056	1,444,020	486,853	1,930,873
2012	3,444,198	3,665,650	1,876,114	596,249	2,472,363
2013	5,878,620	6,069,055	2,892,756	603,186	3,495,942
2014	5,545,372	6,959,626	3,425,201	955,087	4,380,288
2015	5,503,438	4,850,505	3,110,112	784,753	3,894,865
2016	4,149,467	4,076,760	2,224,575	834,771	3,059,346
2017	3,387,471	4,075,827	2,316,609	942,946	3,259,556
2018	1,731,339	2,180,732	1,008,600	407,173	1,415,772
2019	3,370,636	4,152,005	1,888,848	702,328	2,591,176
2020	3,865,040	3,461,090	2,505,507	640,759	3,146,265
2021	8,425,767	5,593,293	5,676,092	808,049	6,484,141
Mean	2,642,945	2,242,353	1,487,242	700,060	2,187,303

Table 2. Summary of length data (total length, inches) sampled from kingfishes in the commercial fishery, 2012–2021.

Southern Kingfish				
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
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
2019	11.4	8.0	24.8	4,360
2020	11.3	7.8	20.0	1,770
2021	11.3	7.8	20.0	1,770
Northern Kingfish				
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
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
2019	12.2	8.1	16.1	174
2020	13.5	10.0	18.6	173
2021	13.5	10.0	18.6	173
Gulf Kingfish				
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
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
2019	12.0	8.9	16.9	154
2020	13.1	11.3	15.6	15
2021	13.1	11.3	15.6	15

Table 3. Summary of length data (fork length, inches) sampled from kingfishes in the recreational fishery, 2012–2021.

Southern Kingfish				
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
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
2019	10.9	6.3	15.7	374
2020	11.2	7.6	16.9	467
2021	11.5	7.5	16.1	347
Northern Kingfish				
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
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
2019	10.9	10.9	10.9	1
2020	11.7	10.7	12.4	7
2021	10.6	8.3	13.1	15
Gulf Kingfish				
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
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
2019	11.1	6.2	15.0	72
2020	12.1	7.4	16.0	92
2021	12.2	7.9	15.5	44

Table 4. Kingfishes age data collected from all sources (commercial and recreational fisheries and fishery independent sampling programs) combined, 2012–2021.

Southern Kingfish				
Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
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
2019	2	1	7	386
2020	2	0	7	249
2021	2	1	6	423
Northern Kingfish				
Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
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
2019	-	-	-	0
2020	4	3	4	6
2021	3	1	5	9
Gulf Kingfish				
Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
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
2019	1	0	6	183
2020	1	0	5	170
2021	2	0	7	205

Table 5. Summary of management trigger organized by category. Bold values indicate years a trigger was activated.

	BIOLOGICAL MONITORING			FISHERIES-INDEPENDENT SURVEYS			OTHER
	Proportion of Adults >= L50			YOY Indices		Adult Index	
Year	Program 195 June	Program 915 July-September	SEAMAP Summer	Program 195 September	SEAMAP Fall	SEAMAP Summer	Relative *F*
1987	0.611			**0.80**			
1988	0.450			**1.34**			
1989	**0.300**		0.585	**1.21**	65.4	**19.7**	8,832
1990	0.563		0.463	**2.77**	48.9	45.3	**40,806**
1991	0.667		0.894	**4.40**	36.9	64.6	11,804
1992	0.429		0.622	**2.23**	26.7	53.7	12,088
1993	0.543		0.456	**0.10**	**14.4**	40.6	**32,840**
1994	0.794		0.917	6.73	42.4	**9.00**	**48,429**
1995	0.440		0.486	7.86	**18.0**	**15.2**	20,115
1996	0.872		0.780	**0.30**	34.5	**10.9**	20,742
1997	0.589		**0.373**	**0.43**	**20.7**	27.4	8,708
1998	1.000		0.769	**0.20**	35.8	**12.1**	5,814
1999	0.920		0.608	**4.37**	40.1	75.4	14,118
2000	0.733		0.929	8.32	32.2	**19.8**	**45,526**
2001	0.660	0.983	**0.303**	5.75	27.3	40.3	15,967
2002	0.704	0.978	0.882	6.91	47.1	**25.4**	15,042
2003	0.872	0.978	0.645	5.53	**18.7**	31.3	4,103
2004	0.513	0.971	**0.284**	**2.81**	58.8	80.9	4,267
2005	0.594	0.971	0.666	**2.02**	34.5	42.2	7,033
2006	0.547	0.980	0.423	28.85	33.1	51.7	11,413
2007	**0.343**	0.976	0.521	8.44	52.9	**18.4**	20,943
2008	0.488	0.978	0.577	15.31	33.9	**9.61**	19,640
2009	0.586	1.000	**0.389**	32.94	**15.3**	37.5	**27,647**
2010	0.523	0.982	0.786	**1.66**	38.9	27.9	14,045
2011	0.432	1.000	0.507	16.61	95.5	34.2	17,134
2012	0.511	1.000	**0.368**	6.03	31.0	100	4,734
2013	0.659	0.947	0.558	23.93	48.5	61.8	6,401
2014	0.420	0.981	0.548	7.41	71.4	68.5	20,074
2015	0.534	0.981	0.550	8.50	557	56.5	9,929
2016	**0.358**	0.950	**0.345**	**2.01**	79.8	61.0	2,979
2017	0.503	0.958	0.684	**3.77**	49.2	**23.9**	2,288
2018	0.639	1.000	0.404	6.76	34.3	32.1	5,056
2019	0.525	0.971	0.447	6.61	36.9	70.3	5,109
2020	0.528	*	*	**2.46**	*	*	*
2021	0.471	1.000	*	**0.66**	*	*	*
Threshold	<0.403	<0.653	<0.394	<4.89	<25.4	<25.5	>23,370
Total Years	35	20	31	35	31	31	31
Years Trigger Activated	3	0	6	18	5	10	5

Table 6. 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 coastwide 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

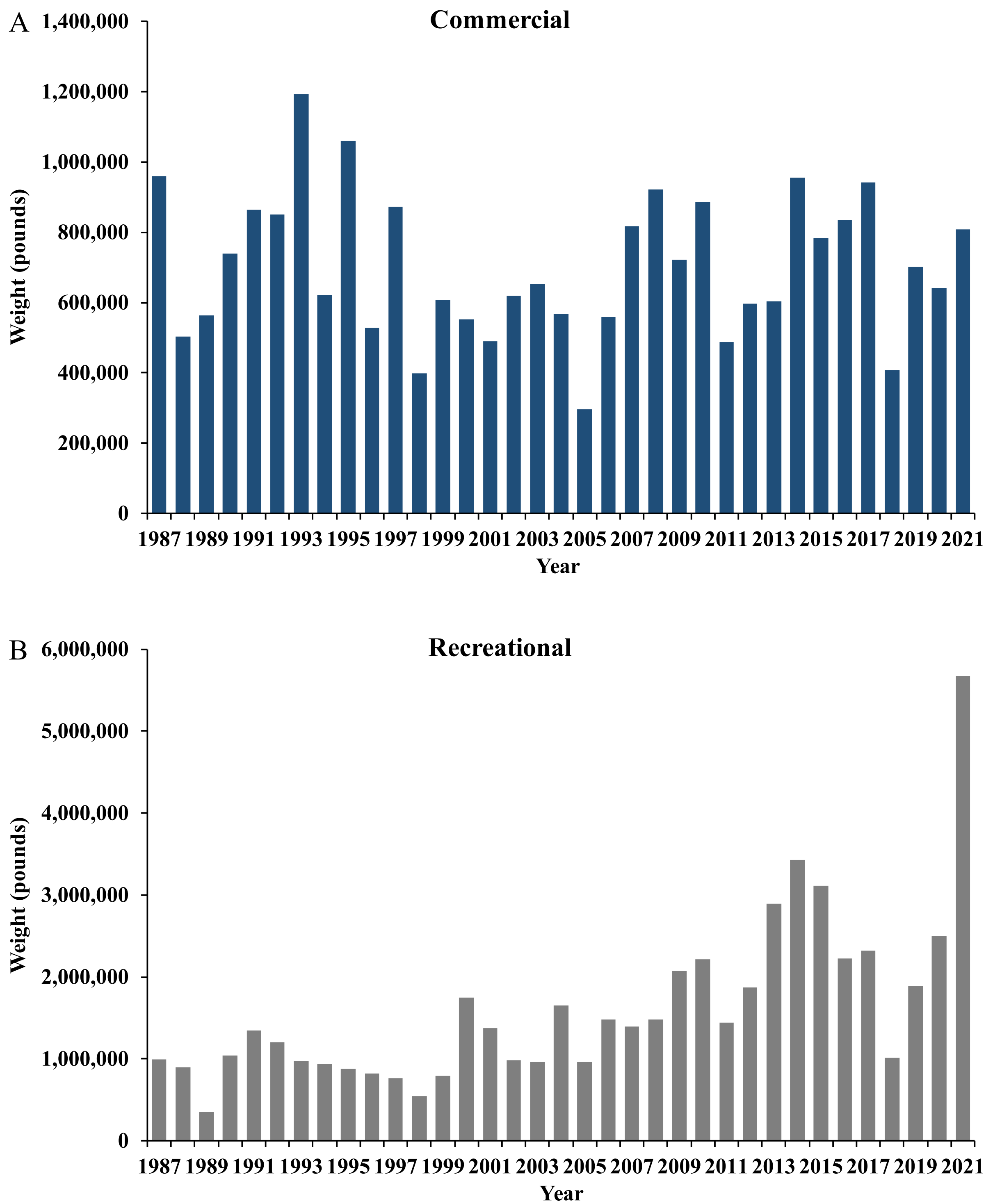

Figure 1. Commercial landings (pounds) reported through the North Carolina Trip Ticket Program (A) and recreational landings (Type A + B1; pounds) estimated from the Marine Recreational Information Program survey (B) for North Carolina from 1987–2021.

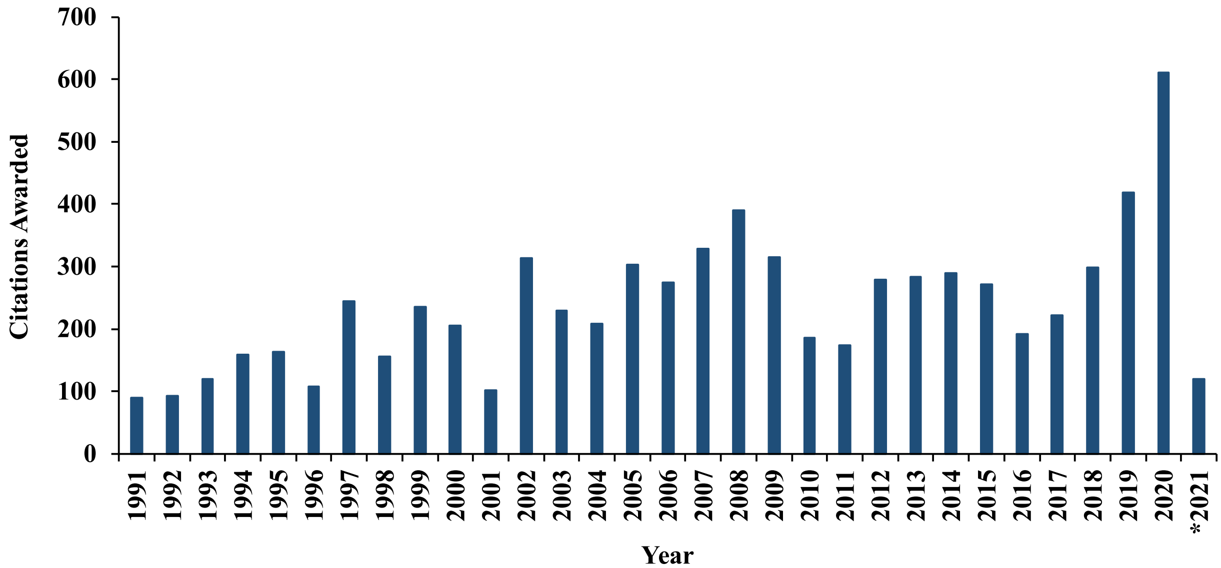

Figure 2. North Carolina Saltwater Fishing Tournament citations awarded for spotted seatrout, 1991–2021. Citations are awarded for kingfishes > two pounds landed. *Prior to May 1, 2021, citations were awarded for kingfishes > one and one-half pounds landed.

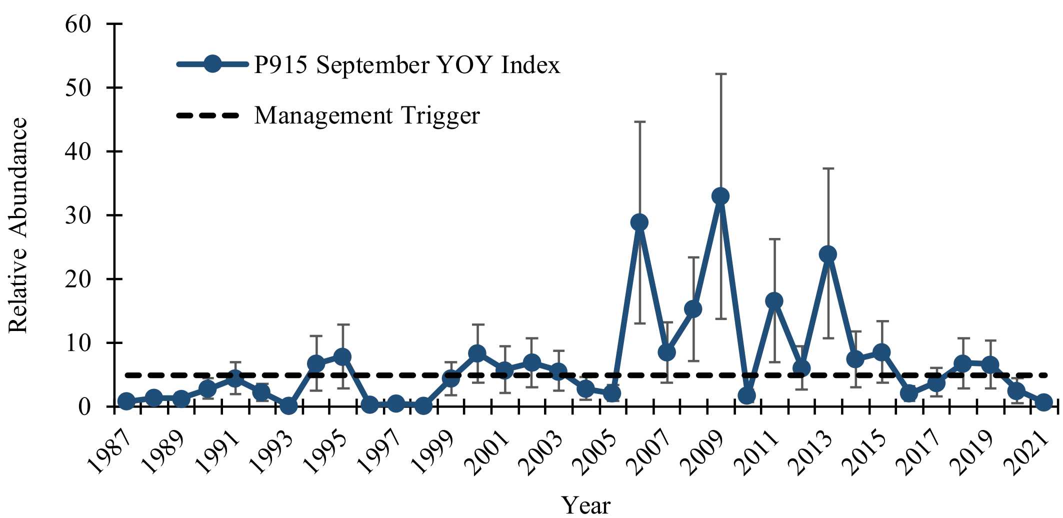

Figure 3. Annual index of relative YOY abundance for southern kingfish derived from the September component of the NCDMF Program 195 survey (excluding strata from the Neuse, Pamlico, and Pungo rivers), 1987–2021. Dotted line represents 2/3 of the average of the base years, 1987–2013.

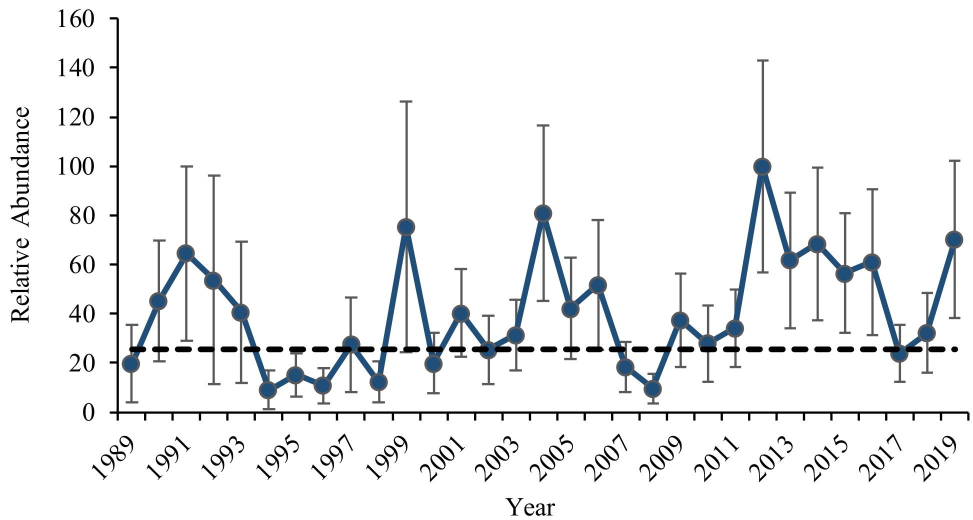

Figure 4. Annual index of relative adult abundance for southern kingfish derived from the summer component of the SEAMAP-SA Coastal Survey (Onslow, Raleigh, and Long bays, inner—shallow—strata), 1989–2019. Survey not conducted in 2020 or 2021. Dotted line represents 2/3 of the average of the base years, 1989–2013.

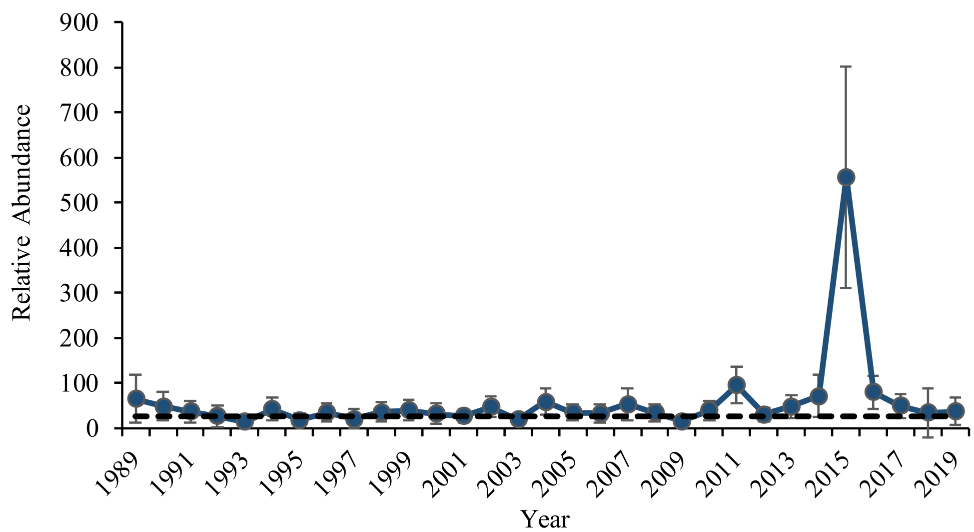

Figure 5. Annual index of relative YOY abundance for southern kingfish derived from the fall component of the SEAMAP-SA Coastal Survey (Onslow, Raleigh, and Long bays, inner—shallow—strata), 1989–2019.Survey not conducted in 2020 or 2021. Dotted line represents 2/3 of the average of the base years, 1989–2013.

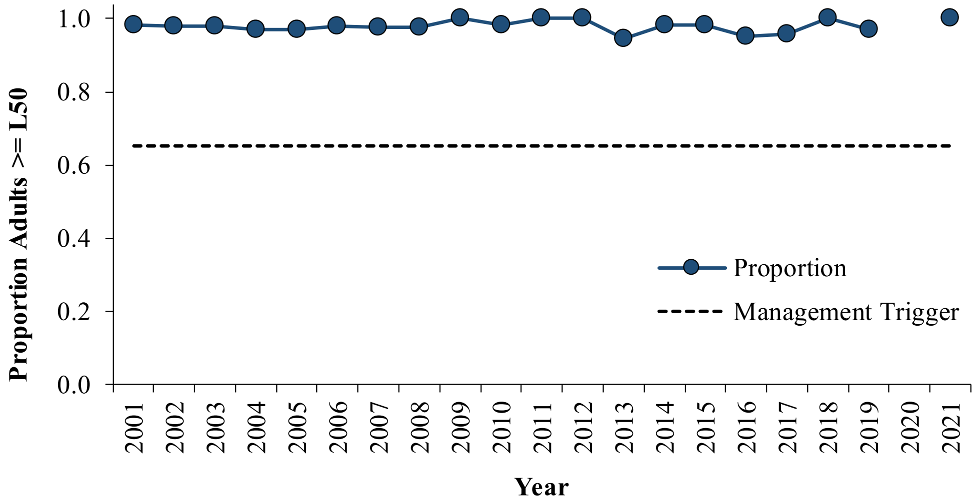

Figure 6. Annual proportion of adults (southern kingfish) greater than or equal to the length at 50% maturity occurring in the July through September component of the NCDMF Program 915 survey (Pamlico Sound, deep strata only), 2001–2021. Dotted line represents 2/3 of the average of the base years, 2001–2013.

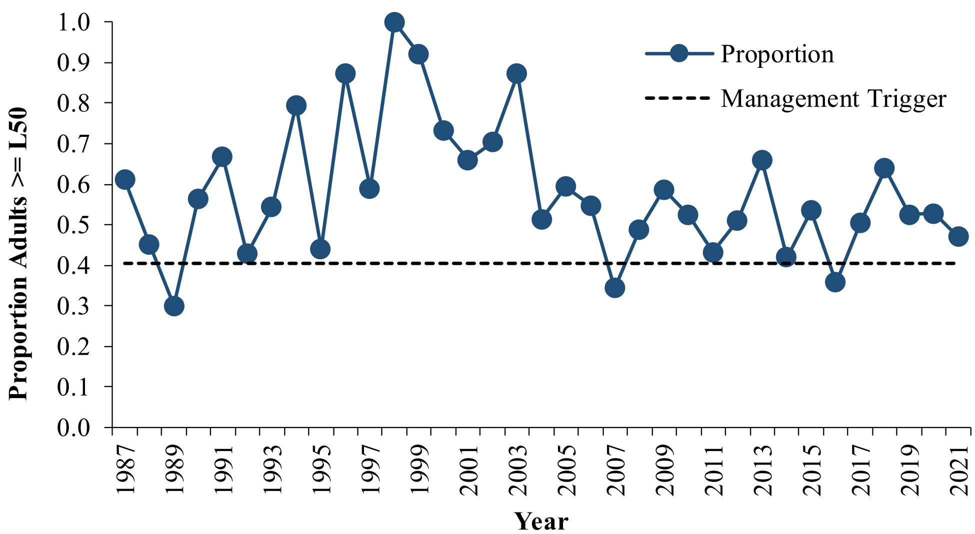

Figure 7. Annual proportion of adults (southern kingfish) greater than or equal to the length at 50% maturity occurring in the June component of the NCDMF Program 195 survey (excluding strata from the Neuse, Pamlico, and Pungo rivers), 1987–2021. Dotted line represents 2/3 of the average of the base years, 1987–2013.

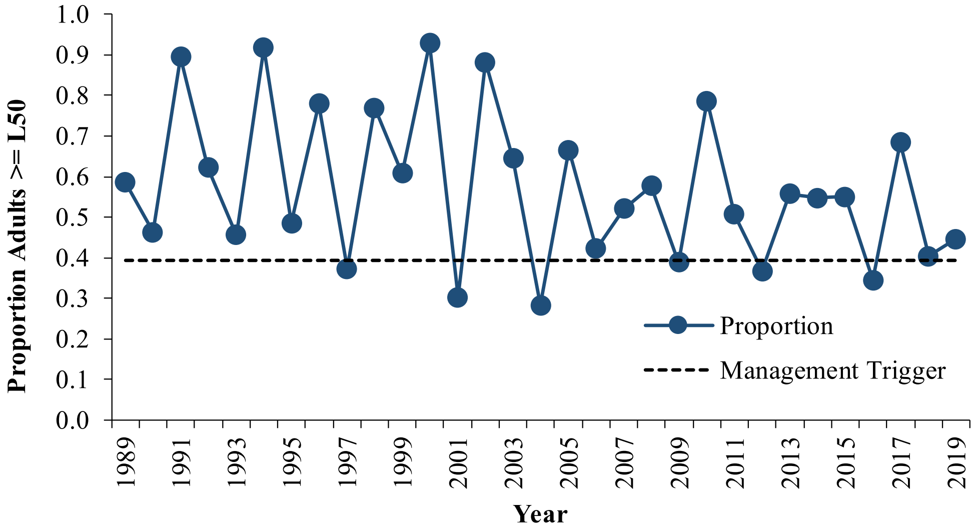

Figure 8. Annual proportion of adults (southern kingfish) greater than or equal to the length at 50% maturity occurring in the summer component of the SEAMAP-SA Coastal Survey (Onslow, Raleigh, and Long bays, inner—shallow—strata), 1989–2019. Survey not conducted in 2020 or 2021. Dotted line represents 2/3 of the average of the base years, 1989–2013.

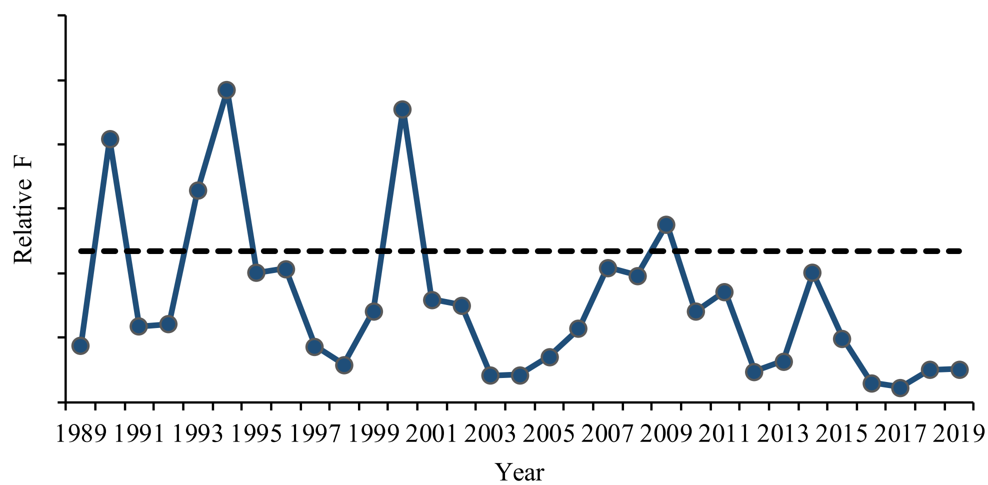

Figure 9. Relative F, as estimated as harvest (commercial and recreational) divided by the SEAMAP-SA Coastal Survey spring index (Onslow, Raleigh, and Long bays, inner—shallow—strata) of relative abundance for southern kingfish, 1989–2019. Survey not conducted in 2020 or 2021. Dotted line represents the average plus 1/3 of the average of the base years, 1989–2013.

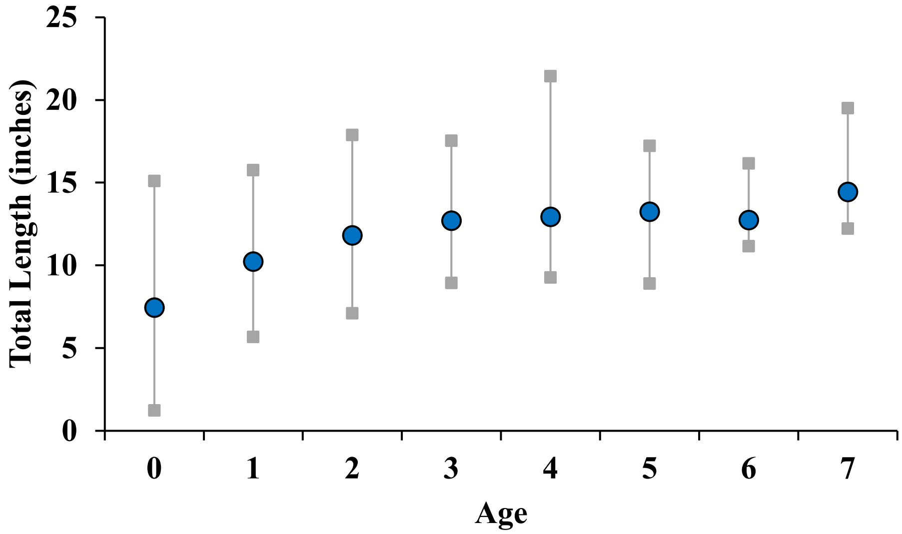

Figure 10: Kingfishes total length at age based on all samples collected, 1997–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed for each age.

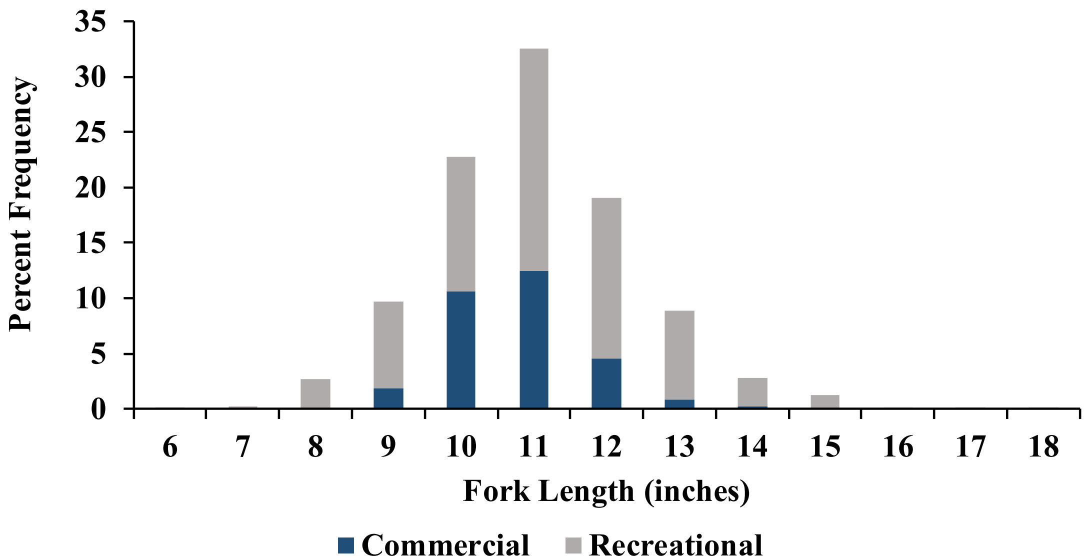

Figure 11: Commercial total length and recreational fork length frequency distribution of kingfishes harvested in 2021.

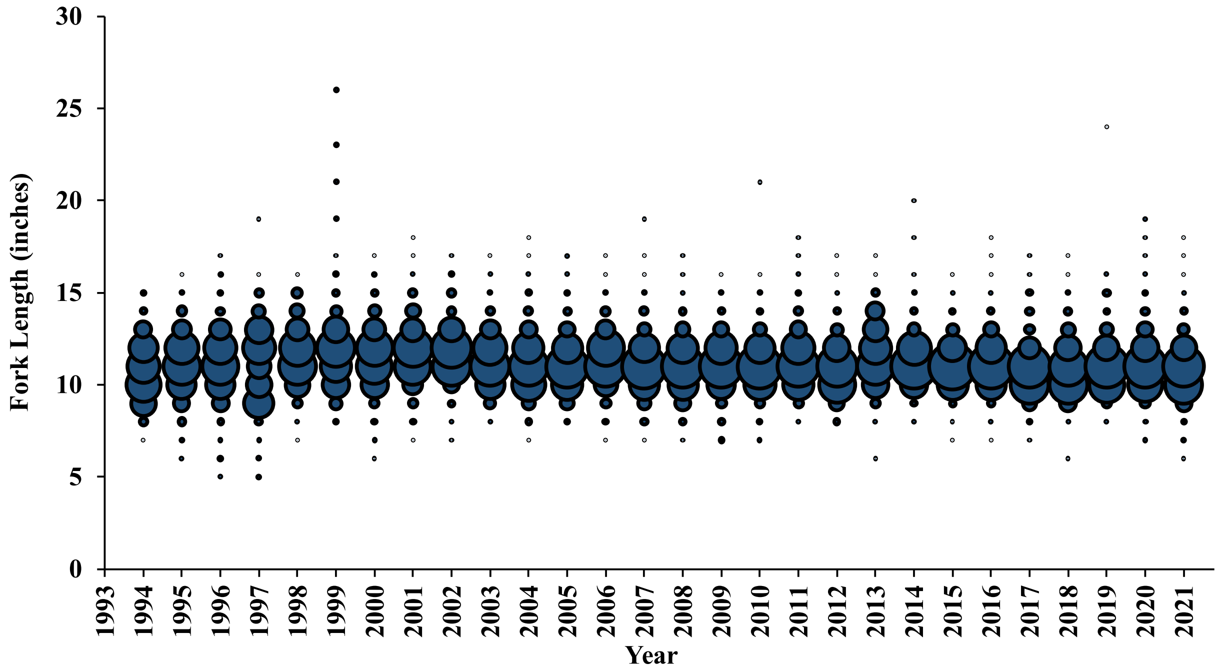

Figure 12: Commercial total length frequency of kingfishes harvested, 1994–2021. Bubble represents the proportion of fish at length.

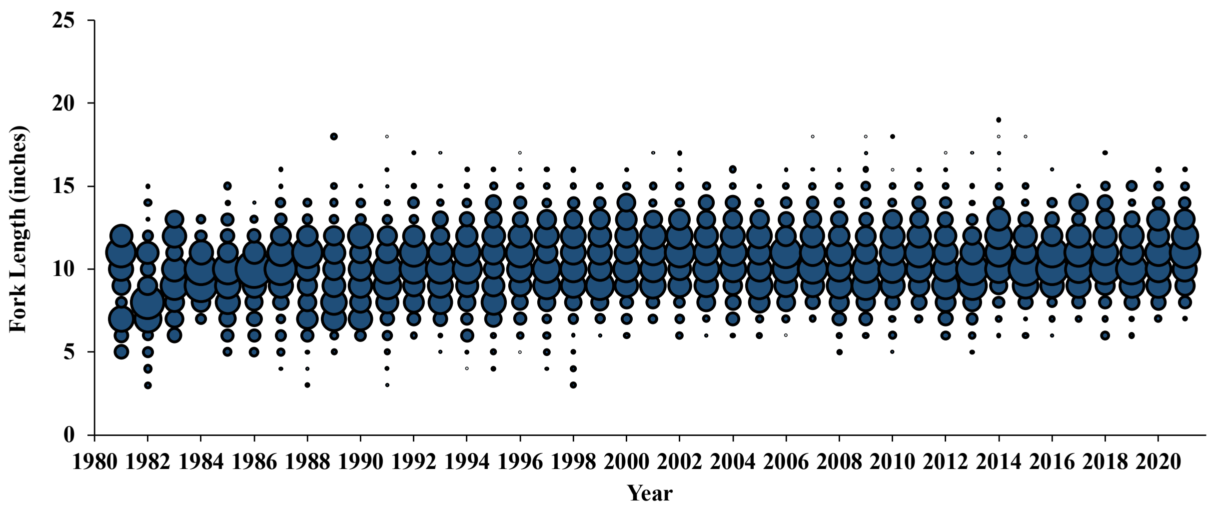

Figure 13: Recreational fork length frequency of kingfishes harvested, 1981–2021. Bubble represents the proportion of fish at length.

FISHERY MANAGEMENT PLAN UPDATE
RED DRUM
AUGUST 2022

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:	August 2017	
Schedule Changes:	None	
Comprehensive Review:	2024	

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 did implement 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 expanding 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 under development. 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 a 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 final approval occurred in March of 2001 and interim measures implemented in October of 1998 were maintained. 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 when Amendment 2 to the ASMFC plan was passed. 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 the ASMFC plan.

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 2022).

Management Unit

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 this goal, the FMP lists the following objectives:

- 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.
- 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.
- 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.
- Develop regulations that while maintaining sustainable harvest from the fishery, consider the needs of all user groups and provides adequate resource protection.
- Promote harvest practices that minimize the mortality associated with regulatory discards of red drum.
- In a manner consistent with the Coastal Habitat Protection Plan, restore, improve and protect essential red drum habitat and environmental quality to increase growth, survival, and reproduction of red drum.
- 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.
- Initiate, enhance, and continue studies to collect and analyze the socio-economic data needed to properly monitor and manage the red drum fishery.

DESCRIPTION OF THE STOCK

Biological Profile

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 designated as the state's official saltwater fish. Large red drum (up to 90 pounds) inhabit the coastal waters throughout the year and are 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 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. A new benchmark assessment is scheduled to begin in 2022 and will be complete in 2024.

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 year's fishing mortality rate relative to the spawning stock biomass survival rates if no fishing mortality was occurring. Based on the results of the 2017 benchmark 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).

DESCRIPTION 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 Fishery

North Carolina's commercial landings in 2021 were 200,364 pounds; an increase over 2020 landings (165,670 pounds) and the 10-year mean (144,071 pounds; Table 1 and Figure 2). Since

1989, landings have fluctuated with no consistent trend. Gill nets have traditionally dominated the harvest of red drum in the commercial fishery. In 2021, gill nets accounted for 89% of the commercial landings (Figure 4).

The North Carolina Red Drum FMP (2001) 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 143,298 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 2020/2021 fishing year resulted in 207,694 pounds of red drum landings, well below the 250,000-pound annual cap.

Recreational Fishery

Recreational fishing activity is monitored through the Marine Recreational Information Program. For information on MRIP methodology see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Recreational landings in 2021 were 1,479,550 pounds; above the 2012-2021 10-year average (1,234,098 pounds) and just below 2020 landings (1,758,789 pounds; Table 1 and Figure 2). Releases totaled 2,545,371 fish in 2021: above the ten-year average of 2,453,323 fish and well above the time-series average of 1,241,180 (Table 1). Recreational releases have increased over time, averaging around 340,000 releases per year for the period of 1991 to 1998 compared to over 2 million releases per year in the most recent 10-year period (2012-2021).

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 3,461 awarded in 2021 (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 2021, 89% of the red drum harvest was taken in gill nets, followed by pound nets with 9% (Figure 4). In all, 759 red drum, primarily from set gill nets, were measured from the commercial fishery in 2021 (Table 3). The average size was 22 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 in landings due to regulations. 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 2021, the average size recreational fish harvested was 22 inches fork length. From 1989 to 2020, 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; sampling occurs 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 2021, 703 juvenile red drum were taken in 120 seine samples for an overall state relative abundance index of 5.86 red drum per haul. The 2021 overall mean index was similar to 2020 (6.56) and above the long-term average of the survey of 5.66 (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 stock without relying solely on commercial and recreational fishery-dependent data. The overall red drum index was 3.65 red drum per set in 2021, above the time series average of 2.81 (Figure 9). It should be noted that during all of 2020 and until June of 2021, no sampling occurred in this survey. It should be noted that sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions. Sampling resumed July 2021. The survey is currently used in the ASMFC Atlantic coast red drum stock assessment as an annual index of relative abundance for sub-adult red drum.

North Carolina initiated an adult red drum longline survey in 2007. 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 gangions placed at 15-meter intervals (100 hooks/set). Soak times are approximately 30 minutes. All random sampling takes place in Pamlico Sound. During the 2021 season, 219 red drum were captured out of 72 stratified random sets (3.04 red drum per set) which is below the time series average of 4.61 red drum per set (Figure 10). The study has recently been impacted by significant events. Samples in 2019 were adversely impacted by Hurricane Dorian which hit the North Carolina coast at the peak of the sampling season and negatively impacted the survey. During 2020, sampling did not occur due to the COVID pandemic. 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 2021, 998 red drum were collected, ranging in age from 0 to 43 years (Table 5). The majority of red drum collected from dependent sources (18 to 27 inches total length) are ages 1 to 2. Red drum over 27 inches are protected from 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).

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
- Improve catch and effort data for the red drum recreational fishery, particularly for the fishery that occurs at night — Needed
- Develop independent surveys to monitor both the sub-adult and adult red drum populations — Ongoing through NCDMF gillnet and longline surveys
- Continue 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
- Identify 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

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). s is determined by a formal, peer reviewed stock assessment. Amendment 2 to the ASMFC Red Drum FMP requires specific compliance criteria, including Stock Status 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.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

No schedule change recommended. Both the state and ASMFC red drum plans have identical management goals (30% threshold and 40% target static spawning potential ratio). Stock status is determined by the formal, peer reviewed stock assessment conducted by the ASMFC. The next red drum stock assessment is scheduled for completion in 2024 and will coincide with the next planned formal review of the North Carolina Red Drum FMP set to begin in July of 2024. It should be noted that any changes to the state FMP must consider compliance requirements of the ASMFC plan.

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TABLES

Table 1. Red drum recreational harvest and number released (Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program), 1989–2021. All weights are in pounds.

	Recreational			Commercial	
Year	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
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	80,388	648,118
2016	169,195	3,203,452	633,496	77,101	710,597
2017	353,716	2,165,656	1,475,852	187,039	1,662,891
2018	299,577	1,729,260	1,452,358	144,610	1,596,968
2019	97,186	2,976,601	436,219	56,419	492,638
2020	413,419	2,686,150	1,758,789	165,670	1,924,459
2021	325,662	2,545,371	1,479,550	200,364	1,679,914
Mean	939,563	1,241,180	737,686	163,512	925,130

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	64,150	250,000
2016/2017	109,954	250,000
2017/2018	198,625	250,000
2018/2019	105,804	250,000
2019/2020	54,175	250,000
2020/2021	207,694	250,000
Average	139,909	

* 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, 1989–2021.

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
2019	22	14	29	174
2020	21	17	27	549
2021	22	13	27	759

Table 4. Red drum length (fork length, inches) data from Marine Recreational Information Program recreational samples, 1989–2021.

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
2019	21	13	27	87
2020	21	10	38	419
2021	22	17	27	430

Table 5. Summary of red drum age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources, 1989–2021.

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
2019	1	0	33	722
2020	1	0	16	315
2021	1	0	43	998

FIGURES

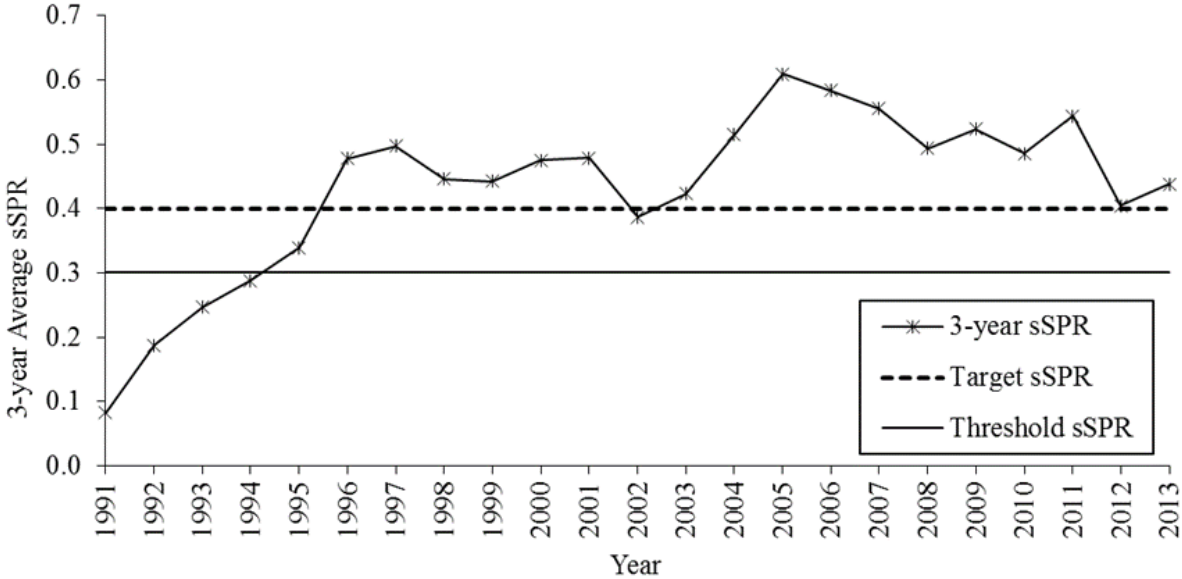

Figure 1. Northern region (North Carolina north) red drum estimates of three-year average static spawning potential ratios (sSPR). Three-year average includes current and previous two year's sSPR estimates. The dashed line shows the 30% overfishing threshold and the solid line shows the 40% target sSPR (Source: ASMFC 2017).

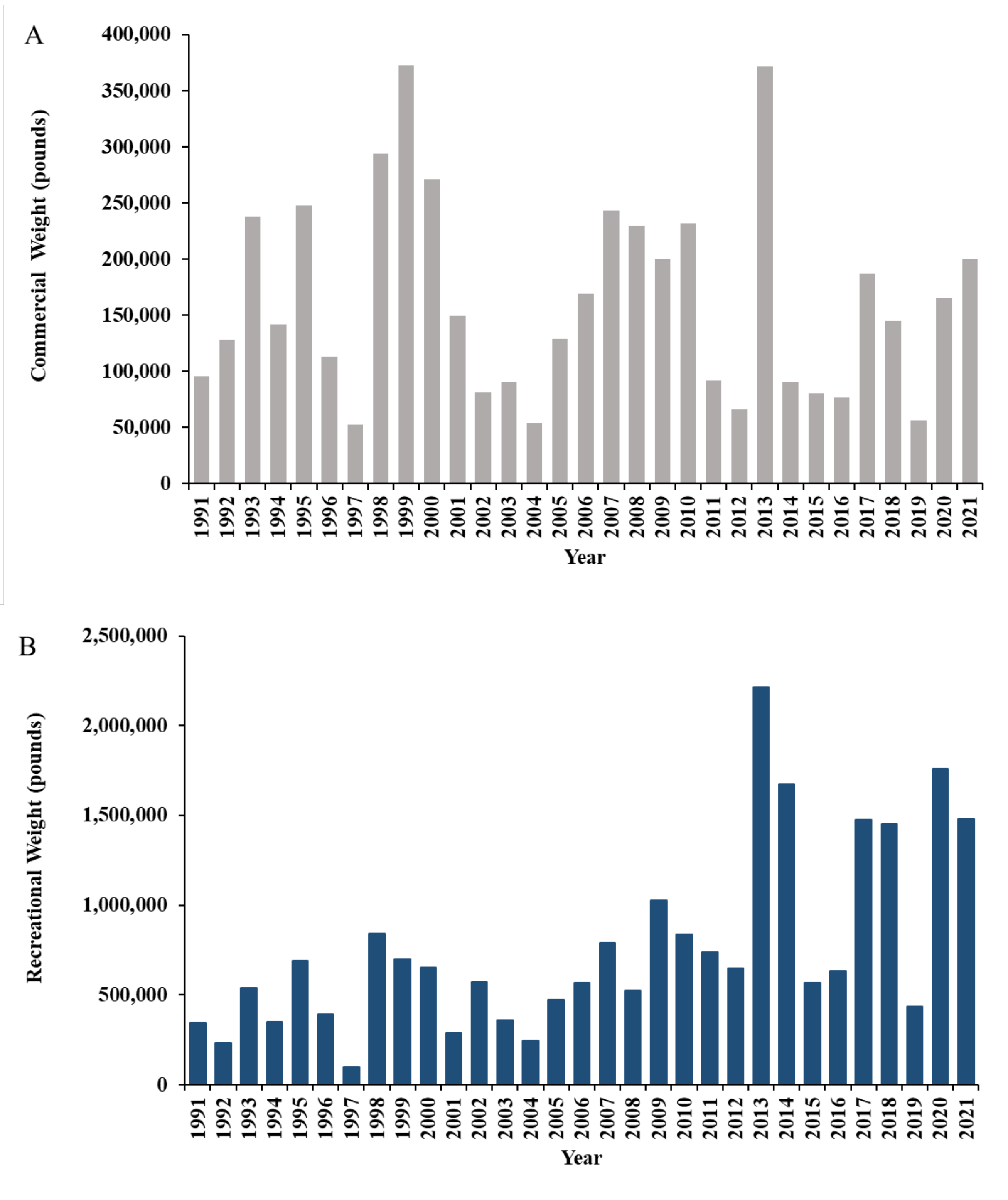

Figure 2. Annual commercial (A) and recreational (B) landings in pounds for red drum in North Carolina from 1991–2021.

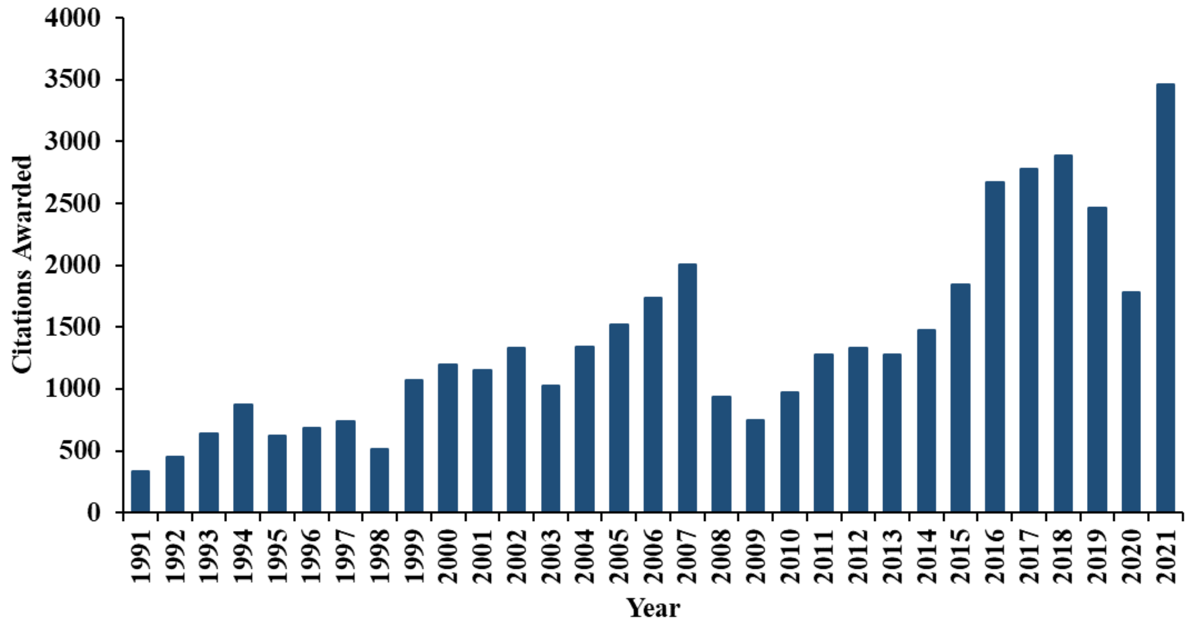

Figure 3. North Carolina Saltwater Fishing Tournament citations awarded for red drum, 1991–2021. Citations are awarded for red drum greater than 40 inches total length. Prior to 1998, citations were awarded for either a red drum released (≥40 inches total length) or harvested (≥40 pounds). Since 1998, all citations are for released fish only.

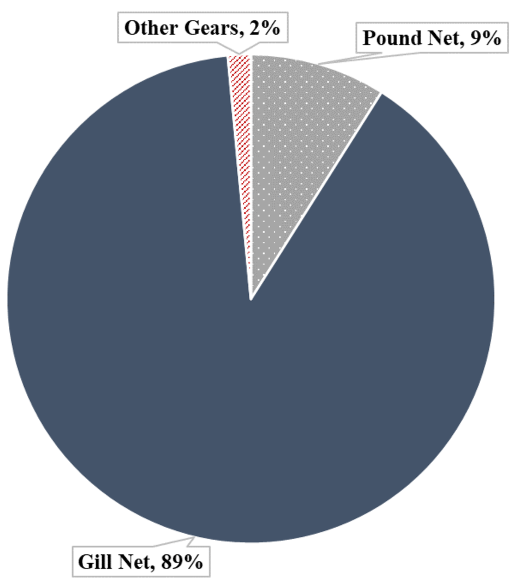

Figure 4. Red drum commercial harvest in 2021 by gear type.

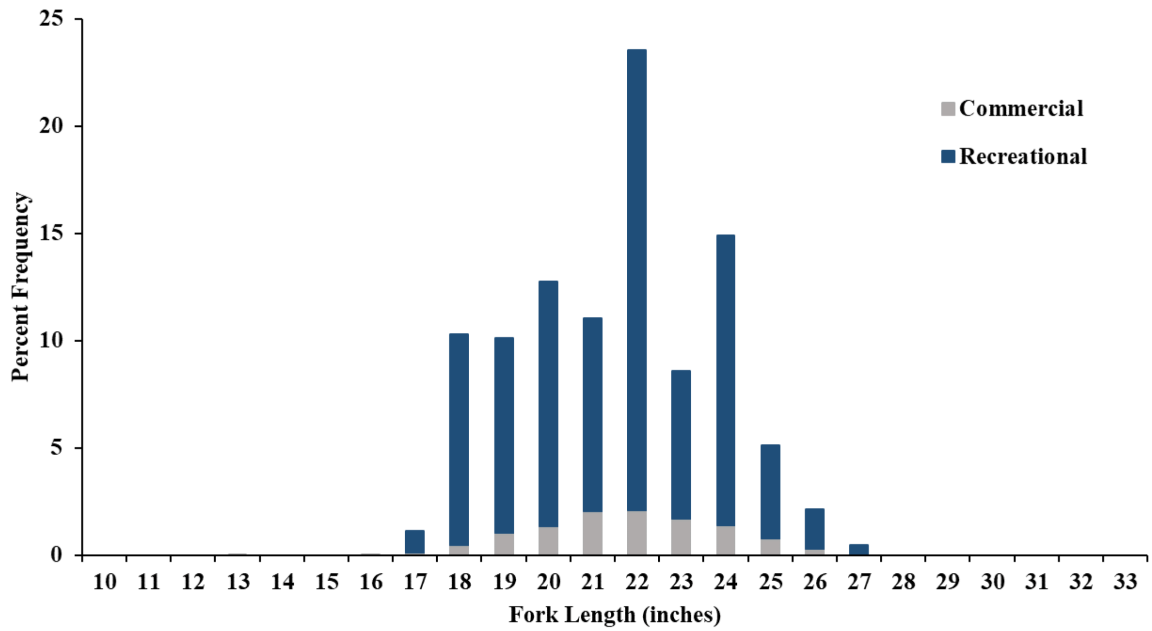

Figure 5. Commercial and recreational length frequency distribution from red drum harvested in 2021.

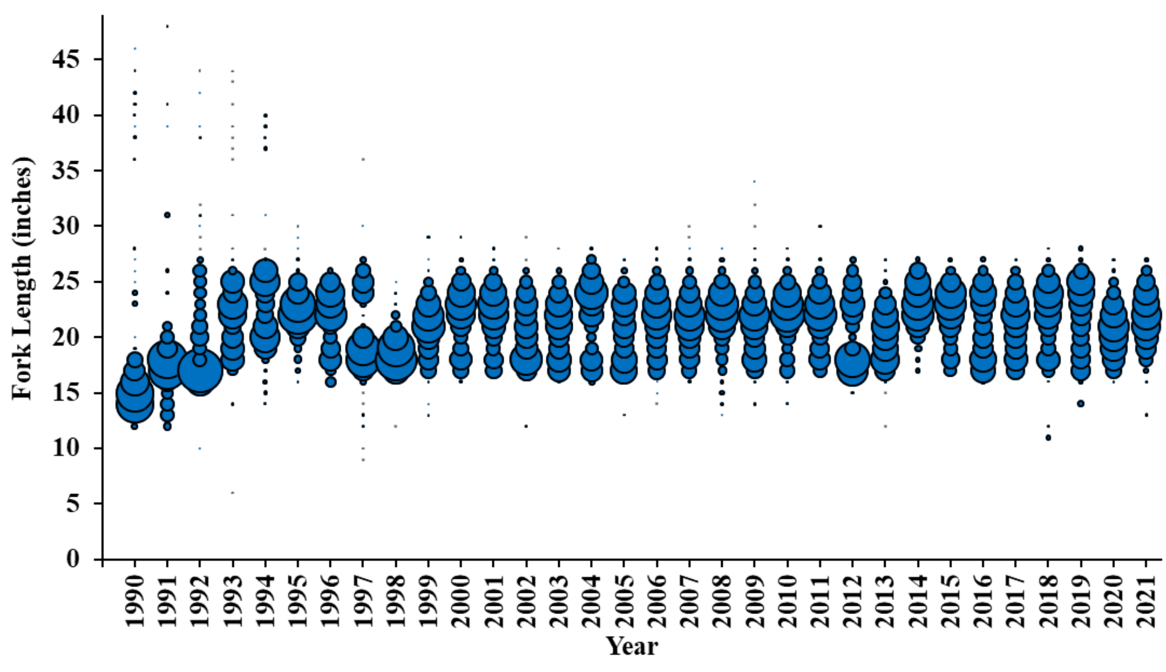

Figure 6. Commercial length frequency (fork length, inches) of red drum harvested, 1990–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

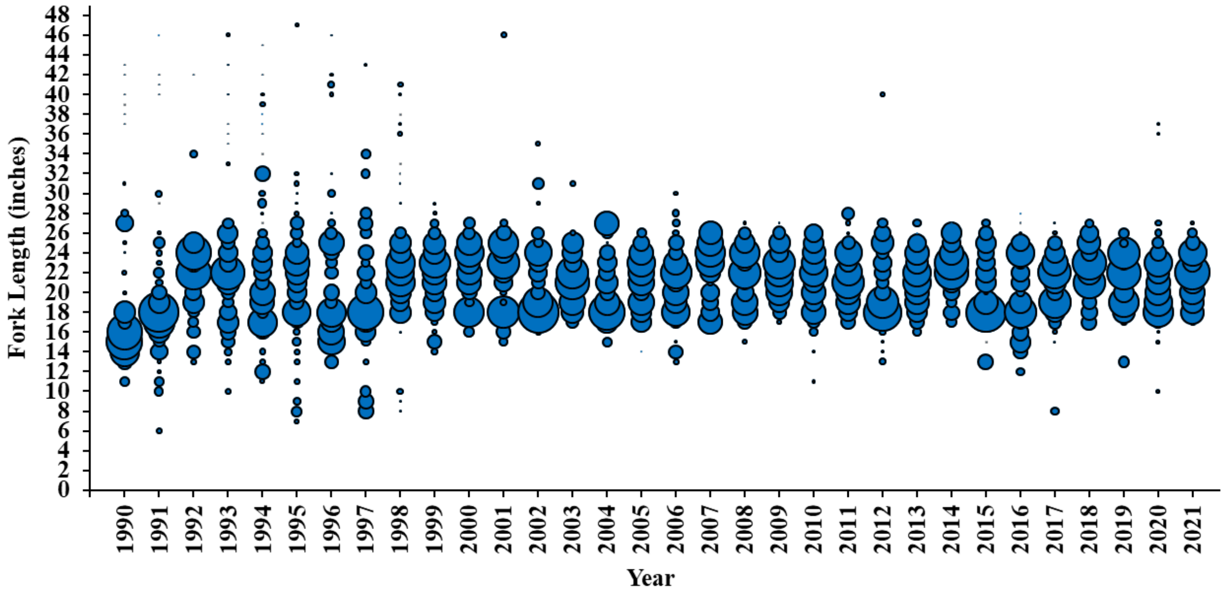

Figure 7. Recreational length frequency (fork length, inches) of red drum harvested, 1990–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

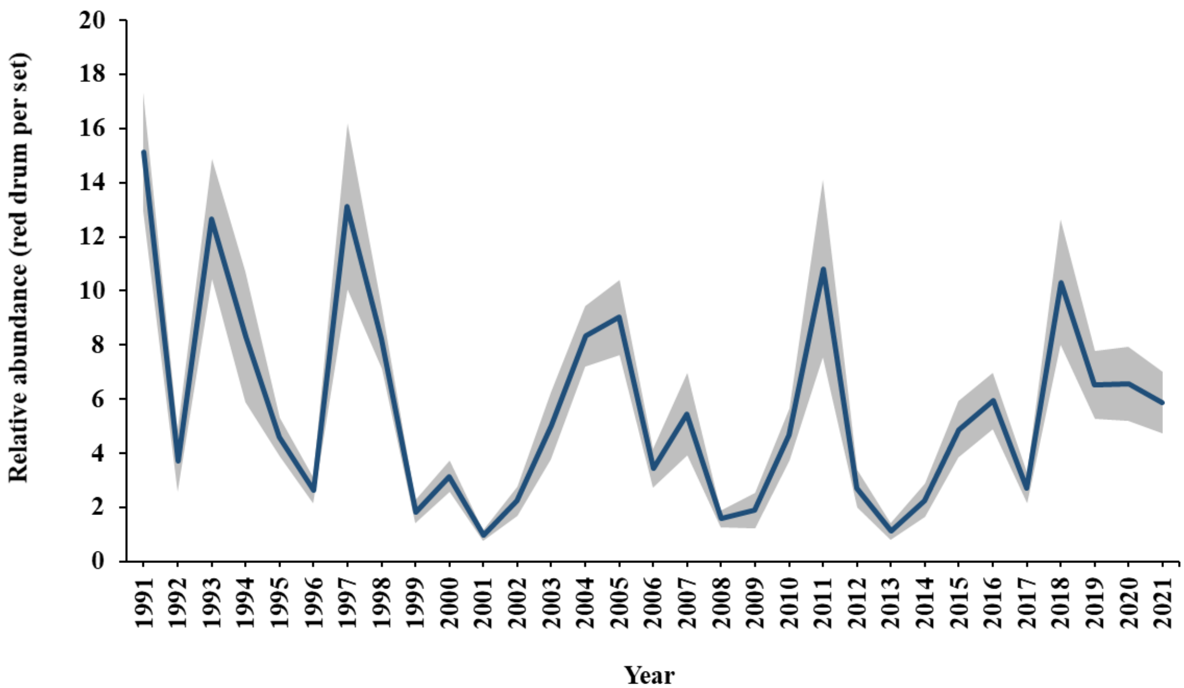

Figure 8. The annual juvenile (age 0) abundance index with standard error shaded in gray from the North Carolina Red Drum Juvenile Seine Survey, 1991-2021.

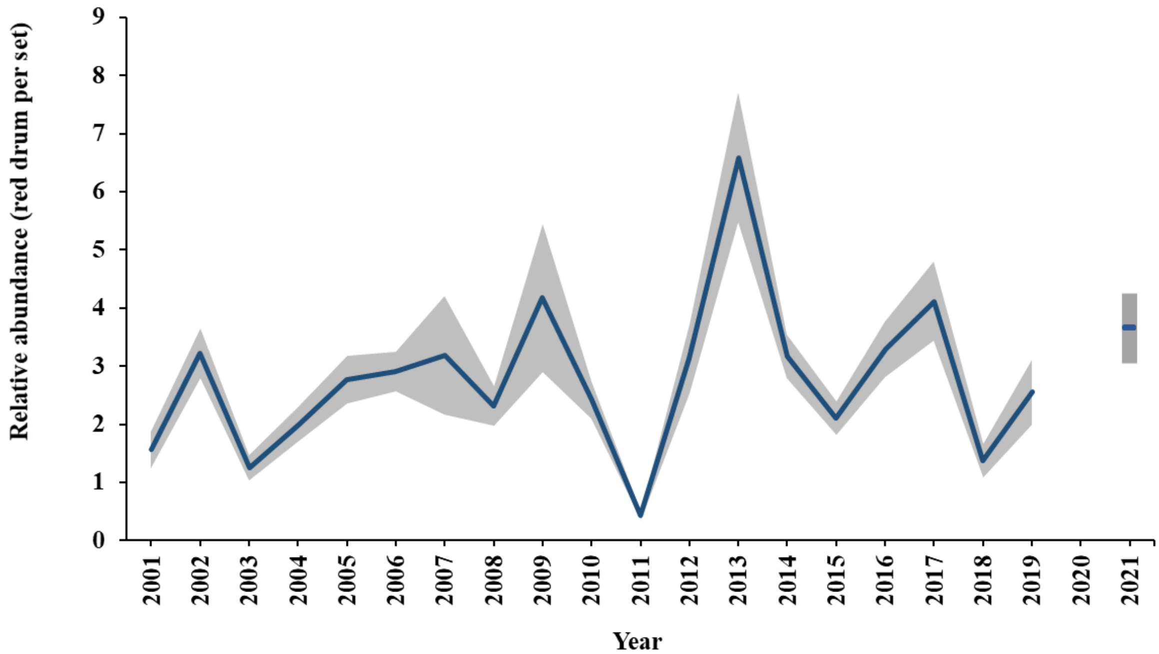

Figure 9. Annual weighted red drum index (number captured ages combined) with standard error shaded in gray from the North Carolina Pamlico Sound Independent Gill Net Survey, 2001–2021. Survey was not conducted in 2020 due to COVID pandemic.

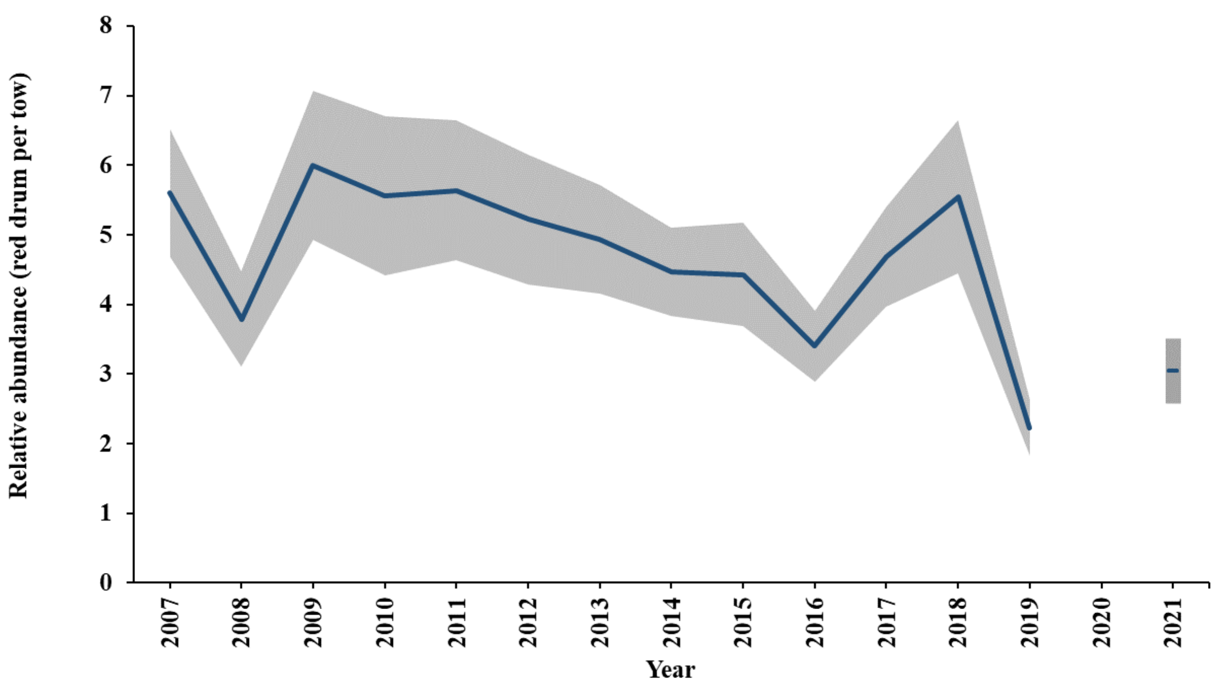

Figure 10. Annual adult red drum index (number captured for ages combined) with standard error shaded in gray from the North Carolina Red Drum Longline Survey, 2007–2021. Sampling in 2019 was adversely impacted by hurricane event and survey was not conducted in 2020 due to COVID pandemic. Sampling resumed in July of 2021.

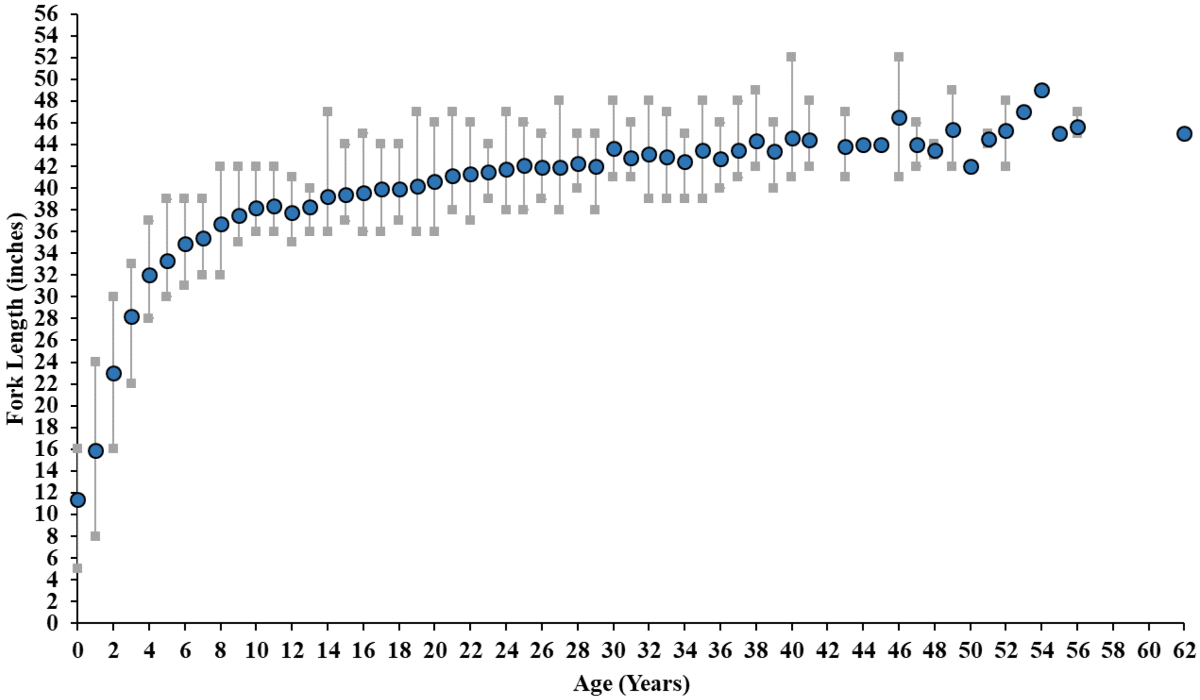

Figure 11. Red drum length-at-age based on all age samples collected, 1983–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
RIVER HERRING
AUGUST 2022

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	
Schedule Changes:	None	
Comprehensive Review:	2027	

In North Carolina blueback herring (*Alosa aestivalis*) and alewife (*Alosa pseudoharengus*), 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 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 and socioeconomic data (NCDMF 2000). Amendment 1 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). Amendment 1 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 was finalized in 2015 with three management 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 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 to maintain a commercial and/or recreational river herring fishery past January 2012. Since a no-harvest provision is in place, North Carolina does not have a sustainable FMP. If Amendment 2 established targets are met in the future and allowing harvest is desired, a sustainable FMP would need to be developed by the state and approved by the ASMFC.

To ensure compliance with ASMFC 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 and alewife management authority lies with the ASMFC. Responsibility for management action in the Economic Exclusive Zone (EEZ), located from 3–200 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:

- Identify and describe population attributes necessary to sustain long-term stock viability.
- Protect, restore, and enhance spawning and nursery area habitats.
- 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.
- 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:

- Prevent further declines in river herring (alewife and blueback herring) abundance.
- Improve our understanding of bycatch mortality by collecting and analyzing bycatch data.
- 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.
- Retain existing or more conservative regulations for American shad and hickory shad.
- Promote improvements in degraded or historic alosine critical habitat throughout the species' range.

DESCRIPTION OF THE STOCK

Biological Profile

River herring is a collective term for alewife and blueback herring. River herring are anadromous fish, meaning they migrate from the ocean, into coastal bays and sounds, and 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 abundant in waters from the Chesapeake Bay south. Mature alewife (ages 3–9) and blueback herring (ages 3–9) 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 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 coastwide river herring stock assessment update was completed in August 2017, with data through 2015, by the ASMFC. Results indicate that river herring remain depleted and at near historic lows on a coastwide basis (ASMFC 2017). The North Carolina portion of the coastwide 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), the stock still remains overfished. The factors leading to the stock status remain largely unchanged since the 2012 stock assessment, despite insignificant fishing pressure. 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 North Carolina Amendment 2 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 remains at approximately 12% of the target of 3.9 million pounds.

It is worthy to note the importance habitat and water quality play in the recovery of the river herring stocks in North Carolina and coastwide (NCDMF 2009). In North Carolina, considerable habitat 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 NCDMF initiated a survey of culverts and obstructions following Amendment 1 to the North Carolina River Herring FMP. The list created from the survey has resulted in the replacement of failing culverts and prioritized others for replacement or repair.

DESCRIPTION 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 Fishery

North Carolina landings of river herring from 1972 through the mid-1980s peaked at 11.5 million pounds (Table 1, 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 Fishery

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 2021. In 2021, a total of 525 blueback herring and 873 alewife were measured from the Chowan River pound net survey. The overall average size of blueback herring was 9.00 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 2021.

The NCDMF has monitored river herring repeat spawning since 1972 (Table 7, Figure 5). Percent repeat spawners for blueback herring from the Chowan River spawning stock is one of the stock recovery indicators identified in North Carolina River Herring FMP Amendment 2. 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. Since 2017, CPUE has declined with 2021 having the lowest CPUE in the time series. The participating pound net fishermen contributed environmental conditions, such as drought and a warm spring, to the decrease in estimated river herring landings. In 2021, approximately 38% 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 the Juvenile Anadromous Survey (Program 100) for river herring, annually since 1972. The survey has been conducted twice a month, using seines, at eleven fixed sites, in the Albemarle Sound-Chowan River area from June through October. Only the first sample from each month is used to calculate the CPUE for juvenile river herring (age 0). CPUE of blueback herring is one of the stock status indicators identified in Amendment 2. The blueback herring CPUE should exceed the three-year moving average threshold of 60-fish per haul, the average for 2019–2021 is 12.86 blueback herring per haul. The three-year average CPUE of juvenile blueback herring has remained well below the threshold 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 2021 overall CPUE was 1.49 for blueback herring, which was a 63% decrease from the previous year (4.06 blueback herring per haul). The 2021 overall CPUE was 14.63 for alewife, which was a 100% increase from the previous year (0.00 alewife per haul) and the highest value in the time series, second only to 1980 (13.47 alewife per haul).

Adult river herring are monitored using the NCDMF Albemarle Sound Independent Gill Net Survey (Program 135). Program 135 began collecting biological data on adult river herring in 1991 but did not start collecting aging structures until 1999. The survey uses a stratified random sampling scheme designed to characterize the size and age distribution for key estuarine species in the Albemarle Sound. The river herring relative abundance index has been calculated from Program 135 since 1991 from the 2.5 and 3.0 inch stretched mesh (combined). Blueback herring and alewife relative abundance index from January through May for the period 1991–2021, are shown in Table 9 and Figure 8. Catch of both species has increased since 2012. No index of abundance is available for the spring survey in 2020 and 2021. Limited sampling occurred in 2020 before Program 135 was suspended starting February 20, 2020, due to COVID-19 restrictions and protected species interactions. The survey resumed in the fall of 2021.

Table 10 and Table 11 describe the mean, minimum and maximum length data for blueback and alewife from Program 135 for the period 1991–2021. Variation in modal, minimum, and maximum ages throughout Program 135 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 Program 135 for the period 1999–2021.

RESEARCH NEEDS

On an annual basis the ASMFC publishes a prioritized list of short term and long-term 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 2020).

For more information on research needs for River herring please see: http://www.asmfc.org/uploads/file/627c1f1bShadRiverHerring_FMP_ReviewFY2020.pdf

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.

- Catch per unit effort (CPUE) of 60 young-of-the-year per haul in the Albemarle Sound juvenile abundance survey.
- Ten percent repeat spawners observed in fishery-dependent pound net samples.
- 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 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 threshold 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. The estimate for spawning stock biomass will be updated with data through 2021 during the next ASMFC coastwide stock assessment for river herring, scheduled for completion in Fall 2023.

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 14.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

Amendment 2 to the North Carolina River Herring FMP was adopted by the Marine Fisheries Commission in 2015. An Atlantic coastwide stock assessment update for river herring was completed in August 2017, with data through 2015, by the ASMFC. Results indicate that river herring remain depleted and at near historic lows on a coastwide basis (ASMFC 2017). It is recommended that the plan be reviewed in 2022 and this annual update serve as the five-year review of the River Herring FMP.

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TABLES

Table 1. Commercial harvest (weight in pounds) of river herring from North Carolina, 1972–2006. Commercial harvest prohibited since 2007.

Year	Commercial Weight Landed (lb)	Year	Commercial Weight Landed (lb)
1972	11,237,143	1990	1,157,625
1973	7,925,898	1991	1,575,378
1974	6,209,542	1992	1,723,178
1975	5,952,067	1993	916,235
1976	6,401,360	1994	644,334
1977	8,523,813	1995	453,984
1978	6,607,153	1996	529,503
1979	5,119,150	1997	334,809
1980	6,218,523	1998	521,930
1981	4,753,723	1999	443,494
1982	9,437,703	2000	332,336
1983	5,868,332	2001	306,761
1984	6,516,109	2002	174,860
1985	11,548,278	2003	199,716
1986	6,814,323	2004	188,541
1987	3,194,975	2005	250,021
1988	4,191,211	2006	109,847
1989	1,491,077	Mean	3,114,461

Table 2. Harvest (weight in pounds) and value of river herring from the North Carolina discretionary river herring harvest season, 2008–2014.

Year	Permits Issued	Quota (lb/permit/period)	Weight landed (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. Mean, minimum, and maximum lengths (fork length, inches) of blueback herring measured from the Chowan River commercial fisheries, 1972–2021. *In 2007 a no-harvest provision for river herring went into effect and the Chowan River Pound Net survey began in 2009.

Year	Mean Length	Minimum Length	Maximum 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
2019*	9.25	8.00	10.50	868
2020*	9.25	8.00	10.75	733
2021*	9.00	7.50	10.25	525

Table 4. Mean, minimum, and maximum lengths (fork length, inches) of alewife measured from the Chowan River commercial fisheries, 1972–2021. *In 2007 a no-harvest provision for river herring went into effect and the Chowan River Pound Net survey began in 2009.

Year	Mean Length	Minimum Length	Maximum 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
2019*	9.50	8.00	11.25	1,004
2020*	9.50	8.00	11.25	1,266
2021*	9.25	7.50	11.00	873

Table 5. Modal age, minimum age, maximum age, and number aged for blueback herring collected through NCDMF fishery-dependent sampling programs, 1972–2021. *In 2007 a no-harvest provision for river herring went into effect and the Chowan River Pound Net survey began in 2009.

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
2019*	4	3	7	276
2020*	4	3	7	253
2021*	5	3	7	221

Table 6. Modal age, minimum age, maximum age, and number aged for alewife collected through NCDMF fishery-dependent sampling programs, 1972–2021. *In 2007 a no-harvest provision for river herring went into effect and the Chowan River Pound Net survey began in 2009.

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
2019*	4	3	7	286
2020*	4	4	8	310
2021*	4	3	9	335

Table 7. Blueback herring and alewife percent (%) repeat spawners from the Chowan River pound net survey, 1972–2021. 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
2019	13	24
2020	11	35
2021	16	37

Table 8. River herring total pound net effort, estimated catch (weight in pounds) and catch per unit effort for the Chowan River pound net survey, 2009–2021.

Year	Total Effort (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
2019	238	54,932	230.8
2020	249	53,810	216.1
2021	233	9,074	38.9
Mean	253.5	61,186.1	247.6

Table 9. Relative abundance index (fish per net) of river herring collected January–May in Program 135 (2.5- and 3.0-inch stretch mesh) in the Albemarle Sound, 1991–2021. *Survey suspended February 20, 2020 and did not resume until fall 2021.

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	0.4	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	1.6	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	8.1	14
2019	462	3,202	6.93	13	2019	462	3,590	7.77	16
*2020	145	778	-	-	*2020	145	92	-	-
*2021	-	-	-	-	*2021	-	-	-	-

Table 10. Mean, minimum, and maximum lengths (fork length, inches) of blueback herring measured from Program 135, 1991–2021. * Survey suspended February 20, 2020 and did not resume until fall 2021.

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
2019	9.50	7.75	11.50	1,687
*2020	9.50	8.50	10.75	92
*2021	-	-	-	-

Table 11. Mean, minimum, and maximum lengths (fork length, inches) of alewife measured from Program 135, 1991–2021. * Survey suspended February 20, 2020 and did not resume until fall 2021.

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
2019	9.50	8.25	11.75	2,063
*2020	9.75	8.25	11.25	735
*2021	-	-	-	-

Table 12. Modal age, minimum age, maximum age, and number aged for blueback herring collected from Program 135, 1991–2021. * Survey suspended February 20, 2020 and did not resume until fall 2021.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1999	5	3	7	241
2000				0
2001				0
2002				0
2003				0
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
2019	4	3	7	211
*2020	5	3	7	59
*2021	-	-	-	-

Table 13. Modal age, minimum age, maximum age, and number aged for alewife collected from Program 135, 1991–2021. * Survey suspended February 20, 2020 and did not resume until fall 2021.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1999	5	4	7	18
2000	4	3	7	190
2001	5	3	6	289
2002	6	4	7	81
2003	4	4	7	127
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
2019	4	3	8	239
*2020	5	4	7	18
*2021	-	-	-	-

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

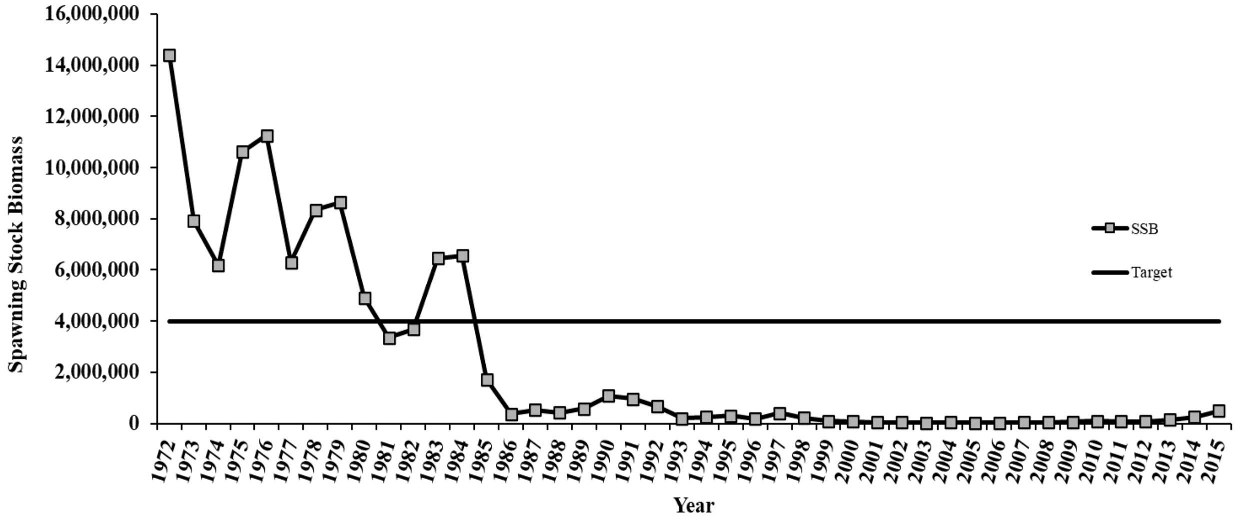

Figure 1. Annual predicted spawning stock biomass (SSB) in pounds for the Chowan River blueback herring stock, compared to the SSBTarget, 1972–2015. SSB is a stock status indicator and 2015 is the terminal year for the last river herring stock assessment update (ASMFC 2017).

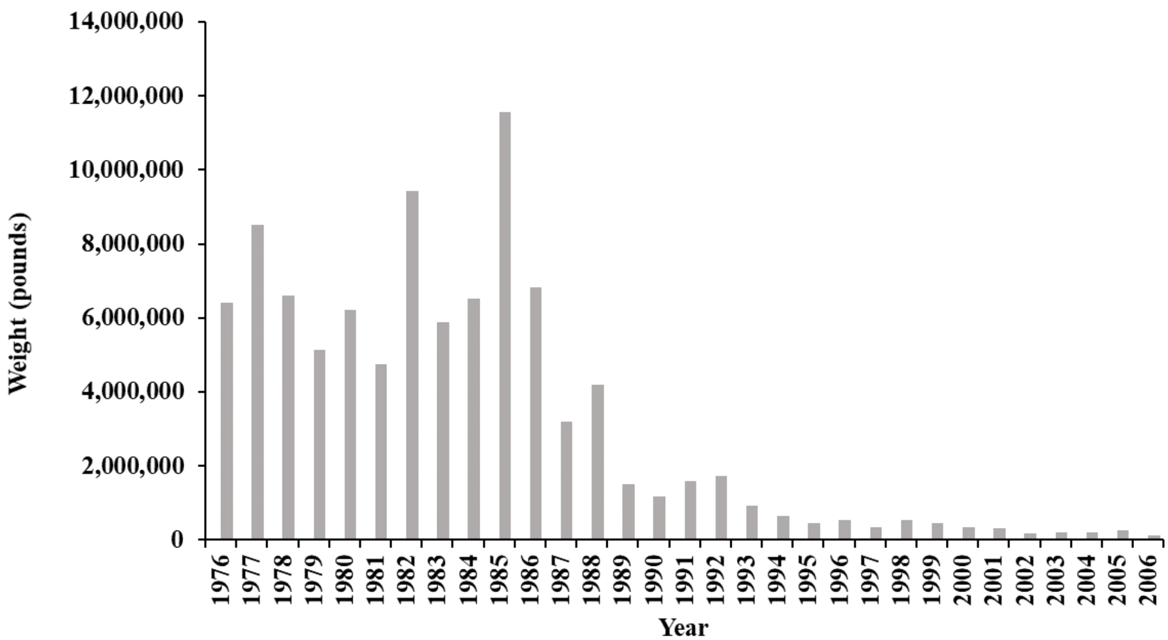

Figure 2. Commercial harvest (weight in pounds) of river herring from North Carolina, 1972–2006. Commercial harvest prohibited since 2007.

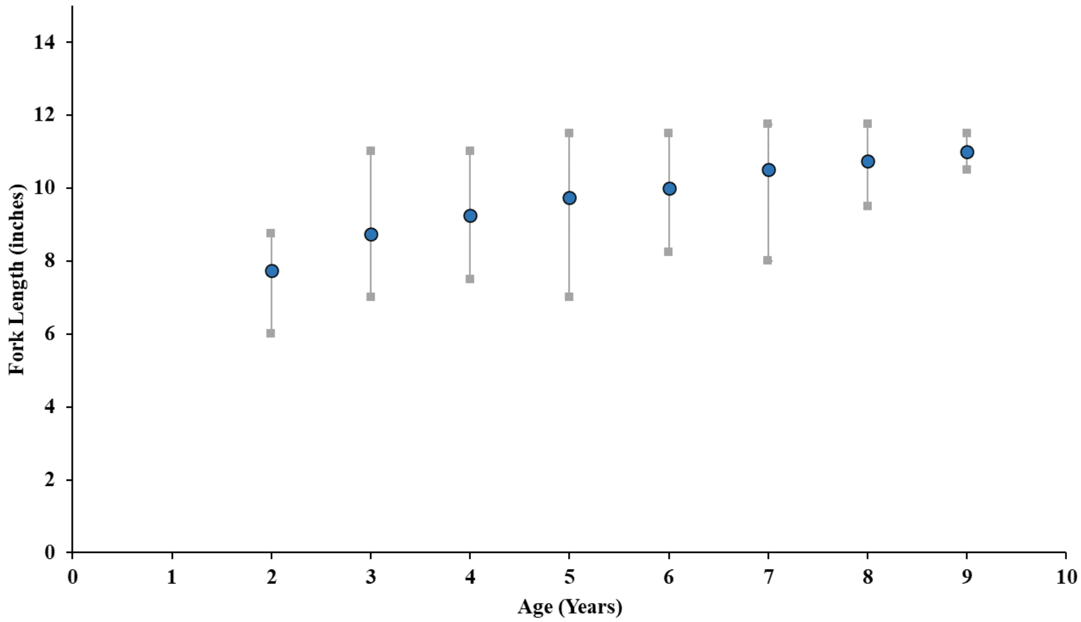

Figure 3. Blueback herring length at age from all age samples collected from fishery-dependent monitoring, 1972–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

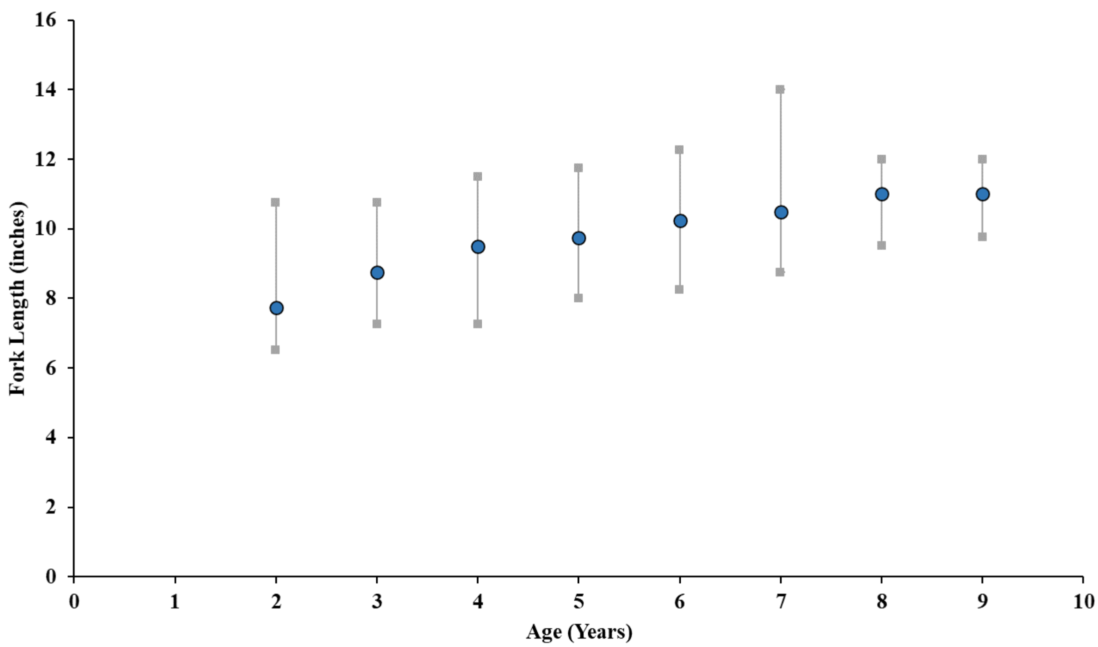

Figure 4. Alewife length at age from all age samples collected from fishery-dependent monitoring, 1972–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

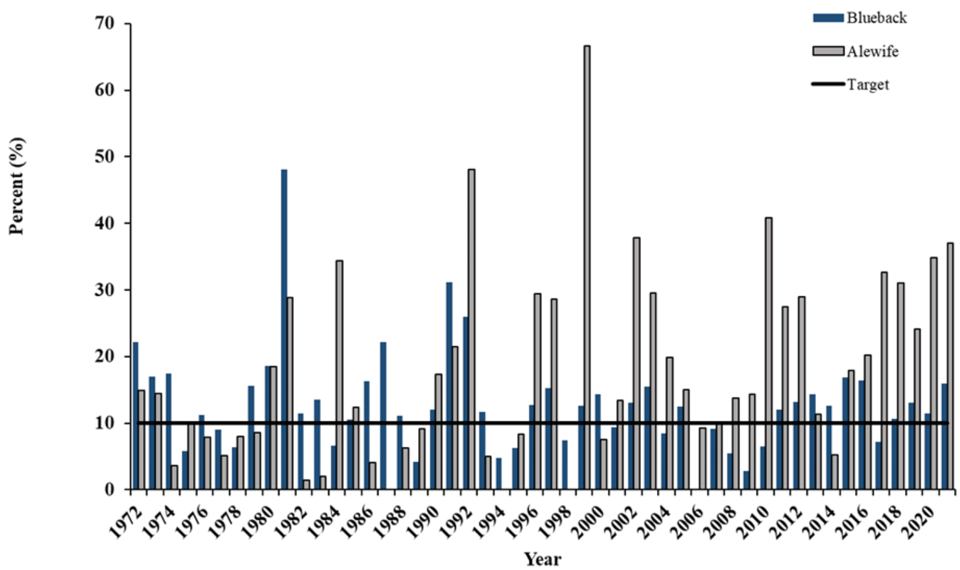

Figure 5. Annual percent of repeat spawners (blueback herring and alewife) and target from the Chowan River Pound Net Survey, 1972–2021. Blueback herring percent repeat spawner is a stock status indicator.

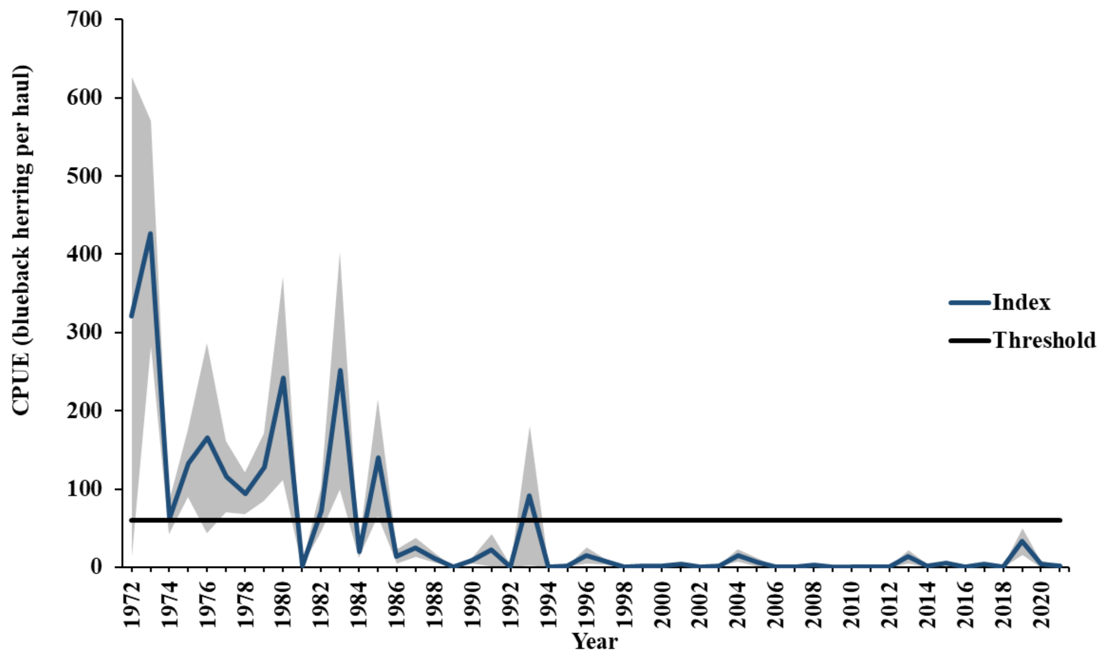

Figure 6. Catch per unit effort (fish per haul) and target of blueback herring collected from Program 100 in Albemarle Sound during June through October 1972–2021. Error bars represent ± 1 standard error. Blueback herring relative abundance is a stock status indicator.

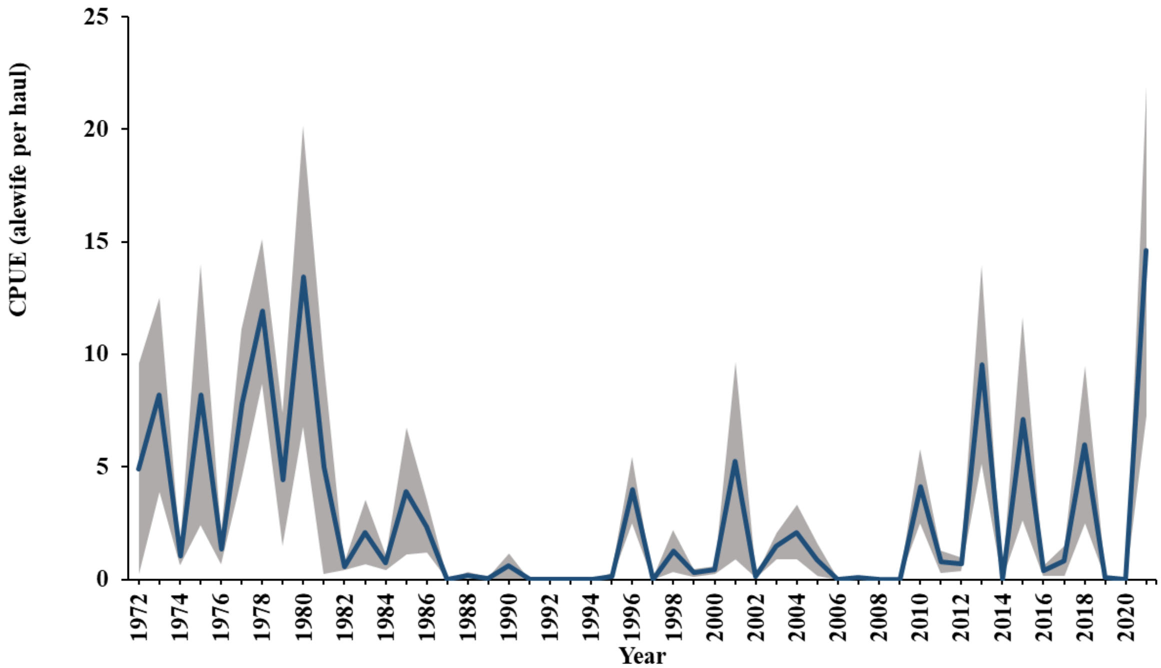

Figure 7. Catch per unit effort (fish per haul) of alewife collected from Program 100 in Albemarle Sound during June through October 1972–2021. Error bars represent ± 1 standard error.

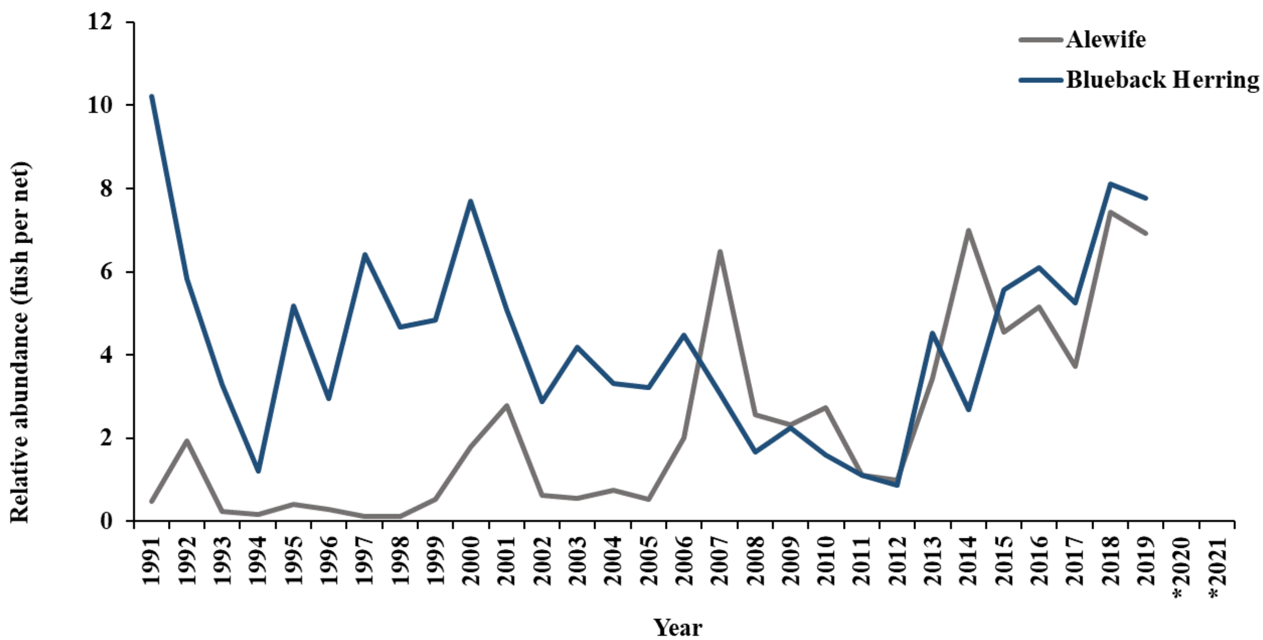

Figure 8. Relative abundance index of river herring (fish per net, 2.5- and 3.0-inch stretch mesh only) collected from Program 135 in Albemarle Sound during January through May, 1991–2021. * Survey suspended February 20, 2020 and did not resume until fall 2021.

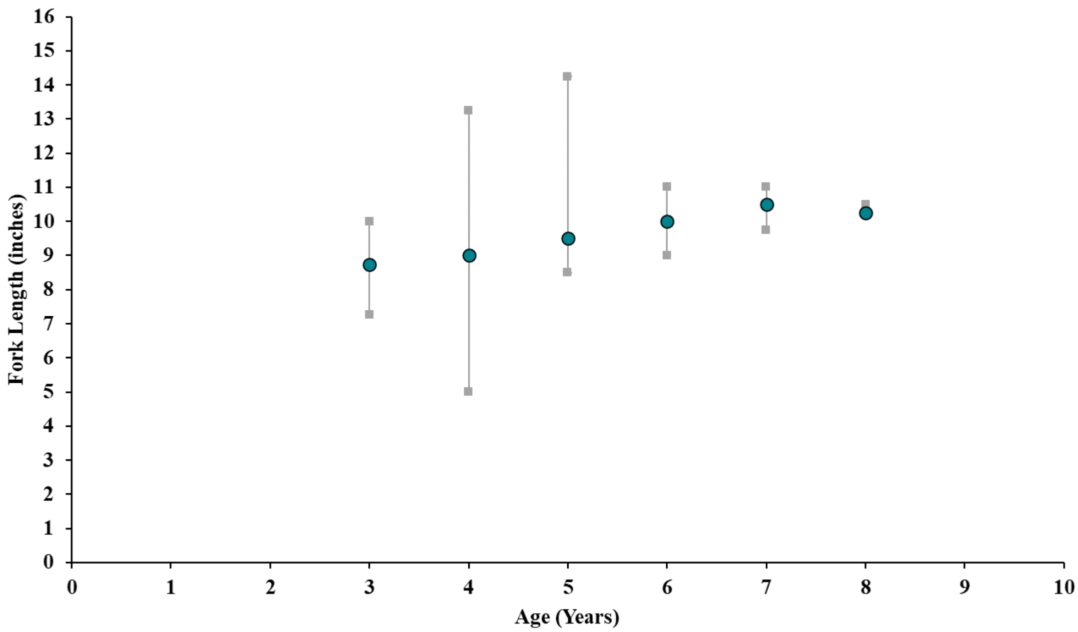

Figure 9. Blueback herring length at age from all age samples collected from Program 135 in the Albemarle Sound, 1972–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age. * Survey suspended February 20, 2020 and did not resume until fall 2021.

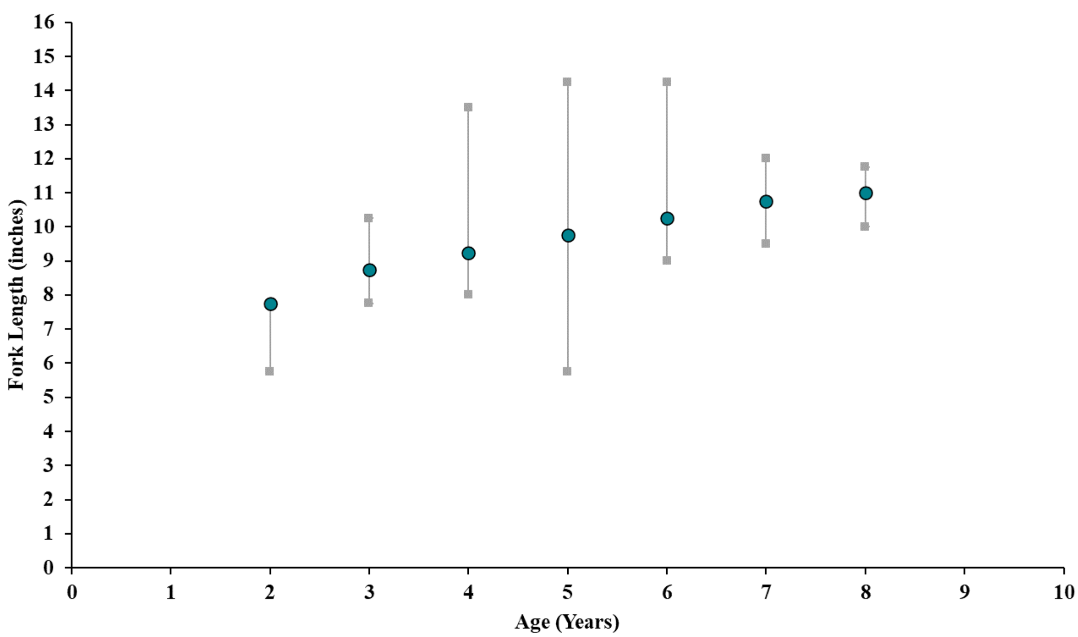

Figure 10. Alewife length at age from all age samples collected from Program 135 in the Albemarle Sound, 1972–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age. * Survey suspended February 20, 2020 and did not resume until fall 2021.

FISHERY MANAGEMENT PLAN UPDATE
SHEEPSHEAD
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	None
Amendments:	None
Revisions:	None
Supplements:	None
Information Updates:	None
Schedule Changes:	None
Comprehensive Review:	None

Sheepshead (*Archosargus probatocephalus*) was initially managed as part of 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 FMP 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

DESCRIPTION OF THE STOCK

Biological Profile

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 (Hildebrand and Cable 1938). Juveniles are associated with shallow vegetated habitat as well as hard structures that offer protection (Parsons and Peters 1987). As sheepshead grow larger, they move to more typical adult habitat including oyster reefs, rocks, pilings, jetties, piers and wrecks (Johnson 1978). Sheepshead exhibit strong site fidelity much of the year and, with the exception of a seasonal spawning migration, tend to stay in the same areas (Wiggers 2010). 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 (Jennings 1985; Wiggers 2010).

Sheepshead are omnivores, meaning they eat plant material as well as animals (barnacles, crabs, oysters; Jennings 1985). Sheepshead grow quickly up to age 6, and then their growth slows. After their first year, sheepshead average 10 inches fork length (FL), at which less than 50% of the individuals are sexually mature (McDonough et al. 2011). Most sheepshead mature at age-2 (12 inches fork length) and all sheepshead are mature by ages 3 to 5 (14 inches FL; McDonough et al. 2011). In North Carolina, sheepshead commonly attain a length of 20 to 25 inches FL with weights ranging from 5 to 15 pounds. The maximum reported age in North Carolina is 34 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 completed in late 2022.

DESCRIPTION OF THE FISHERY

Current Regulations

In 2015, the NCMFC implemented a 10-inch 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 Fishery

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 2021, 85,413 pounds of sheepshead were landed in the commercial fishery (Table 1; Figure 1A).

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 decade, and the gig fishery has also become more popular (Table 2). While the long-haul fishery used to account for up to 20% of the landings, this fishery has accounted for less than one percent of the harvest in recent years. In 2020, the majority (87%) of the commercial landings came from pound nets (57%) and gill nets (27%; the majority from estuarine gill nets); an additional 10% was landed by spears and gigs, combined (Table 2; Figure 2).

Recreational Fishery

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 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 see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

On average, the recreational harvest accounts for 80% of North Carolina's total harvest (pounds) from 1981 – 2020. In 2021, recreational harvest accounted for 92% of the total harvest (Table 1). Like the commercial harvest, 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 1B). In 2021, 928,130 pounds of sheepshead were landed recreationally. Recreational releases increased 69% in 2021 to 873,080 fish (Table 1). Since 2019, recreational catch (harvest + releases) has been increasing, potentially the result of normal fluctuations in availability or possibly the result of increased regulations for other species such as southern flounder. In the last three years, a larger targeted fishery has developed for this species. Annual catch, as well as survey data, will continue to be monitored to determine trends for this stock.

The NCDMF offers award citations for exceptional catches of sheepshead. Harvested sheepshead weighing greater than eight pounds are eligible for an award citation. Since 1991, approximately 2,100 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). In 2021, the number of citations increased 31% from 2020; 115 citations were issued in 2021.

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 2021, 586 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 average size of commercial caught sheepshead was 13 inches FL (Table 3). 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 prior to 2015. The majority of sheepshead landed in 2021 were between 10 inches and 15 inches FL (Figure 4).

Similar to the commercial fishery, average size varies little from year to year in the recreational fishery (Table 4). In 2021, the average size recreational sheepshead was 14 inches FL (Table 4). The majority of sheepshead landed in 2021 were between 9 inches and 18 inches FL (Figure 5). In both fisheries, sublegal fish (<10 inches FL) are still being harvested (Tables 3 and 4; Figure 6). This is most likely due to fishermen 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

In 2001, the NCDMF initiated a fishery-independent gill net survey in Pamlico Sound (Program 915). 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 half-inch increments). By continuing a long-term database of age composition and developing a relative 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 index of abundance (number of sheepshead per set) was 0.51 in 2021 and was above the time series average (Table 5; Figure 7).

For the 2020, indices of abundance are not available for sheepshead from the Fishery-Independent Gill-Net Survey (Program 915) due to the COVID pandemic. Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021.

Data collected by Program 120 (Estuarine Trawl Survey) were used to calculate a relative Juvenile Abundance Index (JAI) by the doctoral candidate working on the coast-wide stock assessment. 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 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 sheepshead, calculated as the average number of fish per tow. The resulting relative abundance index for the time series is variable with no significant trend and peaks in 2008 and 2015 suggesting relatively higher recruitment in those years (Table 6; Figure 8). The Program 120 relative abundance index in 2021 was 0.02, which was a decrease from the previous year. It should be noted that not all trawls were completed in 2021, possibly contributing to the decrease in relative abundance.

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 1 to 8 (Table 7). In 2021, 273 sheepshead were collected ranging in age from 0 to 24; ages are preliminary at this time. The age-length relationship is hard to predict as there is overlap in age for a given length (Figure 9).

RESEARCH NEEDS

The following have been identified as research needs for sheepshead in North Carolina.

- Initiate a sheepshead tagging program to develop estimates of growth, natural mortality, fishing mortality, and track the movement of adults throughout the stock's range; include methods to estimate tag retention, reporting rate, and tagging-induced mortality
- Conduct reproductive studies including spawning periodicity, age- and size-specific fecundity, update maturity schedule, and conduct spawning area surveys in North Carolina and throughout the stock's range
- Expand discard sampling to collect information on gear, depth, location, and age and size distribution of discarded fish for the recreational and commercial sectors
- Conduct studies on size- and age-specific selectivity by gear type
- Determine the patterns and triggers of inshore-offshore migrations

MANAGEMENT STRATEGY

See Table 8 for current management strategies and implementation status for sheepshead.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

Not Applicable

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McDonough, C.J., C.A. Wenner, and W.A. Roumillat. 2011. Age, Growth, and Reproduction of Sheepsheads in South Carolina. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 3:366-382.

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Wiggers, R. 2010. South Carolina Marine Game Fish Tagging Report, 1978-2009. Marine Resources Division, South Carolina Department of Natural Resources. Charleston, S.C. 29422.

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 – 2021. All weights are in pounds.

	Recreational			Commercial	
Year	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight Landed(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
2019	221,419	312,479	590,150	86,394	676,544
2020	247,390	518,140	592,774	76,501	669,275
2021	324,540	873,080	928,130	85,413	1,013,543
Mean	205,330	179,182	500,364	80,149	580,513

Table 2. Commercial harvest (weight in pounds) of sheepshead by gear type, 2011 – 2020 (Source N.C. Trip Ticket Program).

Year	Spears and Gigs[$]	Estuarine Gillnet	Long Haul	Ocean Gillnet	Pound Net	Trawls	Other *	Total Harvest
2012	15,916	32,565	9,801	1,974	46,233	2,140	1,253	109,882
2013	15,259	48,194	12,536	3,055	94,780	3,940	2,462	180,226
2014	21,886	39,524	11,805	3,253	92,988	2,581	1,339	173,376
2015	13,695	27,268	400	5,741	73,035	3,998	713	124,850
2016	14,761	30,851	322	2,509	36,839	7,068	1163	93,513
2017	10,720	33,770	513	1,677	74,246	7,047	636	128,609
2018	9,076	25,686	40	2,936	50,457	1,012	1191	90,398
2019	13,858	25,309	843	3,437	36,496	5,567	897	86,407
2020	7,391	16,964	838	1,966	47,445	1,600	427	76,631
2021	8,960	18,221	293	5,121	48,842	2,850	1126	85,413
Mean	13,152	29,835	3,739	3,167	60,136	3,780	1,121	

** Other gears include fyke nets, crab pots, and hook and line.*

[$] Spear and gigs have also been combined due to data confidentiality.

Table 3. Sheepshead length (fork length, inches) data from commercial fish house samples, 1982 – 2021.

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	13	9	22	77
1995	15	5	23	172
1996	15	7	22	137
1997	16	6	24	102
1998	13	6	24	330
1999	13	8	24	492
2000	16	8	28	1,305
2001	15	8	22	306
2002	13	8	24	412
2003	14	9	24	421
2004	16	8	23	305
2005	17	7	25	443
2006	16	8	24	467
2007	14	7	24	850
2008	13	6	24	1,420
2009	12	6	23	1,399
2010	13	7	24	1,743
2011	15	9	24	1,247
2012	13	7	23	1,161
2013	13	7	24	1,283
2014	14	7	23	1,296
2015	15	8	24	982
2016	15	8	24	964
2017	14	9	23	348
2018	14	8	23	694
2019	15	8	24	624
2020	14	9	22	426
2021	13	8	23	586

Table 4. Sheepshead length (fork length, inches) data from Marine Recreational Information Program samples, 1981 – 2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1981	12	9	20	13
1982	15	8	21	29
1983	18	15	20	3
1984	11	10	13	2
1985	15	13	19	1
1986	15	7	29	29
1987	14	7	23	70
1988	13	6	25	85
1989	12	7	21	76
1990	11	7	22	93
1991	12	5	23	83
1992	12	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	14	7	29	187
2000	13	8	24	239
2001	15	10	30	132
2002	16	10	23	56
2003	14	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
2019	14	10	25	243
2020	13	8	25	260
2021	14	8	22	177

Table 5. Annual weighted sheepshead index of abundance (number per set, all ages combined) from the North Carolina Pamlico Sound Independent Gill Net Survey, 2001 – 2021. N=number of samples; SE=Standard Error; PSE=Proportional Standard Error. Pamlico Sound Independent Gill Net Survey sampling did not occur in 2020 and the first half of 2021.

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	0.3	0.05	17
2010	320	0.18	0.04	22
2011	300	0.16	0.06	38
2012	308	0.12	0.03	25
2013	308	0.3	0.07	23
2014	308	0.45	0.09	20
2015	308	0.26	0.06	23
2016	308	0.2	0.04	20
2017	308	0.44	0.1	23
2018	308	0.41	0.11	27
2019	306	0.33	0.09	27
2020				
2021	168	0.51	0.12	24

Table 6. Annual weighted sheepshead juvenile index of abundance (number per tow) from the North Carolina Juvenile Trawl Survey, 2004 – 2021. N=number of samples; SE=Standard Error; PSE=Proportional Standard Error.

Year	N	CPUE	SE	PSE
2004	54	0.00	0.00	--
2005	54	0.00	0.00	--
2006	54	0.11	0.11	100
2007	54	0.11	0.05	46
2008	54	0.87	0.44	51
2009	54	0.06	0.03	57
2010	54	0.06	0.06	100
2011	54	0.22	0.13	57
2012	54	0.07	0.04	60
2013	54	0.07	0.05	70
2014	54	0.15	0.09	60
2015	54	0.65	0.50	78
2016	54	0.22	0.13	60
2017	54	0.00	0.00	--
2018	54	0.02	0.02	100
2019	54	0.04	0.04	100
2020	54	0.19	0.09	50
2021	44	0.02	0.02	100

Table 7. Summary of sheepshead age samples collected from both dependent (commercial and recreational) and independent (survey) sources, 2008 – 2021*.

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
2019	3	0	29	345
2020	1	1	34	205
2021*	2	0	24	273

**2021 ages are considered preliminary.*

Table 8. 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

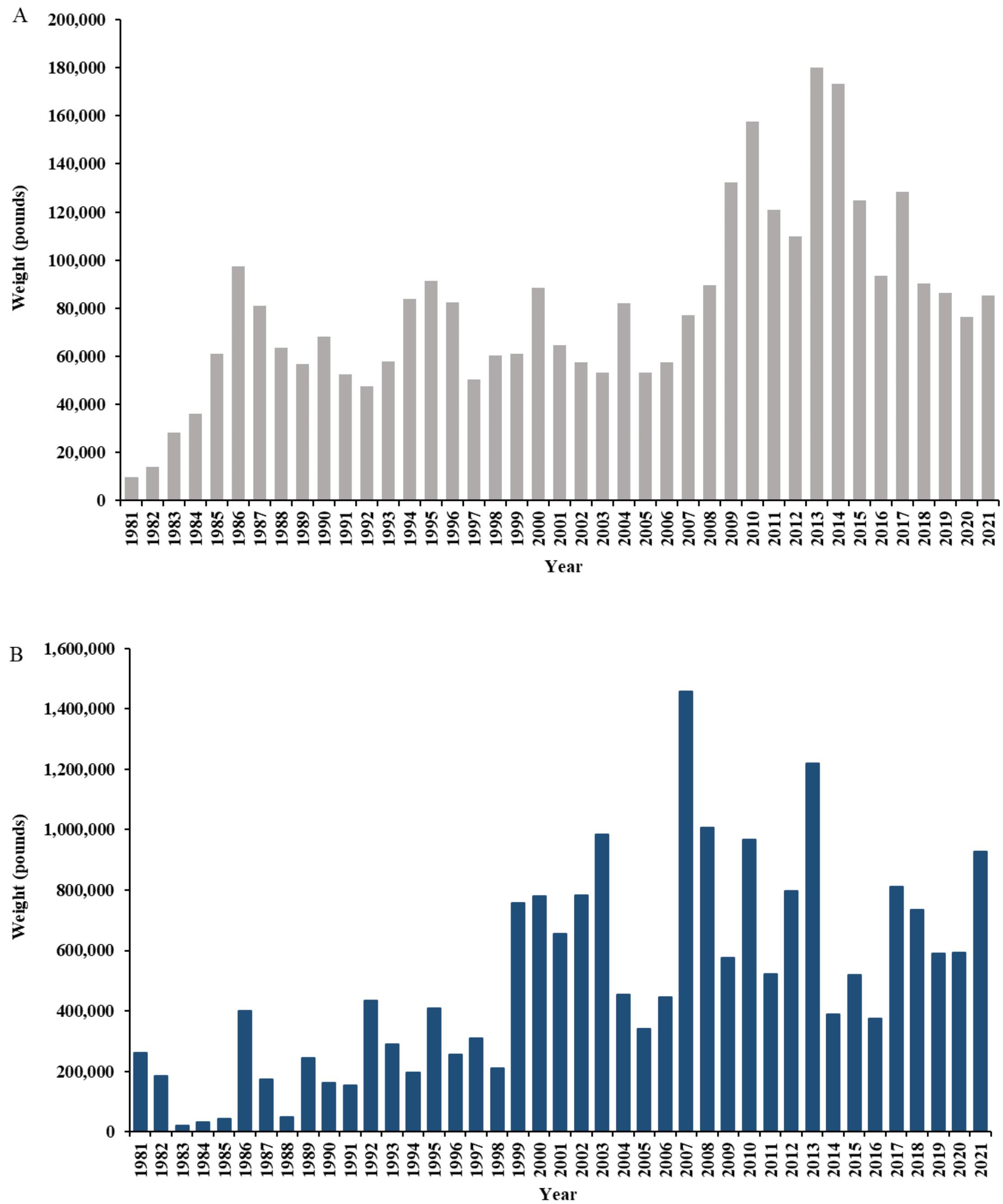

Figure 1. Annual (A) commercial (Atlantic Coastal Cooperative Statistics Program and N.C, Trip Ticket Program) and (B) recreational (MRIP) landings in pounds for sheepshead in North Carolina from 1981 – 2021.

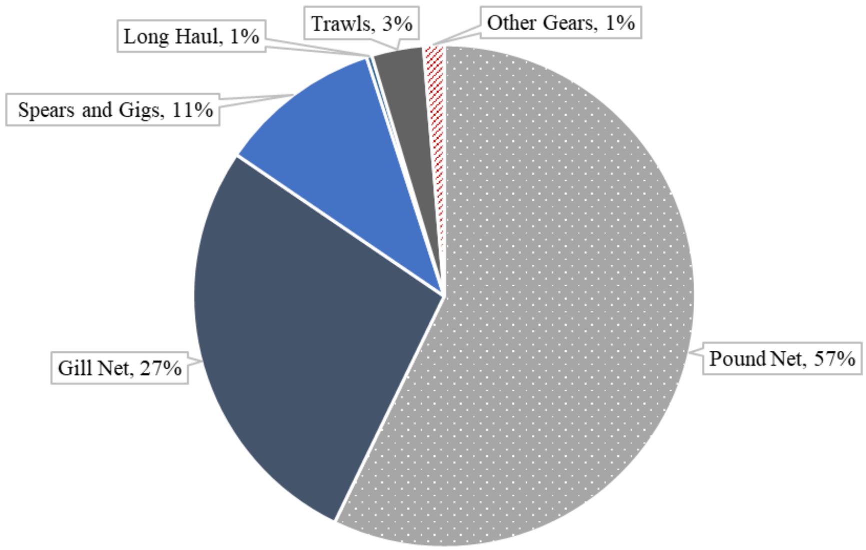

Figure 2. Commercial harvest in 2021 by gear type. Other gears include fyke nets, crab pots, and hook-and-line.

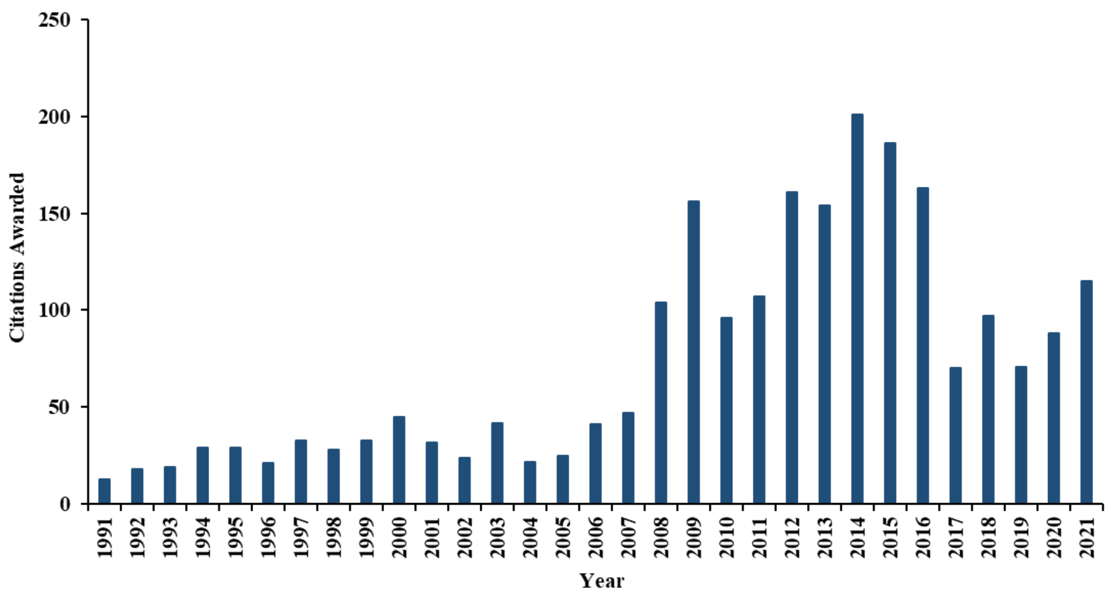

Figure 3. North Carolina Saltwater Fishing Tournament citations awarded for sheepshead from 1991 – 2021.

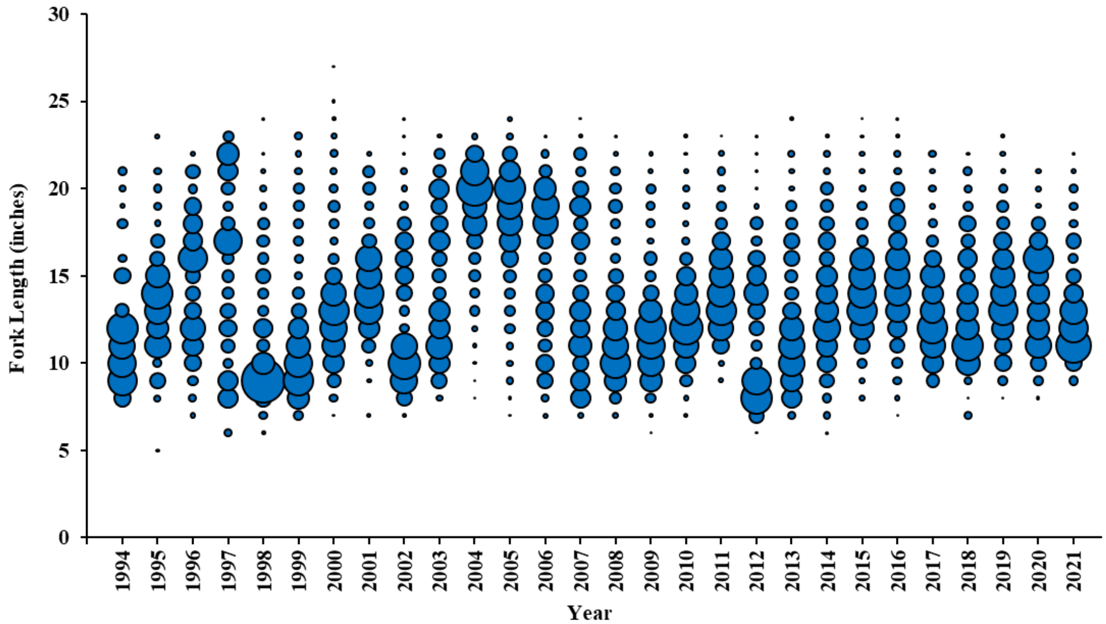

Figure 4. Commercial length frequency (fork length, inches) of sheepshead harvested from 1994 – 2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

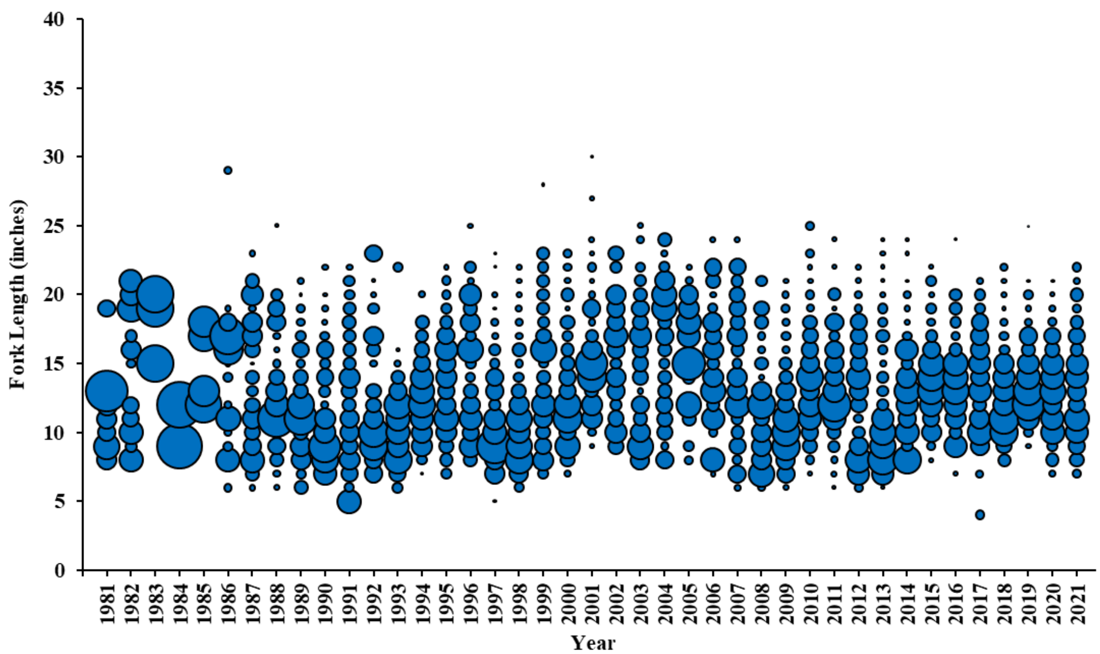

Figure 5. Recreational length frequency (fork length, inches) of sheepshead harvested from 1981 – 2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

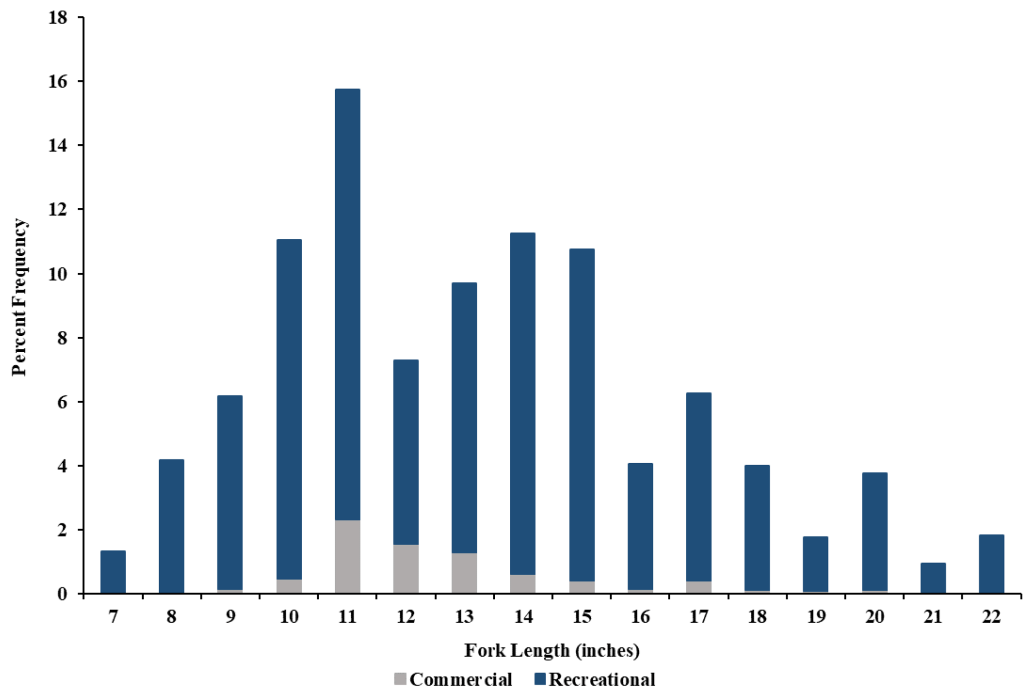

Figure 6. Commercial and recreational length frequency distribution from sheepshead harvested in 2021.

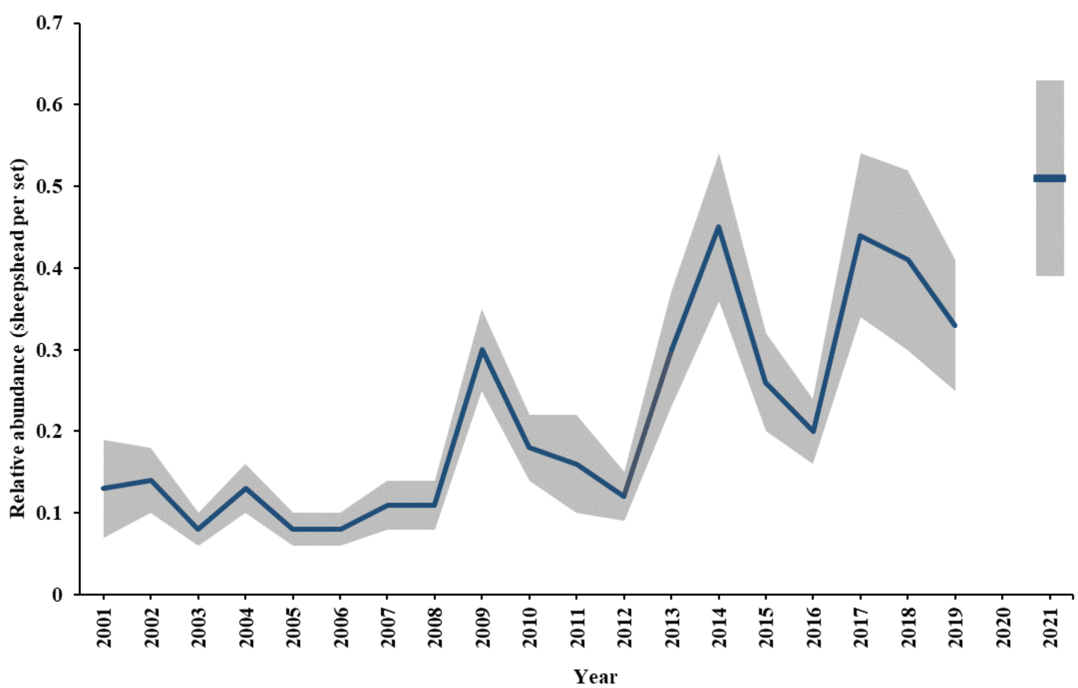

Figure 7. Annual index of abundance of sheepshead in the NCDMF Pamlico Sound Independent Gill Net Survey, 2001–2021. Pamlico Sound Independent Gill Net Survey sampling did not occur in 2020 and the first half of 2021.

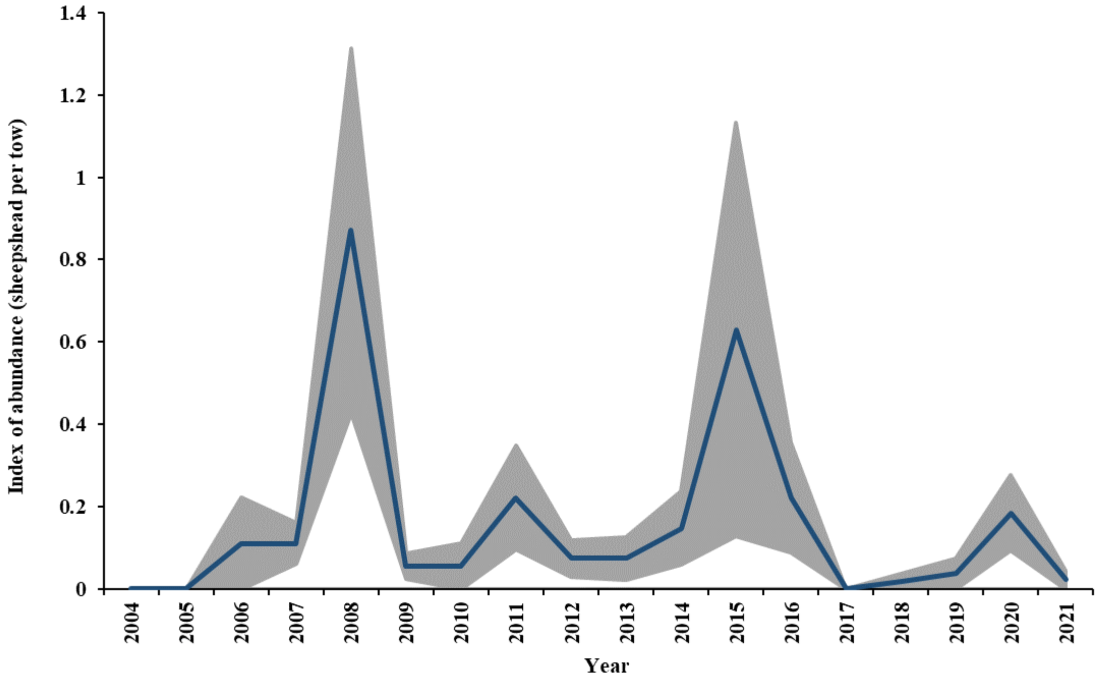

Figure 8. Annual juvenile index of abundance of sheepshead in the NCDMF Juvenile Trawl Survey, 2004 – 2021.

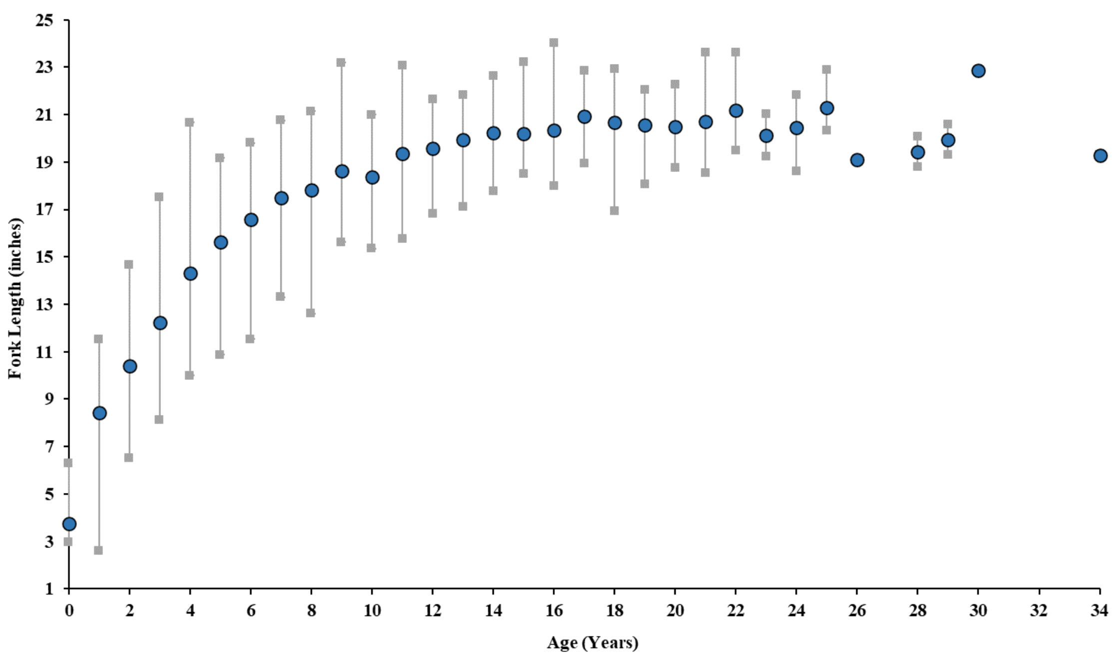

Figure 9. Sheepshead length at age based on all age samples collected from 2008 – 2020. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age. Otoliths from 2021 are not included as ages are preliminary.

FISHERY MANAGEMENT PLAN UPDATE
SHRIMP
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	April 2006	
Amendments:	Amendment 1	February 2015
	Amendment 2	February 2022
Revisions:	Revision to Amendment 1	May 2018
	Revision to Amendment 1	May 2021
Supplements:	None	
Information Updates:	None	
Schedule Changes:	None	
Comprehensive Review:	2027	

The N.C. Shrimp Fishery Management Plan (FMP) was adopted 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 and area closures to protect habitats and juvenile finfish. Shrimp management by size was also developed to optimize the use of the resource. Other strategies were implemented to minimize waste through gear modifications, culling practices, and harvest restrictions. The plan allowed the use of skimmer trawls as a Recreational Commercial Gear License (RCGL) gear 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 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). The plan 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 (Proclamation SH-2-2015). It increased the daily harvest limit for cast nets in closed areas. Amendment 1 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 prohibited, effective May 1, 2015, in the Intracoastal Waterway (IWW) 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 so live bait fishermen with a permit could fish until 12:00 p.m. (noon) on Saturdays; effective May 1, 2017.

Amendment 1 introduced further industry testing of gears in shrimp trawls to reduce bycatch after adoption of the plan. 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 (>1 ½-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%. 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 adopted as a revision to Amendment 1 by the NCMFC in May 2018 (NCDMF 2018). Under the May 2018 Revision to Amendment 1 fishermen are required 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 are 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, through Proclamation SH-3-2019 and continues in 2022 through proclamation SH-1-2022. The commission also recommended 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 FMP. In the fall of 2019, two gear configurations were tested in the Atlantic Ocean using the same methods and goals set forth by the NCMFC in Amendment 1, including a 40% target reduction of finfish bycatch above the industry standard gear at the time. One gear consisting of two inline federal fisheyes with a 1¾-inch tailbag met the management goal of a 40% reduction, achieving a 52% reduction in finfish bycatch. This gear was previously certified for use in the Pamlico Sound and will be required in all shrimp trawls used in the Atlantic Ocean beginning July 1, 2022, through Proclamation SH-3-2022.

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 8-inch minimum size limit for spot and a 10-inch minimum size limit for Atlantic croaker. In February 2017, the NCMFC approved 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 were not available to implement the proposed rule changes without undue detriment to the agency's existing activities and the rules were never adopted.

With the adoption of Amendment 1, a management strategy was also included for the Habitat and Water Quality Advisory Committee (AC) to provide input on changing the designation of certain Special Secondary Nursery Areas (SSNAs) that had not been opened to trawling since 1991 to permanent Secondary Nursery Areas (SNAs). Due to overlapping issues associated with petitions for rulemaking related to nursery area designations and shrimp management the development of this management measure was delayed. At its February 2020 business meeting the NCMFC selected to change the designation of 10 SSNAs that had not been opened to trawling in many years to permanent SNAs. Under the May 2021 Revision to Amendment 1 (NCDMF 2021) the designation of SSNAs in Pungo, Scranton, Slade, South, Bond/Muddy, and Saucepan creeks as well as the Newport, Cape Fear and Lockwood Folly rivers were changed to permanent SNAs.

In August 2019, the FMP schedule was approved to move the timeline forward one year to start development of Amendment 2. The goal of Amendment 2 is to further reduce bycatch of non-target species and minimize ecosystem impacts. The NCMFC adopted the Shrimp FMP Amendment 2 in February 2022. The amendment retained measures implemented with the May 2018 and 2021 revisions to the Shrimp FMP Amendment 1 and implemented several management changes: 1) prohibit all trawling within all Crab Spawning Sanctuaries year-round (Proclamation M-12-2022), 2) prohibit trawling in Bogue Sound and the Carolina Beach Boat Basin, except within the Intracoastal Waterway (Proclamations SH-5-2022 and SH-6-2022), 3) establish a single, state-wide recreational creel limit for cast nets (48 quarts, heads on or 30 quarts, heads off; Proclamation SH-4-2022), 4) change the flexible opening date in all SSNAs to a static Sept. 1, 5) continue collaboration with the industry workgroup to identify and test gear modifications to further reduce bycatch in the shrimp fishery, 6) provide for adaptive management for future action to address issues related to submerged aquatic vegetation identified through Division collaboration with the Coastal Habitat Protection Plan support staff, the Habitat and Water Quality Advisory Committee, and stakeholder groups, 7) maintain existing headrope limits for shrimp trawls in internal coastal waters but allow for adaptive management to resolve user conflicts, and 8) investigate the feasibility and use of a long-term shrimp trawl observer program that encompasses all seasons, areas, and gears (Table 1).

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 Amendment 2 is to manage the shrimp fishery to provide adequate resource protection, optimize long-term harvest, and minimize ecosystem impacts (NCDMF 2022). The following objectives will be used to achieve this goal.

- Reduce by catch of non-target species of finfish and crustaceans, as well as protected, threatened, and endangered species.
- Promote the restoration, enhancement, and protection of habitat and environmental quality in a matter consistent with the Coastal Habitat Protection Plan (CHPP).
- Develop a strategy through the CHPP to review current nursery areas and to identify and evaluate potential areas suitable for designation.
- Use biological, environmental, habitat, fishery, social, and economic data to effectively monitor and manage the shrimp fishery and its ecosystem impacts (i.e., bycatch, habitat degradation).

- Promote implementation of research and education programs designed to improve stakeholder and the general public's understanding of shrimp trawl by catch impacts on fish population dynamics.

DESCRIPTION OF THE STOCK

Biological Profile

There are three shrimp species that make up the fishery in North Carolina. They are the brown shrimp, pink shrimp, and white shrimp. The lifecycles of these species are similar in that adult shrimp spawn offshore and eggs are hatched into free-swimming larvae. Larvae develop through several stages into post-larvae. Once post-larval shrimp enter estuaries, growth is rapid and is dependent on salinity and water temperature. As 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 maximum size can range from seven to 11 inches, depending on species (Eldred et al. 1961; Gunter 1961; McCoy 1968, 1972; McCoy and Brown 1967; Williams 1984).

Stock Status

Population size is controlled by environmental conditions, and while fishing reduces the population size over the season, fishing is not believed to impact year class strength unless the spawning stock has been reduced below a minimum threshold level by environmental conditions. Annual variations in catch are presumed due to a combination of environmental conditions, fishing effort, and the effects of changes in the economics of the fishery. Because of high fecundity and migratory behavior, the three shrimp species are capable of rebounding from very low population sizes in one year to large populations the next, provided environmental conditions are favorable (MacArthur and Wilson 1967; McCoy and Brown 1967; McCoy 1968, 1972; Perez-Farfante 1969; Purvis and McCoy 1972; Whitaker 1981, 1982, 1983; Morley et al. 2022).

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. A stock assessment is not available for this species. (If there is a plan for establishing a stock assessment feel free to briefly explain and reference the FMP for more details.)

DESCRIPTION OF THE FISHERY

Current Regulations

The NCMFC has established several rules that directly govern the harvest of shrimp and the use of trawls. Below are rules and excerpts from rules that directly affect the shrimp fishery. The rules below do not cover all gear, area, or other rules which may impact the shrimp fishery. As state and federal regulations may change, please contact the North Carolina Division of Marine Fisheries (NCDMF) for the most current regulations.

Shrimp cannot be taken by nets until the division Director opens the season by proclamation (NCMFC Rule 15A NCAC 03L .0101). The Director has the proclamation authority to specify hours of day or night or both and any other conditions appropriate to manage the fishery. Areas open to trawling are also considered open areas for shrimp harvest for all other gears including cast nets. Proclamations identifying areas open and closed to the harvest of shrimp can be found at: https://deq.nc.gov/fisheries-management-proclamations#currentprocs.

Area Restrictions

Shrimp and crab trawl nets cannot be used in any primary or permanent SNA; however, the NCDMF director can open SSNAs to trawling by proclamation from August 16 through May 14 (NCMFC Rule 15A NCAC 03N .0104 and .0105). In the Albemarle Sound and its tributaries, the use of shrimp trawls is prohibited (NCMFC Rule 15A NCAC 03J .0104). Additional trawl net prohibited areas are established in parts of Pamlico, Core, and Back sounds (NCMFC Rule 15A NCAC 03J .0104 and 03R .0106). Shrimp trawling is prohibited in military danger zone and restricted areas throughout all internal coastal waters (NCMFC Rule 15A NCAC 03R .0102).

With the adoption of Amendment 2, trawling at all coastal inlets in Crab Spawning Sanctuaries was prohibited year around (Proclamation M-12-2022). In designated pot areas, the use of trawls is prohibited from June 1 to November 30 (NCMFC Rule 15A NCAC 03J .0104(b)(6), 03J .0301(a)(2), 03R .0107 and Proclamation SH-5-2022) and within the shoreline to the depth of six feet [NCMFC Rule 15A NCAC 03J .0104(6)]. Trawling is prohibited in oyster seed management areas (NCMFC Rule 15A NCAC 03K .0208 and 03R .0116) and oyster sanctuaries (NCMFC Rule 15A NCAC 03K .0209 and 15A NCAC 03R .0117). In the Pamlico, Pungo, and Neuse rivers as well as portions of New Hanover and Brunswick counties, shrimp trawl prohibited areas were implemented as part of the 2006 Shrimp FMP and Amendment 1 to protect habitat, reduce bycatch, reduce use conflict, and protect small shrimp (NCMFC Rule 15A NCAC 03L .0103(e) and 03R .0114). With the adoption of Amendment 2, shrimp trawling in Bogue Sound and the Carolina Beach Boat Basin was prohibited, except within the Intracoastal Waterway (Proclamations SH-5-2022 and SH-6-2022).

In the Atlantic Ocean, the use of commercial gears is prohibited within 750 feet of licensed fishing piers [NCMFC Rule 15A NCAC 03J .0402(a)(1)(ii)]. Commercial fishing gears are also restricted within 750 feet from piers at specified times of the year in Onslow, Pender, New Hanover counties [NCMFC Rule 15A NCAC 03J .0402(a)(2)(A)(B)(i)(ii)(iii)]. All trawls are restricted from use within one-half mile of the beach between the Virginia line and Oregon Inlet in the Atlantic Ocean (NCMFC Rule NCAC 03J .0202(2). Additional area restrictions have been implemented in the Southport Boat Harbor, Brunswick County and at the Progress Energy intake canal at the Brunswick County Nuclear Power Plant for public safety (NCMFC Rule 15A NCAC 03J .0206 and .0207).

Gear Restrictions

The use of otter trawls upstream of Highway 172 Bridge in the New River was prohibited as part of the 2006 Shrimp FMP, limiting trawling to skimmer trawls [NCMFC Rule 15A NCAC 03J .0208(a)(b)]. The 2006 FMP also established a maximum combined headrope limit of 90 feet in internal coastal waters of North Carolina, except in the Pamlico Sound and mouths of the Pamlico and Neuse rivers where up to 220 feet of combined headrope may be used [NCMFC Rule 15A NCAC 03L .0103(c)(d)]. The 220 feet maximum headrope limit was implemented in Pamlico Sound to cap fleet capacity as part of Amendment 1 [NCMFC Rule 15A NCAC 03L .0103(d)(1)(2)(3)]. Recreational fishermen possessing a Recreational Commercial Gear License (RCGL) are limited to one shrimp trawl with a maximum headrope length of 26 feet [NCMFC Rule 15A NCAC 03O .0302(2)].

Minimum mesh size requirements for shrimp trawls (otter and skimmer) are one and one-half inches (NCMFC Rule 15A NCAC 03L. 0103L). However, in the Pamlico Sound and portions the Pamlico and Neuse rivers where up to 220 feet of headrope is allowed as well as the Atlantic Ocean the minimum tail bag mesh size is one and three-quarter inches (Proclamations SH-1-2022 and SH-3-2022). Net material used as chafing gear must be four inches mesh length, except smaller mesh may be used along the bottom half of the tailbag (NCMFC Rule 15A NCAC 03L .0103). The minimum mesh size for channel nets, float nets, butterfly nets, and hand seines is one and one-quarter inches [NCMFC Rule 15A NCAC 03L. 0103L(a)(2)]. The minimum mesh size for shrimp pots is one and one-fourth inches stretch or five-eighths inch bar [NCMFC Rule 15A NCAC 03J .0301(e)].

Bycatch reduction devices are required in all trawls used to harvest shrimp [NCMFC Rule 15A NCAC 03J .0104(d)]. Proclamation SH-1-2022 describes the BRD requirements for otter trawls in Pamlico Sound and the Pamlico, Bay, and Neuse rivers where up to 220 feet of combined headrope is allowed. Otter and skimmer trawls in all other waters statewide are required to have two BRDs installed on each net. Primary and secondary BRD requirements for the Croatan and Roanoke sounds, portions of the Pamlico, Bay, and Neuse rivers, and Core Sound to the SC-NC state line are listed in Proclamation SH-2-2019. Proclamation SH-3-2022 describes the BRD requirements for otter trawls in the Atlantic Ocean.

All shrimp trawls must conform with the federal requirements for Turtle Excluder Devices (TEDs) [NCMFC Rule 15A NCAC 03L .0103(h)]. All otter trawl nets are required to have a federally approved TED with bar spacing up to four inches if using mechanical retrieval methods. Federally approved TEDs are listed in United States Code of Federal Regulations Title 50, Section 223.207. Effective August 1, 2021, all skimmer trawls 40 feet and greater must have a federally approved TED installed with a bar spacing no greater than three inches in each net. Skimmer trawls less than 40 feet will not be required to use TEDs but must limit tow times to 55 minutes from April 1 through October 31, and 75 minutes from November 1 through March 31 [50 CFR 223.206(d)(2)(ii)(A)].

Channel nets or other fixed or stationary nets in the IWW are prohibited from blocking more than two-thirds of any natural or manmade waterway, in the middle third of any marked navigation channel [NCMFC Rule 15A NCAC 03J .0101(1)(2)(3)]. Channel nets cannot be set with any portion of the set within 50 feet of the center line of the IWW channel or in the middle third of any navigation channel marked by the Corps of Engineers or the Coast Guard. Channel nets must be always attended [NCMFC Rule 15A NCAC 03J .0106(a)(3)(4)(5)] and not exceed 40 yards in length. 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 with a non-metal line when not attached to the net; metallic floats or buoys to mark sets are prohibited [NCMFC Rule 15A NCAC 03J .0106(b)(c)(d)(e)].

The leads or any fixed or stationary net or device to direct shrimp into shrimp pots is prohibited [NCMFC Rule 15A NCAC 03J .0301(l)]. Recreational fishermen holding a RCGL may use up to five shrimp pots [NCMFC Rule 15A NCAC 03O .0302(a)(3)]. Recreational pots must be marked with a hot pink buoy and owner's identifying information [NCMFC Rule 15A NCAC 03J .0302(a)]. The use of more than one shrimp pot attached to the shore along privately owned land or to a privately owned pier is prohibited without possessing a valid RCGL [NCMFC Rule 15A NCAC 03J .0302(b)]. A pound net permit is required to deploy a shrimp pound and the set must be operational for a minimum of 30 consecutive days during the permit period [NCMFC Rule 15A NCAC 03J .0501(b)(1)(2)]. Shrimp pounds are defined as pound net set with all pounds (holding pen) 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(6)]. RCGL holders may use one pound net with leads up to 10 feet in length with an enclosure up to 36 inches; attendance is required at all times and all gear must be removed from the water when not being fished [NCMFC Rule 15A NCAC 03O .0302(8)]. Shrimp pound sets must be properly marked with the permittee's identification and Pound Net Set Permit number, marked with a 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 [NCMFC Rule 15A NCAC 03J .0501(b)(c)]. Shrimp pound net sets must be set a minimum of 100 yards from a RCGL shrimp pound net set or 300 yards from an operational permitted shrimp pound net set [NCMFC Rule 15A NCAC 03J .0501(d)(2)].

Effort Restrictions

Shrimp trawling is prohibited in internal coastal waters from 9:00 p.m. on Friday through 5:00 p.m. on Sunday [NCMFC Rule 15A NCAC 03J .0104(b)(1)]. However, weekend shrimp trawling is allowed in Atlantic Ocean, with the use of fixed and channel nets, hand, seines, shrimp pots, and cast nets, or for a holder of a Permit for Weekend Trawling for Live Shrimp [NCMFC Rule 15A NCAC 03L .0102, 03O .0503(1)(2)(3)]. In portions of the Pungo, Pamlico, Bay, Neuse, and New rivers the use of trawl nets is prohibited from one hour after sunset to one hour before sunrise prohibited from December 1 through February 28 [NCMFC Rule 15A NCAC 03J .0208]. Upstream of the Highway 172 Bridge in New River shrimp trawling (skimmer only) is prohibited from 9:00 p.m. through 5:00 a.m. when opened by proclamation from August 16 through November 30 (NCMFC Rule 15A NCAC 03J .0208).

Incidental Catch

The possession of more than 500 pounds of finfish from December 1 through February 28 and 1,000 pounds of finfish from March 1 through November 30 is prohibited while using a trawl in internal waters [NCMFC Rule 15A NCAC 03J .0104(a)]. Shrimp trawls cannot be used to take blue crabs in internal waters, except when the weight of the crabs does not exceed 50% of the total weight of the combined crab and shrimp catch or 300 pounds, whichever is greater [NCMFC Rule 15A NCAC 03J .0104(f)(2)]. 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 [NCMFC Rule 15A NCAC 03J .0202(5)]. Channel nets are prohibited from to taking blue crabs in internal waters, except when the weight of the crabs does not exceed 50% of the total weight of crab and shrimp or 300 pounds, whichever is greater [NCMFC Rule 15A NCAC 03J .0106(h)(1)(A)(B)].

Recreational Creel Limits

Recreational fishermen using cast nets are limited to no more than 48 quarts (heads on) or 30 quarts (heads off) of shrimp per person per day or per vessel per day if a vessel is used in all Coastal Fishing Waters (Proclamation SH-4-2022). Recreational fishermen using limited amounts of commercial gear authorized under the Recreational Commercial Gear License (NCMFC Rule 15A NCAC 03O .0302) are limited to 48 quarts (heads on) or 30 quarts (heads off) of shrimp per person per day or if vessel is used, per vessel per day (RCGL maximum two limits per vessel in areas open to shrimping[NCMFC Rule 15A NCAC 03O .0303(e)(f) and Proclamations SH-5-2022 and SH-6-2022].

Commercial Fishery

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 and Bogue sounds, and the North, Newport, and White Oak rivers. In the southern portion of the state, the fishery is characterized by a large number of small boats fishing internal waters (primarily the IWW, 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.

A variety of methods are used to catch shrimp including otter trawls, skimmer trawls, channel nets, shrimp pounds, and cast nets. Otter trawls derived their name from the two trawl doors (otter doors/boards) that attach to the bridle that are hydro-dynamically designed to hold the wings of the net open. As the net is pulled along the bottom, the otter boards plane in opposite directions holding the net open. Otter trawls are used for all three species in both the estuary and the ocean. Two-seam trawls are 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. Skimmer trawls consists of two rigid frames attached to each side of a vessel with nets attached along the two sides of the frame. Metal skids keep the frames off the bottom as the nets are pushed through the water column. Unlike otter trawls, the tailbags of skimmer trawls can be checked while fishing. Skimmer trawls are primarily used for white shrimp and are capable of fishing waters as shallow as two feet.

Use of gears other than trawls has increased primarily in the area from New River to Rich's Inlet. Channel nets are stationary nets that use tidal currents to fish the surface and middle depths of the water column. The mouth of the nets is held open by upright wooden shafts attached to a buoy and anchor on one side and a small vessel on the other. Float and butterfly nets also 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. 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. Trawls, cast nets, and seines are used to harvest 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 2021 have averaged 7,578,093 pounds per year. In 2021, 9,152,121 pounds of shrimp were landed. Total landings decreased 6% from 2020 to 2021. In 2021, 61% of the harvest occurred in the Atlantic Ocean (less than 3 miles from shore), with the remainder occurring in estuarine waters. Landings in the Atlantic Ocean (less than 3 miles from shore) increased 23%, while landings in estuarine waters decreased 32% (Figure 2). Annual shrimping effort (number of trips) has fluctuated with shrimp abundance, but it appears to have gradually declined since 1994 (NCDMF 2015, 2022). This may be due to a number of things including cheaper imported shrimp prices, increasing fuel prices, and fishermen retiring. 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). Hurricane Florence (9/17/18) directly hit North Carolina, likely contributing to the decrease in landings in 2018. The number of trips decreased 10% from 2020 to 2021 (Figure 3).

Recreational Fishery

Shrimp are harvested recreationally throughout the state by otter trawls, skimmer trawls, seines, cast nets, shrimp pots and shrimp pounds with specific gear limitations. The NC Coastal Angling Program uses multiple surveys to obtain recreational harvest and landings data; however, the recreational harvest of shrimp is limited to the Cast Net and Seine Mail Survey and the RCGL Survey.

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 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. Recreational landings of shrimp from RCGL gears are currently unknown since there is no directed survey for this gear.

In October of 2011, NCDMF began surveying Coastal Recreational Fishing License (CRFL) holders to determine if they used cast nets or seines. This mail survey was implemented to develop catch and effort estimates for recreational harvest with these specific gear types, including recreational shrimp harvest. Catch refers to the number of shrimp harvested by each angler and effort is the number of trips taken by the angler. This data is then extrapolated to represent the population of CRFL holders and presented as catch and effort estimates. The estimated annual average number of shrimp caught (harvest and released) using a cast net and/or seine was 190,874 shrimp from 2012 to 2021 (Figure 4). In 2021, 134,262 shrimp were caught. The total number of shrimp harvested decreased 47% and the number released decreased 58% from 2020 to 2021; however, the number of trips increased 47%.

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 N.C. 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 feet headrope trawl with a 1/4-inch mesh in the body and 1/8-inch mesh in the tailbag is used. A one-minute tow is conducted covering 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. During 2020, sampling was impacted due to the COVID pandemic. Executive Order (EO) 116, issued on March 10, 2020, declared North Carolina under a State of Emergency and was soon followed by EO 120 which implemented a statewide Stay at Home Order for all non-essential State employees. During this time, sampling did not occur in May, but did occur in early and late-June. In 2021, sampling resumed in the months of May and June.

Annual trends in brown shrimp relative abundance, measured as the number of brown shrimp per station in Program 120 sampling, shows fluctuations from year to year (Figure 5). The annual brown shrimp index of relative abundance increased 47% from 2020 to 2021; however, this increase may be attributed to sampling resuming in May 2021 (Table 2; Figure 5). The proportional standard error was below 20 in all but four years from 1988 to 2021 (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 index of relative abundance can also be used to determine year class strength. Trends in overall shrimp landings from June and July, months that brown shrimp make up most of the harvest, show similar trends as the Program 120 data (Figure 6). Currently, there are no juvenile indices of abundance for white and pink shrimp in North Carolina.

RESEARCH NEEDS

The following research needs are from Amendment 2 to the N.C. Shrimp FMP (NCDMF 2022). The list below outlines the specific needs and highlights the prirority and status of each.

High

- Create a long-term shrimp trawl observer program to characterize bycatch across all strata (for example: dominant species, protected species, season, areas, gear type, vessel type, number of nets/rigs, headrope length, TED position, etc.). — Needed
- Improve accuracy of self-reported license gear survey data or investigate other means of accurately obtaining shrimp fleet characteristics. — Needed
- Collect improved effort data (e.g., headrope length, number of nets, tow time, number of tows) to provide bycatch estimates based on actual time fished (or number of tows), rather than number of trips. — Needed
- Create and validate juvenile abundance indices for white and pink shrimp. — Needed
- Determine the cumulative impacts of shrimp trawl bycatch on individual species population dynamics and the ecosystem. — Needed
- Determine the spatial, temporal, and biological characteristics of submerged aquatic vegetation that maximize their ecological value to shrimp for restoration and conservation purposes. — 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.
- Develop alternative non-bottom disturbing gears to efficiently catch shrimp. — Needed

Medium

- Determine the influence of current bottom disturbing gears patterns (location, frequency, etc.) on sub-tidal shell, and SAV in Pamlico Sound. — Needed
- Continue to locate, map, and quantify the bottom habitat structure, bathymetry, and sediment types in North Carolina estuaries. — Ongoing
- Measure the effects of trawling on sediment size distribution and organic carbon content.
- Establish continuous water quality monitoring in the Pamlico system to evaluate water quality effects on shrimp and the fish habitats they rely. — Needed
- Develop research methods to understand costs and benefits of maintaining shrimp habitat and water quality to inform decision-making on shrimp management. — Needed

Low

- Initiate research to determine the impacts of endocrine disrupting chemicals (EDCs) on the various life stages of shrimp. — Needed
- Expand current social and economic surveys to specifically collect information on shrimp fishermen. — Needed

MANAGEMENT STRATEGY

There are no management triggers or methods to track stock abundance, fishing mortality, or recruitment between benchmark reviews from the current FMP. Several management issues were explored in Amendment 2; Table 1 outlines the specific issues and the implementation status of each strategy.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

The division is continuing to implement management strategies from Amendment 2, which was adopted by the NCMFC in February 2022. The next scheduled review of this plan will begin in July 2027.

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TABLES

Table 1. Summary of management strategies and outcomes from N.C. Shrimp Fishery Management Plan Amendment 2.

Management Strategy	Implementation Status
Prohibit trawling within all Crab Spawning Sanctuaries.	Existing proclamation authority; Proclamation issued, M-12-2022.
Prohibit trawling in Bogue Sound and the Carolina Beach Yacht Basin, except within the Intracoastal Waterway	Existing proclamation authority; Proclamations issued, SH-5-2022 and SH-6-2022.
Establish a single, state-wide recreational creel limit for cast nets (48 quarts, heads on or 30 quarts, heads off).	Existing proclamation authority; Proclamation issued, SH-4-2022.
Change the flexible opening date in all Special Secondary Nursery Areas to a static Sept. 1.	Existing proclamation authority; Proclamations will be issued if deemed appropriate by the NCDMF Director.
Continue collaboration with the industry workgroup to identify and test gear modifications to further reduce bycatch in the shrimp fishery.	Ongoing. Issue a press release to solicit members for the shrimp industry workgroup.
Provide for adaptive management for future action to address issues related to submerged aquatic vegetation identified through Division collaboration with the Coastal Habitat Protection Plan support staff, the Habitat and Water Quality Advisory Committee, and stakeholder groups.	Ongoing. Update SAV maps that will be reviewed by the division, CHPP staff, and the Habitat and the Water Quality AC to address SAV impact. Identified recommendations will be brought back to the appropriate committees and the NCMFC for future action.
Maintain existing headrope limits for shrimp trawls in internal coastal waters but allow for adaptive management to resolve user conflicts.	No action required.
Investigate the feasibility and use of a long-term shrimp trawl observer program that encompasses all seasons, areas, and gears.	Ongoing. Develop an information paper to be brought back to the NCMFC for future action.

Table 2. 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 3. Program 120 annual sampling for brown shrimp from core stations in May and June combined. Number of samples (stations), brown shrimp index of relative abundance (number 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), 1988-2021.

Year	Number of stations	Relative abundance	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	205	57.8	7.2	102.8	177.6	0	759	11,859	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	33.8	5.5	78.9	233.6	0	714	7,028	16
2019	208	31.6	11.7	168.4	532.4	0	2,237	6,580	37
2020	208	24.5	2.9	41.2	168.5	0	284	5,088	12
2021	208	35.9	4.7	67.4	187.8	0	429	7,469	13

FIGURES

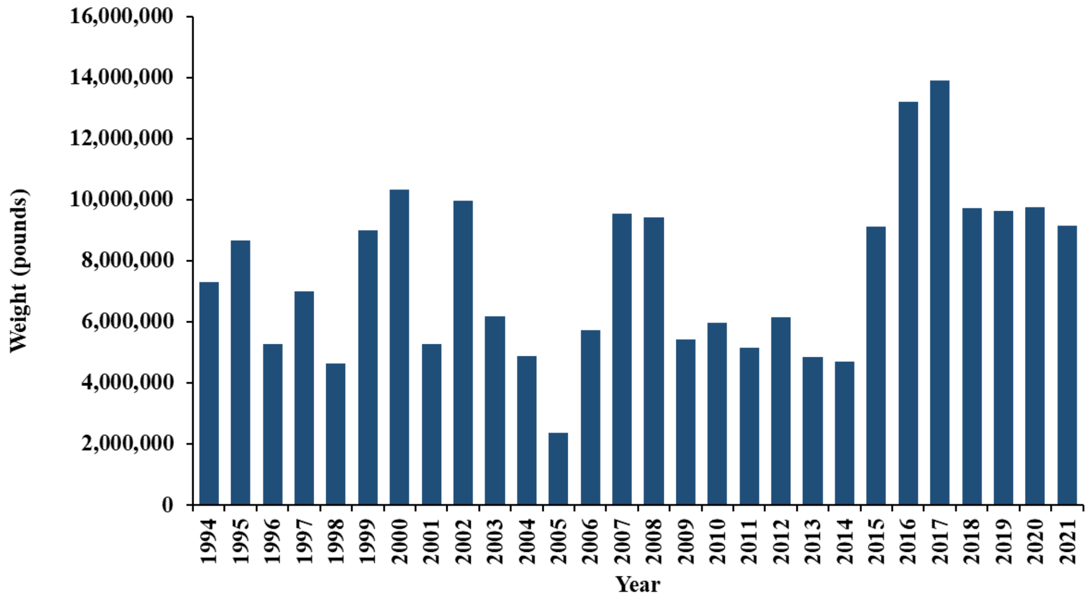

Figure 1. Annual commercial shrimp landings (pounds) from all three shrimp species combined in North Carolina, 1994-2021. Data from the NCDMF Trip Ticket Program.

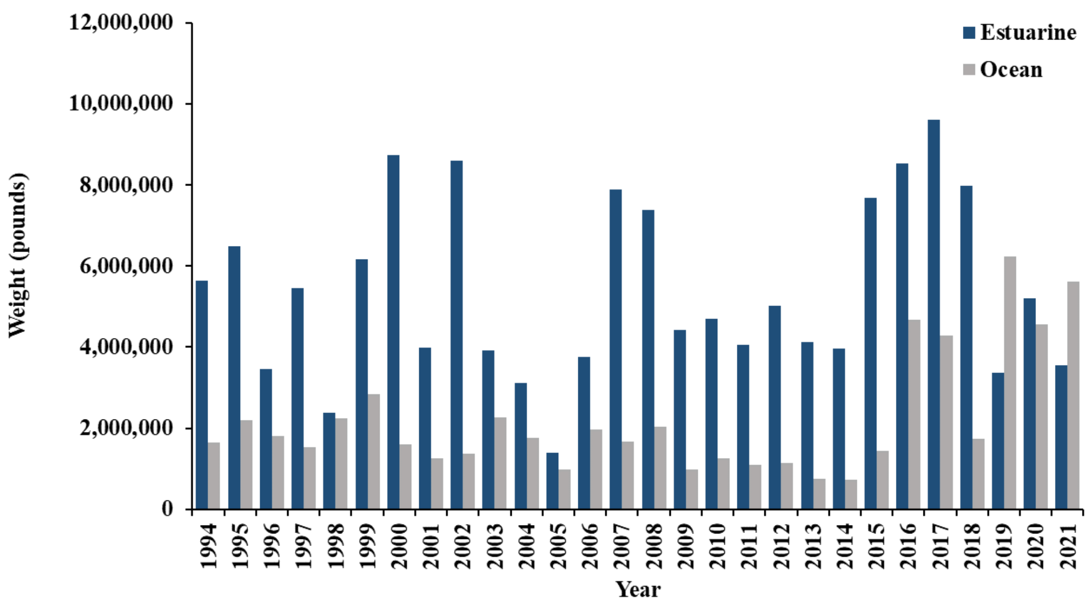

Figure 2. Annual commercial shrimp landings (pounds) by area from all three shrimp species combined in North Carolina, 1994-2021. Data from the NCDMF Trip Ticket Program.

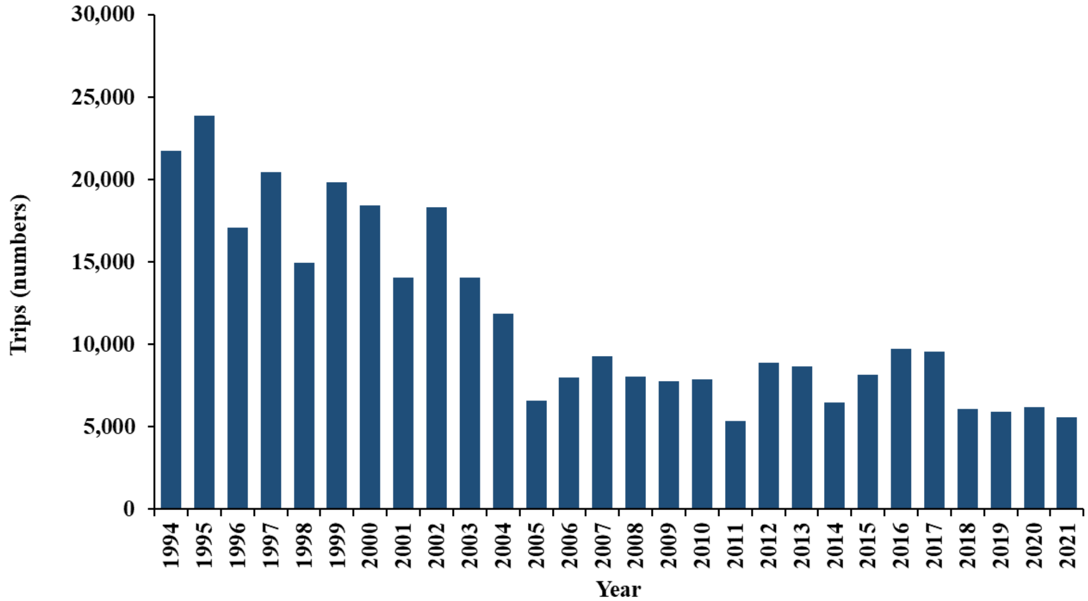

Figure 3. Annual number of commercial trips reported for all three species combined in inside and ocean waters, 1994-2021. Data from the NCDMF Trip Ticket Program.

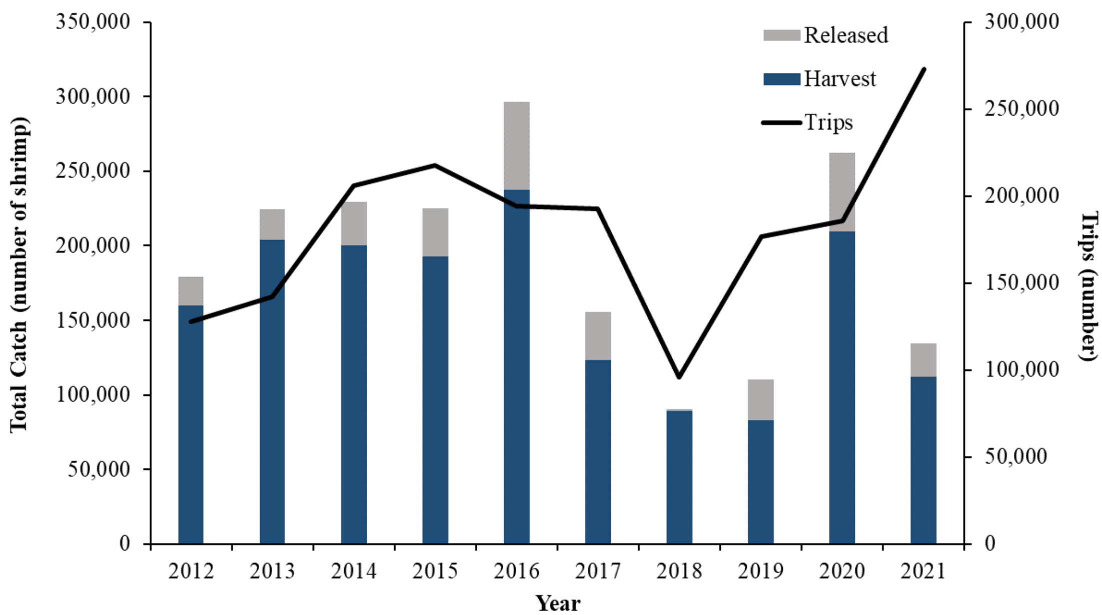

Figure 4. Annual number of shrimp harvested and trips taken from cast nets and seines for recreational purposes, 2012-2021.

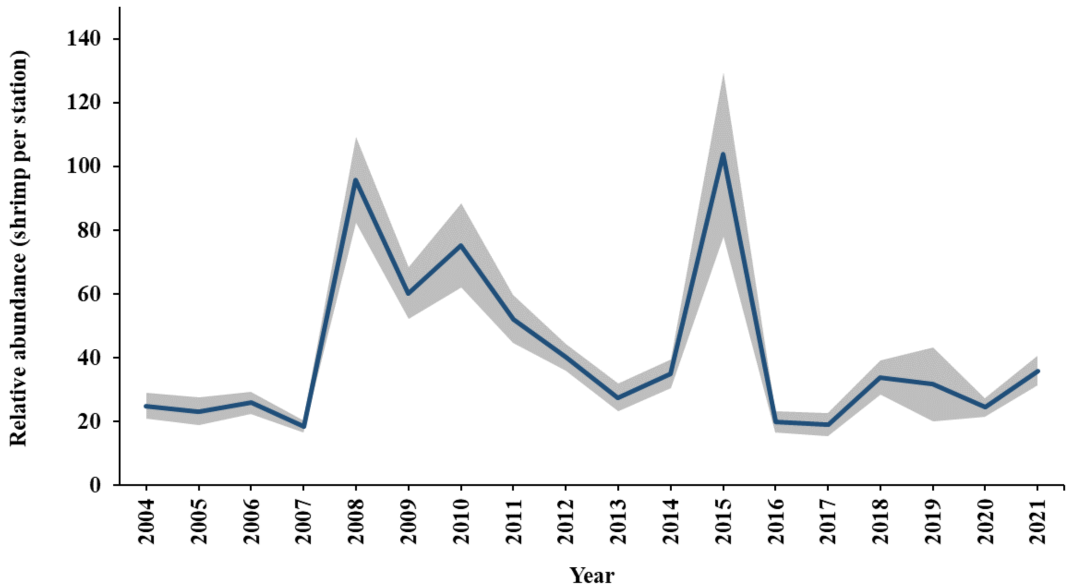

Figure 5. Annual index of relative abundance (shrimp per station) of brown shrimp from Program 120 estuarine trawl survey, 1988-2021. Shaded area represents standard error.

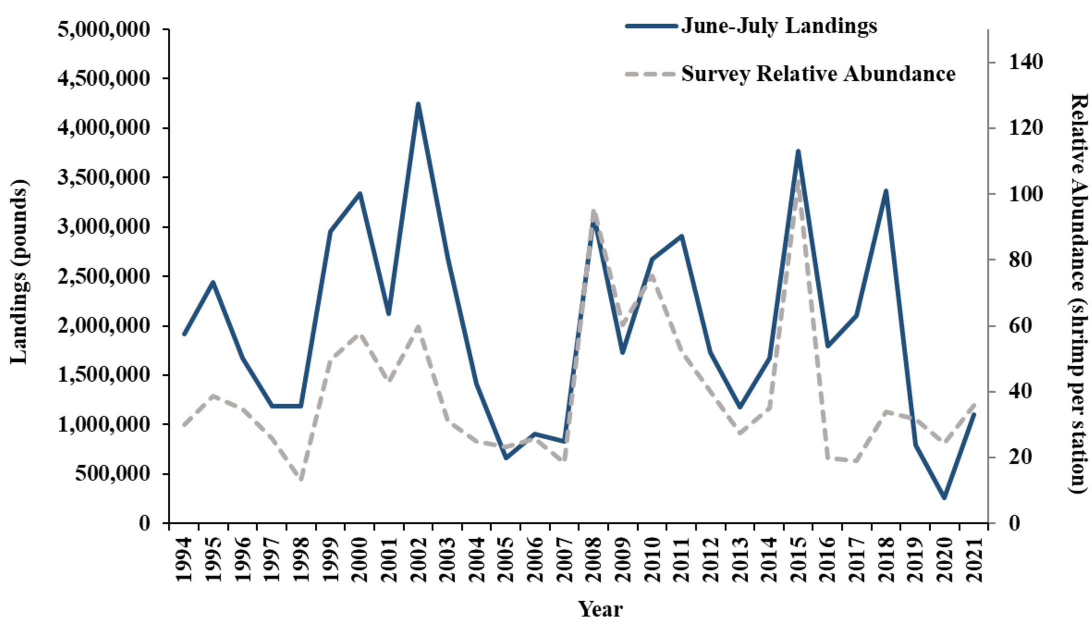

Figure 6. Comparison of brown shrimp commercial shrimp landings (pounds) in the months of June and July to the brown shrimp Program 120 index of relative abundance (shrimp per station), 1994-2021.

FISHERY MANAGEMENT PLAN UPDATE
SOUTHERN FLOUNDER
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	February 2005	
Amendments:	Amendment 1	February 2013
	Amendment 2	August 2019
	Amendment 3	May 2022
Revisions:	None	
Supplements:	Supplement A to the FMP	February 2011
	Supplement A to Amendment 1	November 2015
Information Updates:	None	
Schedule Changes:	None	
Comprehensive Review:	2027	

Southern flounder (*Paralichthys lethostigma)* in North Carolina are currently management under Amendment 3 to the North Carolina Southern Flounder Fishery Management Plan (FMP) (NCDMF 2022). Development of Amendment 3 began upon final approval of Amendment 2. Amendment 3 was developed to address comprehensive, long-term management strategies to continue the rebuilding of the southern flounder stock started under Amendment 2. Amendment 2 was intended to reduce harvest pressure on the portion of the stock in North Carolina quickly while more robust measures were developed. The plan development team developed Amendment 3 to the Southern Flounder FMP in conjunction with the Southern Flounder FMP Advisory Committee. Like Amendment 2, Management in Amendment 3 was based on the 2019 coast-wide stock assessment. The original 2018 assessment pooled-sex model was updated with data through 2017 including incorporating the new MRIP estimates that were available (Flowers et al. 2019).

At its May 26, 2022, North Carolina Marine Fisheries Commission (NCMFC) business meeting, the NCMFC adopted Amendment 3 to the Southern Flounder FMP as proposed by the North Carolina Division of Marine Fisheries (NCDMF).

Actions to achieve sustainable harvest in Amendment 3 include:

- Combine mobile gears (gill nets, gigs, and “other” gears) into one gear category and maintain pound nets as their own separate commercial fishery.
- Divide mobile gears into two areas using the ITP boundary line for management units B-D.

- Divide the pound net fishery into three areas maintaining consistency with areas in Amendment 2.
- Maintain 72% reduction and current sub-allocation for the pound net fishery with direction from the MFC as follows: “In 2024, as the shift in allocation is set to start the Division will provide recommendations to the NCMFC on approaches to maintaining a sustainable sub-allocation for the commercial pound net fishery, as needed based on the economic and biotic conditions at that time”.
- Implement trip limits for pound nets and gigs only to maximize reopening after reaching division closure threshold.
- Implement a single season for the recreational gig and hook-and-line fisheries to constrain them to an annual quota.
- Reduce the recreational bag limit of flounder to one fish per person per day.
- Do not allow harvest of southern flounder using a Recreational Commercial Gear License (RCGL).
- One-fish recreational ocellated bag limit during March 1 through April 15 in ocean waters only using hook-and-ling gear and a one-fish bag limit consisting of any species of flounder during the southern flounder recreational season.
- Do not establish inlet corridors for southern flounder during spawning migrations.
- Adopt the adaptive management framework based on the peer-reviewed and approved stock assessment.
- At the Nov. 2020 business meeting, the NCMFC requested analysis of various recreational and commercial allocation percentages. In March 2021, the NCMFC voted on and approved sector allocations of 70/30 commercial to recreational for 2021 and 2022 and shifting to 60/40 for 2023, and 50/50 parity beginning in 2024.
- Based on recognition of a series of coincident concerns specific to the initial steps in rebuilding the southern flounder fishery, the NCMFC voted in Feb. 2022 to delay the transition to 50/50 parity by two years (time for at least one cycle of larval to female maturity). The selected allocations will be 70/30 for 2023 and 2024, 60/40 for 2025, and 50/50 parity starting in 2026.
- Do not implement a slot limit and maintain the 15-inch TL current minimum size limit.
- Continue to allow anchored large-mesh gill nets to harvest southern flounder in the North Carolina southern flounder fishery.

Management Unit

In Amendment 3 to the North Carolina Southern Flounder FMP, the management unit was defined as North Carolina coastal 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

The goal and objectives of Amendment 3 to the North Carolina Southern Flounder FMP were approved by the NCMFC at their February 2020 business meeting. The goal is to manage the southern flounder fishery to achieve a self-sustaining population that provides sustainable harvest using science-based decision-making processes. The following objectives will be used to achieve this goal:

- Implement management strategies within North Carolina and encourage interjurisdictional management strategies that maintain/restore the southern flounder spawning stock with expansion of age structure of the stock and adequate abundance to prevent overfishing.
- Restore, enhance, and protect habitat and environmental quality necessary to maintain or increase growth, survival, and reproduction of the southern flounder population.
- Use biological, environmental, habitat, fishery, social, and economic data needed to effectively monitor and manage the southern flounder fishery and its ecosystem impacts.
- Promote stewardship of the resource through increased public outreach and interjurisdictional cooperation throughout the species range regarding the status and management of the southern flounder fishery, including practices that minimize bycatch and discard mortality.
- Promote the restoration, enhancement, and protection of habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan.

DESCRIPTION OF THE STOCK

Biological Profile

Southern flounder is a bottom dwelling species of the left eyed flounder family found in the Atlantic Ocean, Gulf of Mexico, 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 the east coast of 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 NCDMF suggests that with the onset of maturity, females 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 than males. 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 6 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 2019 stock assessment, the probability that fishing mortality in 2017 is above the threshold value of 0.53 is 96.4%, whereas there is a 100% chance the fishing mortality in 2017 is above the target value of 0.35. The probability that the SSB in 2017 is below the threshold or target value (3,900 and 5,452 metric tons, respectively) is 100%. Therefore, the current status of the southern flounder stock is overfished, and overfishing is occurring (Figures 1 and 2).

Stock Assessment

The 2009 stock assessment used a statistical catch-at-age model run using the Age Structured Assessment Program (Takade-Heumacher and Batsavage 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 coast-wide 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 is overfished and overfishing is still occurring (Figures 1 and 2; Flowers et al. 2019). 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 (Flowers et al. 2019).

DESCRIPTION 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 inch stretched mesh minimum mesh size for gill nets, closed season in internal waters unless opened by proclamation, 2022 season opening data has yet to be determined. The commercial fishery will operate under a quota beginning in the fall of 2022 with two gear categories; mobile gears which will be divided into two management areas using the B-D boundary line from the turtle and sturgeon ITPs and the pound net fishery which will be divided into three management areas consistent with Amendment 2. There are no current trip limits in internal waters, but they can be implemented for pound nets and gigs only upon reaching a predetermined division closure threshold to reopen the fishery without exceeding the quota and a 100-pound trip limit in ocean waters unless the individual has a License to Land Flounder from the Atlantic Ocean; commercial ocean landings are allowed using trawl gear only.

Recreational: 15-inches TL minimum size limit, one-fish creel limit from all joint and coastal waters, closed season for internal and ocean waters except if opened by proclamation. Beginning in 2022 the recreational flounder fishery will operate under seasons to constrain the fishery to a quota. The 2022 recreational internal and ocean waters season will be from September 1 through September 30 with a one-fish per person per day bag limit and a one-fish ocellated bag limit during March 1 through April 15, 2023, in ocean waters only using hook-and-line gear if sufficient quota is available beginning in March 2023.

Commercial Fishery

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 3). Peak commercial landings occurred in 1994 (Table 1; Figure 3). 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 in the Albemarle Sound, but decreased in Pamlico Sound and Core Sound; pound net landings also increased 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 protected species interactions. Pound net harvest surpassed gill net harvest 2014 through 2020 (Figure 3). Gig harvest of southern flounder has generally increased, especially since 2010. Harvest by other commercial gears has generally decreased to its lowest point in 2021 and currently makes up a small portion of commercial harvest. Commercial harvest from 2019 – 2021 was impacted due to regulations implemented through Amendment 2 to the NC Southern Flounder FMP. Amendment 2 implemented seasons in the commercial southern flounder fishery for the first time, and the 2021 season was less than 37 consecutive days with the longest area being open 21 days. This reduction in days reduced harvest minimally compared to 2020 as the commercial fishery still exceeded its expected harvest by 88,328 pounds.

Trends in commercial trips have generally followed landings trends (Figure 4). 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. The number of trips targeting southern flounder have decreased since regulatory changes due to Amendment 2 when seasons were implemented limiting the number of days flounder could be harvested.

Recreational Fishery

Recreational harvest of southern flounder is mainly by hook and line and gigs, with a small amount of harvest by spearfishing or 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 2010-2020 averaged 11% 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 5). Hook and line harvest peaked in 2010 (Table 1). Recreational harvest was impacted in 2020 and 2021 due to regulations implemented through Amendment 2 to the NC Southern Flounder FMP. In addition, the season was shortened from 45 days in 2020 to 14 consecutive days in 2021 due to excessive overages that occurred during the 2020 season. This reduction in season length did not have the intended impact as the recreational fishery exceeded its expected harvest by 474,636 pounds.

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 2014 while harvest has been variable. (Figure 6). 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.

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 the North Carolina Onboard Observer Program and 570 the North Carolina Shrimp Trawl Characterization Study 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 data from 2005 to 2021 (Table 2). In 2021, 52% of southern flounder were harvest by gill nets, followed by pound nets (41%), gigs (7%), and other gear accounted for >1% (Figure 7). An increase in mean length was observed due to the changes in minimum commercial size regulation, increasing to 15-inches in 2016 (Table 2; Figure 8). In addition, during 2021 harvest of 17-inch fish was greater in proportion to total catch than previous years (Figure 8).

There were no clear trends in recreational length data from 2005 to 2021 (Table 3). Annual mean lengths collected through age sampling programs have been consistent, 2021 average length of 17 inches was consistent with previous years where 17 inches was the mean length as seen 13 of the last 17 years. MRIP length frequency data show harvest of smaller fish has declined as changes to minimum size limits has occurred (Table 3; Figure 9).

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). Program 135 was dropped from this update as the program has had significant changes in sample design that limits its catches of southern flounder thus reducing its usefulness as a data source for this species moving forward. Age data primarily is collected in Program 915, although the other three surveys do collect age data. Methodology for analyzing trends in relative abundance for each survey changed with the 2018 stock assessment when generalized linear models (GLMs) were used to calculate relative yearly relative abundance index values. These indices were not updated, as a result, nominal relative abundance index values have been included in this report.

There were no clear trends in fishery-independent length data from 2005 to 2021 (Table 4). Annual mean lengths were fairly consistent and 2011 and 2016 had the second largest mean length in the time-series. However, the number of fish measured in 2020 was the lowest of any year from 2005 to 2021. The reduced number of measurements from independent samples is reflective of the sampling impacts due to the pandemic.

Data collected by Program 915 were used for an index of relative (juvenile and adult) abundance in the January 2019 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 the index of abundance 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 relative abundance index for Program 915 peaked in 2010 and the low point was in 2016 for the time-series analyzed (2003-2021) and has a decreasing trend (Table 5; Figure 10). The relative abundance index for 2021 was above the series average for the first time since 2013 and there has been an increase each year since the low in 2016.

During 2020, and the first part of 2021 no index of abundance is available for southern flounder from the fishery-independent assessment (Program 915). Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021.

Data collected by Program 120 were used for a relative Juvenile Abundance Index (JAI) in the January 2019 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 head rope trawl with a one-fourth inch mesh in the body and one-eighth inch mesh in the tail bag 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 2021. The JAI for Program 120 peaked in 1996 and the low point was in 2020 for the time-series analyzed (1991-2021) and shows a variable trend (Table 5; Figure 11) with each of the last 6 years being below the time series average. The JAI in 2021 increased to the highest point since 2013. The 2020 JAI was the second lowest in the 30-year time series however, sampling was impacted by the COVID pandemic, and the full sampling regime was not completed. Sampling typically occurs over the months of May and June. Due to the pandemic all sampling was conducted in June. The impacts to the JAI due to the changes to the sampling regime are unknown.

Data collected by Program 195 were not used as a JAI in the January 2019 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 head rope, 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. Data from this survey were used to produce a southern flounder JAI from 1991 to 2021. The JAI for Program 195 peaked in 1996 and the low point was in 1998 for the time-series analyzed (1991-2021; Table 5; Figure 12). However, annual relative abundance for four of the last seven years has been above the 30-year time series average. JAI for 2020 and 2021 are incomplete as sampling was conducted only in a portion of the areas typically sampled due to the pandemic. The impacts to the JAI due to the changes to the sampling regime are unknown.

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 2020, a set of 1,210 southern flounder were aged ranging in age from 0 to 5 years (Table 6). 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 13). Age data from 2021 are not available at this time.

RESEARCH NEEDS

The management strategies and implementation status from Amendment 3 to the N.C. Southern Flounder FMP can be found in Table 6. The following research recommendations were included in Amendment 3; status of need is provided in parentheses. Those recommendations followed by an asterisk (*) were identified as the top five high priority research recommendations and are discussed further below.

High

- Conduct studies to quantify fecundity and fecundity-size/age relationships in Atlantic southern flounder.*
- Improve estimates of the discard (B2) component (catches, lengths, and ages) for southern flounder from MRIP. — underway*
- Expand, improve, or add fisheries-independent surveys of the ocean component of the stock.*
- Determine locations of spawning aggregations of southern flounder. — underway*
- Complete an age validation study using known age fish.*
- Research and evaluate data on the sub-legal fish in the recreational fishery as it relates to potential future reductions in minimum size limits. — underway

Medium

- Promote data sharing and research cooperation across the South Atlantic southern flounder range (North Carolina, South Carolina, Georgia, and Florida).
- Further research on factors that impact release mortality of southern flounder in the recreational hook-and-line fishery.
- Research on deep hooking events of different hook types and sizes on southern flounder.
- Coast-wide at-sea observations of the flounder pound net fishery.
- Develop a survey that will provide estimates of harvest and discards for the recreational gig fisheries in North Carolina, South Carolina, Georgia, and Florida.
- Develop a survey that will provide estimates of harvest and discards from gears used to capture southern flounder for personal consumption.
- 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).
- Expand, improve, or add inshore and offshore surveys of southern flounder to develop indices for future stock assessments.
- Collect age and maturity data from the fisheries-independent Southeast Area Monitoring and Assessment Program (SEAMAP) Trawl Survey given its broad spatial scale and potential to characterize offshore fish.
- Conduct studies to better understand ocean residency of southern flounder.
- 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.
- Work to reconcile different state-level/regional surveys to better explain differences in trends.

- Evaluate the utility of circle hooks in the southern flounder recreational hook-and-line fishery.
- Development of alternative gears to catch southern flounder. — some research completed; more may be needed
- Study revenue variability and profitability of commercial southern flounder fishing in North Carolina based on catch characteristics.
- Generate a stated preference survey of North Carolina recreational anglers to understand perceived value of targeting southern flounder compared to other estuarine finfish species.

Low

- Develop a recreational catch per unit effort (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.
- Explore potential impacts stocking may have on the southern flounder population and the costs associated with implementing a stocking program.
- Continued otolith microchemistry research to gain a better understanding of ocean residency of southern flounder. — underway
- Implement fishery dependent sampling of the commercial spear fishery for flounder in the ocean.
- Determine harvest estimates and implement fishery dependent sampling of the recreational spear fishery for flounder in the ocean.
- Further research on flatfish escapement devices in crab pots that minimize undersized flounder bycatch and maximize the retention of marketable blue crabs.
- Expand tagging study to ocean component of the stock to estimate emigration, immigration, movement rates, and mortality rates throughout the stock's range.
- 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.
- Further research on the size distribution of southern flounder retained in pound nets with 5.75-ISM and 6-ISM escape panels.
- Research on the species composition and size distribution of fish and crustaceans that escape pound nets through 5.75-ISM and 6-ISM escape panels.

- Develop a survey that will estimate harvest and discards from commercial gears used for recreational purposes.
- Continue at-sea observations of the large-mesh gill-net fishery including acquiring biological data on harvest and discards. — underway
- Develop survey that better represents the for-hire industry.
- Continued gear research in the design of gill nets and pound nets to minimize protected species interactions. — some research completed; more may be needed
- Investigate the impacts of warming water temperature on the southern flounder stock.
- Develop a study that evaluates inlets and their relationship to southern flounder migration.
- Develop studies to investigate the impacts of emerging compounds on southern flounder.

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

MANAGEMENT STRATEGY

Amendment 3 was adopted by the NCMFC in May 2022. This Amendment includes more comprehensive management strategies which will be implemented via proclamation throughout 2022 (Table 7).

In concurrence with the incorporated actions from Amendment 1, Supplement A to Amendment 1 as modified by the Aug. 17, 2017, settlement agreement, and Amendment 2, sustainable harvest was implemented in Amendment 3 to maintain 72% reductions in fishing mortality (F=0.18) in the commercial and recreational fisheries to a level that ends overfishing within two years and allows the SSB to increase between the threshold and the target within 10 years of adoption of Amendment 2.

To meet the reduction in fishing mortality, quotas with accountability measures were established for the commercial and recreational sectors for the first time in the North Carolina Southern Flounder Fishery as well as a reduction in the recreational bag limit from four fish per person per day to one fish per person per day and the elimination of RCGL holders from harvesting southern flounder (Table 7). These reductions in total removals allow for increased escapement of spawning stock and expansion of the age structure to continue rebuilding of the stock.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

At its May 2022 business meeting the NCMFC adopted Amendment 3 to the N.C. Southern Flounder FMP. Actions approved through this plan will be implemented through proclamation in 2022. In addition, the division has tentatively scheduled an update to the 2019 stock assessment to begin in 2023.

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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 1989–2021. All weights are in pounds. * indicates years with harvest seasons in place.

	Recreational			Commercial	
Year	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (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	1,396,384	1,847,510
2018	217,805	1,002,753	495,289	903,811	1,399,100
2019*	163,045	1,353,286	387,203	800,080	1,187,283
2020*	152,244	1,678,494	398,769	479,984	878,753
2021*	266,421	1,940,051	560,440	478,134	1,038,574
Average	217,786	1,051,122	449,696	2,471,595	2,968,359

Table2. Southern flounder total length (inches) data for NCDMF commercial fishery sampling programs 2005–2021 (includes harvest and some discard information).

Year	Mean Length	Minimum Length	Maximum Length	Total Measured
2005	16	2	31	28,972
2006	16	5	31	39,572
2007	16	4	29	23,768
2008	16	1	28	39,302
2009	16	4	28	33,403
2010	16	5	29	27,176
2011	16	5	30	32,000
2012	16	4	30	29,865
2013	16	1	32	33,776
2014	16	1	28	26,354
2015	16	2	30	19,717
2016	17	6	27	14,712
2017	17	3	30	14,775
2018	17	2	27	8,892
2019	16	8	26	8,355
2020	17	10	28	4,163
2021	16	11	27	4,360

Table 3. Southern flounder total length (inches) data for MRIP recreational fishery sampling in North Carolina, 2005–2021.

Year	Mean Length	Minimum Length	Maximum Length	Total Measured
2005	17	13	26	202
2006	16	10	31	343
2007	17	14	24	220
2008	17	13	27	311
2009	17	12	26	306
2010	17	11	28	754
2011	17	14	26	478
2012	18	14	30	400
2013	17	13	27	390
2014	17	14	26	199
2015	17	14	24	177
2016	17	14	25	225
2017	17	14	26	215
2018	17	13	27	276
2019	18	14	24	131
2020	18	12	26	187
2021	17	15	26	168

Table 4. Southern flounder total length (inches) data for NCDMF fishery-independent sampling programs 2005–2021.

Year	Mean Length	Minimum Length	Maximum Length	Total Measured
2005	8	0	25	3,769
2006	9	0	23	3,560
2007	7	0	22	3,812
2008	10	0	27	4,270
2009	10	1	27	3,230
2010	9	1	23	4,168
2011	12	1	28	2,604
2012	10	1	26	4,878
2013	9	1	27	3,534
2014	9	1	25	2,339
2015	9	1	24	2,133
2016	11	2	30	1,426
2017	9	1	22	2,238
2018	9	0	24	2,123
2019	10	0	24	2,664
2020	5	1	18	595
2021	9	0	24	2,529

Table 5. Annual nominal relative abundance index values for southern flounder and standard error (SE) in NCDMF independent surveys (programs 120, 195, and 915) 1991–2021. Indices for programs 120 and 195 are considered juvenile (young-of-year) abundance indices.

Year	P915 Index	P915 SE	P195 Index	P195 SE	P120 Index	P120 SE
1991			0.6	0.2	1.13	0.17
1992			4.83	1.3	2.49	0.30
1993			3.81	1.1	2.93	0.38
1994			3.33	1.2	1.79	0.24
1995			2.83	0.7	1.69	0.24
1996			9.65	2.0	7.82	0.95
1997			3.1	0.8	2.74	0.29
1998			0.37	0.1	0.90	0.15
1999			1.91	0.5	2.49	0.30
2000			0.77	0.2	3.74	0.43
2001			0.82	0.3	4.38	0.46
2002			3.28	1.5	4.49	0.56
2003	5.63	0.58	2.94	0.8	6.31	1.01
2004	5.14	0.56	1.28	0.2	3.89	0.46
2005	4.37	0.42	3.25	1.0	3.05	0.38
2006	3.04	0.48	1	0.3	2.63	0.33
2007	2.38	0.27	1.07	0.3	3.64	0.39
2008	4.91	0.59	0.94	0.5	2.40	0.33
2009	3.37	0.44	1.28	0.3	1.93	0.26
2010	5.90	0.77	1.14	0.3	5.03	0.66
2011	3.84	0.59	0.6	0.2	1.09	0.19
2012	3.73	0.35	4.44	1.9	3.07	0.39
2013	4.26	0.40	1.05	0.3	2.64	0.33
2014	2.99	0.32	0.64	0.2	1.86	0.30
2015	2.19	0.38	2.46	0.4	1.67	0.27
2016	1.88	0.26	0.73	0.3	0.53	0.11
2017	2.21	0.24	6.02	2.2	1.03	0.16
2018	2.50	0.30	2.94	1.0	1.36	0.18
2019	3.17	0.40	3.74	1.0	1.03	0.20
2020*	NA	NA	1.94	0.88	0.62	0.13
2021*	3.84	0.63	0.78	0.30	2.38	0.36

* 2020/2021 sampling impacted by Executive Order (EO) 116, issued March 10, 2020.

Table 6. Age data for southern flounder from NCDMF sampling 2005–2021.

Year	Mean Age	Minimum Age	Maximum Age	Total Aged
2005	2	0	7	803
2006	2	0	6	877
2007	2	0	8	744
2008	2	0	7	1,107
2009	1	0	6	492
2010	1	0	7	1,233
2011	1	0	6	912
2012	1	0	6	1207
2013	1	0	6	972
2014	1	0	7	1,280
2015	2	0	6	834
2016	2	0	5	773
2017	1	0	7	1,178
2018	1	0	5	965
2019	1	0	6	2,119
2020	2	0	5	1,210
2021	NA	NA	NA	NA

Table 7. Management action taken as a result of Amendment 3 to the N.C. Southern Flounder FMP.

MANAGEMENT STRATEGY	OUTCOME
Management measures limiting the number of fishing days per week and the amount of yardage allowed for large mesh gill nets in various areas of the state	Implemented through proclamation (refer to Amendment 1)
A minimum distance (area dependent) between gill net and pound net sets, per NCMFC Rule 15A NCAC 03J .0103 (d)	Implemented through proclamation (refer to Amendment 1)
A recreational minimum size limit of 15 inches TL	Implemented through proclamation (Refer to Amendment 1)
Increase minimum mesh size to harvest southern flounder to 6.0- inch stretched mesh	Implemented through Proclamation (Refer to Supplement A to Amendment 1)
Increase minimum size limit for commercial fisheries to 15 inches	Implemented through Proclamation (Refer to Supplement A to Amendment 1)
Increase minimum mesh size for escape panels to 5.75-inch stretched mesh	Implemented through Proclamation (Refer to Supplement A to Amendment 1)
Removal of all commercial gears targeting southern flounder from the water (e.g., commercial and RCGL anchored large mesh gill nets and gigs) or make them inoperable (flounder pound nets) in areas and during times outside of the seasons implemented. Exceptions will be allowed for commercial large mesh gill net fisheries that target American and hickory shad and catfish species if these fisheries are only allowed to operate during times of the year and locations where bycatch of southern flounder is unlikely	Implemented through Proclamation (Refer to Amendment 2)
Making it unlawful to possess flounder in internal and ocean waters during the closed recreational season.	Implemented through Proclamation (Refer to Amendment 2)
Making it unlawful to possess flounder harvested from the internal waters of the state during the closed commercial season	Implemented through Proclamation (Refer to Amendment 2)
Making it unlawful to use any method of retrieving live flounder from pound nets that cause injury to released fish (no picks, gigs, spears, etc.)	Implemented through Proclamation (Refer to Amendment 2)

MANAGEMENT STRATEGY	OUTCOME
Reduce commercial anchored large-mesh gill net soak times to single overnight soaks where nets may be set no sooner than one hour before sunset and must be retrieved no later than one hour after sunrise the next morning in the Neuse, Tar/Pamlico rivers and the Albemarle Sound areas that have previously been exempt	Implemented through Proclamation (Refer to Amendment 2)
Reduce the maximum yardage allowed in the commercial anchored large-mesh gill net fishery by 25% for each Management Unit; allowing a maximum of 1,500-yards in Management Units A, B, and C, and a maximum of 750-yards in Management Units D and E unless more restrictive yardage is specified through adaptive management through the sea turtle or sturgeon Incidental Take Permits (ITP).	Implemented through Proclamation (Refer to Amendment 2)
Reduce daily bag limit for recreational harvest of southern flounder to 1 flounder per person per day	Implemented through Proclamation (Amendment 3)
Implement quota for the commercial mobile gear and pound net fisheries and define management areas	Implemented through Proclamation (Refer to Amendment 3)
Implement recreational (hook and line, gig) seasons to constrain them to an annual quota	Implemented through Proclamation (Refer to Amendment 3)
Eliminate harvest of southern flounder through the use of a Recreational Commercial Gear License	Implemented through Proclamation (Refer to Amendment 3)
Implement trip limits for gigs and pound nets only to maximize reopening only after reaching division closure threshold	Implemented through proclamation (Refer to Amendment 3)
Implement a one-fish ocellated bag limit during March 1 through April 15 in ocean waters only using hook-and-ling gear	Implemented through proclamation (Refer to Amendment 3)
Adopt the adaptive management framework based on the peer-reviewed and approved stock assessment	Implemented through proclamation (Refer to Amendment 3)
The NCMFC approved a motion to set the allocation for Amendment 3 at 70% commercial and 30% recreational at the February 26, 2021, business meeting	Implemented through proclamation (Refer to Amendment 3)
Continue to allow anchored large-mesh gill nets to harvest southern flounder in the North Carolina southern flounder fishery	Implemented through proclamation (Refer to Amendment 3)

FIGURES

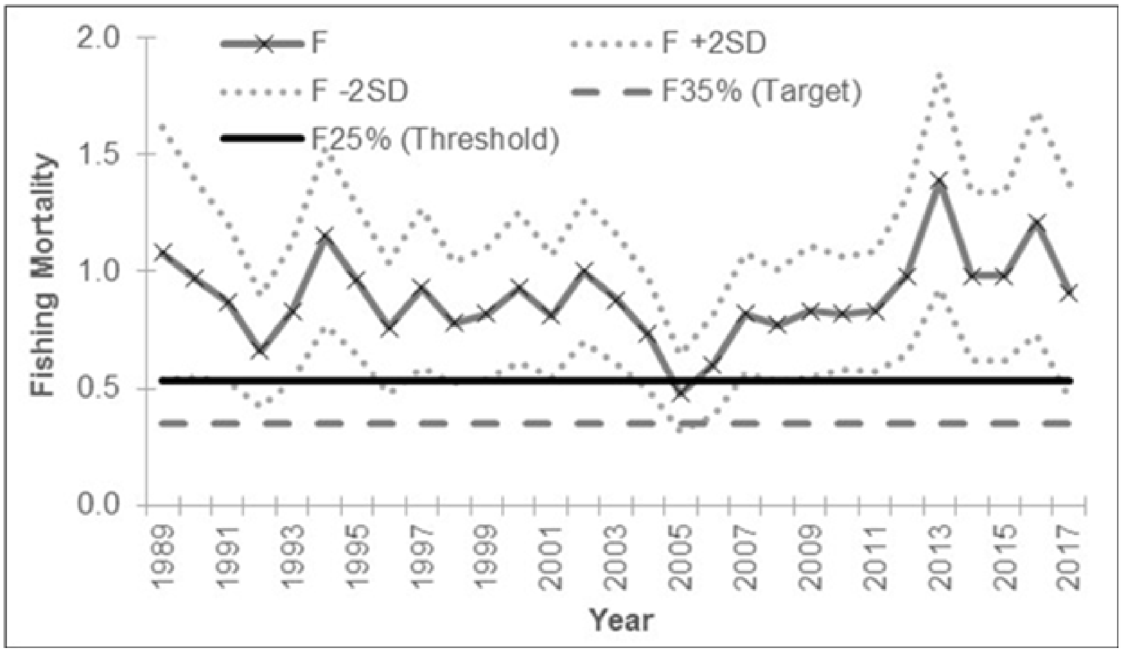

Figure 1. Estimated fishing mortality rates (numbers-weighted, ages 2–4) compared to established reference points, 1989–2017. (Source: Flowers et al. 2019).

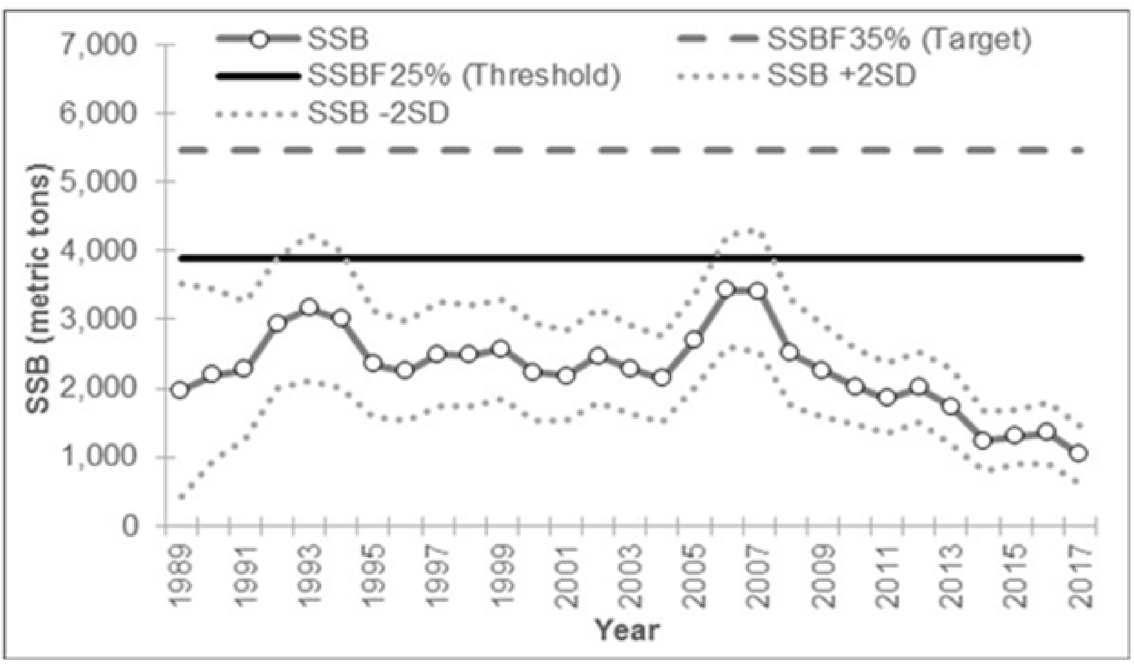

Figure 2. Estimated spawning stock biomass compared to established reference points, 1989–2017. (Source: Flowers et al. 2019).

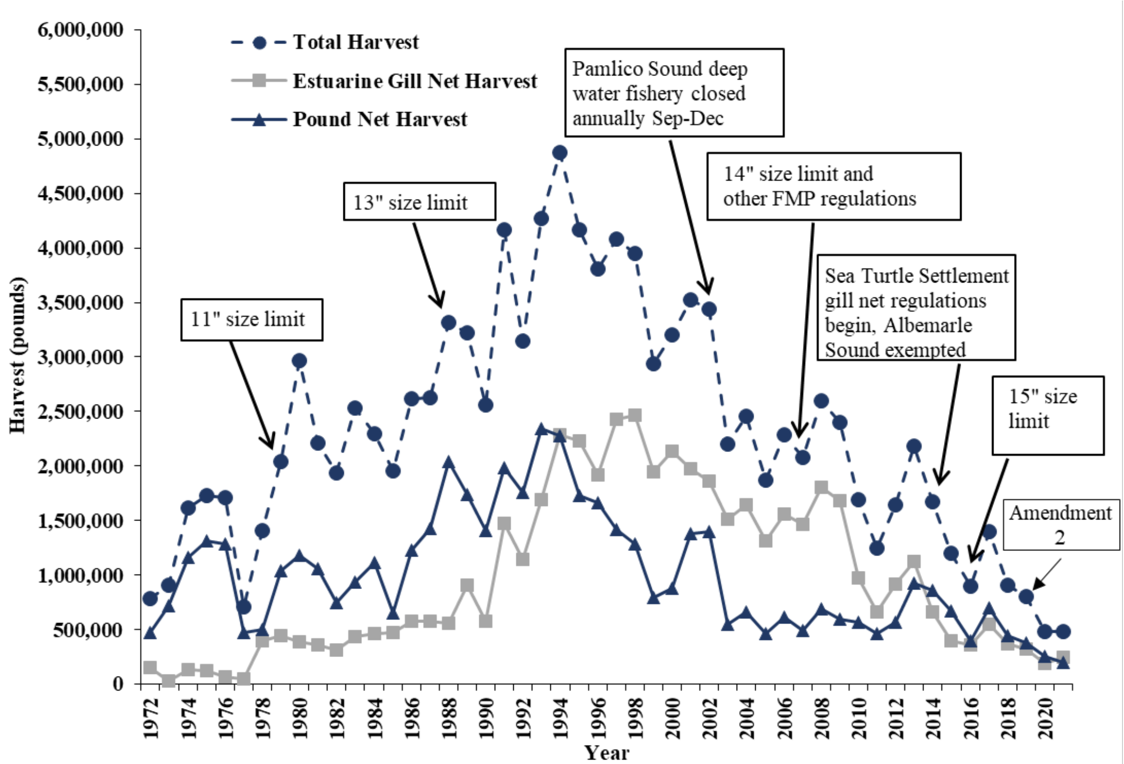

Figure 3. Southern flounder harvest (pounds) for total commercial fishery and top two gears (gill nets and pound nets) from N.C. Trip Ticket Program 1972–2021 with major fishery regulation changes.

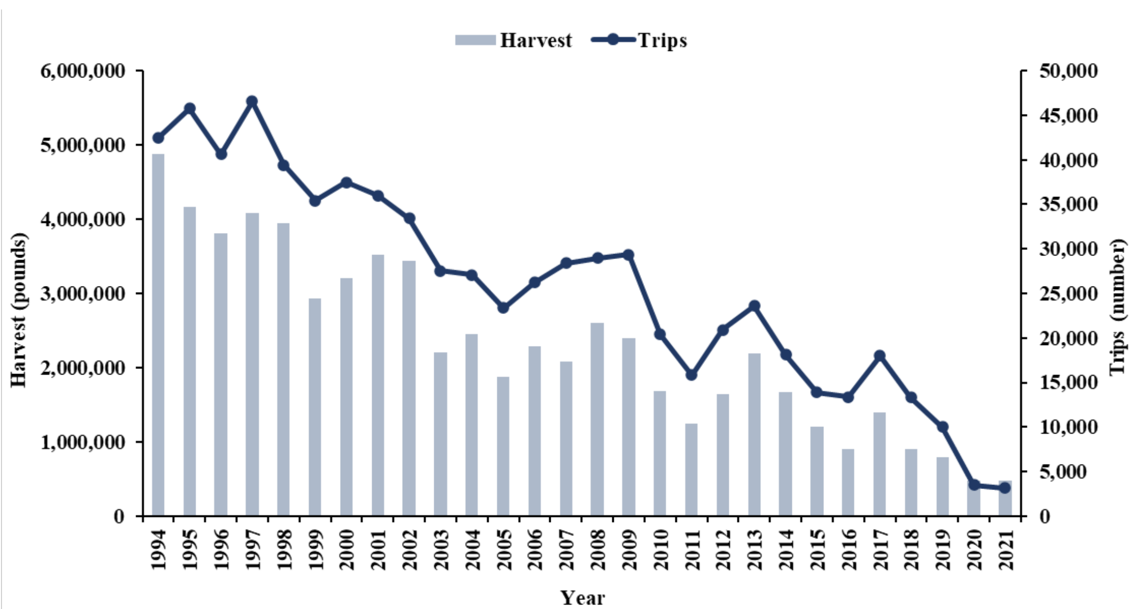

Figure 4. Southern flounder commercial trips (numbers) and harvest (pounds) from N.C. Trip Ticket Program, 1994–2021.

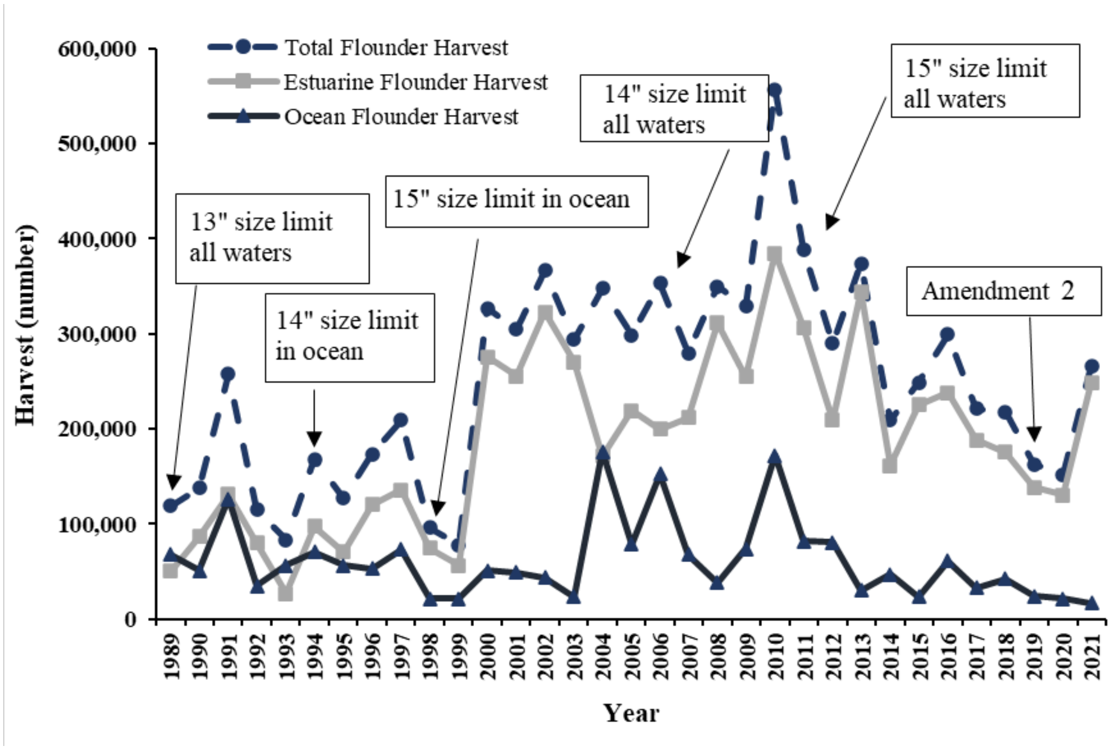

Figure 5. Southern flounder recreational hook and line harvest in numbers of fish from MRIP data 1989–2021 and major fishery regulation changes.

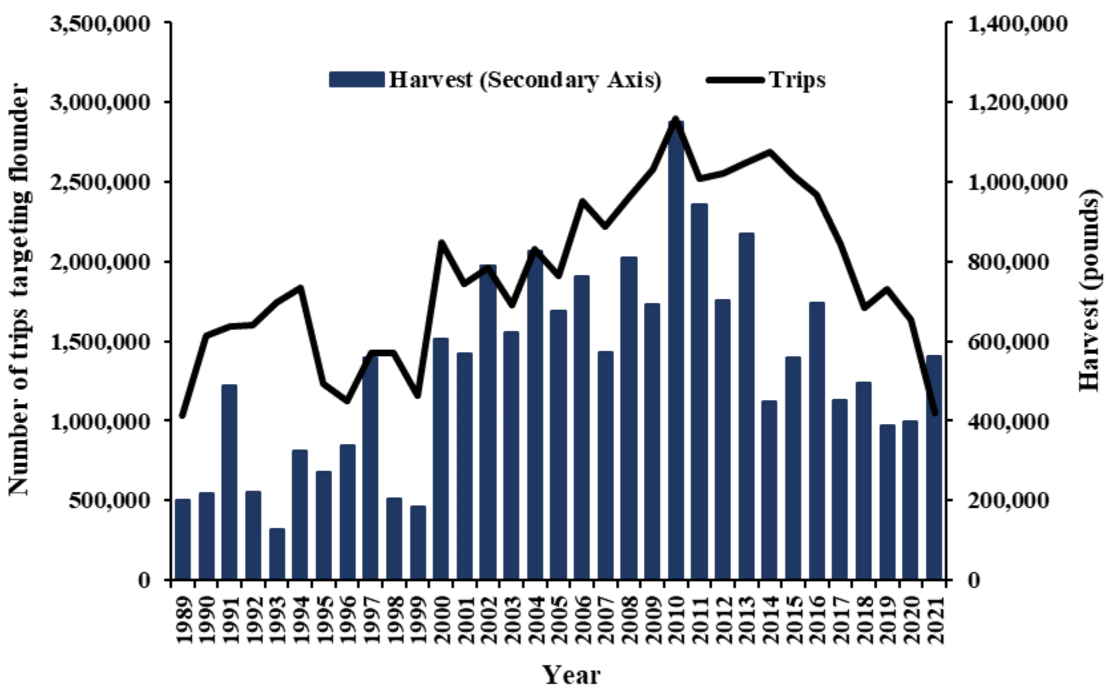

Figure 6. Recreational hook and line harvest (in numbers of fish) and all trips that harvested or released paralichthid flounder species, from MRIP data 1989–2021. Data from prior to 2004 were calibrated to align with MRIP estimates post-2004.

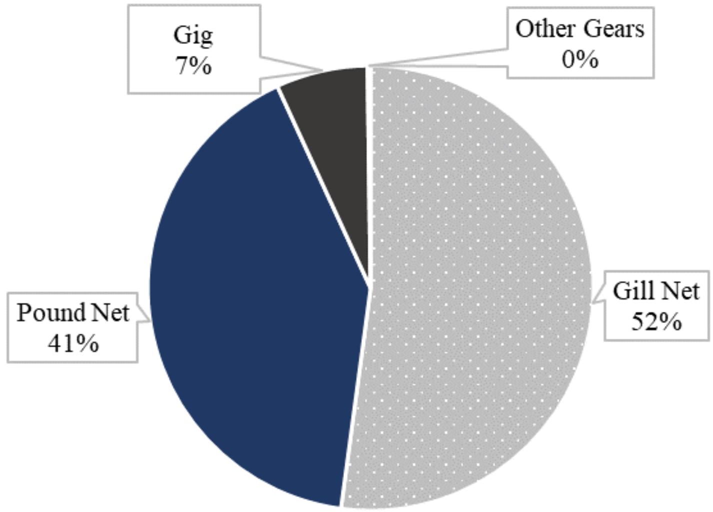

Figure 7. North Carolina commercial harvest of southern flounder in 2021 by gear type.

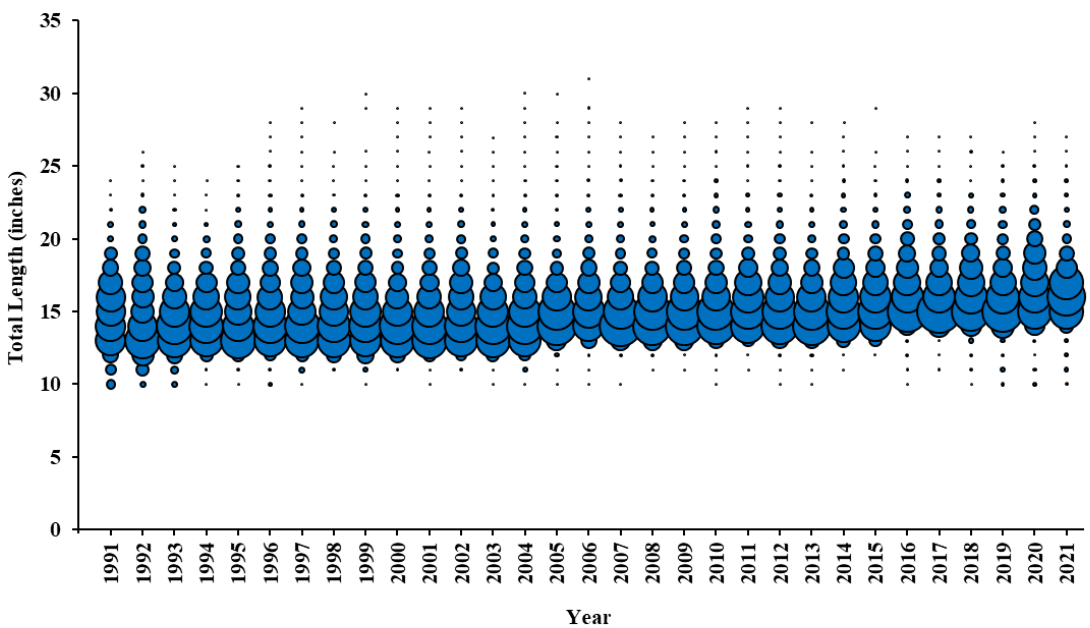

Figure 8. Commercial length frequency (total length, inches) of southern flounder harvested in North Carolina, 1991–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

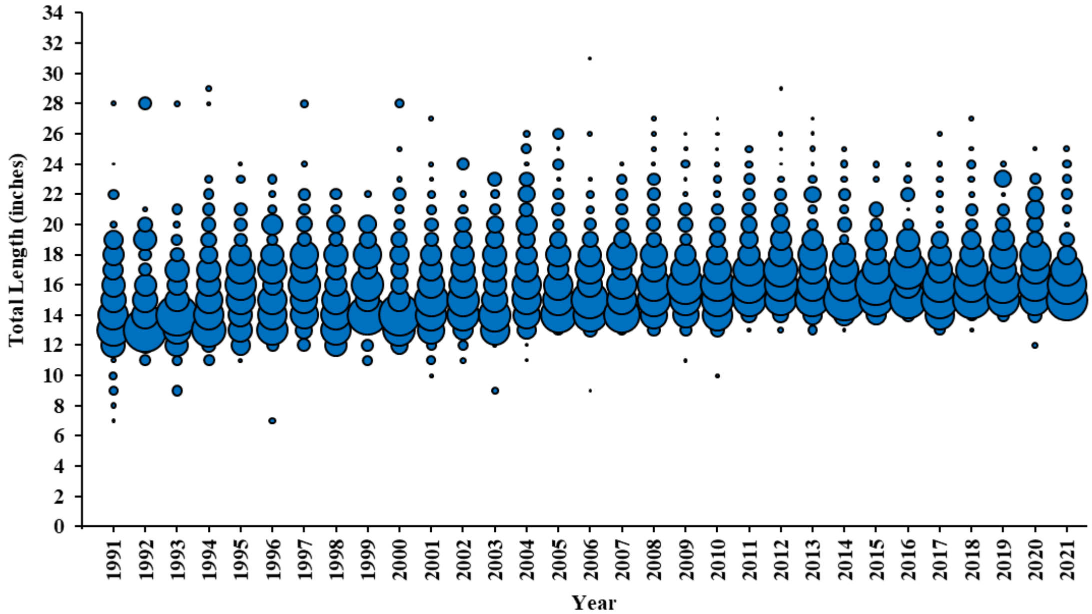

Figure 9. Recreational length frequency (total length, inches) of southern flounder harvested in North Carolina from MRIP, 1991–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

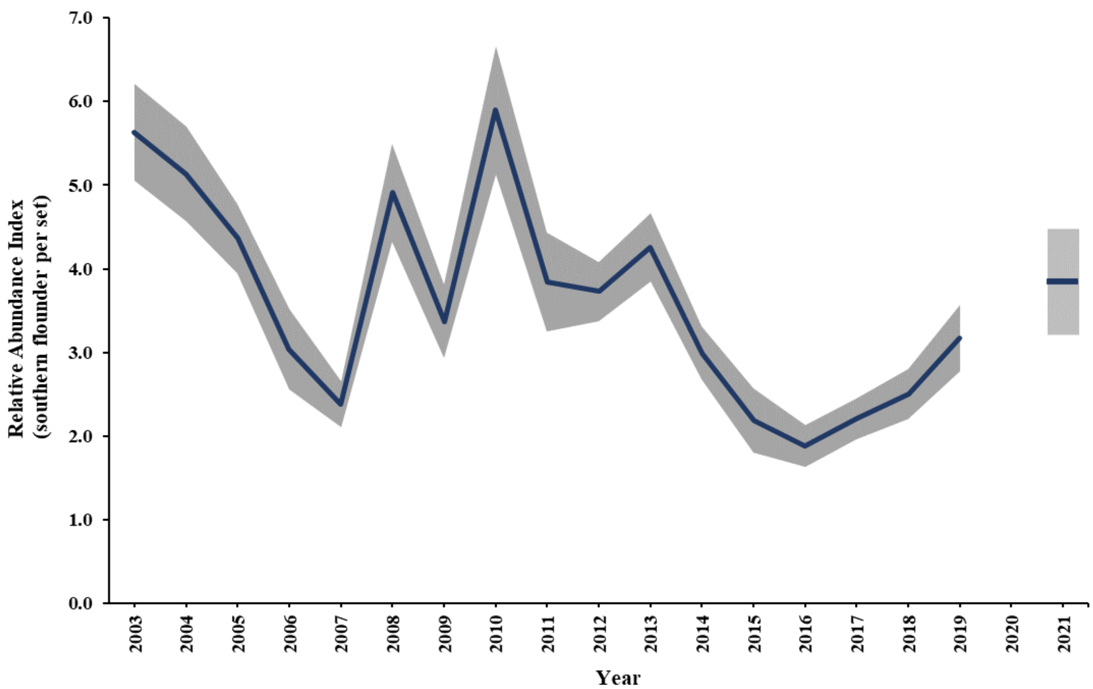

Figure 10. Annual nominal relative abundance index with standard error shaded in gray for southern flounder (juveniles and adults) caught in the North Carolina Pamlico Sound Independent Gill Net Survey, 2003–2021. Note: 2020 and 2021 sampling impacted by Executive Order (EO) 116, issued March 10, 2020.

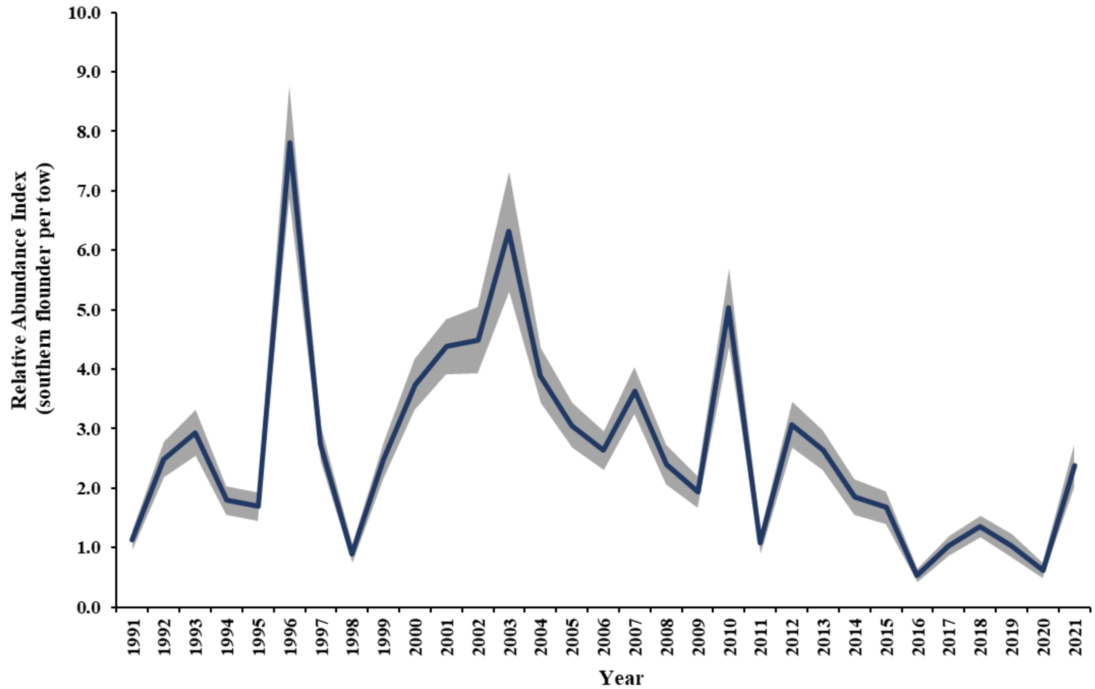

Figure 11. Annual nominal relative abundance index with standard error shaded in gray for southern flounder (juveniles and adults) caught in the North Carolina Estuarine Trawl Survey, 1991–2021. Note: 2020 sampling impacted by Executive Order (EO) 116, issued March 10, 2020.

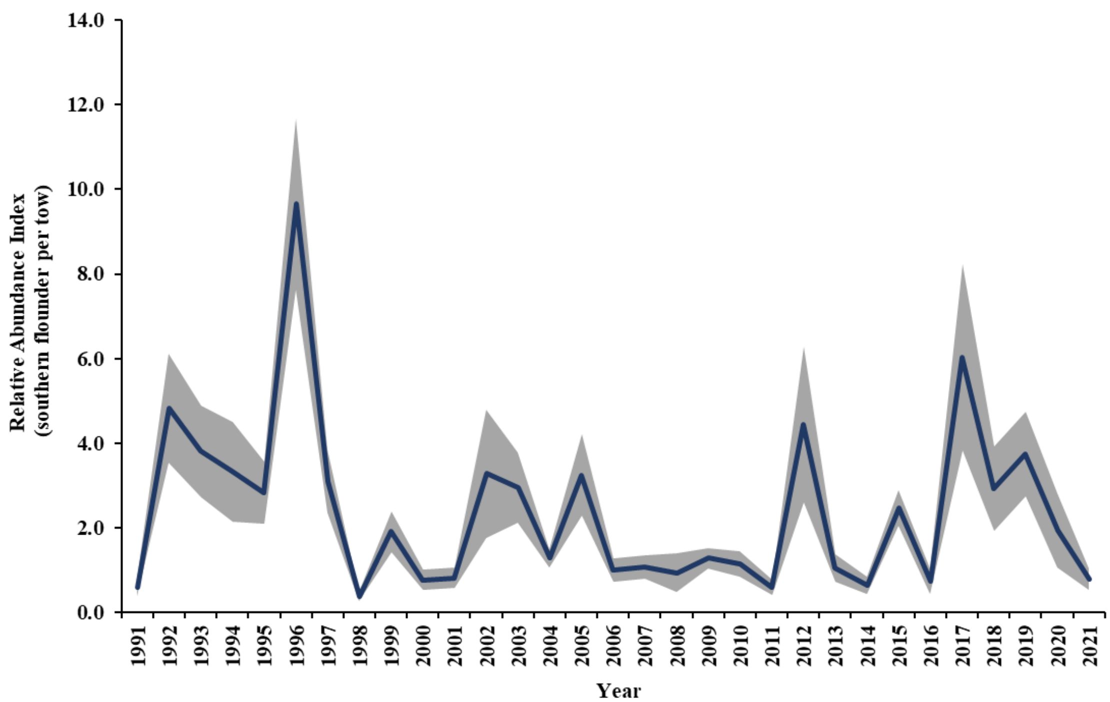

Figure 12. Annual nominal relative abundance index with standard error shaded in gray for southern flounder (juveniles and adults) caught in the North Carolina Pamlico Sound Survey, 1991–2021. Note: 2020 and 2021 sampling impacted by Executive Order (EO) 116, issued March 10, 2020.

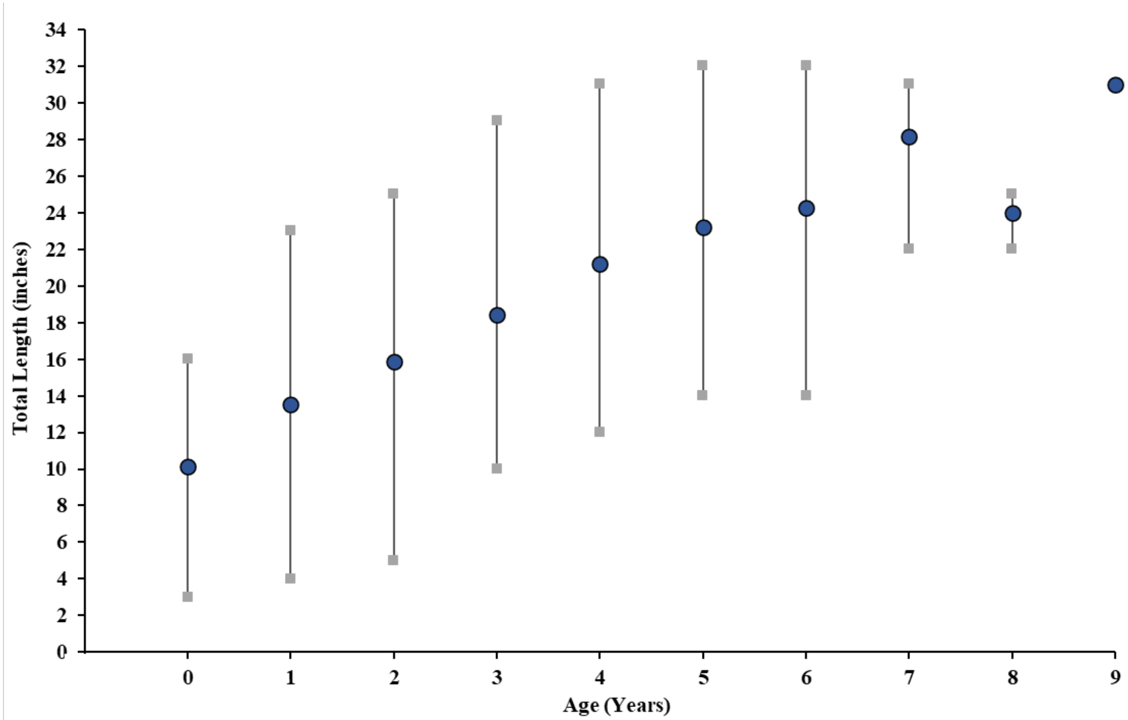

Figure 13. Southern flounder length at age based on all age samples collected in North Carolina, 1991–2020. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
SPOTTED SEATROUT
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	February 2012	
Amendments:	None	
Revisions:	None	
Supplements:	Supplement A to the FMP	February 2014
Information Updates:	None	
Schedule Changes:	None	
Comprehensive Review:	2019 — Ongoing	

Spotted seatrout (*Cynoscion nebulosus*) is 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 the North Carolina FMP for Interjurisdictional Fisheries (NCDMF 2022). Supplement A to the 2012 North Carolina Spotted Seatrout FMP (NCDMF 2014) 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. The 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 a new amendment is completed.

As required in the approved 2012 FMP, a stock assessment (NCDMF 2015a) 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 began in late 2020. The North Carolina Division of Marine Fisheries (NCDMF) will review the state FMP for spotted seatrout to determine if changes to management are needed through the FMP amendment process, after the stock assessment is complete and accepted for management use.

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 limit).
- Manage the spotted seatrout stock to maintain appropriate 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; NCDMF 2022). 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.

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:

- Develop an objective management program that provides conservation of the resource and sustainable harvest in the fishery.
- Ensure the spawning stock is of sufficient capacity to prevent recruitment-overfishing.
- Address socio-economic concerns of all user groups.

- Restore, improve, and protect important habitats that affect growth, survival, and reproduction of the North Carolina spotted seatrout stock.
- Evaluate, enhance, and initiate studies to increase understanding of spotted seatrout biology and population dynamics in North Carolina.
- Promote public awareness regarding the status and management of the North Carolina spotted seatrout stock.

DESCRIPTION OF THE STOCK

Biological Profile

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). Genetic data supports a single unit stock in Virginia and North Carolina (Ellis et al. 2019). In addition, based on genetic data, New River, North Carolina is an area of complex, seasonal mixing between two genetically distinct populations (Ellis et al. 2019): Georgia through Cape Fear River, North Carolina, and Bogue Sound, North Carolina and north (O'Donnell et al. 2014; Ellis et al. 2019). 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 9.9 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 2015b) indicated the spotted seatrout stock in North Carolina and Virginia is not overfished and overfishing is not occurring (Figures 1 and 2).

Stock Assessment

The 2014 assessment of 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 2015b). Data included 1991 through 2012 and relied on expanded fishery-independent data sources, including Virginia age, a juvenile abundance index, and North Carolina State University tag-return data (Ellis 2014). The fishing year was defined as the biological year, March 1 through February 28 or 29, to incorporate cold stun mortalities within a single model year.

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) has declined since 2007. In 2012, estimated SSB was 2,513,270 pounds (1,140 metric tons), which is greater than the threshold (SSB30%=868,621 pounds or 395 metric tons; Figure 1), indicating the stock is not overfished. There is no trend in fishing mortality (*F*), but periods of high *F* seem to coincide with spawning stock biomass declines and may be attributed to cold stun events. The 2012 estimate of fishing mortality was 0.40, which is less than the threshold (F20%=0.66), indicating 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 began in 2020 coinciding with the scheduled FMP review and is scheduled to be completed in late 2022.

DESCRIPTION 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 state-wide cold stun event.

Commercial Fishery

Annual landings have been variable throughout the time series (Table 1; Figure 3). Commercial landings in 2021 (694,784 pounds) increased by 22% compared to the previous year (568,574 pounds; Table 1; Figure 3). Commercial landings in 2021 were the highest since 1991. This sharp increase in commercial landings is most likely due to several strong year classes of fish and mild winters in 2019, 2020 and 2021, resulting in high numbers of available fish. During the early to mid-1990s, landings in the ocean and estuarine areas were more similar than in the remainder of the time series (1995-2021) in which estuarine landings have dominated. The primary gear of harvest are estuarine gill nets (set, drift, and run around).

Recreational Fishery

Recreational landings of spotted seatrout are estimated from the Marine Recreational Information Program (MRIP). Recreational estimates across all years have been updated and are now based on the MRIP's new Fishing Effort Survey-based calibrated estimates. For more information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational harvest of spotted seatrout estimated by MRIP (Type A + B1) in 2020 was 2,241,421 pounds, or 1,223,508 fish, much higher than the time series average of 1,535,506 pounds, or 976,689 but lower than the previous year (Table 1; Figure 3). Estimated recreational releases in 1(6,332,064 fish) were well above the time series average of 3,484,026 fish, and slightly higher than the previous year's releases of 6,215,778 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 338 citations (Table 2; Figure 4). The number of awarded citations in 2021 (655 citations) increased from the previous year (579 citations) and was the highest number of citations since 2007 (1,000 citations). The number of release citations (fish over 24 inches that are released) awarded (283 release citations) was the highest since release citations began in 2008. The percent of spotted seatrout release citations (43%) was the highest since 2018 and 2019 (both at 37%; 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; in addition, modal length for the commercial fishery was slightly higher (17 inches fork length) than the recreational fishery (15 inches fork length; Table 3; Figure 5). Undersized fish represent a small portion of the harvest in both sectors; 4.5% of commercial harvest and 1.3% of the recreational harvest was below the 14-inch size limit in 2021 (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. The mean length of spotted seatrout in 2021 (17.5 inches fork length) was similar to the time series (1991-2020) average (16.6 inches fork length) and the mean and minimum lengths in 2021 (17.5 and 10.9-inches fork length, respectively) were all approximately equal to the previous two years (Table 3; Figure 6). In addition, for the past three years (2019-2021), minimum length has been consistently greater than the time series average (9.3 inches fork length). Maximum length in 2021 decreased to 29.9 inches fork length and was just above the time series average (29.3 inches fork length). The bulk of spotted seatrout landings by the commercial fishery in 2021 came from the ocean and estuarine gill net fishery (95%) with pound nets (2%), gigs (1%), and all other gears (mainly beach seines, swipe nets, and haul seines) accounting for the rest (2%).

Recreational catch is almost exclusively hook-and-line with few fish being landed by gigs. The mean (17.0 inches fork length), minimum (11.1 inches fork length), and maximum (26.5 inches fork length) lengths of fish measured in 2021 from the recreational fishery were similar to the previous year (17.0, 12.1, 26.8 inches fork length, respectively) and greater than the time series (1991-2020) average of each (16.0, 10.4, 25.8 inches fork length, respectively; Table 3; Figure 7). Ninety-two percent of the spotted seatrout sampled from the recreational fishery in 2021 were between 14 and 19 inches (Figure 5).

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 and June. 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 spotted seatrout specific stations are used to generate an index of relative abundance of age zero spotted seatrout, calculated as the average number of fish per tow. The resulting relative abundance index for the time series is variable with no significant trend overall, and peaks in 2006, 2008, 2012, 2013, and 2018 suggesting relatively higher recruitment in those years (Figure 8). The Program 120 relative abundance index in 2021 was 0.20, which was a 70% decrease from the previous year, and the lowest value since the beginning in 2004 (0.67 spotted seatrout per tow). The 2021 relative abundance index was a 90% decrease from the time series average (2004-2020; 2.08 spotted seatrout per tow).

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 encompassing 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. Relative abundance from Pamlico Sound has remained relatively steady from 2001 to 2015 (averaged 0.51 fish per set), increased to a time series high in 2019 (1.81 fish per set) and remained high in 2021 (1.46 fish per set; Figure 9). For the central river stations that include Pamlico, Pungo and Neuse rivers, abundance rose sharply in 2021 to the highest value in the time series (1.38 fish per set). Spotted seatrout abundance in the Cape Fear and New rivers has fluctuated without trend throughout the time series (Figure 11). Relative abundance in 2021 in the Cape Fear and New rivers was 0.91 fish per set, the second highest value in the time series. During 2020 no indices of abundance are available for spotted seatrout from the fishery-independent assessment (Program 915). Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021.

Spotted seatrout age samples are collected from numerous NCDMF fishery independent and dependent sources. To date, a total of 20,668 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, ranging from age five to age nine. Modal ages, which give an indication of the age of the largest cohort in the fishery, averages age one. Spotted seatrout length-at-age was summarized based on all available age data (1991-2020; Figure 12). Average growth of spotted seatrout slows down around age-4, but fish as large as 24.7 inches have the potential to be young of the year (age-0), demonstrating the species' fast growth. In 2021, the number of fish aged (1,006 fish) increased from the previous year (634 fish), which is to be expected with delays in sampling due to COVID-19 in 2020. Spotted seatrout sampled in 2021 had a modal age of 1 and maximum age of 6, an increase from the previous year (5).

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; CRFL grant 2F40 is investigating an optimal sampling design for P120
- 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 Conducted
- Investigation of the relationship of temperature with both adult and juvenile mortality. — Ongoing: Ellis et al. 2017a, 2017b; CRFL project 2F40-F024 started in 2015, monitoring temperatures in overwintering habitat of spotted seatrout
- Incorporate cold stun event information into the modeling of the population. — Unsuccessfully attempted using stock synthesis model from the 2012 stock assessment, is being investigated in the 2019 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 from the 2012 stock assessment, is being investigated further during 2019 benchmark stock assessment

- Obtain samples (length, age, weight, quantification) of the cold stun events as they occur. — Ongoing: obtained samples in 2001, 2010, 2014, 2015, 2018; length, weight, sex, age; unable to quantify extent of kills
- Define overwintering habitat requirements of spotted seatrout. — Preliminary work completed in Ellis et. al (2017a, 2017b)
- 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. — Preliminary work completed in Ellis et. al (2017a)
- 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. — Not Completed
- 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. — Genetic study completed: NCSU study CRFL grant 2F40-F022; tagging studies ongoing: Tim Ellis data (2008-2013); CRFL project 2F40-F017, NC Multi Species Tagging Study 2014 — Present
- Tagging studies to verify estimates of natural and fishing mortality. — Ongoing: 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). — Ongoing: 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 time series available for P915 as well as P915 surveys 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

MANAGEMENT STRATEGY

Maintain a spawning potential ratio of 20% to 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 and 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. The Director maintains authority to intervene in the event of a catastrophic cold stun event and close the fishery in specific areas or statewide until June 15. This reduces fishing mortality on spotted seatrout until after the peak in their spawning season.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

The review of the plan is underway. A benchmark stock assessment is being conducted, incorporating data through February 2020.

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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 spotted seatrout from North Carolina for the period 1991–2021.

	Recreational			Commercial	
Year	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (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
2019	1,937,250	7,185,562	3,334,163	378,491	3,712,654
2020	2,053,354	6,215,778	3,632,315	568,764	4,201,079
2021	1,223,508	6,332,064	2,241,421	694,784	2,936,205
Mean	976,689	3,484,026	1,535,506	308,709	1,844,215

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 1991–2021.

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
2019	468	172	37
2020	579	193	33
2021	655	283	43

+ 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, 1991–2021.

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
2019	17.3	10.1	28.9	2,622	16.7	10.7	24.6	1,574
2020	17.5	10.9	33.4	2,851	17.0	12.1	26.8	1,119
2021	17.5	10.9	29.9	3,432	17.0	11.1	26.5	1,019

Table 4: Modal age, minimum age, maximum age, and number aged for spotted seatrout collected through NCDMF sampling programs, 1991–2021

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
2019	1	0	8	1,167
2020	2	0	5	634
2021	1	0	6	1,006

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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.	Preliminary research accomplished (Ellis et al. 2017a, 2017b), additional work 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

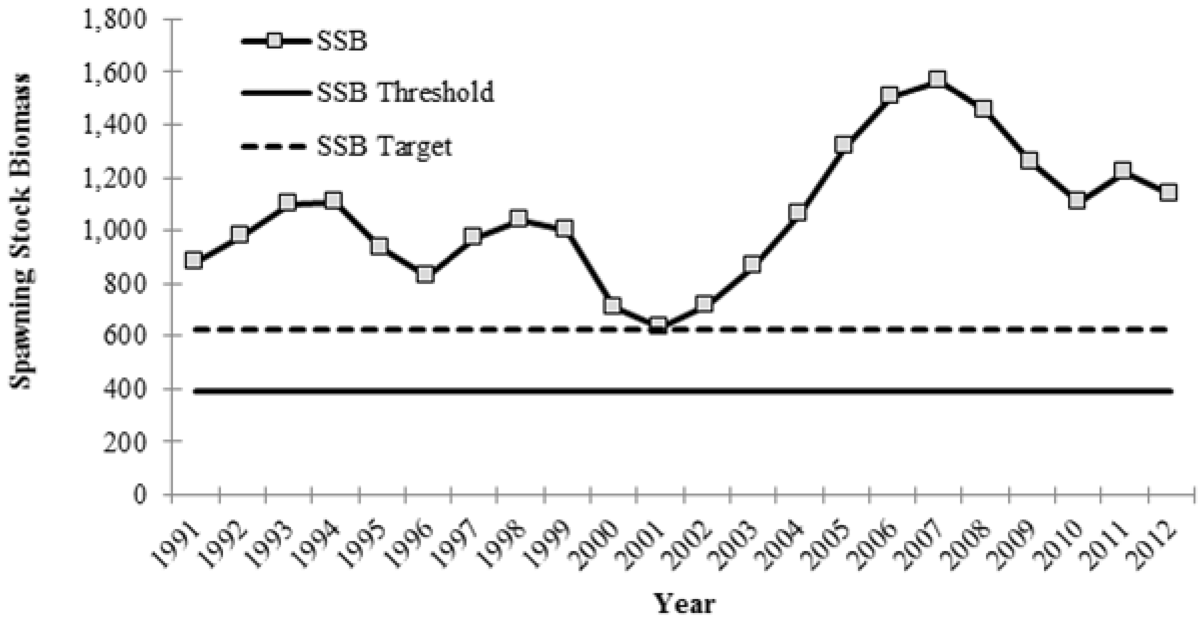


Figure 1. Annual predicted spawning stock biomass in metric tons, compared to estimated $SSB_{Threshold}$ ($SSB_{20\%}$) and SSB_{Target} ($SSB_{30\%}$), 1991–2012. 2012 is the terminal year for the last spotted seatrout stock assessment (NCDMF 2015b).

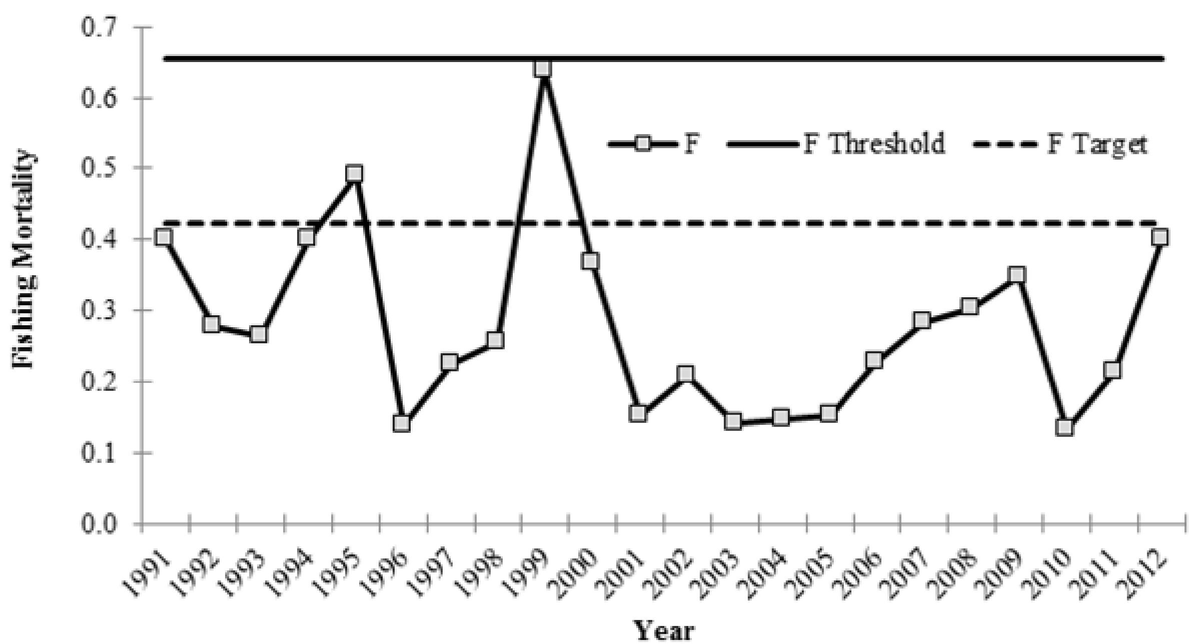
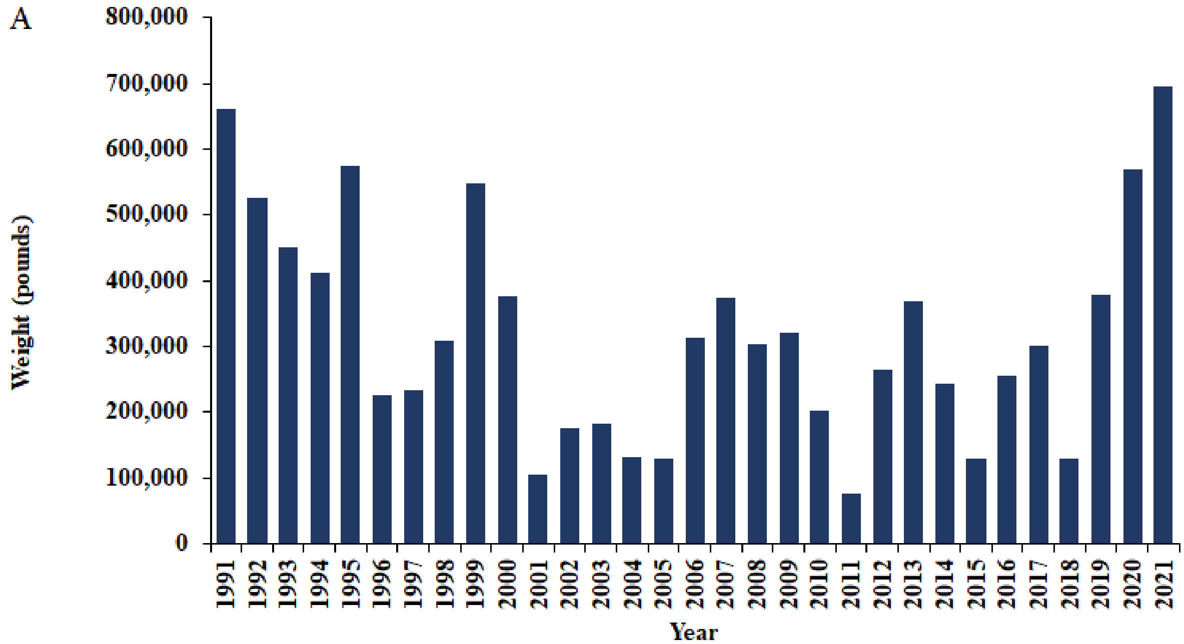


Figure 2. Annual predicted fishing mortality rates (numbers-weighted, ages 1–4) compared to estimated $F_{Threshold}$ ($F_{20\%}$) and F_{Target} ($F_{30\%}$), 1991–2012. 2012 is the terminal year for the last spotted seatrout stock assessment (NCDMF 2015b).



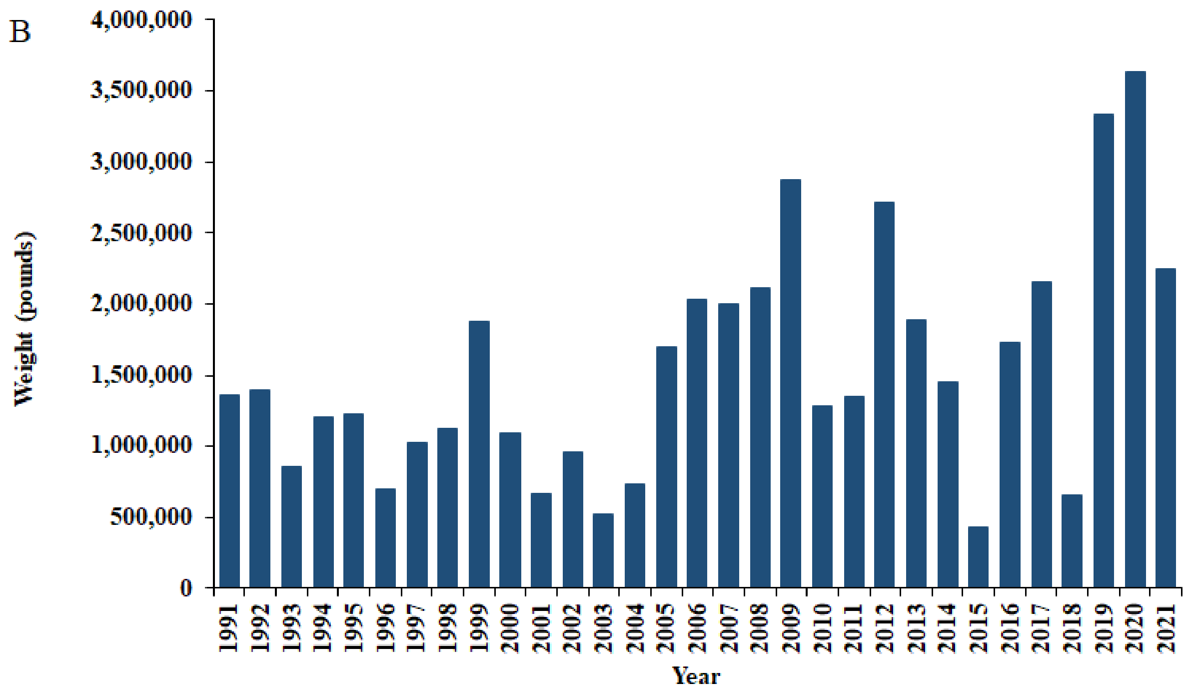


Figure 3. Commercial landings (pounds) reported through the North Carolina Trip Ticket Program (A) and recreational landings (Type A + B1; pounds) estimated from the Marine Recreational Information Program survey (B) for North Carolina, 1991–2021.

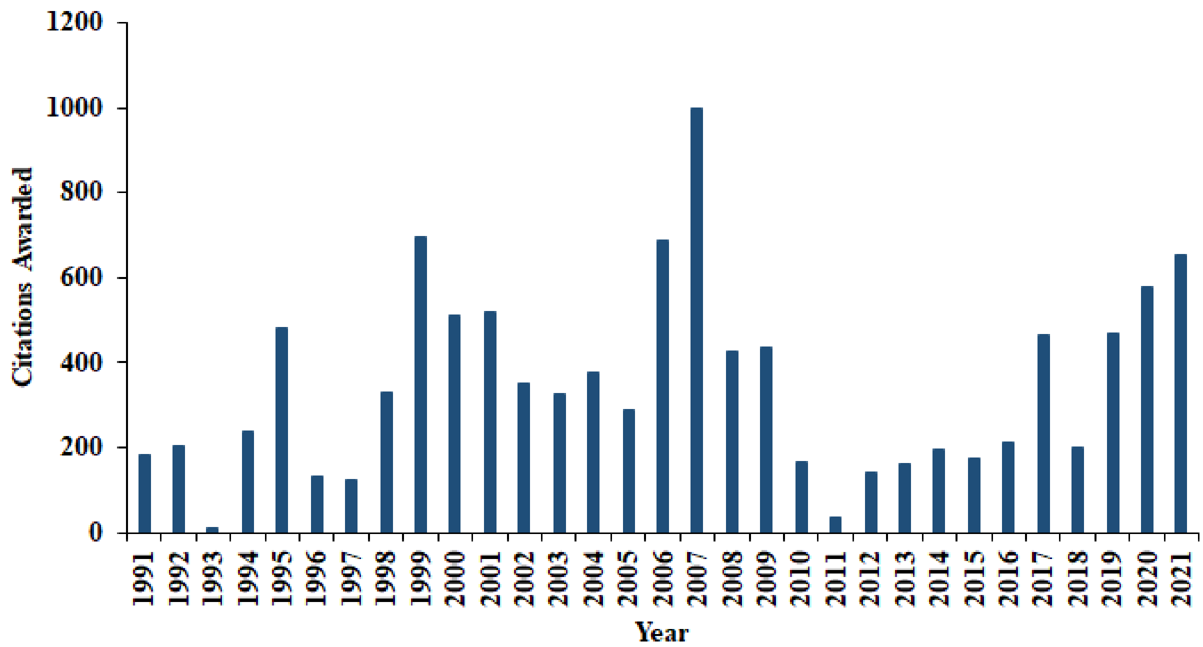


Figure 4. North Carolina Saltwater Fishing Tournament citations awarded for spotted seatrout, 1991–2021. Citations are awarded for spotted seatrout >24 inches total length for release or > five pounds landed.

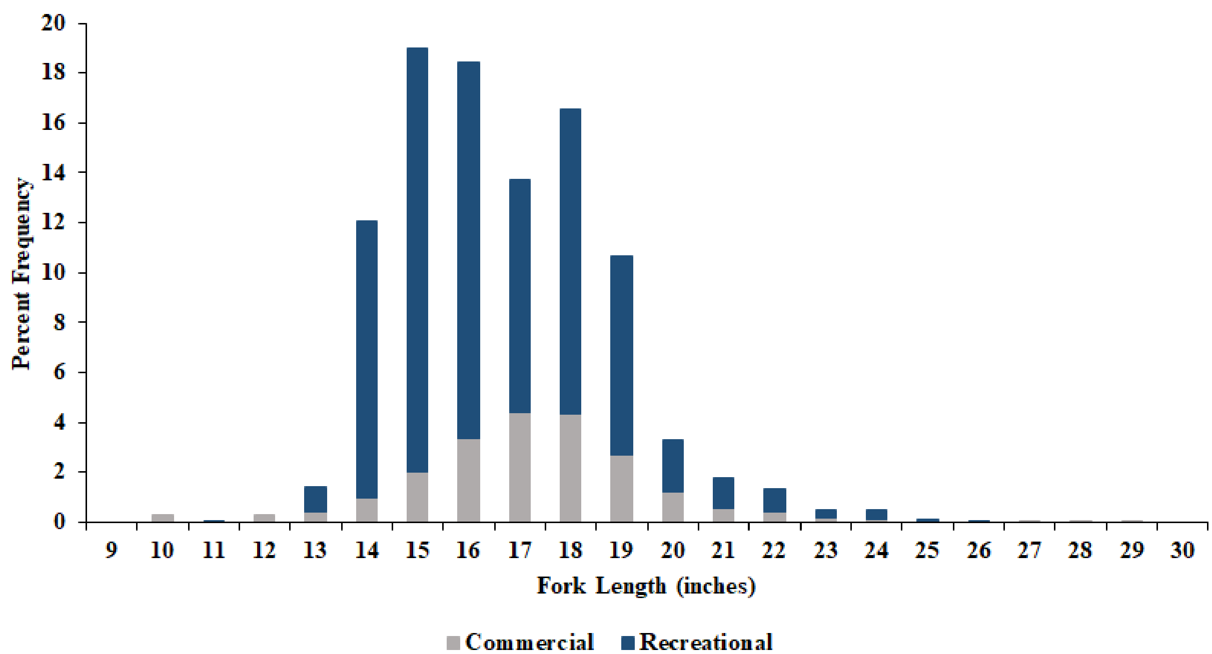


Figure 5. Commercial and recreational length frequency distribution from spotted seatrout harvested in 2021.

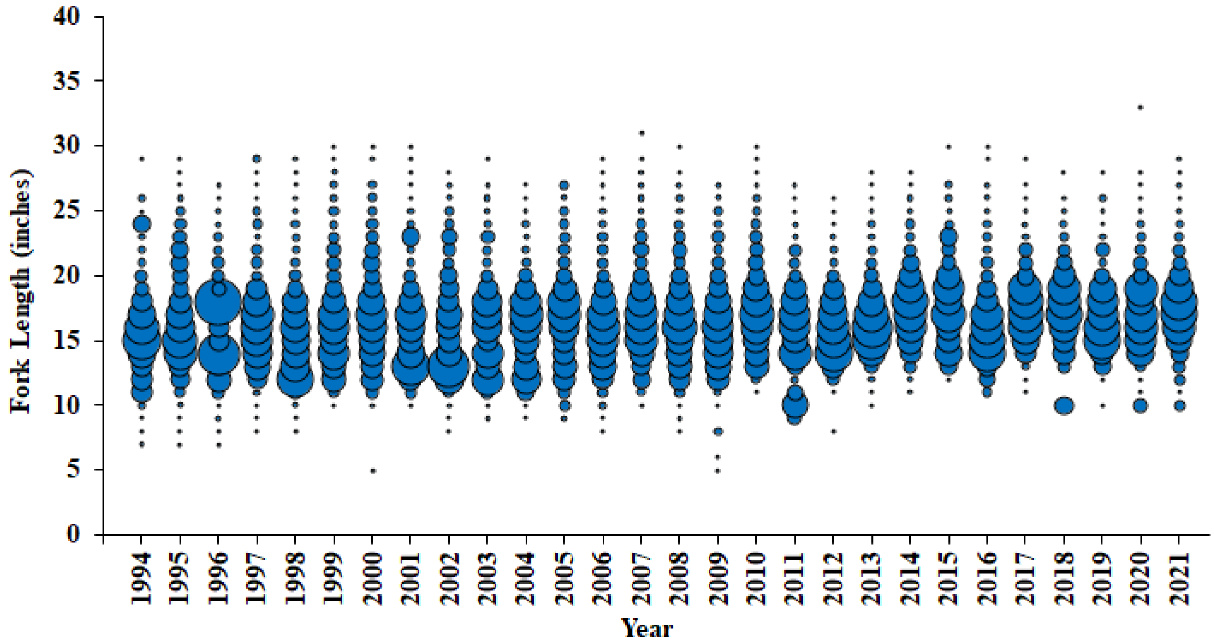


Figure 6. Commercial length frequency (fork length, inches) of spotted seatrout harvested, 1994–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

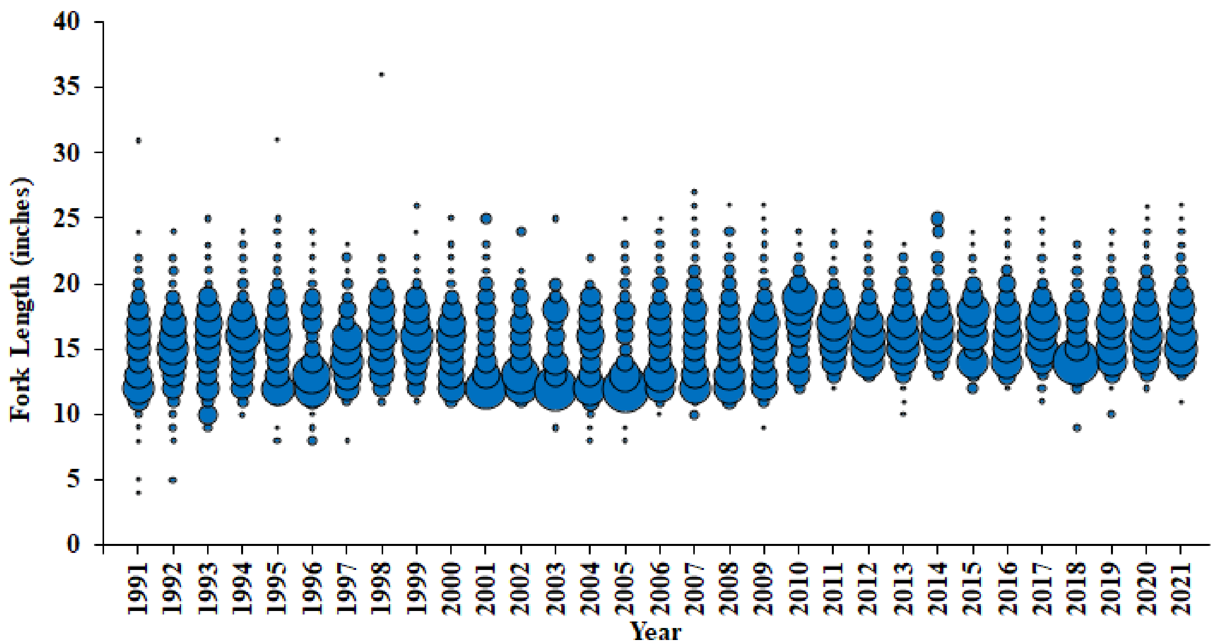


Figure 7. Recreational length frequency (fork length, inches) of spotted seatrout harvested, 1991–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

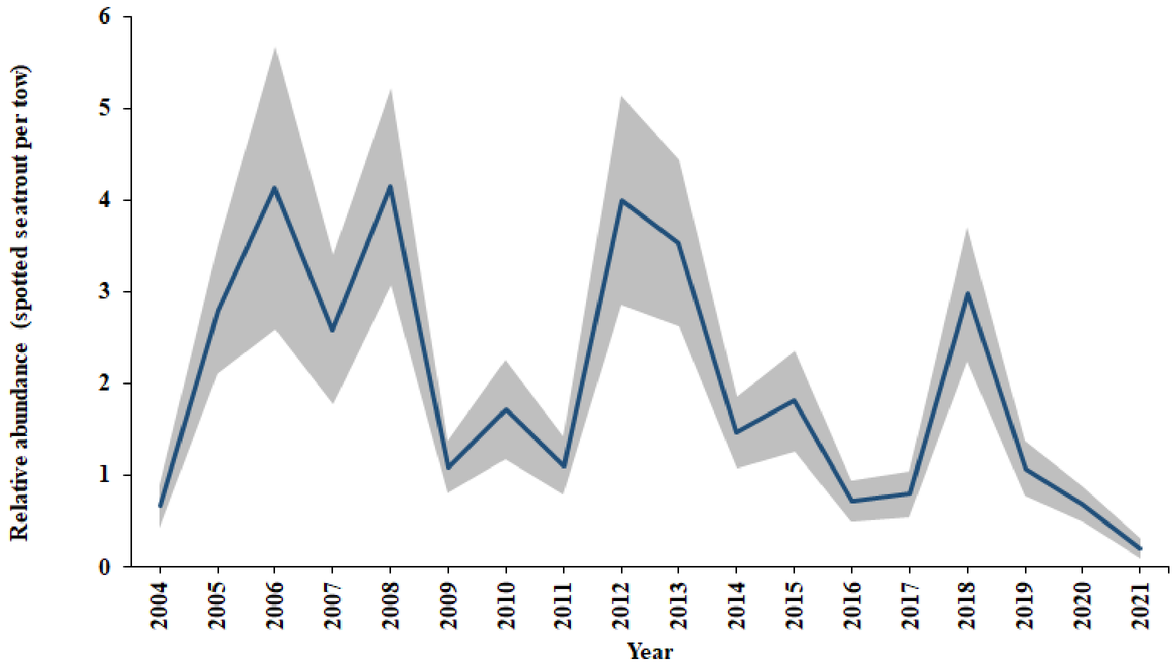


Figure 8. Relative abundance index (fish per tow) from the North Carolina Estuarine Trawl Survey (Program 120) during June and July, 2004–2021. Error bars represent ± 1 standard error.

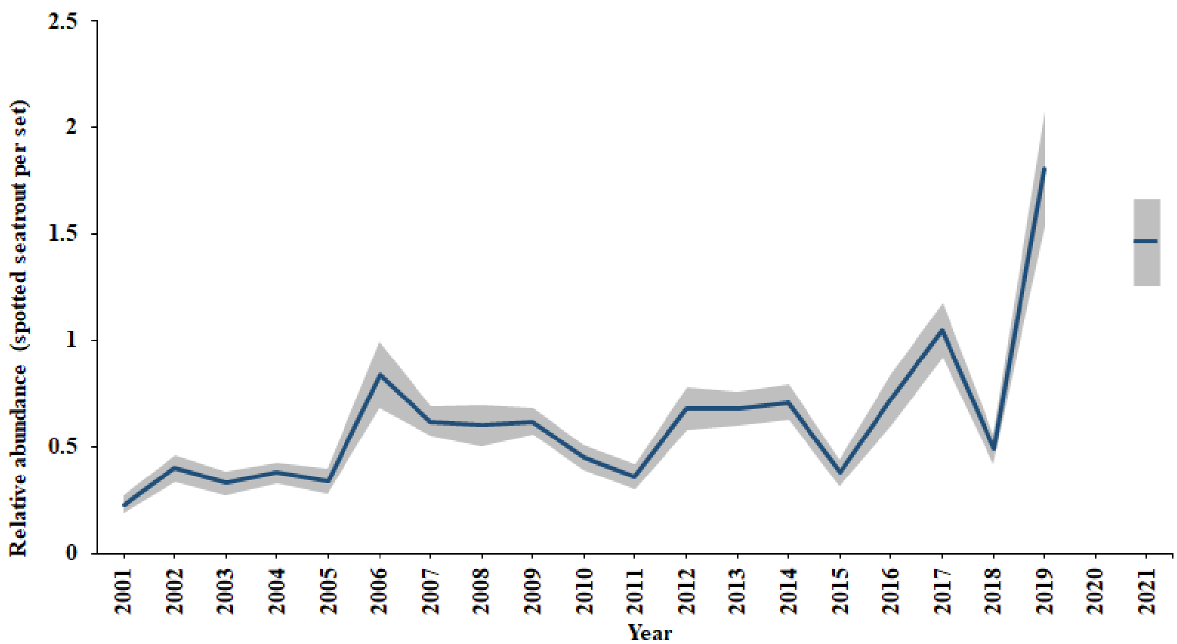


Figure 9. Relative abundance index (fish per set) of spotted seatrout collected from Program 915 in Pamlico Sound, 2001–2021. Error bars represent ± 1 standard error. Sampling not conducted in 2020.

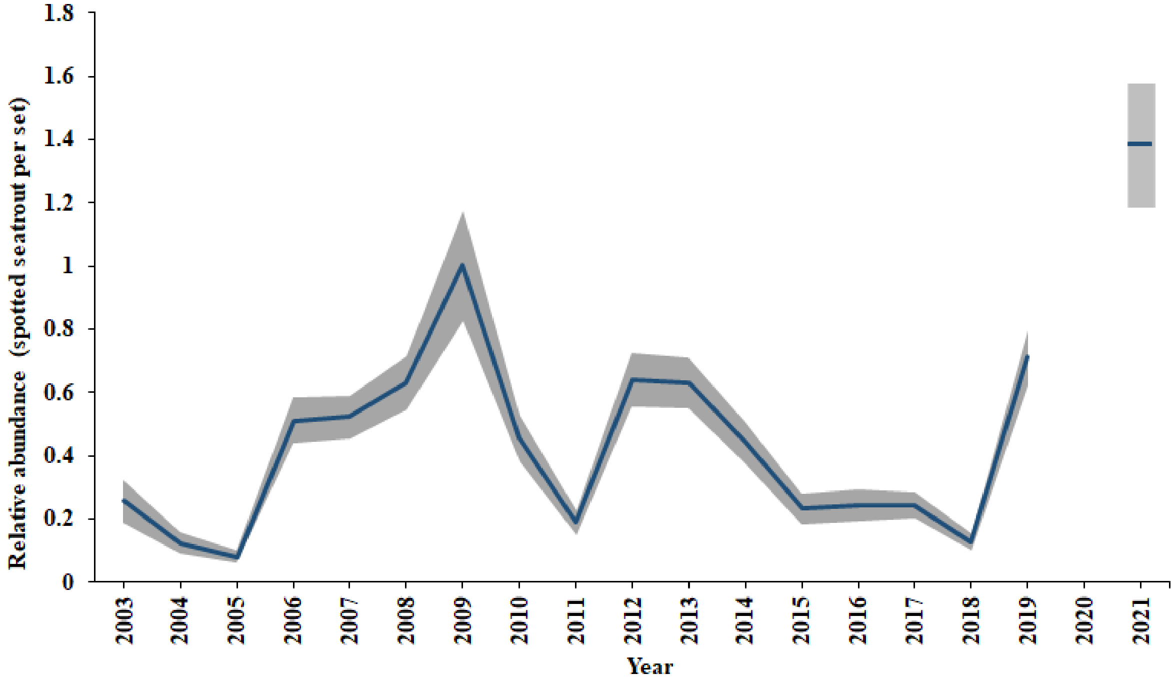


Figure 10. Relative abundance index (fish per set) of spotted seatrout collected from Program 915 in Pungo, Pamlico, and Neuse rivers, 2004–2021. Error bars represent ± 1 standard error. Sampling not conducted in 2020.

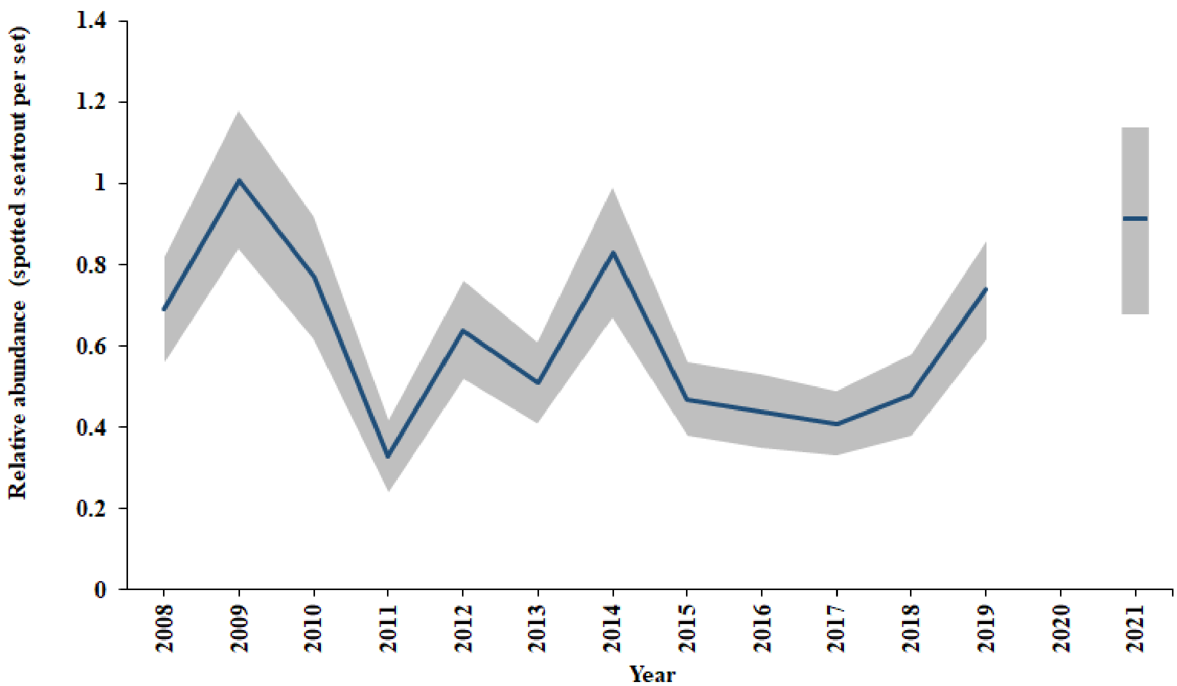


Figure 11. Relative abundance index (fish per set) of spotted seatrout collected from Program 915 in New and Cape Fear rivers, 2008–2021. Error bars represent ± 1 standard error. Sampling not conducted in 2020.

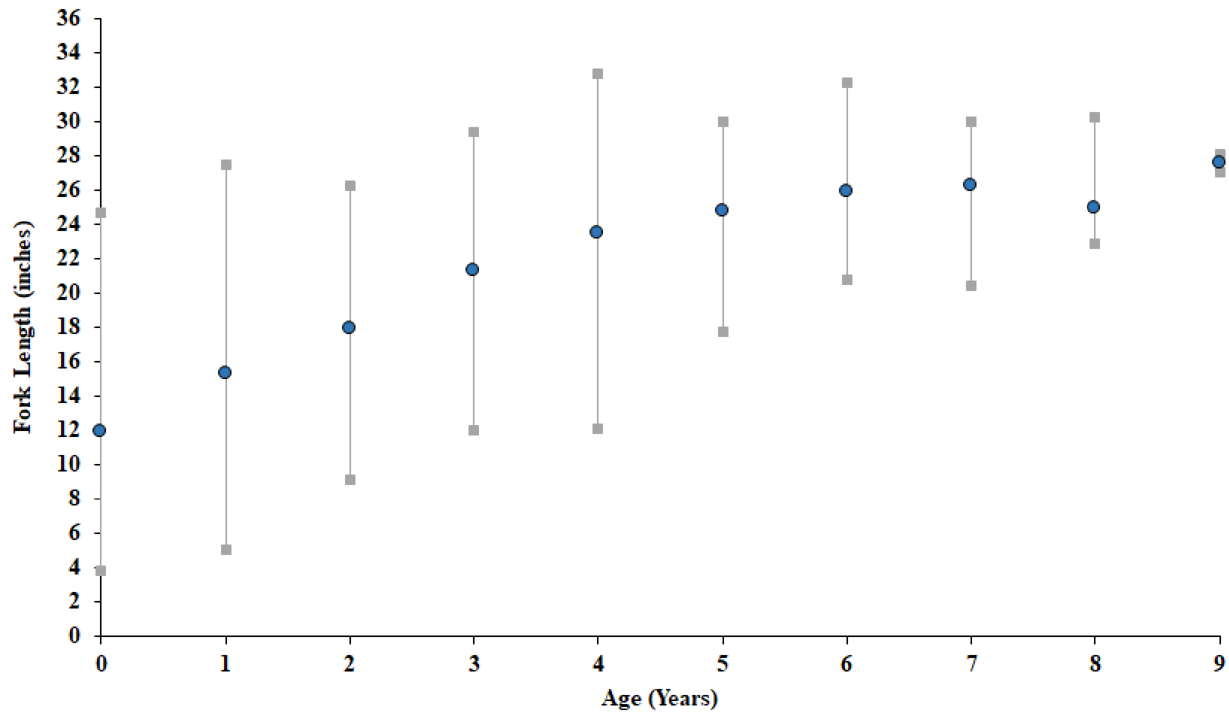


Figure 12. Spotted seatrout length at age based on all age samples collected from 1991 to 2020. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
STRIPED MULLET
AUGUST 2022

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	
Schedule Changes:	None	
Comprehensive 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 3A). 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 preliminary findings 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 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 but could not determine if the stock was overfished (NCDMF 2018).

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 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 2021 commercial landings indicate neither the maximum or minimum triggers have been exceeded. Review of the FMP was initiated in 2020, following the FMP review schedule.

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:

- 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.
- Promote the protection, enhancement, and restoration of habitats and water quality necessary for the striped mullet population.
- Minimize conflict among user groups, including non-fishing user groups and activities.
- Promote research to improve the understanding of striped mullet population dynamics and ecology to improve management of the striped mullet resource.
- Initiate, enhance, and/or continue studies to collect and analyze the socio-economic data needed to properly monitor and manage the striped mullet fishery.
- Promote public awareness regarding the status and management of the North Carolina striped mullet stock.

DESCRIPTION OF THE STOCK

Biological Profile

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, sand and 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).

The male and female maximum ages for striped mullet in North Carolina are 14 and 13 years old and a 15-year-old striped mullet of unknown sex was observed in 2017 by NCDMF (NCDMF 2022). The maximum size of striped mullet in North Carolina is recorded at 27.5 inches' total length (NCDMF 2022).

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). Spawning individuals have been reported from September to March; however, peak spawning activity occurs from October to early December (Bichy 2000). Skipped spawning has been exhibited by striped mullet on the east coast of Florida (Myers et al. 2020) and on the eastern coast of Australia (Fowler et al. 2016). Striped mullet in North Carolina appear to mature at a younger age and larger size than other striped mullet populations (Bichy 2000). Length at 50 percent maturity occurs at 11.1 inches fork length for males (Bichy 2000) and 12.6 inches fork length for females (NCDMF 2021a).

Stock Status

The 2022 North Carolina striped mullet stock assessment (NCDMF 2022) indicated the striped mullet stock in North Carolina is overfished and overfishing is occurring.

Stock Assessment

The North Carolina striped mullet stock was modeled using stock synthesis version 3.30, an integrated statistical catch-at-age, forward-projecting, length based, age-structured model using data from 1950 to 2019. Input data included commercial landings, recreational harvest, fisheries-independent survey indices (Program 915), and biological data collected.

Both the observed data and the model predictions suggest a decreased presence of larger, older striped mullet in the population. The model has estimated declining trends in age-0 recruitment and female spawning stock biomass (SSB) over the last several decades. Estimates of fishing mortality (F) exhibit an increasing trend. Model results also indicate consistent overestimation of biomass and the highest risk for overfishing.

A fishing mortality threshold of $F_{25\%}$ and a fishing mortality target of $F_{35\%}$ were maintained from the prior assessment since the fishery continues to target mature female fish during the spawning season and the ecological importance of striped mullet. Complementary reference points for stock size were adopted based on female SSB, $SSB_{25\%}$ and $SSB_{35\%}$. The stock assessment model estimated a value of 0.37 for $F_{25\%}$ and a value of 0.26 for $F_{35\%}$. These estimates represent numbers-weighted values for ages 1 through 5. Predicated F in 2019 is 0.42, which is larger than the $F_{25\%}$ threshold and so suggests that overfishing is occurring (Figure 1). The model estimated a value of 1,364,895 (619 metric tons) for the $SSB_{25\%}$ threshold and a value of 2,238,075 (1,015 metric tons) for the $SSB_{35\%}$ target. Female SSB in 2019 was estimated at 579,915 pounds (263 metric tons), which is smaller than the $SSB_{25\%}$ threshold and so suggests the stock is overfished (Figure 2).

An external peer review was held in April 2022. The panel concluded the assessment model and results ae suitable for providing management advice for at least the next five years. The Panel considers the current model a substantial improvement from the previous assessment, representing the best scientific information available for the stock.

DESCRIPTION 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 in 2006 to exempt mullet from the requirements of the rule to continue allowing mullet to be used for cut bait.

Commercial Fishery

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 (runaround, set, and drift) replaced seines as the dominant commercial gear type in 1979. Because the commercial fishery primarily targets striped mullet for 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 and females are ripe with eggs. Striped mullet are primarily targeted commercially using runaround gill nets in the estuarine and ocean waters of North Carolina. 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). In 2020 and 2021, the stop net fishery was open from October 15 through December 31 (Proclamations M-17-2020 and M-21-2021). 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. In addition, the use of cast nets in the striped mullet commercial fishery has been increasing since around 2003.

Since 1991, commercial landings have ranged from a low of 965,198 pounds in 2016 to a high 3,063,853 pounds in 1993 (Table 1; Figure 3A). 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 to 2014 before declining in 2015 and again in 2016, dropping below the minimum commercial landings trigger established by Amendment 1. Commercial landings in 2021 increased to 2,135,952 pounds, which is 1,005,952 pounds above the minimum commercial landings trigger.

Recreational Fishery

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). Beginning in 2002, MRIP began deferring to mullet genus to classify unobserved type B1 (harvested/unavailable catch) and B2 (released/unavailable catch) catch. As a result, the magnitude of recreational harvest for mullet genus in units of numbers far exceeds that of both striped mullet and white mullet. This methodological improvement served to greatly increase the precision of estimates albeit without species level resolution. As such, estimates of recreational harvest for mullet prior to 2002 are considered unreliable.

The 2022 striped mullet stock assessment used the sum of recreational striped mullet harvest and a proportion of the recreational harvest of mullet genus for removals by the recreational fleet (NCDMF 2022). The proportion of mullet genus assumed to be striped mullet in the recreational harvest was 29%, a value derived from a study by the NCDMF of cast net recreational harvest for striped mullet (NCDMF 2006).

Recreational harvest peaked in 2002 and 2003 at greater than four million fish harvested (Table 1, Figure 3B). From 2004 to 2017 recreational harvest remained stable at around one million fish before declining in 2018, 2019 and 2020 to around 500,000 fish. This decline was likely related to decreased abundance of striped mullet and regulations that drastically shortened the recreational fishing season for southern flounder, a fishery where live mullet is a popular bait. Recreational harvest in 2021 was 1,484,850 fish.

The length-frequency distributions collected in North Carolina's MRIP survey are considered to be an inaccurate representation of the recreational fishery. This is due to biases in the methodology of the program and angler behavior. Lengths collected in North Carolina's MRIP survey are recorded at the dock and therefore only represent fish brought back to be kept by the angler. Anglers typically only keep the largest mullet, whether it be for personal consumption, or to be saved for use as cut bait. This bias toward keeping only the largest striped mullet has caused them to be disproportionately represented in the MRIP data. The vast majority of striped mullet harvested in the recreational fishery are used as live bait for other fisheries. For this type of fishing, "finger mullet", or age-0 fish, approximately four inches in total length are used.

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 a 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 (NCDMF 2021b).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

The number of striped mullet measured per year in fishery-dependent programs between 1994 and 2021 ranged from 123 to 13,212 with the lowest number measured in 1996 (Table 2). In 2021, 7,239 striped mullet were measured from commercial catches; a more than 70% increase from the previous year. Variation in mean length was low, usually 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 fell within a small range with maximum length ranging from 20.0 to 28.0 inches fork length, though in 1994 and 1996, maximum length was below 20.0 inches (Table 3).

From 1994 through 2021 the size range of striped mullet captured in the commercial fishery as determined from commercial fish house samples ranged from 6.0 to 28.0 inches FL (Figure 4). Modal length generally falls between 11.0 and 15.0 inches. In all years there are few striped mullet over 18.0 inches present in the catch.

Fishery-Independent Monitoring

The Fishery-Independent Gill-Net Survey (Program 915), began in 2001 and included sampling in the Pamlico Sound along the Hyde and Dare County shorelines. In July 2003, sampling was expanded to include the Neuse, Pamlico, and Pungo rivers. Additional areas in the Southern District including the New and Cape Fear rivers were added in April 2008. A stratified random sampling design is used based on area and water depth. Sampling occurs from mid-February to mid-December using an array of gill nets with stretched mesh sizes ranging from 3.0 inches to 6.5 inches.

To provide the most relevant indices for use in the 2022 stock assessment, Program 915 data were limited to those collected from shallow water during August through December. A combined index, with a starting year of 2008 and data collected from the Pamlico Sound, Pamlico River, Pungo River, Neuse River, and New River was calculated. Relative abundance increased through 2011 before declining to its lowest point in 2015 (Figure 5). Since 2015, abundance has increased with peaks in 2018 and 2021.

From 2008 to 2021, the size of striped mullet captured during the August to November portion of Program 915 in the Pamlico Sound, Pamlico River, Pungo River, Neuse River, and New River ranged from 7.0 to 26.0 inches FL (juveniles excluded, see NCDMF 2022 for juvenile length cut offs; Figure 6). Modal length ranged from 11.0 to 13.0 inches FL and was 12.0 inches FL in most years. Few striped mullet less than 10.0 inches FL and greater than 15.0 inches FL are captured in this survey.

During 2020 no indices of abundance are available for striped mullet from Program 915. Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021.

Striped mullet age samples are collected from numerous NCDMF fishery independent and dependent sources. Modal age was two in all years except 1996, 1999, 2001, 2003 and 2005 when modal age was one, and 2017 when modal age was 1-2 (Table 3). 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. There is substantial overlap in length at age for striped mullet (Figure 7). Striped mullet grow quickly from age 0 to age 2 before growth slows after age 3.

RESEARCH NEEDS

The following research needs were compiled from those listed in the 2022 Striped Mullet Stock Assessment (NCDMF 2022). Improved assessment and management of striped mullet is dependent upon research needs being met. Research needs are broken into high, medium, and low priority.

High

- Increase sampling of recreational mullet catches to determine the proportion of striped versus white mullet and improve estimates of recreational landings.
- Improve characterization of the length and age structure of recreational fisheries removals by increasing the number of age samples and number of trips sampled for lengths and ages from fisheries-dependent sources.
- Develop a reliable fisheries-independent abundance index for larger juveniles to characterize trends in recruitment.
- Consider expanding Program 915 to include the northern part of the state (Albemarle sound and major tributaries).
- Evaluate the current sampling methodology of Program 146 and effectiveness for sampling striped mullet; since this survey was not considered useful for the assessment of striped mullet, consider dropping this survey and focusing effort elsewhere if it is not contributing to management of other species.
- Consider running a simpler, single-sex version of the stock assessment model.

Medium

- Consider a tagging program to provide estimates of stock size, F, and M.
- Consider genetic and/or tagging studies to examine extent of the unit stock on a regional basis for the south Atlantic as well as the Gulf of Mexico.
- Expand ichthyoplankton survey to other inlets throughout the state.
- Conduct an age validation study of known age fish to provide estimates of ageing error.

- Consider alternative weighting of data sources in future stock assessments.
- Develop estimates of fecundity for North Carolina striped mullet.

Low

- Perform an acoustic tagging study to evaluate spatial and temporal variation in habitat use to more effectively design and conduct fisheries-independent surveys.
- Investigate the predation impact on striped mullet; striped mullet is widely believed to be an important forage species but there is little evidence to support this claim in the North Carolina stock.
- Investigate environmental factors that influence the spatial and temporal distribution of larval striped mullet.

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; 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 be 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 basis 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; 2) user group conflicts; 3) updating the management framework for the N.C. striped mullet stock.

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. The management strategy is under review as part of the scheduled review of the plan and the overfished and overfishing stock status determined from the most recent stock assessment.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

Striped mullet commercial landings in 2021 were 2,135,952 pounds, which is above the minimum and below the maximum commercial landing triggers established in Amendment 1. Review of the plan is underway. Results of the 2022 striped mullet stock assessment (NCDMF 2022) indicate the North Carolina striped mullet stock is overfished and overfishing is occurring through the terminal year of 2019. As statutorily required, management measures will be developed through Amendment 2 to end overfishing and rebuild spawning stock biomass.

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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 spotted seatrout from North Carolina, 1991–2021. Number released and weight landed cannot be determined because of uncertainty in reported species identification.

Year	Recreational			Commercial	
	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1991	.	.	.	1467448	1467448
1992	.	.	.	1820494	1820494
1993	.	.	.	3063853	3063853
1994	.	.	.	1726242	1726242
1995	.	.	.	2298446	2298446
1996	.	.	.	1756863	1756863
1997	.	.	.	2442657	2442657
1998	.	.	.	2218108	2218108
1999	.	.	.	1460850	1460850
2000	.	.	.	2829086	2829086
2001	.	.	.	2317655	2317655
2002	5967684	.	.	2596304	2596304
2003	4090368	.	.	1629314	1629314
2004	1394707	.	.	1598617	1598617
2005	1312234	.	.	1620394	1620394
2006	1059444	.	.	1728607	1728607
2007	1766373	.	.	1668804	1668804
2008	1191633	.	.	1675859	1675859
2009	1167086	.	.	1685615	1685615
2010	1319070	.	.	2082832	2082832
2011	1139786	.	.	1627894	1627894
2012	1369975	.	.	1859587	1859587
2013	1453038	.	.	1549157	1549157
2014	1352690	.	.	1828351	1828351
2015	1420378	.	.	1247044	1247044
2016	1491533	.	.	965337	965337
2017	1537183	.	.	1366351	1366351
2018	489321	.	.	1314385	1314385
2019	562089	.	.	1362217	1362217
2020	531875	.	.	1299464	1299464
2021	1484850	.	.	2135952	2135952
Total	1671366	.	.	1803594	1803594

Table 2. Mean, minimum, and maximum lengths (fork length, inches) of striped mullet measured from the commercial fisheries, 1994–2021.

Year	Mean Length	Minimum Length	Maximum Length	Total 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
2019	14.6	8.7	22.8	4,922
2020	13.8	8.3	21.9	4,246
2021	14.3	8.8	24.7	7,239

Table 3. Modal age, minimum age, maximum age, and number aged for striped mullet collected through NCDMF sampling programs, 1996–2021. Age data from 2021 are preliminary.

Year	Modal Age	Minimum Age	Maximum Age	Total 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	1	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	769
2016	2	0	8	956
2017	1-2	0	15	695
2018	2	0	10	770
2019	2	0	13	827
2020	2	0	7	269
2021	2	0	10	933

FIGURES

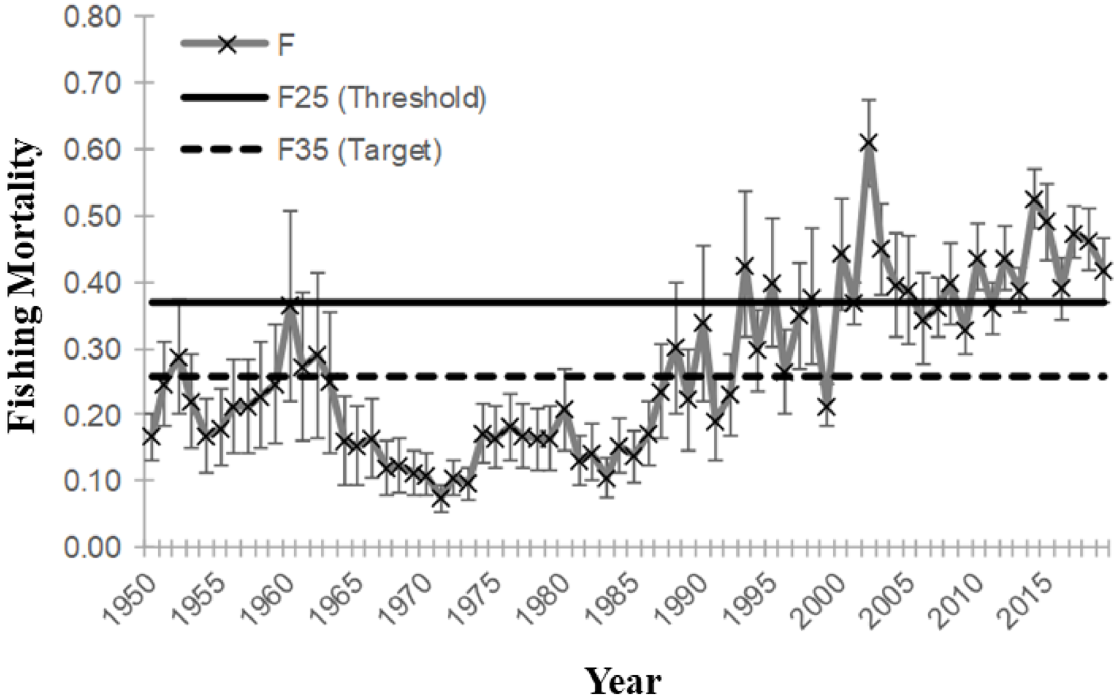


Figure 1. Annual predicted fishing mortality rates (numbers-weighted, ages 1–5) compared to estimated FThreshold (F25%) and FTarget (F35%), 1950–2019. 2019 is the terminal year for the most recent striped mullet stock assessment (NCDMF 2022).

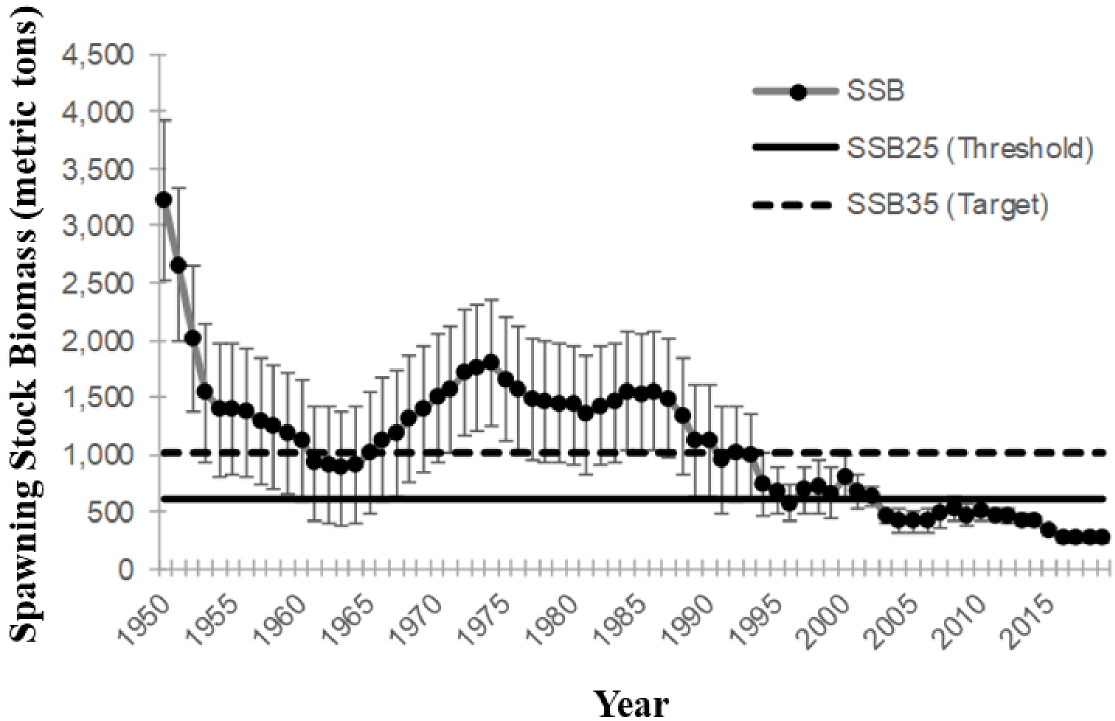
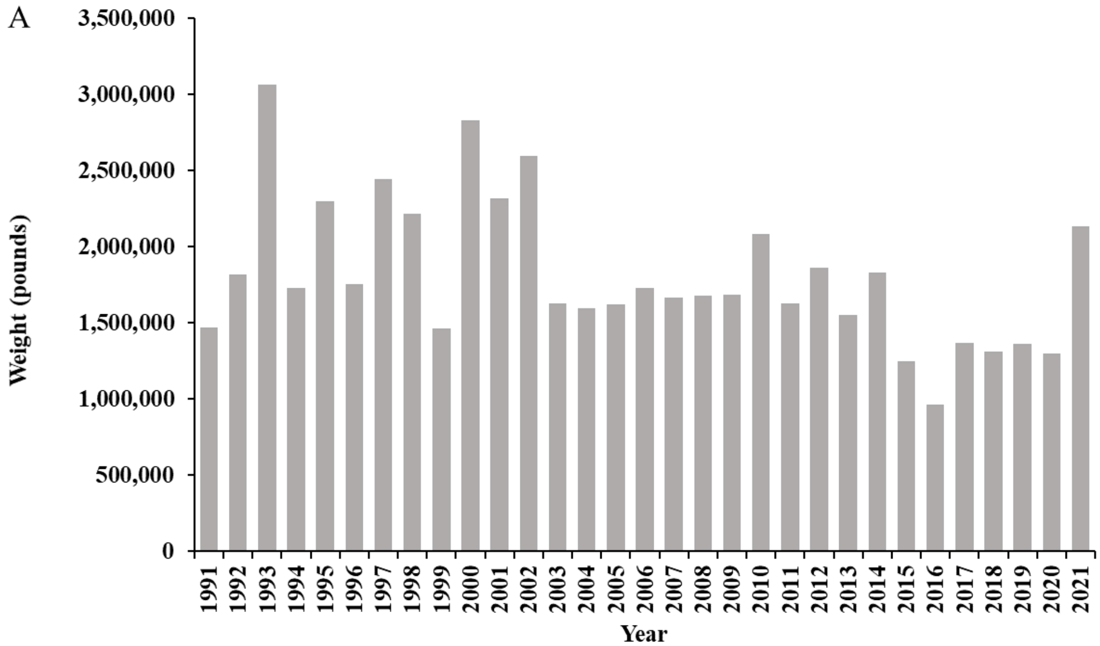


Figure 2. Annual predicted spawning stock biomass in metric tons, compared to estimated SSBThreshold (SSB25%) and SSBTarget (SSB35%), 1950–2019. 2019 is the terminal year for the most recent striped mullet stock assessment (NCDMF 2022).



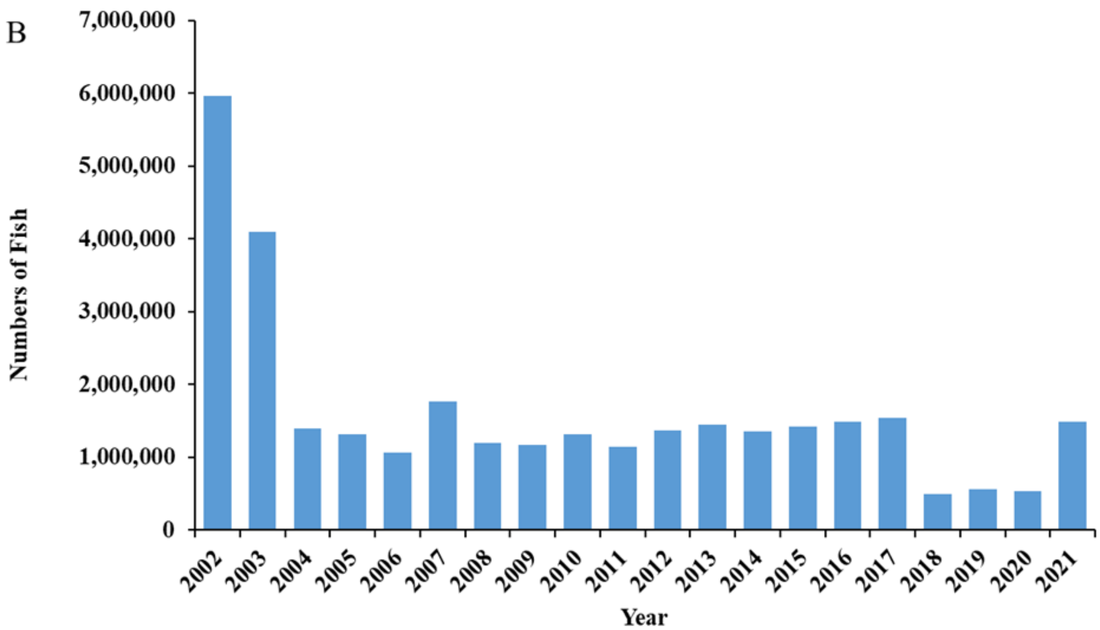


Figure 3. Striped mullet commercial landings (pounds) reported through the North Carolina Trip Ticket Program (A), 1991–2021. Recreational landings (Type A + B1; numbers of fish) includes estimates of striped mullet plus 29% of the mullet genus harvest from the Marine Recreational Information Program survey for North Carolina, 2002–2021 (B).

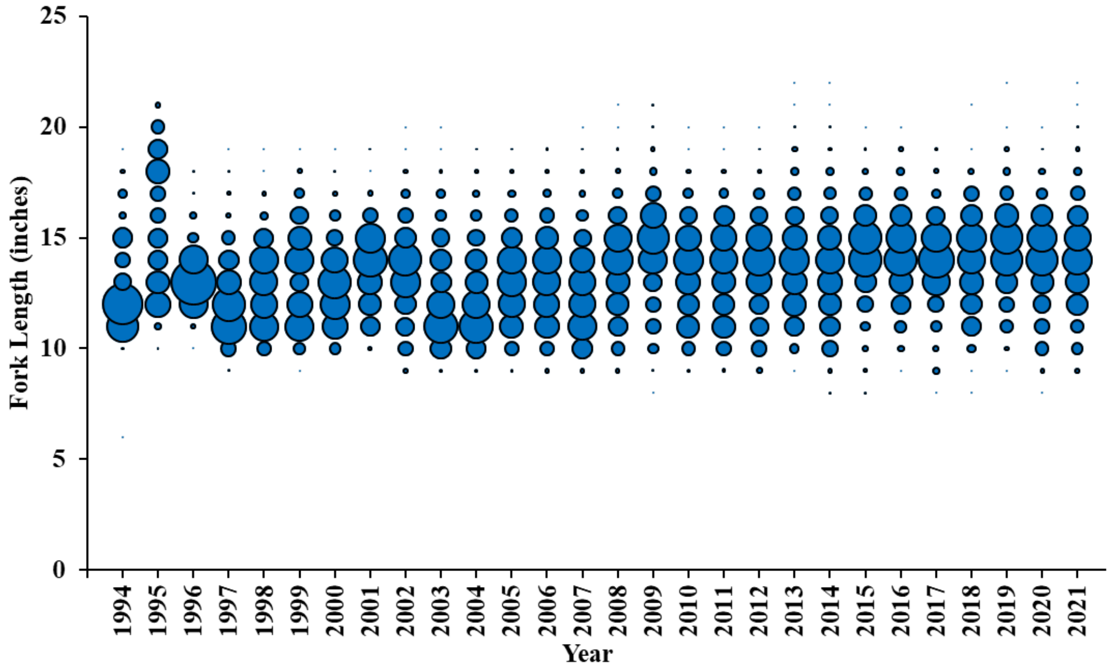


Figure 4. Commercial length frequency (fork length, inches) of striped mullet harvested, 1994–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

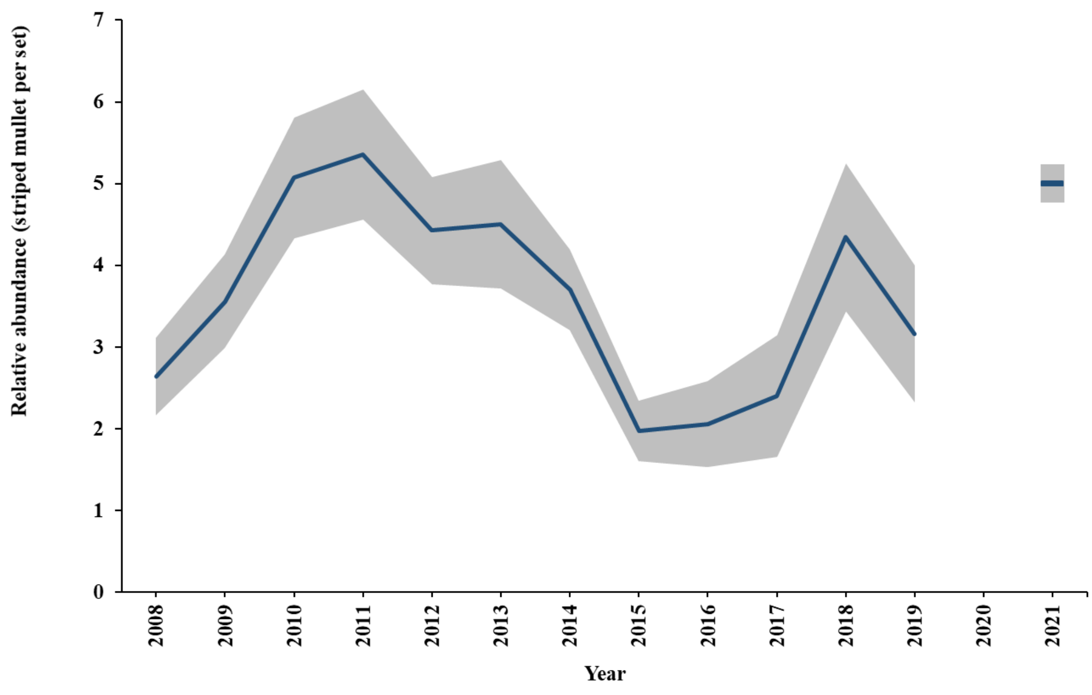


Figure 5. Relative Abundance index (fish per set) of striped mullet collected from Program 915 in Pamlico Sound, Pamlico, Pungo, Neuse and New rivers from August-December 2008–2021. Gray shading represent ± 1 standard error. Sampling was not conducted in 2020.

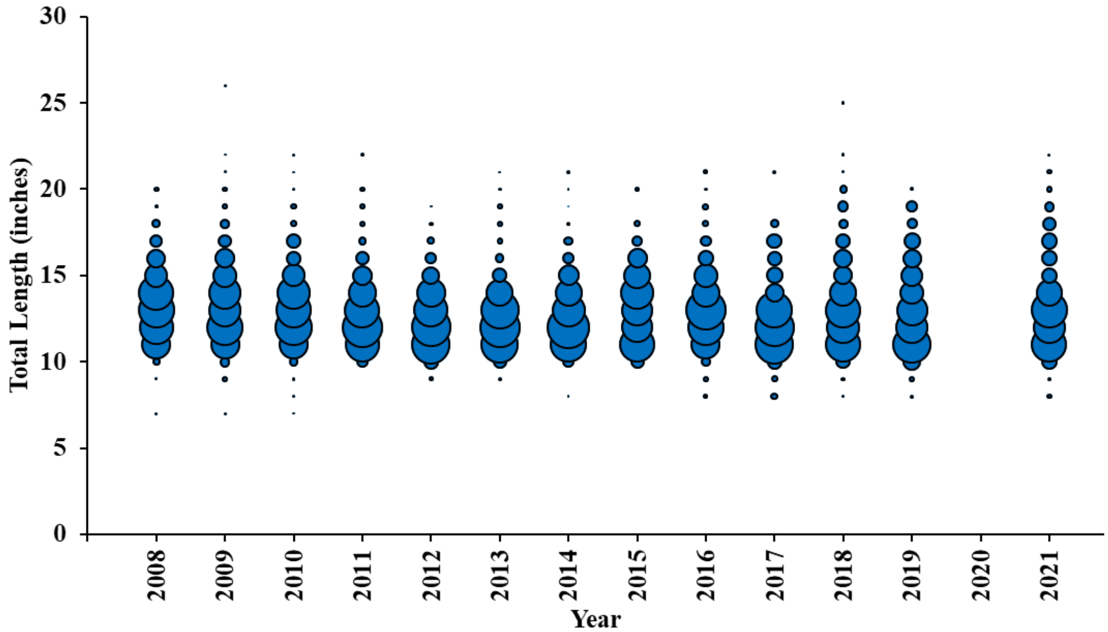


Figure 6. Length frequency (fork length, inches) of striped mullet collected from Program 915 in Pamlico Sound, Pamlico, Pungo, Neuse and New rivers from August-December (juveniles excluded), 2008–2021. Sampling was not conducted in 2020.

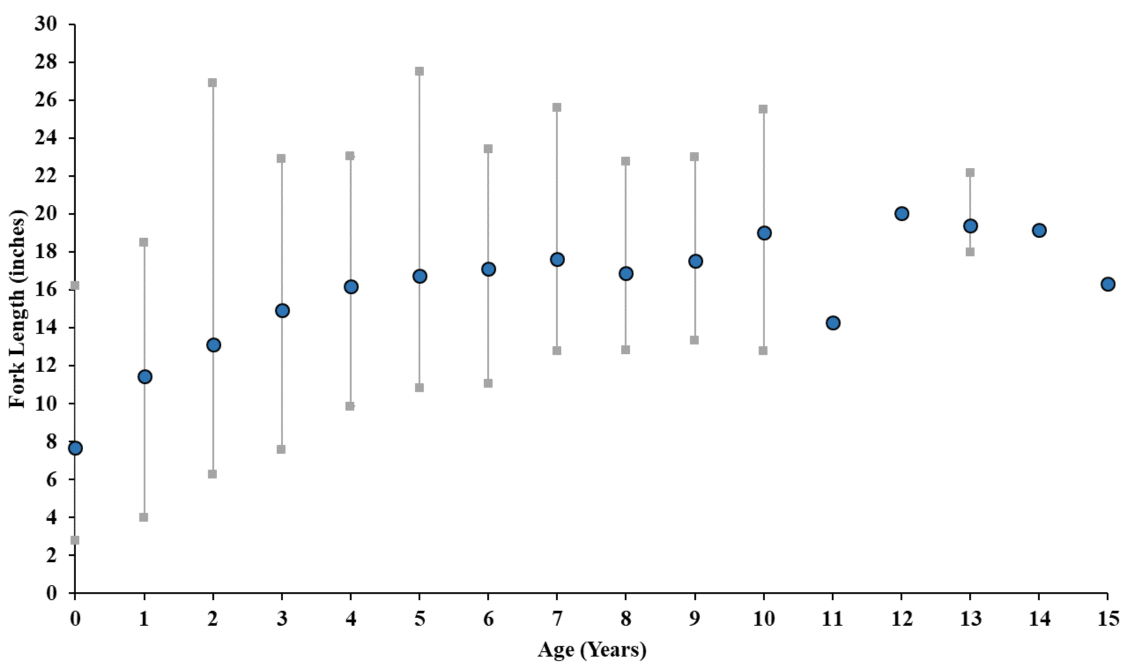


Figure 7. Striped mullet length at age based on all age samples collected, 1996–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
AMERICAN EEL
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation	November 1999		
		Addendum I	February 2006
		Addendum II	October 2008
		Addendum III	August 2013
		Addendum IV	October 2014
		Addendum V	January 2019
Comprehensive Review:	2022		

American eel is managed under the Atlantic States Marine Fisheries Commission (ASMFC) Interstate Fishery Management Plan (FMP) for American Eel. The 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.

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). 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. The addendum addresses concerns and issues in the commercial glass and silver eel fisheries, and domestic eel aquaculture. Addendum IV established a coastwide catch cap and a mechanism for 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:

- The coastwide catch cap is exceeded by more than 10 percent in a given year (998,438 pounds)
- The coastwide catch cap is exceeded for two consecutive years, regardless of the percent overage.

If either trigger is exceeded, a state-by-state commercial yellow eel quota would be implemented with North Carolina receiving an 11.8 percent allocation (107,054 pounds).

The aquaculture provision in Addendum IV allows states to submit an Aquaculture Plan to allow for limited harvest of glass eels for use in domestic aquaculture facilities. Specifically, states are allowed to request a harvest of 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 2012 stock assessment was updated with data from 2010-2016, however, neither reference points nor stock status could be determined. The trend analysis and stable low commercial landings support the conclusion that the American eel population in the assessment range remains depleted.

Addendum V was initiated in response to results of the 2017 stock assessment update and concerns that current management triggers do not account for annual fluctuations in landings. If a management trigger is exceeded immediate implementation of state-by-state quotas would pose significant administrative challenges (ASMFC 2019). Adopted in January 2019, Addendum V increases the yellow eel coastwide 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 coastwide 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 coastwide cap is exceeded by 10% or more in two consecutive years (10% of the coastwide cap = 91,647 pounds; coastwide cap + 10% = 1,008,120 pounds). If management is triggered, only those states accounting for more than 1% of the total yellow eel landings are 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 programs, are favorable to law enforcement, and are in watersheds that are prone to relatively high mortality rates.

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 but was only approved by ASMFC for one harvest season (November 2019 through March 2020). The NCDMF has not submitted an American Eel Aquaculture Plan to the ASMFC since 2020.

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 North Carolina Wildlife Resources Commission (NCWRC) 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.

To ensure compliance with interstate requirements, North Carolina also manages this species under the North Carolina Fishery Management Plan for Interjurisdictional Fisheries (IJ FMP). There are two main goals of the IJ FMP; first 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. Second, to 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 goals 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

American eel is managed as a coastwide 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 goals of the ASMFC American Eel FMP are 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 with the aim to provide 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:

- 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.
- Increase understanding of factors affecting eel population dynamics and life history through research and monitoring.
- Protect and enhance American eel abundance in all watersheds where eel now occur.
- 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.
- Investigate the abundance level of eels at the various life stages necessary to provide adequate forage for natural predators to support ecosystem health and food chain structure.

DESCRIPTION OF THE STOCK

Biological Profile

The American eel (*Anguilla rostrata*) is a catadromous species meaning they are born in saltwater, then migrate into freshwater as juveniles where they grow into adults before migrating back to 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, freshwater 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 two 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, feeding at night on a variety of invertebrates and smaller fish, but will also eat dead animal matter. American eels live in a variety of habitats but 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

The 2017 stock assessment update found the American eel population remains depleted in U.S. waters (ASMFC 2017). No overfishing status determination can be made based on the analyses performed

Stock Assessment

The 2012 stock assessment was updated in 2017 with data through 2016. American eel indices of abundance were analyzed using three methods of trend analysis: Mann-Kendall, Manly, and ARIMA. The Mann-Kendall test detected significant downward trends 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. Only two indices had positive trends, all of the remaining survey indices tested had no trend. 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, so the assessment maintained the depleted stock status. While it is highly likely the American eel stock is depleted, no overfishing determination can be made based solely on the trend analyses performed.

A benchmark stock assessment for American eel began in 2020 and is ongoing. All potential data sources will be reviewed, and the terminal year of the assessment will be 2019.

DESCRIPTION OF THE FISHERY

Current Regulations

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 nine-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 ½-by-½ inch minimum mesh size requirement for the commercial eel pot fishery. Eel pots with an escape panel consisting of a 1 by ½ inch mesh are allowed until January 1, 2017. In June 2021, the NCWRC modified Rule 15A NCAC 10C .0401 to allow eels greater than nine inches in length and with a minimum body depth greater than ½ inch to be cut for use as bait in Inland Fishing Waters.

Commercial Fishery

Average commercial landings and value from 2011 through 2020 was 37,276 pounds and $85,980. In 2021, the commercial landings and value was 5,505 pounds and $15,139 (Table 1). Commercial landings have fluctuated since 1974 with a peak in 1980 and significant declines beginning in the late 1980s (Figure 1). In 1979 and 1980, over 900,000 pounds were landed, however, since the late 1980s landings have averaged less than 100,000 pounds and in 2021 landings were the second lowest recorded in the time-series.

Recreational Fishery

There are no recreational landings data available for American eels, which are not typically a recreationally targeted species. Since American eels are caught incidentally in the estuarine environment by recreational fishermen using hook and line, the Marine Recreational Information Program (MRIP) does not provide reliable harvest data. Also, the MRIP survey design 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 Addendum I to the American Eel Fisheries Management Plan, the NCDMF initiated (January 2007) mandatory reporting of harvest and effort information for American eels harvested by commercial 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 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. The BBISP samples once-weekly at night during floodtide 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 2019, relative abundance of American eel (glass eel) has fluctuated from a low in 1991 to a high in 2005, with a 33-year average of 0.0125 eels per cubic meter (Figure 2). In 2019, American eel relative abundance (0.0072 eels per cubic meter) remained below the time-series average. Lengths of American eels captured in the BBISP from 2001 to 2019 (n=541) ranged from 41 to 153 millimeters (1.6 to 6.0 inches; Figure 3) 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 BBISP continued their long-term sampling program in 2020 (January to March); however, no samples were collected in April and May, or in November and December due to COVID-19 restrictions. Currently, there is a two-year backlog of unsorted samples (2020 to 2021).

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. From 1971 to 2021, relative abundance has fluctuated from lows in 1973, 2000, and 2020 to a peak in 2011, and a 27-year average of 0.14 American eels per tow (Figure 4). In 2020, relative abundance (0.01 eels per tow) was the lowest recorded in the time-series. Due to COVID restrictions all 2020 sampling was conducted in June. In 2021 there was a slight upward trend in the relative abundance value with 0.04 eels per tow (Figure 4).

RESEARCH NEEDS

The items listed below are research needs identified in the 2012 stock assessment (ASMFC 2012) and progress toward accomplishing those objectives as described in the 2017 American Eel Stock Assessment Update (ASMFC 2017) based on input from the ASMFC American Eel TC and SAS. A single asterisk (*) denotes short-term recommendations and two asterisks (**) denote long-term recommendations.

- 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 Atlantic Coastal Cooperative Statistics Program (ACCSP) standards for collection of catch and effort data (ACCSP 2004)* — Ongoing through the American Eel Logbook Reporting Program
- Monitor catch and effort in personal-use fisheries that are not currently covered by the Marine Recreational Fishing Statistics Survey (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
- 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
- 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
- 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
- Perform economics studies to determine the value of the fishery and the impact of regulatory management** — No Action
- 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
- 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
- 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
- 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
- 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
- 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
- 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
- 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
- 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
- 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 the 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
- 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
- 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
- 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 (coastwide or regional) tagging studies of eels at different life stages; tagging studies could address a number of issues including: Natural, fishing, and discard mortality; survival; Growth; Passage mortality; Movement, migration, and residency;

Validation of ageing methods; Reporting rates; and Tag shedding or tag attrition rate** — No Action

MANAGEMENT STRATEGY

Under Addendum V, the commercial yellow eel fishery is regulated through an annual coastwide catch cap set at 916,473 pounds. Management action is initiated if the yellow eel coastwide 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 2021, the commercial landings in North Carolina were 5,505 pounds, therefore if the coastwide management trigger was exceeded, North Carolina would not 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 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. The NCDMF submitted an American eel Aquaculture Plan to ASMFC requesting approval to harvest up to 200 pounds of glass eels from coastal fishing waters in 2015, 2016, 2017 and 2019. The NCDMF did not submit an American Eel Aquaculture Plan to the ASMFC in 2021 and does not have an active glass eel fishery.

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TABLES

Table 1: Commercial landings of American eel (in pounds) in North Carolina, 1974-2021.

Year	Pounds
1974	451,956
1975	237,684
1976	510,083
1977	258,296
1978	695,605
1979	954,534
1980	960,196
1981	436,007
1982	475,524
1983	404,157
1984	706,298
1985	224,263
1986	338,377
1987	127,964
1988	57,369
1989	152,656
1990	56,494
1991	12,082
1992	17,739
1993	32,711
1994	95,991
1995	173,698
1996	141,592
1997	128,668
1998	91,084
1999	99,939
2000	127,099
2001	107,070
2002	59,820
2003	172,065
2004	128,875
2005	49,278
2006	33,581
2007	37,937
2008	23,833
2009	65,481
2010	122,104
2011	61,960
2012	64,110
2013	33,980
2014	60,755
2015	57,791
2016	39,991
2017	24,752
2018	18,058
2019	8,154
2020	3,291
2021	5,505
Mean	190,955

FIGURES

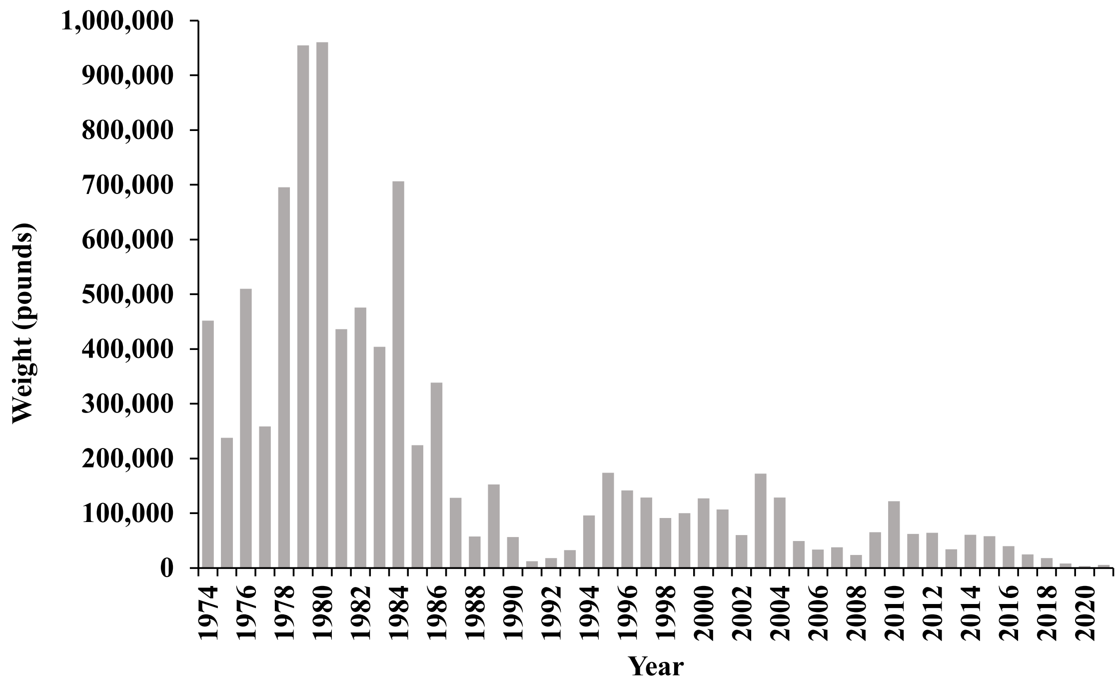

Figure 1: American eel commercial landings (pounds) reported through the North Carolina Trip Ticket Program, 1974–2021.

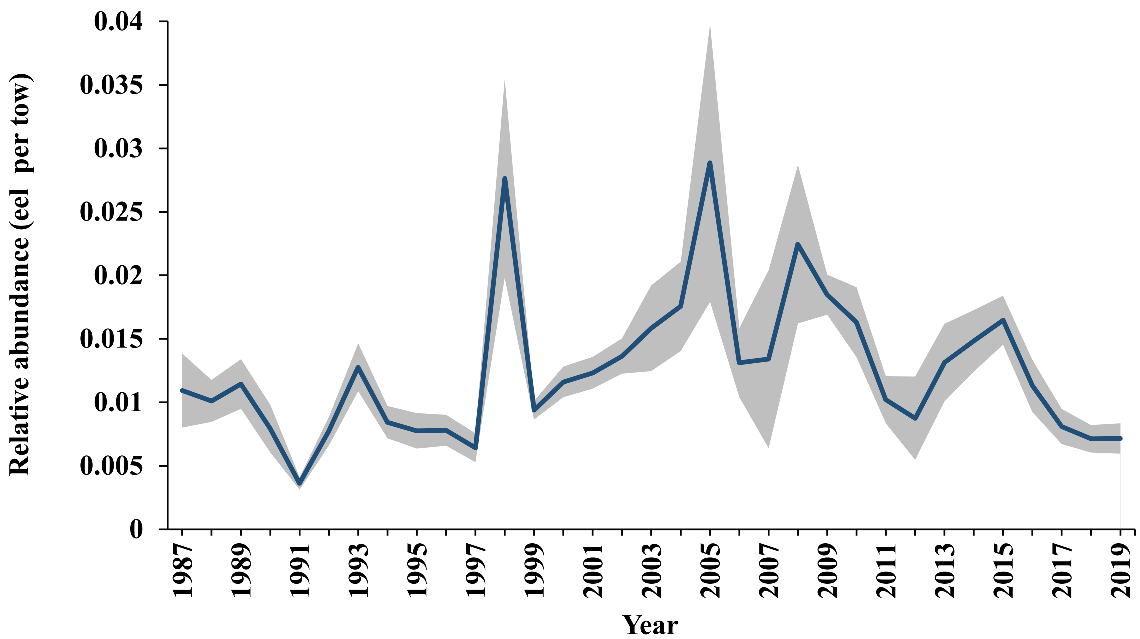

Figure 2: Relative abundance index (larval fish per tow) of American eel collected from the BBISP, 1987–2019. Error bars represent ± 1 standard error. There is a two-year backlog of unsorted samples (2020–2021).

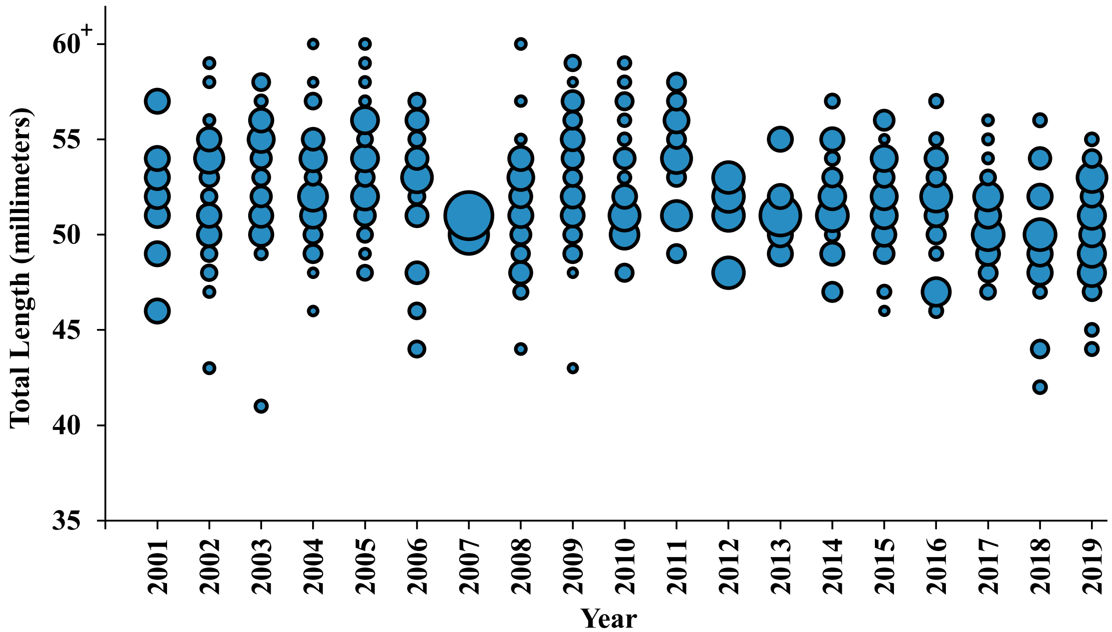

Figure 3: Length frequency (total length, millimeters) of American eel collected in the BBISP, 2001–2019. Bubbles represent fish captured at length and the size of the bubble is equal to the proportion of fish at that length. There is a two-year backlog of unsorted samples (2020–2021). (Note: the 60+ category includes three fish; 62, 91, and 153 millimeters).

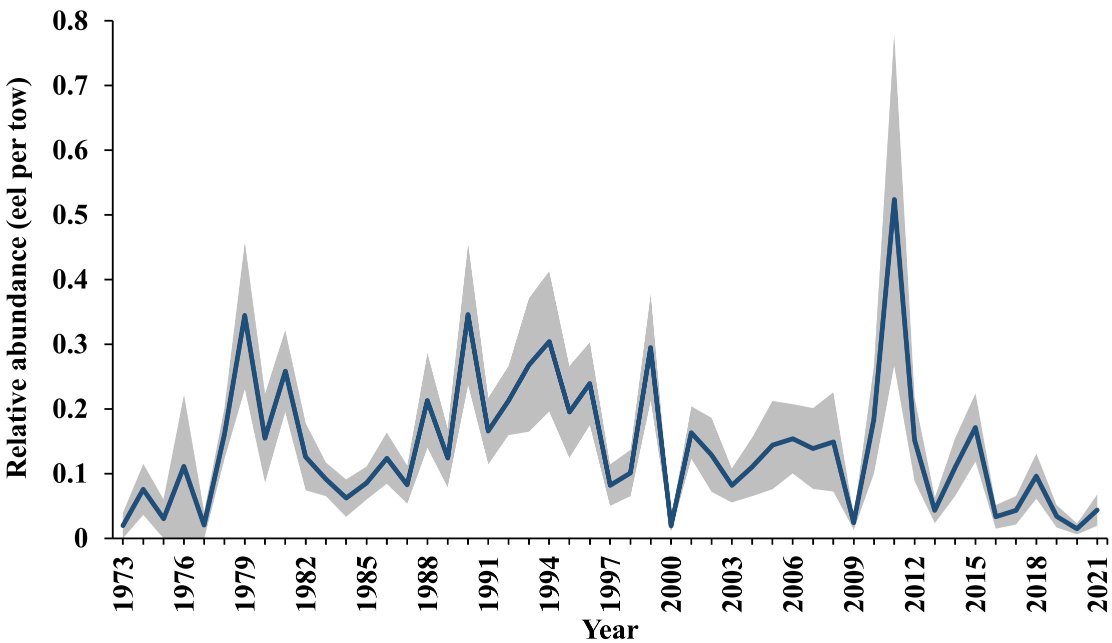

Figure 4. Relative abundance index (fish per tow) of American eel collected from the North Carolina Estuarine Trawl Survey (Program 120) from 1973–2021. Error bars represent ± 1 standard error.

FISHERY MANAGEMENT PLAN UPDATE
AMERICAN SHAD
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	October 1985		
	Amendment 1		April 1999
		Technical Addendum 1	February 2000
		Addendum I	August 2002
		Amendment 3	February 2010
Supplements:	Supplement — October 1988		
Comprehensive Review:	To be determined		

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 coastwide 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 fishing/recovery plans that meet the requirements of Amendment 3, known as the North Carolina American Shad Sustainable Fishery Management Plan (SFMP) (NCDMF 2011 and NCDMF 2017). North Carolina submitted habitat plans that meet the requirements of Amendment 3, known as the North Carolina American Shad Habitat Plan (NCDMF 2014 and NCDMF 2020).

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:

- Maximize the number of juvenile recruits emigrating from freshwater stock complexes.
- Restore and maintain spawning stock biomass and age structure to achieve maximum juvenile recruitment.

- Manage for an optimum yield harvest level that will not compromise Objectives 1 and 2.
- Maximize cost effectiveness to the local, state, and federal governments, and the ASMFC associated with achieving Objectives 1 through 3.

DESCRIPTION OF THE STOCK

Biological Profile

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 in which they were born 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 coastwide stock assessment of American shad stated that populations in the Albemarle Sound, including Roanoke River, are sustainable and not depleted, whereas a determination of stock status could not be assigned for the Tar-Pamlico, Neuse, and Cape Fear rivers due to limited information (ASMFC 2020).

Stock Assessment

The 2020 American shad benchmark stock assessment found coastwide populations of American shad to be depleted. Factors such as overfishing, inadequate fish passage at dams, predation, pollution, water withdrawals, channelization of rivers, changing ocean conditions, and climate change are likely responsible for the decline from historic shad abundance levels. The assessment found that American shad recovery is limited by restricted access to spawning habitat, with 40% of historic habitat in the U.S. and Canada currently blocked by dams and other barriers possibly equating to a loss of more than a third of spawning adults. The abundance of American shad relative to historic levels is unknown for most systems but was determined to be depleted for the Potomac River and Hudson River, and not depleted for the Albemarle Sound. Coastwide adult mortality is largely unknown and juvenile mortality status cannot be determined due to insufficient data collection. The stock assessment chose to use the ‘depleted’ determination instead of ‘overfished’ because of the impact of fishing on American shad stocks cannot be separated from all other factors that impact abundance. The Tar-Pamlico rivers, Neuse River, and Cape Fear River status for adult mortality rate and abundance could not be determined, except for the Neuse River adult mortality rate was found to be sustainable (ASMFC 2020). The 2020 benchmark assessment for American shad was endorsed by the Peer Review Panel and accepted by the ASMFC Shad and River Herring Board for management use in August 2020. The ASMFC has not conducted a coastwide assessment of hickory shad.

DESCRIPTION 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 April 15–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 18 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 3.25–4.0 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 1–November 30. 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 for flounder season on September 1, 2021.

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 rivers 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 rivers 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.

A management response for striped bass has been in effect since March 18, 2019, prohibiting the use of all gill nets upstream of the ferry lines from the Bayview to Aurora ferry in the Tar-Pamlico

River and the Minnesott Beach and Cherry Branch ferry in the Neuse River (Proclamation M-6-2019). This prohibition directed by the N.C. Marine Fisheries Commission was in response to Supplement A to Amendment 1 to the N.C. Estuarine Striped Bass FMP, and was intended to reduce striped bass fishing mortality, and has essentially protected American shad as well by removing gill nets from the normal fishing grounds for American shad in the Tar-Pamlico River.

Commercial Fishery

North Carolina's commercial landings in 2021 were 58,884 pounds; well below 2020 landings (134,556 pounds, Table 1, Figure 1). Gill nets configured for harvesting American shad were prohibited in the ASMA (Management Unit A) effective March 18, 2021, due to the ASMA striped bass commercial quota being met (Proclamation M-10-2021). While American shad could still be landed commercially until March 24, 2021, gill nets are the primary gear used for shad in the ASMA and the gear restriction did have some impact on landings. Overall, 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 the landings break down by the four areas of the state, as stated in the American Shad SFMP. The Albemarle Sound area accounts for approximately 91% of total state landings in 2021.

Recreational Fishery

Recreational fishing activity is monitored through coordination with the North Carolina Wildlife Resources Commission (NCWRC) 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 2,624 fish in 2021 (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 during 1994–2000 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 2020, gill nets accounted for greater than 98% of the commercial landings.

A total of 417 females and 71 males was measured from the commercial fishery in 2021 (Table 3, Table 4). The average size was 17 inches fork length for female and 16 inches fork length for male American shad (Figure 3, Figure 4). 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 5 and Figure 6 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 2021.

Fishery-Independent Monitoring

The NCDMF does not have a dedicated juvenile (age 0) survey for American Shad but conducts two juvenile beach seine surveys in the Albemarle Sound area, Juvenile Anadromous Survey (Program 100). Although the surveys were designed to monitor river herring [blueback herring (*Alosa aestivalis*) and alewife (*Alosa pseudoharengus*)] and striped bass, both surveys capture American shad. The river herring beach seine survey has been conducted in the Chowan River and Albemarle Sound area to monitor Blueback Herring and Alewife abundance since 1972. The survey established 11 stations in the near-shore nursery areas of the Chowan River and Albemarle Sound, sampled twice a month. The striped bass beach seine survey has been conducted in the western Albemarle Sound to monitor juvenile striped bass since 1993. This survey was designed to determine the critical point (egg, larval, or early juvenile stage) that was limiting spawning success resulting in near zero catches in the juvenile trawl surveys for striped bass. The survey established nine stations in the near-shore nursery areas of the western Albemarle Sound, where early-stage juvenile striped bass would be settling after larval metamorphosis from spawning grounds on the Roanoke River. The stations are sampled once a week, for six weeks (starting the first week in June). American shad captured are recorded but not consistently until 1995. Following the six weeks of sampling, the stations are sampled bimonthly through October.

The ASFMC 2007 benchmark assessment for American Shad only considered the juvenile river herring beach seine survey data for a relative abundance index for American Shad. Due to the consistently low level of catch since 1972, the authors felt that the survey did not adequately reflect the true abundance of juvenile American Shad and should not be used for management. During the ASMFC 2020 benchmark stock assessment for American Shad a combination of seine stations from the river herring survey (five stations) and the striped bass survey (9 stations), all samples June through October, were selected to determine a juvenile abundance starting in 1996 (zero catches in 1995). A Zero-inflated Negative Binomial GLM model was determined as the best recommended predications of relative annual abundance. Water temperature, salinity, month and cloud cover were all shown to significantly impact catch rates and presence. The best performing model was Counts ~ Year + water temperature + salinity | salinity + cloud cover + month. Updates to annual trends in abundance are illustrated in Figure 7 as arithmetic mean, in lieu of updating the model annually. The 2021 relative abundance was 3.19 (American shad per tow) over three times the relative abundance in 2020 (0.93 American shad per tow).

Adult American shad are monitored using the NCDMF Albemarle Sound Independent Gill Net Survey (Program 135) and NCWRC electrofishing surveys to estimate female catch relative abundance 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.

Program 135 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 gill net surveys outside to the Albemarle Sound-Roanoke River area are biologically sampled and reported annually to the ASMFC, due to low numbers of catch relative abundance is not estimated.

An overall index of abundance (female and male combined) is not available for American shad from Program 135 for 2021 (Figure 8). Program 135 was suspended February 20, 2020, due to COVID-19 restrictions and protected species interactions. The 2020 index provided in Figure 8 is based on the limited sampling that occurred in that year. The survey resumed in the fall of 2021.

A total of 9 females and 6 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 17 inches fork length and male are 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 9 and Figure 10 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 during 2000–2021.

RESEARCH NEEDS

On an annual basis the ASMFC publishes a prioritized list of short term and long-term 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 2020).

For more information on research needs for River herring please see: http://www.asmfc.org/uploads/file/627c1f1bShadRiverHerring_FMP_ReviewFY2020.pdf

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-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. 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 each 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. Due to the Covid-19 pandemic in 2020, the NC Wildlife Resources Commission and the NC Division of Marine Fisheries were unable to complete sampling necessary to update the sustainability parameters due to restrictions on sampling implemented by both agencies in response to the Covid-19 pandemic. The Cape Fear River season dates were changed in 2021 to prevent opening the fishery on a weekend but number of days remains the same. Due to the suspension of the Albemarle Sound independent gill net survey, sampling necessary to update the sustainability parameters for the Albemarle Sound were unavailable for 2021. Therefore, the current season length remained unchanged for 2022.

The 2021 updates to sustainability parameters showed no parameter exceeding the respective threshold. Additionally, it is important to note a management response for striped bass has been in effect since March 18, 2019, prohibiting the use of all gill nets upstream of the ferry lines from the Bayview to Aurora ferry in the Tar-Pamlico River. This management measure has essentially protected American shad as well as striped bass by removing gear from the normal fishing grounds.

Albemarle Sound-Roanoke River:

The Albemarle Sound-Roanoke River system has three sustainability parameters: female CPUE based on the NCDMF Albemarle Sound Independent Gill Net Survey (IGNS, Program 135), 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 2015–2021 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 11 shows the female CPUE based on the NCDMF Albemarle Sound IGNS. Figure 12 shows the CPUE based on the NCWRC electrofishing survey. Figure 13 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 14 shows the female CPUE based on the NCWRC electrofishing survey and figure 15 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 16 shows the female CPUE based on the NCWRC electrofishing survey and figure 17 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 21 to April 12 (previously 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 18 shows the female CPUE based on the NCWRC electrofishing survey and figure 29 shows the female relative *F* based on the NCWRC electrofishing survey.

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.

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TABLES

Table 1. Commercial harvest (weight in pounds) of American shad from North Carolina, 1972–2021. Commercial harvest from the Atlantic Ocean prohibited since 2007.

Year	Commercial Weight Landed (lb)	Year	Commercial Weight Landed (lb)
1972	468,484	1997	219,526
1973	321,000	1998	327,556
1974	368,833	1999	131,617
1975	241,240	2000	297,990
1976	167,190	2001	151,075
1977	120,201	2002	274,657
1978	402,017	2003	395,251
1979	277,818	2004	270,245
1980	199,206	2005	189,462
1981	351,500	2006	184,710
1982	407,034	2007	298,597
1983	380,897	2008	118,855
1984	382,331	2009	167,114
1985	190,044	2010	232,326
1986	279,142	2011	203,755
1987	111,860	2012	235,795
1988	111,567	2013	257,348
1989	52,997	2014	191,302
1990	30,833	2015	95,966
1991	29,037	2016	62,245
1992	38,020	2017	90,868
1993	12,544	2018	53,878
1994	110,975	2019	40,975
1995	205,867	2020	134,566
1996	199,638	2021	58,884
		Mean	202,897

Table 2. Recreational harvest (number of fish landed and weight in pounds) and releases (number of fish) and commercial harvest (weight in pounds) of American shad from the North Carolina Central Southern Management Area (CSMA), 2012–2021. Recreational weight landed is estimated using an individual fish weight of 2.8 pounds derived from Fishery-Independent sampling.

	Neuse River					Tar-Pamlico River					Cape Fear River				
	Recreational			Commercial		Recreational			Commercial		Recreational			Commercial	
Year	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
2012	1,017	655	2,848	23,976	26,824	959	4,396	2,685	12,936	15,621				10,333	10,333
2013	1,388	2,771	3,886	17,320	21,206	2,603	10,180	7,288	9,776	17,064	20,519	34,902	57,453	24,888	82,341
2014	413	998	1,156	11,358	12,514	168	1,314	470	18,769	19,239	7,453	11,025	20,868	46,148	67,016
2015	94	137	263	2,990	3,253	1,006	3,917	2,817	3,346	6,163	4,136	6,388	11,581	25,039	36,620
2016	252	1,423	706	2,568	3,274	1,051	2,820	2,943	765	3,708	10,244	11,388	28,683	12,937	41,620
2017	519	2,591	1,453	11,451	12,904	898	2,217	2,514	4,384	6,898	1,352	2,669	3,786	10,778	14,564
2018	112	358	314	3,987	4,301	685	2,767	1,918	1,580	3,498	5,366	7,924	15,025	14,931	29,956
2019	215	123	602	1,531	2,133	552	3,120	1,546		1,546	2,271	3,408	6,359	5,076	11,435
2020	830	2,813	2,324	109	2,433	209	838	585	129	714	3,582	3,740	10,030	6,038	16,068
2021	36	69	101	59	160	837	6,950	2,344	16	2,360	2,624	6,914	7,347	4,838	12,185

Table 3. Mean, minimum, and maximum lengths (fork length, inches) of female American shad measured from the commercial fisheries, 1972–2021.

Year	Mean Length	Minimum Length	Maximum 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
2019	17	14	19	444
2020	15	12	19	281
2021	17	15	19	417

Table 4. Mean, minimum, and maximum lengths (fork length, inches) of male American shad measured from the commercial fisheries, 1972–2021.

Year	Mean Length	Minimum Length	Maximum 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
2019	14	12	18	85
2020	15	12	17	74
2021	16	14	18	71

Table 5. Modal age, minimum age, maximum age, and number aged for American shad (male and female combined) collected through NCDMF fishery-dependent sampling programs, 1972–2021.

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	1,138
1976	5	4	9	664
1977	5	3	7	585
1978	6	3	7	953
1979	5	4	9	1,060
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
2019	6	4	8	273
2020	6	4	8	255
2021	6	4	8	301

Table 6. Mean, minimum, and maximum lengths (fork length, inches) of female American shad measured from NCDMF fishery-independent sampling programs, 2000–2021.

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
2019	16	6	19	95
2020	17	15	18	41
2021	17	15	18	9

Table 7. Mean, minimum, and maximum lengths (fork length, inches) of male American shad measured from NCDMF fishery-independent sampling programs, 2000–2021.

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
2019	15	11	17	91
2020	15	12	16	32
2021	15	13	16	6

Table 8. Modal age, minimum age, maximum age, and number aged for American shad (male and female combined) collected through NCDMF fishery-independent sampling programs, 2000–2021.

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
2019	5	3	7	152
2020	6	3	8	71
2021	5	4	7	15

FIGURES

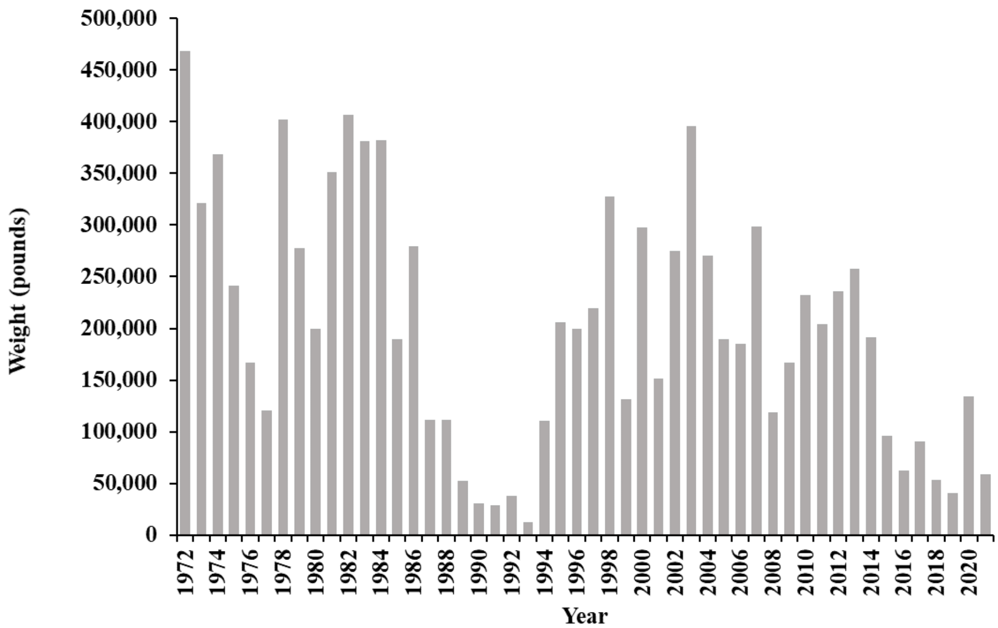

Figure 1. Commercial harvest (weight in pounds) of American shad from North Carolina, 1972–2021.

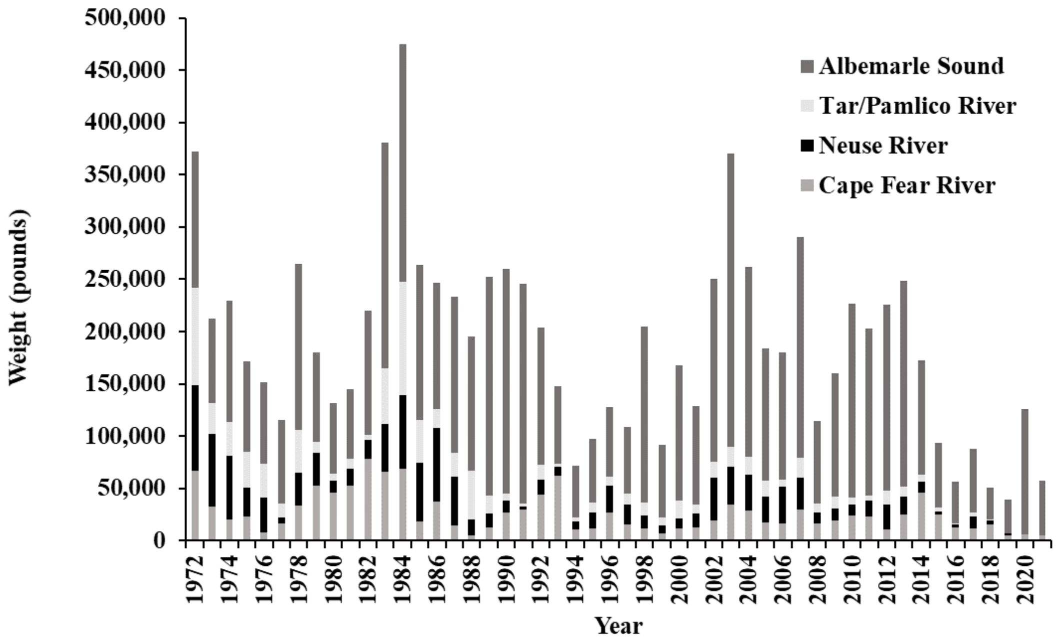

Figure 2. Commercial harvest (weight in pounds) of American shad from North Carolina by major waterbody, 1972–2021.

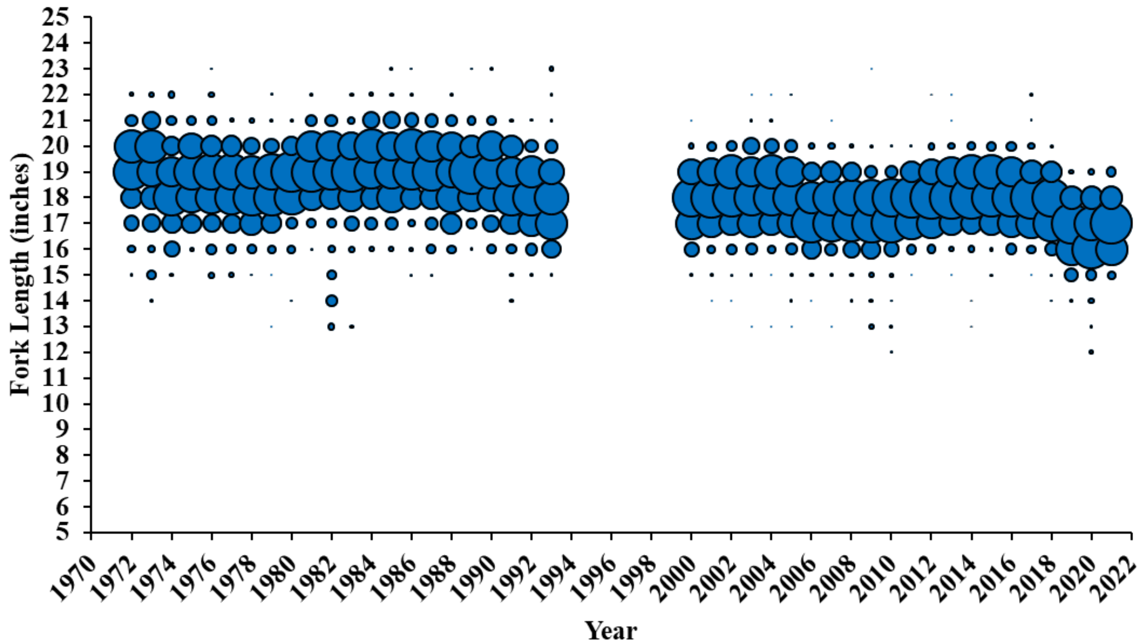

Figure 3. Commercial length frequency (fork length, inches) of female American shad harvested, 1972–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

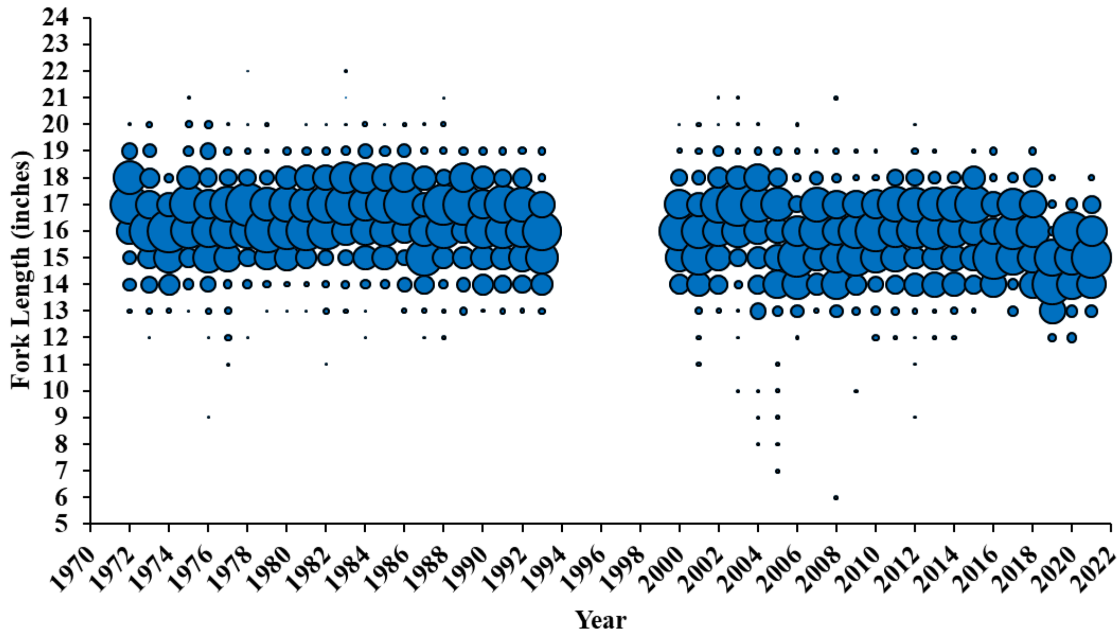

Figure 4. Commercial length frequency (fork length, inches) of male American shad, 1972–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

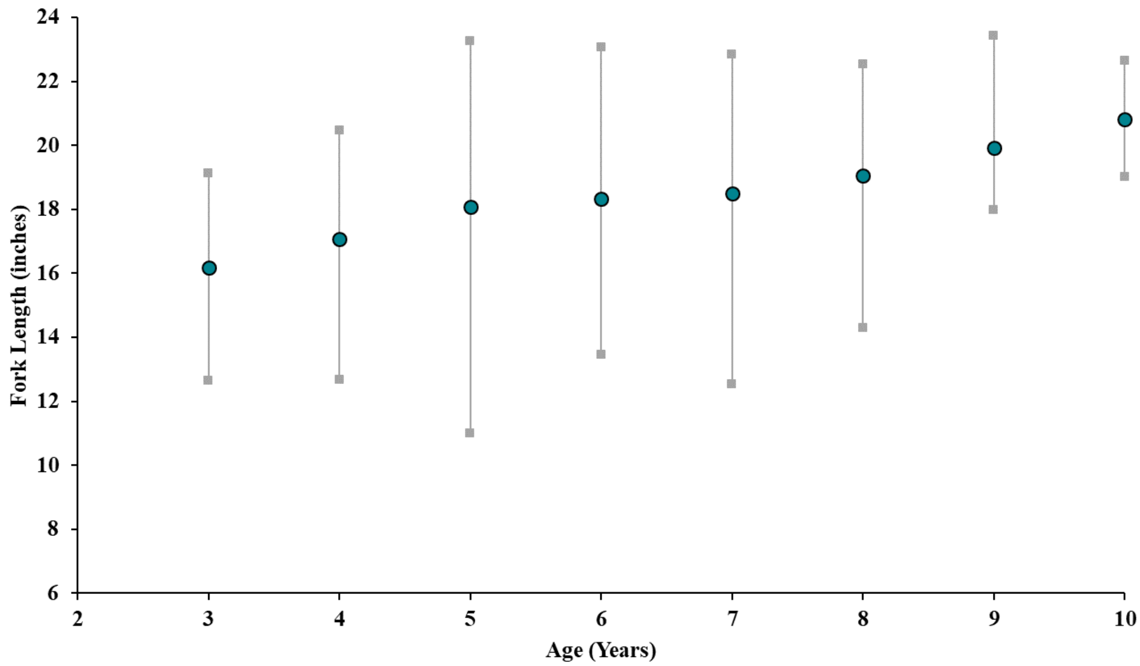

Figure 5. Female American shad length at age from all age samples collected from fishery-dependent monitoring, 1972–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

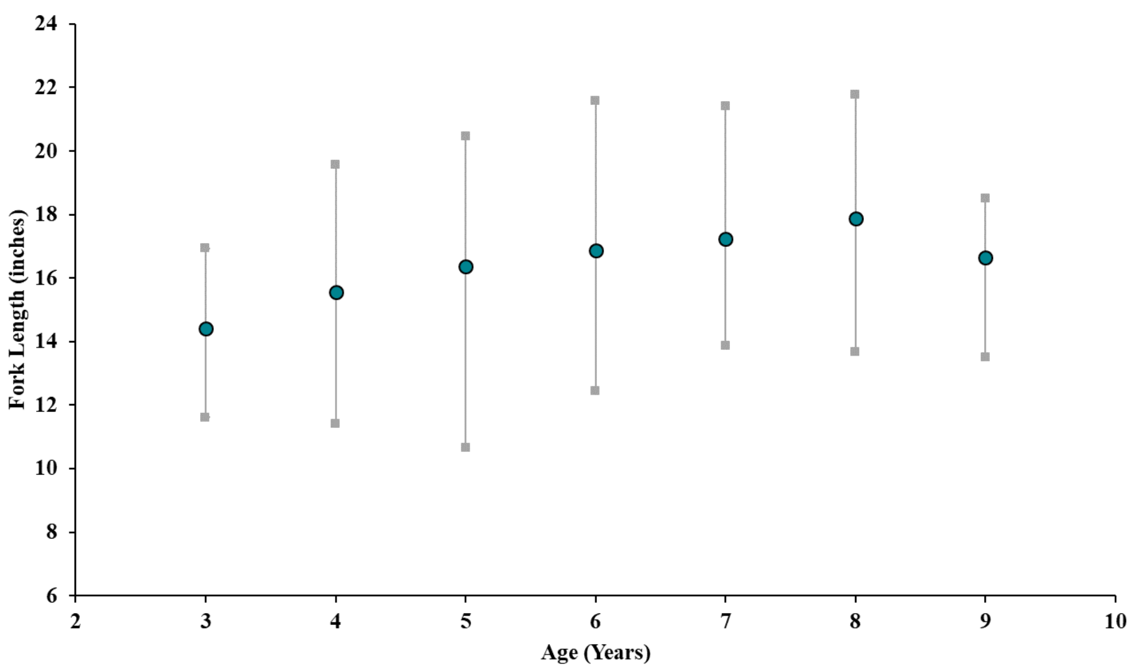

Figure 6. Male American shad length at age from all age samples collected from fishery-dependent monitoring, 1972–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

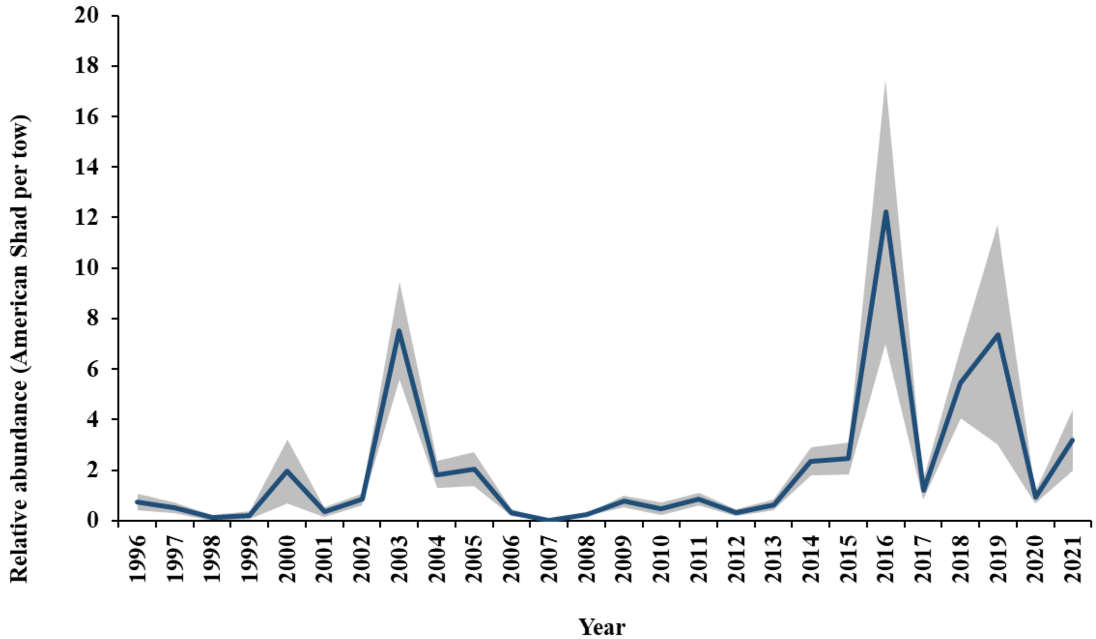

Figure 7. Relative abundance index (fish per tow) of American shad collected from Program 100 in Albemarle Sound during June through October 1996–2021. Error bars represent ± 1 standard error.

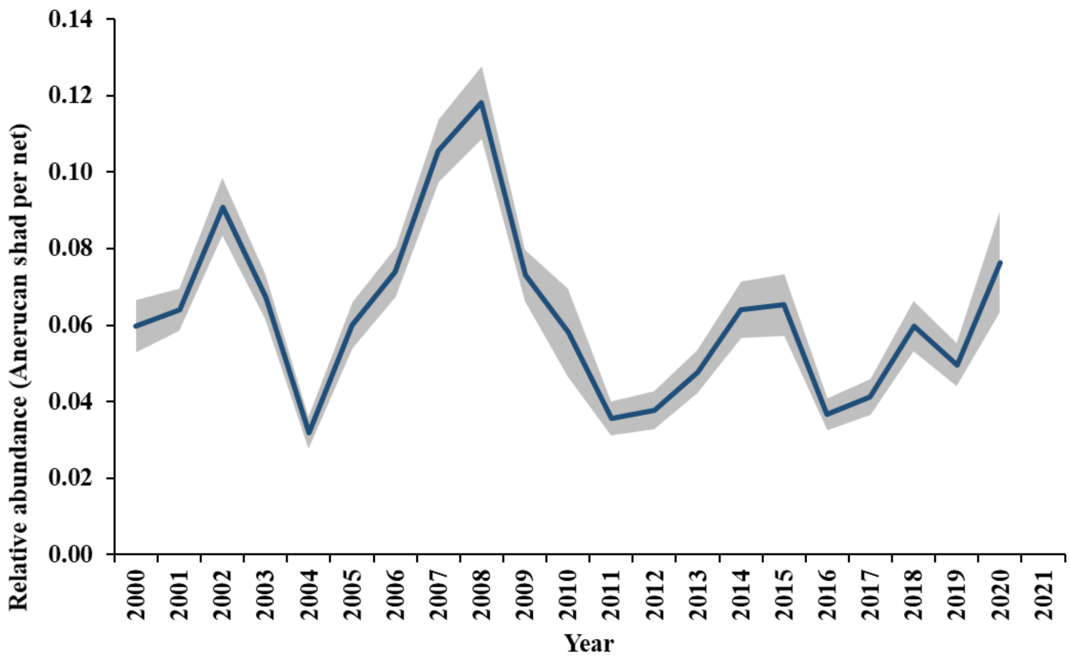

Figure 8. Relative abundance index of American shad (fish per net, all mesh sizes) collected from Program 135 in Albemarle Sound during January through May 2000–2021. Error bars represent ± 1 standard error.* Survey suspended February 20, 2020, and did not resume until fall 2021.

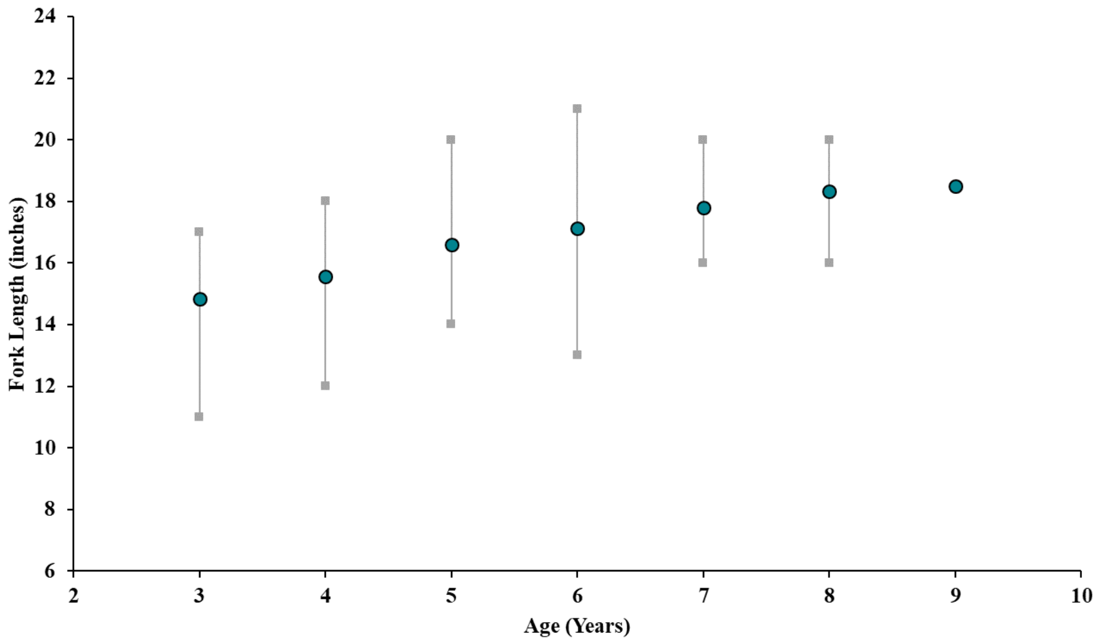

Figure 9. Female American shad length at age from all age samples collected through NCDMF fishery-independent sampling programs, 2000–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

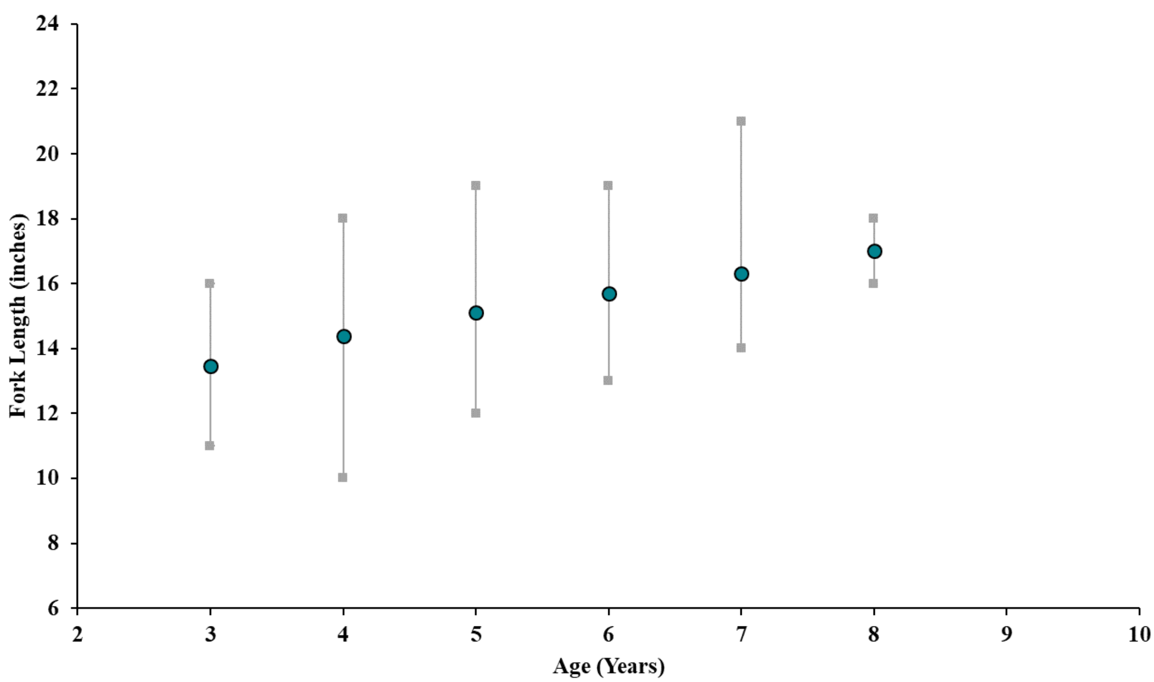

Figure 10. Male American shad length at age from all age samples collected through NCDMF fishery-independent sampling programs, 2000–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

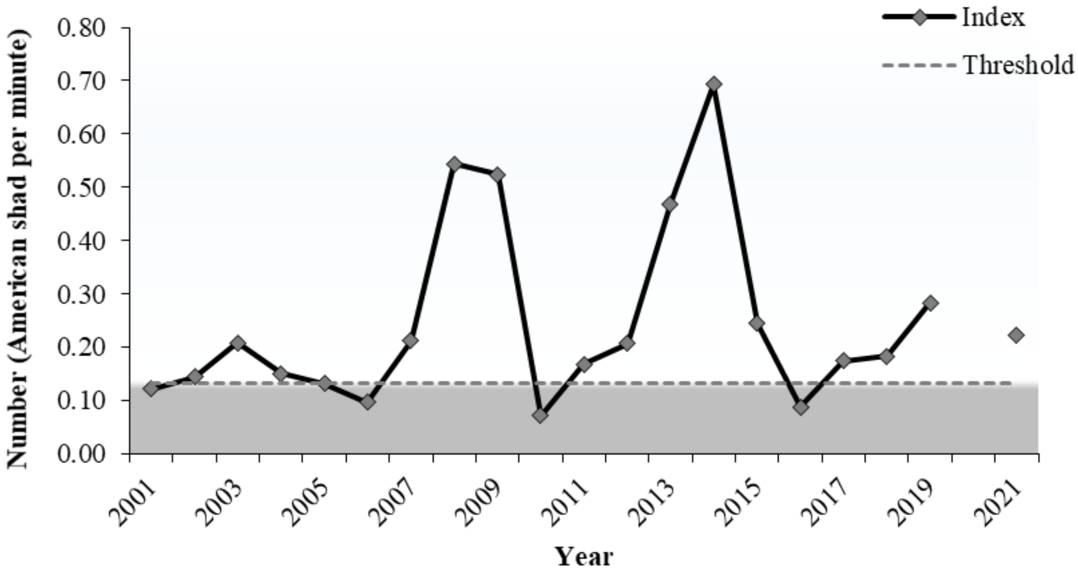

Figure 11. Albemarle Sound-Roanoke River sustainability parameter for female CPUE in the NCDMF IGNS, 2000–2021. Grey areas represent a parameter exceeding the threshold. NCDMF IGNS suspended February 20, 2020, and did not resume until fall 2021.

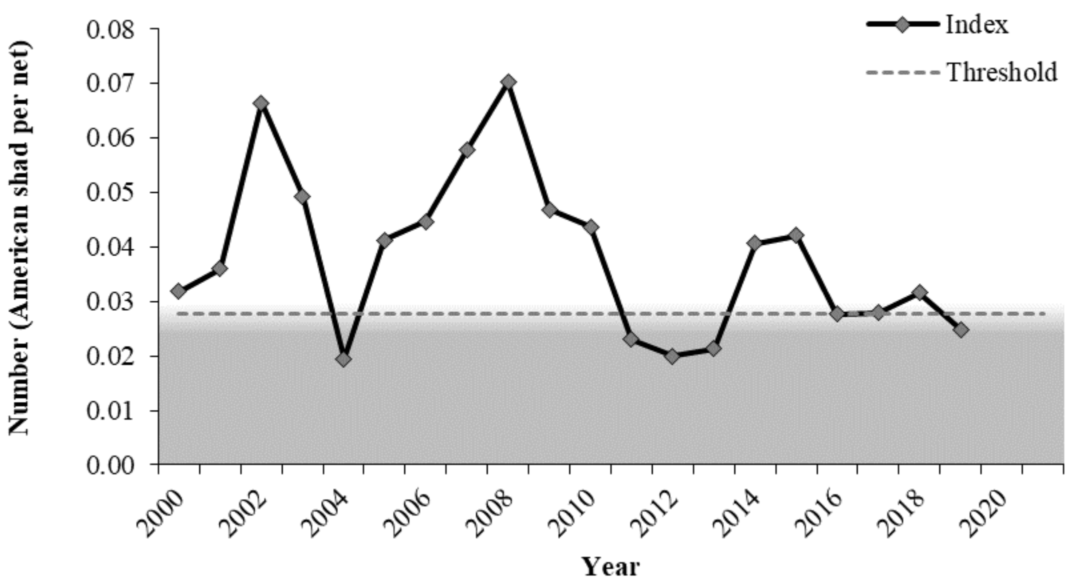

Figure 12. Albemarle Sound-Roanoke River sustainability parameter for female CPUE in NCWRC electrofishing survey, 2001–2021. Grey areas represent a parameter exceeding the threshold.

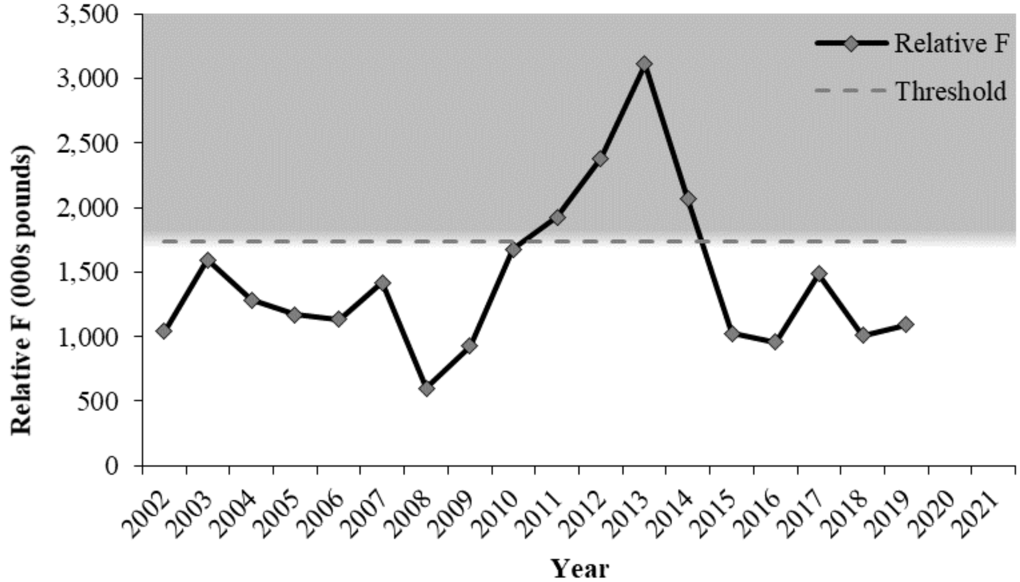

Figure 13. Albemarle Sound-Roanoke River sustainability parameter for female relative *F* in the NCDMF IGNS, 2002–2021. Grey areas represent a parameter exceeding the threshold. NCDMF IGNS suspended February 20, 2020, and did not resume until fall 2021.

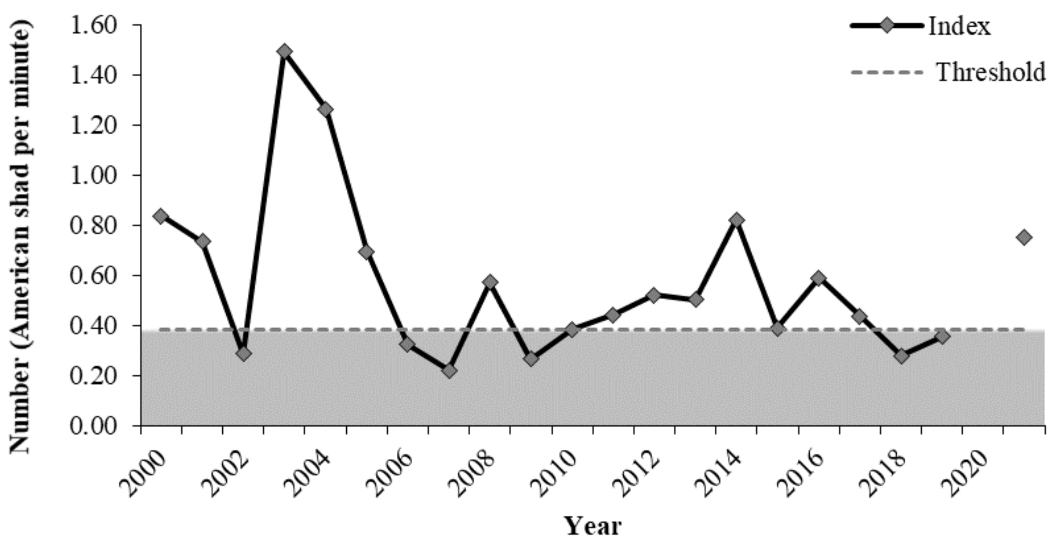

Figure 14. Tar-Pamlico River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2000–2021. Grey areas represent a parameter exceeding the threshold.

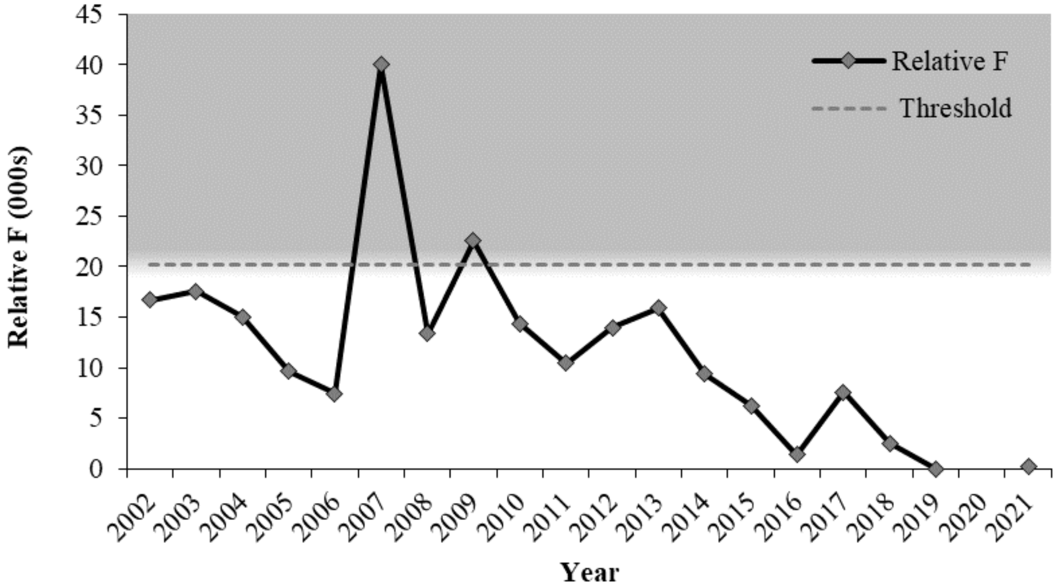

Figure 15. Tar-Pamlico River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2002–2021. Grey areas represent a parameter exceeding the threshold.

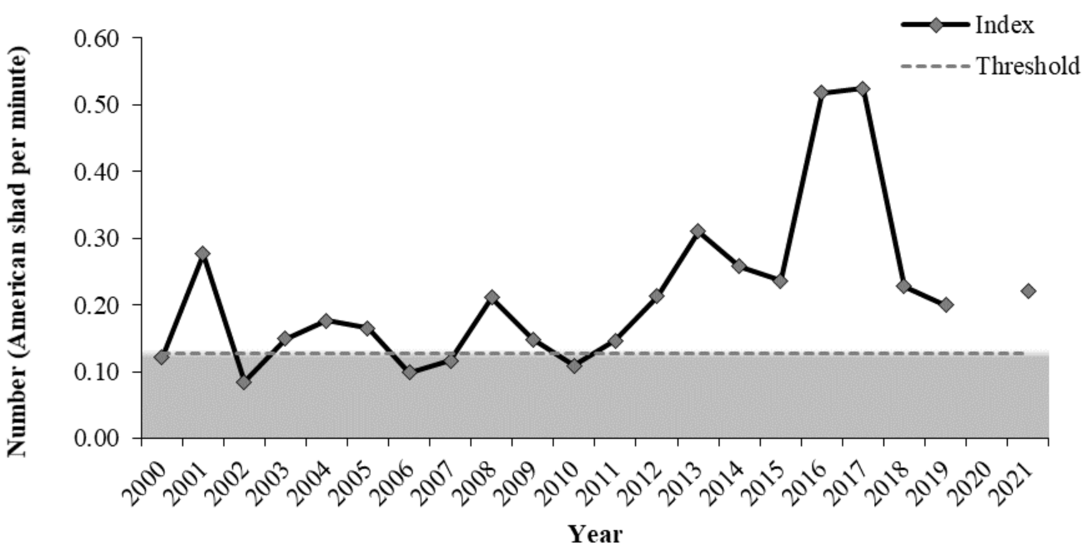

Figure 16. Neuse River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2000–2021. Grey areas represent a parameter exceeding the threshold.

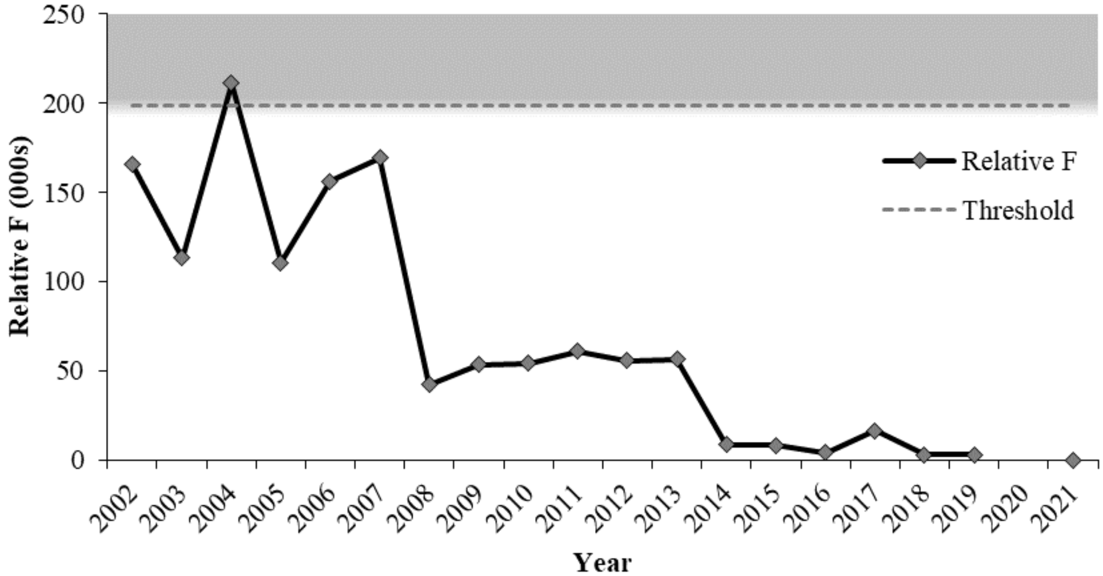

Figure 17. Neuse River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2002–2021. Grey areas represent a parameter exceeding the threshold.

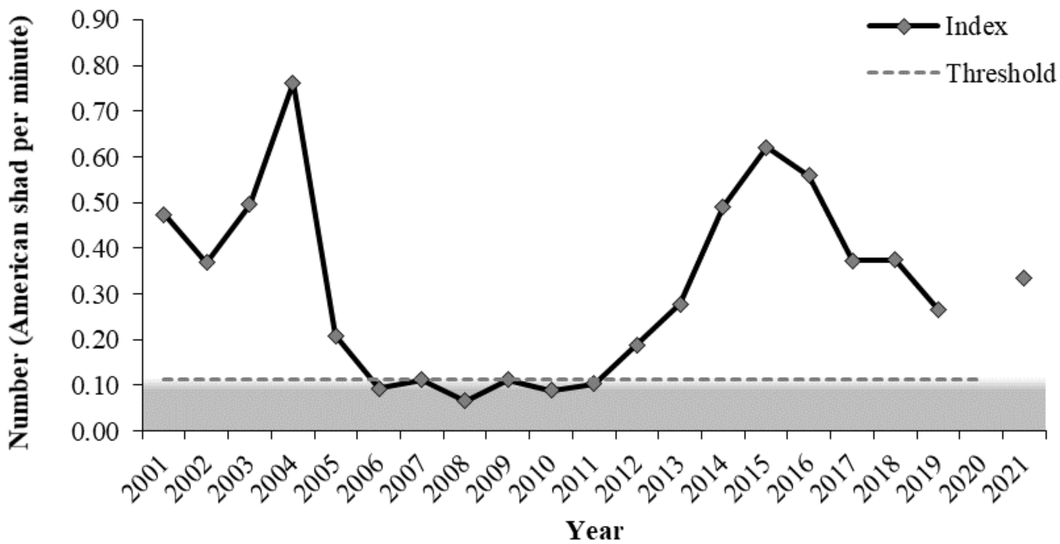

Figure 18. Cape Fear River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2001–2021. Grey areas represent a parameter exceeding the threshold.

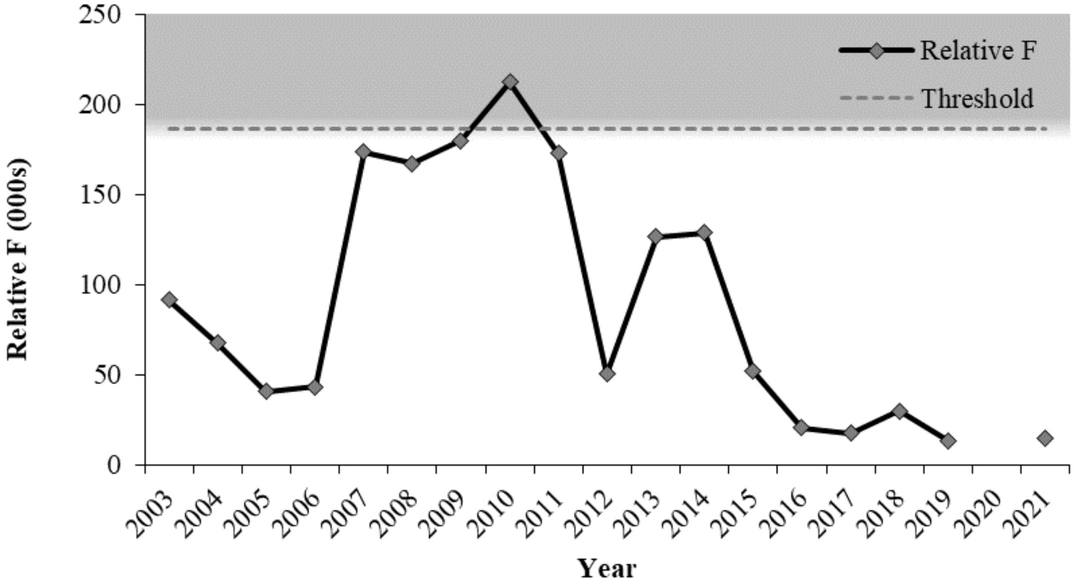

Figure 19. Cape Fear River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2003–2021. Grey areas represent a parameter exceeding the threshold.

FISHERY MANAGEMENT PLAN UPDATE
ATLANTIC CROAKER
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	October 1987	
	Amendment 1	November 2005
	Addendum I	March 2011
	Addendum II	March 2014
	Addendum III	February 2020

Comprehensive Review: 2024

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 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 management use 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 included relative percent change in landings, biological data monitoring, effort vs. landings, Marine Recreational Information Program catch per unit effort (CPUE), along with 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 results from the 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 for fast-growing, early maturing species like Atlantic croaker because 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 replaced the management triggers stipulated in Addendum I (ASMFC 2014). The harvest component of the TLA is a composite of commercial and recreational harvest data. The population, or adult abundance, component is a composite of fishery independent survey indices (e.g., Northeast Fishery Science Center (NEFSC) and Southeast Area Monitoring and Assessment Program (SEAMAP)). If thresholds for both population characteristics meet or exceed thresholds for a three-year period, management measures are triggered.

In February 2020, the Board approved Addendum III to Amendment 1, which revised the TLA's trigger mechanism and management response for the recreational and commercial fisheries (ASMFC 2020a). Addendum III incorporated the use of a regional approach (Mid-Atlantic NJ-VA and South Atlantic NC-FL) to better reflect localized fishery trends and changed the TLA to trigger management action if three of the four terminal years exceed threshold levels. State-specific management action is initiated when the proportion of red exceeds specified thresholds (30% or 60%) for both harvest and abundance. If management action is triggered, the coastwide response includes recreational bag limits and quantifiable measures to achieve percent reductions in commercial harvest. Response requirements vary depending on which threshold is exceeded. Addendum III also defines the mechanism by which triggered management actions may be removed, after abundance characteristics are no longer triggering management action. The TLA is reviewed annually in September. For additional information and links to the above-mentioned FMP, amendment, and addendums please refer to the ASMFC webpage for Atlantic croaker (http://www.asmfc.org/species/atlantic-croaker).

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. The goals of the North Carolina FMP for Interjurisdictional Fisheries is to adopt FMPs, consistent with North Carolina Law, approved by the Mid-Atlantic Fishery Management Council (MAFMC), South Atlantic Fishery Management Council (SAFMC), or the Atlantic States Marine Fisheries Commission (ASMFC) by reference and implement corresponding fishery regulations in North Carolina to provide compliance or compatibility with approved FMPs and amendments, now and in the future. The goal of the councils and ASMFC plans, established under the Magnuson-Stevens Fishery Conservation Management Act (federal councils) 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 the fisheries (NCDMF 2015).

Management Unit

New Jersey through the east coast of Florida.

Goal and Objectives

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

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

DESCRIPTION OF THE STOCK

Biological Profile

Atlantic croaker (*Micropogonias undulatus*) inhabit marsh, submerged aquatic vegetation, mud, and sand-bottom areas (Odell et al. 2017) from the Gulf of Maine to Argentina, but are most abundant from the Chesapeake Bay to northern Florida. However, the center of Atlantic croaker distribution is forecast to shift northward due to climate change (Hare et al. 2010). Atlantic croaker feed on shrimp, crabs, worms, shellfish, and small fishes (Powers et al. 2005; Nye et al. 2011). Atlantic croaker has a protracted spawning season beginning in the early fall and extending through December with a peak during September and October (White and Chittenden 1977;

Barbieri et al. 1994). Eggs and recently hatched larvae spawned in ocean waters drift toward land and the advanced larval stages and juveniles continue their migration inshore by actively swimming into estuarine nursery areas (Odell et al. 2017). Maximum recruitment (the number of fish entering the population) of juveniles is usually in the spring, with movement to offshore waters in the fall (Haven 1959; Norcross and Austin 1988). Higher overwinter survival of juvenile Atlantic croaker has been linked to increased winter water temperatures (Hare and Able 2007; Morley et al. 2016).

Atlantic croaker grow quickly, and can reach sizes over 20 inches (Ross 1988). Most Atlantic croaker are mature by the end of their first year (White and Chittenden 1977; Barbieri et al. 1994; ASMFC 2010), with length at 50 percent maturity generally falling between seven- and nine-inches total length (Barbieri et al. 1994; ASMFC 2010; NCDMF 2021a). 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

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 II and revised under Addendum III, is reviewed annually in years when an assessment is not already being conducted.

Results from the 2020 TLA (2019 terminal year) indicated harvest indices for both regions and abundance indices for the Mid-Atlantic were above 30% in three of the last four years and thus the TLA for Atlantic croaker triggered at the 30% threshold or moderate concern and management action as outlined in Addendum III was enacted in March 2021 (ASMFC 2020b).

Results of the 2021 TLA (2020 terminal year) indicated harvest indices for both regions and abundance indices for the Mid-Atlantic remained above 30% in three of the last four years. The harvest composite index triggered for the seventh year in a row in the Mid-Atlantic region and the sixth year in a row in the South Atlantic region (Figure 1; ASMFC 2021). The adult abundance (age 2+) composite characteristic has exceeded the 30% threshold since 2010 in the Mid-Atlantic region (no 2019 or 2020 data points as ChesMMAP indices were not available) but has not exceeded the 30% threshold in the South Atlantic region since 2010 (no 2020 data points; Figure 2; ASMFC 2021). The adult composite index in the South Atlantic has indicated an increasing or stable trend. While not used for management decisions, the composite juvenile abundance index consisting of North Carolina Pamlico Sound Survey is reviewed annually. The index has been variable since 2002 with some indication of increases in abundance since 2010 except for 2018 with a usually high red portion indicating low abundance (Figure 3; ASMFC 2021).

Stock Assessment

The next Atlantic croaker Benchmark Stock Assessment is scheduled for 2024. The most recent benchmark stock assessment, completed in 2017, did not pass peer review and will not be used for management. The assessment was not recommended for management because of concern over uncertainty in biomass estimates due to conflicting signals among abundance indices and catch time series as well as sensitivity of model results to assumptions and model inputs (ASMFC 2017, 2019). The review panel noted that discard estimates from the shrimp trawl fishery was an improvement from the last assessment and recommended shrimp trawl discard estimates be incorporated into annual monitoring using the TLA.

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/FMSY is greater than 1 and the stock is considered overfished if SSB/(SSBMSY(1-M)) is less than 1.

DESCRIPTION OF THE FISHERY

Current Regulations

The 2020 TLA update (2019 terminal year) for Atlantic croaker triggered at the 30% threshold and coastwide management action as outlined in Addendum III was enacted in March 2021. The management response outlined in Addendum III specifies, non de minimis states are required to implement a 50 fish bag limit for their recreational fishery and must reduce commercial harvest by 1% of the average state commercial harvest from the previous 10 years.

In North Carolina, the 50 fish per person per day recreational bag limit became effective April 15th, 2021 (FF-24-2021) and remains in place for the 2022 season. The commercial Atlantic croaker fishery closed December 16th, 2021 through December 31st, 2021 to meet the required 1% reduction (FF-65-2021). The same commercial closure period will occur in December 2022. Management measures will remain in place for at least three years (until 2023) and future TLA updates will determine future management action after this time.

Commercial Fishery

Data collected from the North Carolina Trip Ticket program indicates commercial harvest was at its greatest in the late 1990's to early 2000s' peaking at 14,429,197 pounds in 2003 (Table 1; Figure 4a). Landings in the past five years have been the lowest in the time series dropping to a time series minimum of 540,622 pounds harvested in 2021. Commercial harvest averaged 6,164,385 pounds from 1991 through 2021 and has generally been declining since 2003 with significant landings declines beginning in 2010. Commercial landings are currently supported almost entirely (99%) by the gill net fishery with 88% of landings reported from ocean gill nets and 11% of landings from estuarine gill nets (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 Fishery

Atlantic croaker are targeted recreationally by shore-based anglers and those fishing from private vessels during the summer and fall. 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 to 2008, an average of 14,534 pounds were harvested per year (NCDMF 2021b). Recreational estimates across all years have been updated and are now based on the Marine Recreational Information Program (MRIP) Fishing Effort Survey-based calibrated estimates. For more information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

From 1991 through 2021 recreational harvest of Atlantic croaker in North Carolina ranged from 164,644 to 758,751 pounds or between 472,917 and 1,935,961 fish (Table 1, Figures 4b and 6). Harvest by weight has generally declined since 2014 with the three lowest reported values occurring consecutively from 2018 to 2020, while the number of individuals harvested has increased since a time series low in 2018. In 2021, 1,066,533 fish and 376,121 pounds of Atlantic croaker were harvested, a 58% increase in number of fish and a 68% in weight from 2020.

The number of recreational releases has been variable over the time series with a noticeable peak in 2014 (Figure 6). The percentage of releases has steadily increased over the time series from 55% to 90%. In 2021, anglers released 9,539,047 fish, a 72% increase from 2020. This spike in discard percentage may be the result of the 50 fish bag limit enacted in 2021.

The number of Atlantic croaker measured during MRIP sampling has generally declined, with 122 individuals measured in 2021 (Table 2). Mean total length (TL) in 2021 was the same as 2020 at 8.9 inches and has fluctuated little since 1991 ranging from 8.4 to 10.4. Similarly, minimum and maximum TL have fluctuated little since 1991. Most of the recreational catch consists of fish from 6.0 to 10.0 inches TL (Figure 7). There was a wider range of lengths harvested during the 1990’s and early 2000’s. Length distribution from the 2021 recreational harvest ranged from 6.0 to 12.0 inches and when compared to commercial catches had greater representation of smaller size classes (Figure 8).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

In 2021, 4,208 Atlantic croaker lengths were obtained from commercial fish house sampling with a mean TL of 9.6 inches, and lengths ranging from 5.9 to 13.7 inches (Table 3). Mean TL has varied little ranging from 9.3 inches to 12.1 inches and has generally declined since 2005. Minimum TL ranged from 3.9 inches to 7.4 inches and maximum TL ranged from 24.8 to 13.3 inches. Bait samples are included in calculations of mean, minimum and maximum length.

Modal length generally increased from 1994 to the early 2000’s (Figure 9). There is a noticeable decline and contraction in size classes beginning in 2015, with most fish falling between 7.0 and 11.0 inches.

Size trends in 2021 commercial samples indicate a dominance of 9.0-inch fish with few over 11.0 inches or under 8.0 inches (Figure 8). When compared to the recreational fishery, the commercial fishery harvested a narrower range of sizes.

Fishery-Independent Monitoring

The number of Atlantic croaker aged in North Carolina's comprehensive life history program (P930) from 1996 through 2021 has ranged from 237 in 2011 to 1,071 in 1998 (Table 4). Modal age was one or two in most years but has been zero in recent years including 2008, 2016, 2017, 2020. Minimum age was zero in every year while maximum age ranged from six to 15 years. Maximum age was between 11 and 15 years from 2001-2010 and between six and ten from 2011-2021. A total of 488 fish were aged in 2021 with a modal age of one and a maximum age of nine. There is significant overlap in length at age, though mean length tends to plateau at age seven and length does not exceed 22 inches in any age class (Figure 10).

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. Length cutoffs for juvenile Atlantic croaker were updated in 2022 after analyzing length distribution of age-0 and age-1 Atlantic croaker in P930. Juvenile Atlantic croaker are defined as fish <160 mm TL (6.3 inches) in June, and fish <210 mm TL (8.3 inches) in September.

The COVID pandemic impacted sampling in 2020 and 2021. Executive Order (EO) 116, issued on March 10, 2020, declared North Carolina under a State of Emergency and was soon followed by EO 120 which implemented a statewide Stay at Home Order for all non-essential State employees. In 2020, sampling was limited to 28 stations sampled in June and 35 stations sampled in September. A total of 35 stations were sampled in June 2021 and 32 stations were sampled in September 2021. Limited sampling likely impacted abundance indices calculated from Sound Survey data. An initial analysis of this impact was conducted for the 2020 Atlantic croaker abundance indices and concluded the magnitude of abundance may be overestimated slightly but limited sampling was likely able to capture the general abundance trends.

The Atlantic croaker weighted JAI from the Pamlico Sound Survey from 1987 through 2021 has been variable in both June and September. Annual fluctuations in the June JAI are most notable after 2009 when steep increases in abundance are followed by steep declines (Figure 11). The June JAI has ranged from 69 individuals per tow in 1996 to 1,297 individuals per tow in 2010 with a time series average of 420 individuals per tow. The time series average in September is slightly greater at 500 individuals per tow ranging from 96 individuals per tow in 1987 to 1,376 individuals per tow in 2020. The September JAI fluctuates around the time series average but the past ten years indicated a slightly increasing trend. The 2021 JAI contradicts the increasing abundance trend showing a steep decline in September 2021 of 299.7 individuals per tow. The June JAI in 2021 at 515 individuals per tow shows the continuation of the decline from June 2020.

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 12). 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. Interestingly, the length composition from both June and September 2021 shows a wider range than previous years.

RESEARCH NEEDS

There is no research or monitoring programs required of the states except for the submission of an annual compliance report. However, several coastwide and state specific research recommendations have been identified and ranked through the ASMFC FMP and stock assessment process. The high priority research recommendations are reported below. Additional research and monitoring recommendations can be found in the 2016 Atlantic Croaker Stock Assessment Peer Review Report here under Term of Reference 8 (ASMFC 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.

- Describe the coast-wide distribution, behavior, and movement of croaker by age, length, and season, with emphasis on collecting larger, older fish.
- Continue state and multi-state fisheries-independent surveys throughout the species range and subsample for individual lengths and ages. Ensure NEFSC trawl survey continues to take lengths and ages. Examine potential factors affecting catchability in long-term fishery independent surveys.
- Quantify effects of BRDs and TEDs implementation in the shrimp trawl fishery by examining their relative catch reduction rates on Atlantic croaker.
- Continue to develop estimates of length-at-maturity and year-round reproductive dynamics throughout the species range. Assess whether temporal and/or density- dependent shifts in reproductive dynamics have occurred.
- Re-examine historical ichthyoplankton studies for an indication of the magnitude of estuarine and coastal spawning, as well as for potential inclusion as indices of spawning stock biomass in future assessments. Pursue specific estuarine data sets from the states (NJ, VA, NC, SC, DE, ME) and coastal data sets (MARMAP, EcoMon).

MANAGEMENT STRATEGY

The TLA established under Addendum II and revised under Addendum III (approved February 2020) to Amendment 1 is used as a precautionary management framework for Atlantic croaker. The TLA provides guidance in lieu of a current stock assessment. Addendum III incorporated the use of a regional approach (Mid-Atlantic NJ-VA and South Atlantic NC-FL) to better reflect localized fishery trends. 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 any three of the four most recent years, then management action is required. The harvest composite index triggered at the 30% threshold in both regions in 2019. The adult abundance characteristics for the Mid-Atlantic exceeded the threshold in 2019 while the South Atlantic abundance composite characteristic did not exceed the trigger in 2019. Since both population characteristics were above the 30 percent threshold in at least three years from 2016-2019, management actions were implemented in March 2021.

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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), 1991–2021. All weights are in pounds.

	Recreational			Commercial	
Year	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
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	1,819,020	2,376,755
2016	1,109,570	7,254,382	443,728	2,092,287	2,536,015
2017	666,930	4,631,445	237,160	1,008,015	1,245,175
2018	472,917	4,311,368	164,644	1,643,646	1,808,290
2019	651,268	3,634,211	224,337	1,278,340	1,502,677
2020	673,377	5,560,605	223,685	570,423	794,108
2021	1,066,533	9,539,047	376,121	540,622	916,743
Mean	1,142,212	4,400,777	465,680	6,164,385	6,630,066

Table 2. Mean, minimum, maximum total length (inches), and total number of Atlantic croaker measured by Marine Recreational Information Program sampling in North Carolina, 1991–2021.

Year	Mean Total Length	Minimum Total Length	Maximum Total Length	Total Number Measured
1991	8.5	5.1	39.3	627
1992	8.5	4.6	13.2	535
1993	8.7	5.0	21.2	861
1994	8.6	4.8	15.6	2,065
1995	9.2	4.3	15.6	1,268
1996	10.0	5.3	16.7	1,169
1997	9.6	5.0	16.5	937
1998	9.3	6.0	16.7	599
1999	9.7	6.3	17.2	681
2000	9.6	6.7	17.6	360
2001	10.0	6.5	15.8	529
2002	9.7	6.0	15.0	255
2003	10.4	7.3	18.4	289
2004	10.1	7.0	17.4	263
2005	9.6	6.7	17.2	140
2006	8.8	4.8	14.9	198
2007	8.4	4.1	13.9	113
2008	9.4	4.3	15.4	188
2009	8.9	5.7	15.8	210
2010	9.8	6.2	16.8	330
2011	9.6	4.9	14.3	255
2012	9.2	4.9	14.1	230
2013	9.1	5.9	15.4	267
2014	9.1	4.1	14.1	215
2015	9.2	5.8	13.9	142
2016	9.3	6.3	13.2	219
2017	9.0	6.7	12.5	169
2018	8.9	6.5	19.1	119
2019	9.0	5.9	19.1	147
2020	8.9	5.9	19.1	127
2021	8.9	6.6	12.8	122

Table 3. Mean, minimum, maximum total length (inches), and total number of Atlantic croaker measured from North Carolina commercial fish house samples, 1994–2021. Bait samples are included in calculations of mean, minimum and maximum length.

Year	Mean Total Length	Minimum Total Length	Maximum Total Length	Total Number Measured
1994	9.3	4.6	15.2	20,282
1995	9.9	4.6	18.0	21,286
1996	11.0	4.3	18.3	32,339
1997	11.1	4.3	17.9	26,341
1998	11.7	3.9	19.7	22,818
1999	11.8	3.9	19.1	20983
2000	11.6	4.0	19.8	29,022
2001	12.0	4.5	19.7	30,506
2002	12.0	5.1	19.7	21,985
2003	12.1	4.9	18.6	25,881
2004	12.0	3.9	20.0	23,335
2005	12.0	4.9	19.7	21,719
2006	11.4	4.7	24.8	20,541
2007	11.3	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	11.3	5.0	17.8	21,511
2011	11.5	4.6	16.6	15,947
2012	11.2	5.5	17.9	10,930
2013	11.2	5.6	17.2	9,062
2014	10.3	4.4	16.7	11,523
2015	10.6	5.4	15.5	9,593
2016	10.7	7.4	15.2	6,959
2017	10.0	6.6	15.2	6,022
2018	10.3	6.2	15.2	3,771
2019	9.9	6.1	15.2	4,775
2020	9.4	5.4	13.3	1,807
2021	9.6	5.9	13.7	4,208

Table 4. Modal, minimum, maximum age, and total number of Atlantic croaker aged in North Carolina from fishery dependent and fishery independent sampling, 1996–2021. Includes otolith ages only. Age data from 2021 is preliminary.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1996	2	0	6	836
1997	1	0	9	428
1998	1	0	9	1,071
1999	1	0	9	671
2000	1	0	9	815
2001	2	0	12	793
2002	1	0	11	605
2003	1	0	12	516
2004	2	0	13	681
2005	3	0	14	597
2006	1	0	13	658
2007	5	0	15	321
2008	0	0	15	739
2009	1	0	14	709
2010	4	0	13	703
2011	1	0	8	237
2012	2	0	7	349
2013	1	0	8	577
2014	2	0	8	1,070
2015	1	0	9	993
2016	0	0	6	474
2017	0	0	7	451
2018	1	0	8	544
2019	2	0	10	537
2020	0	0	7	380
2021	1	0	9	488

FIGURES

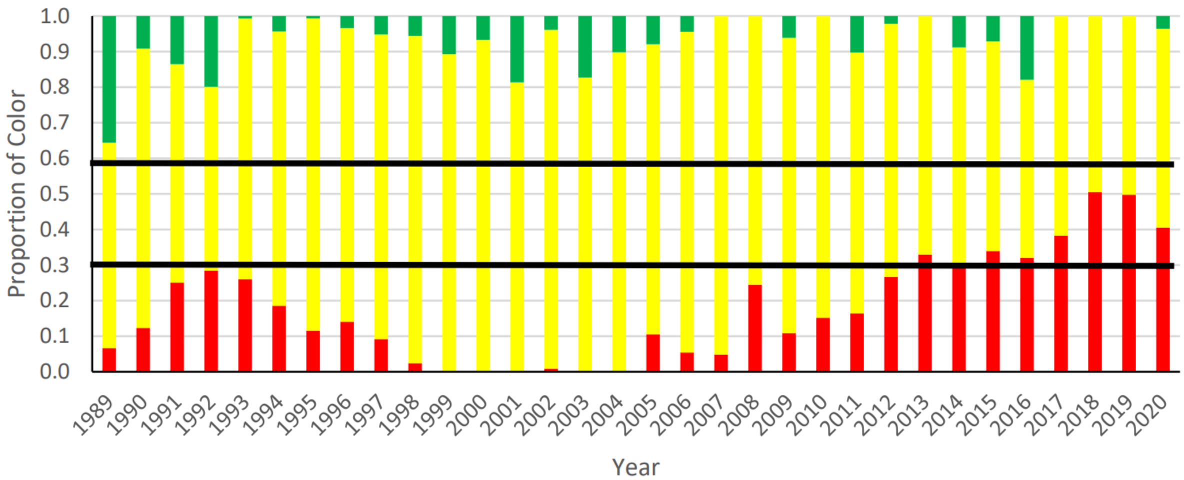

Figure 1. Annual color proportions for the harvest composite TLA of South Atlantic region (NC-FL) Atlantic croaker recreational and commercial landings, 1989–2020 (ASMFC 2021). The reference period is 2002–2012.

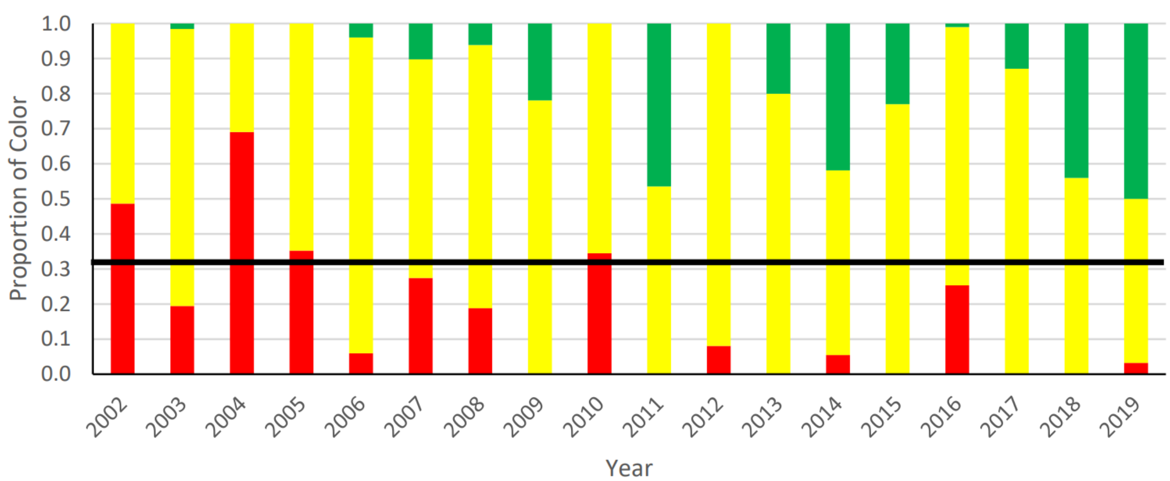

Figure 2. Annual color proportions for the abundance composite TLA of South Atlantic region (NC-FL) for adult (age 2+) Atlantic croaker fishery independent indices (SEAMAP and SCDNR trammel survey), 2002–2019 (no 2020 data point due to limited sampling; ASMFC 2021). The reference period is 2002–2012.

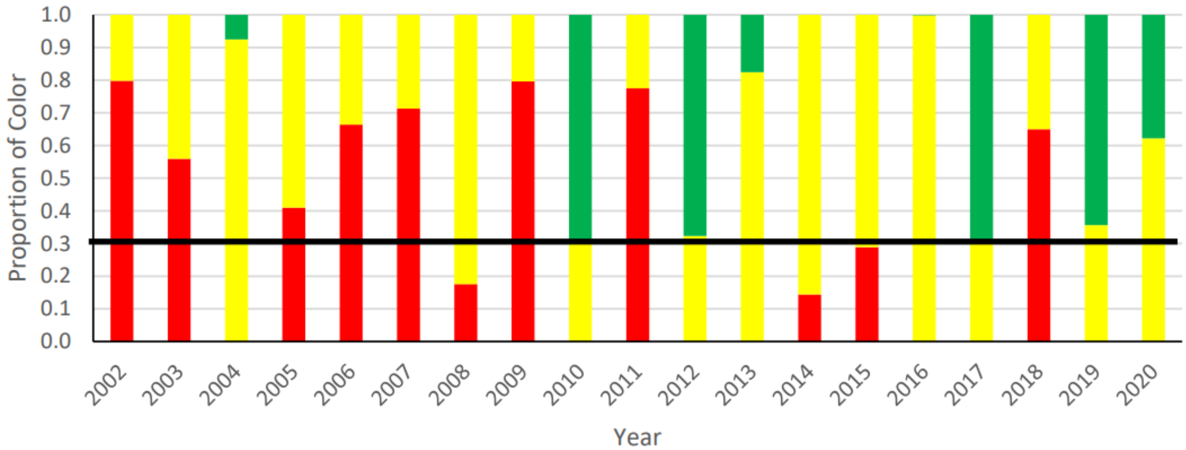

Figure 3. Annual color proportions for the abundance composite TLA of South Atlantic region (NC-FL) for juvenile (age 0) Atlantic croaker from the NCDMF Pamlico Sound Survey, 2002–2020 (ASMFC 2021). Reference period is 2002–2012. Juvenile index does not trigger management action

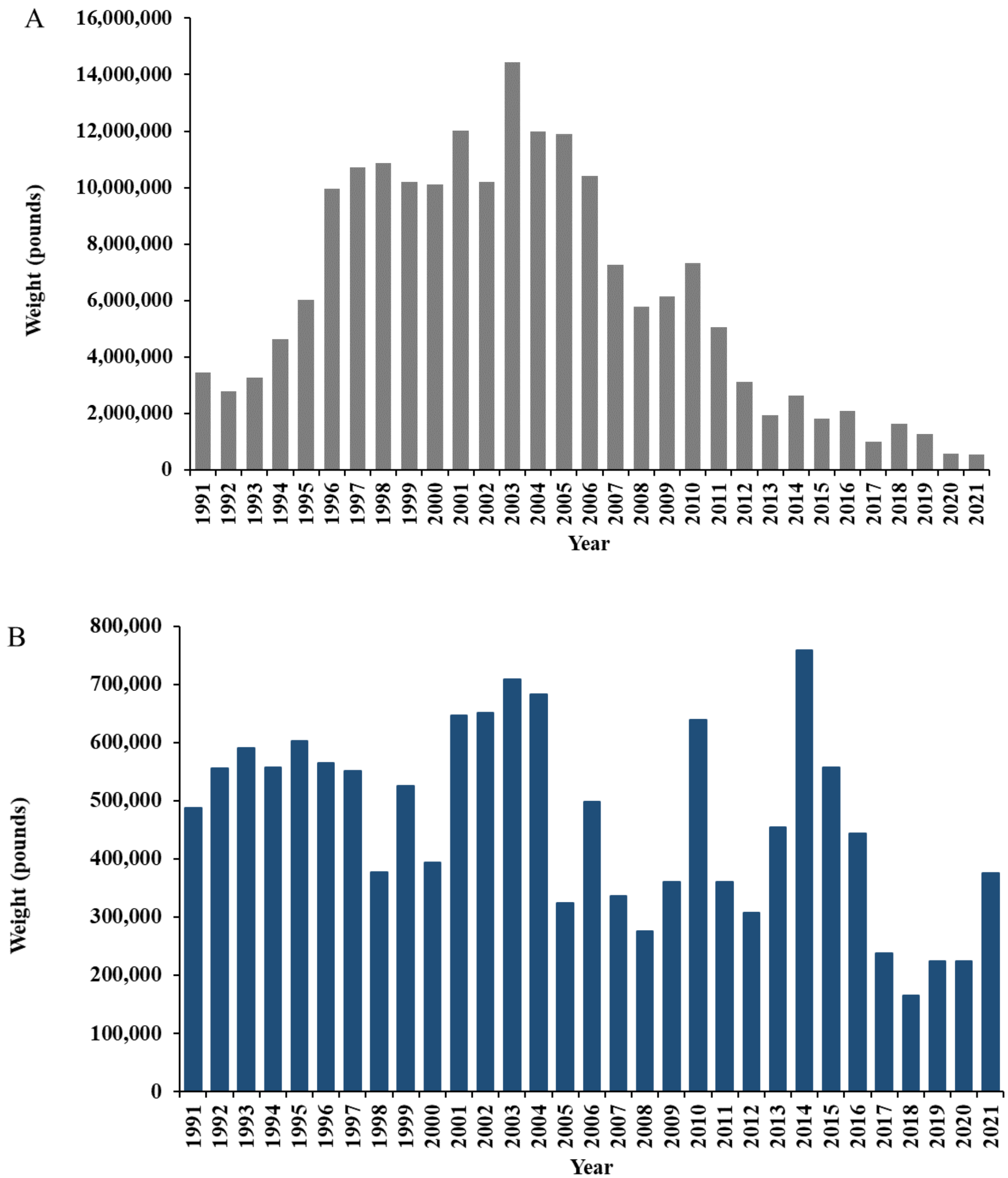

Figure 4. Annual A) commercial landings (North Carolina Trip Ticket Program) and B) recreational harvest (Marine Recreational Information Program) in pounds for Atlantic croaker in North Carolina, 1991–2021.

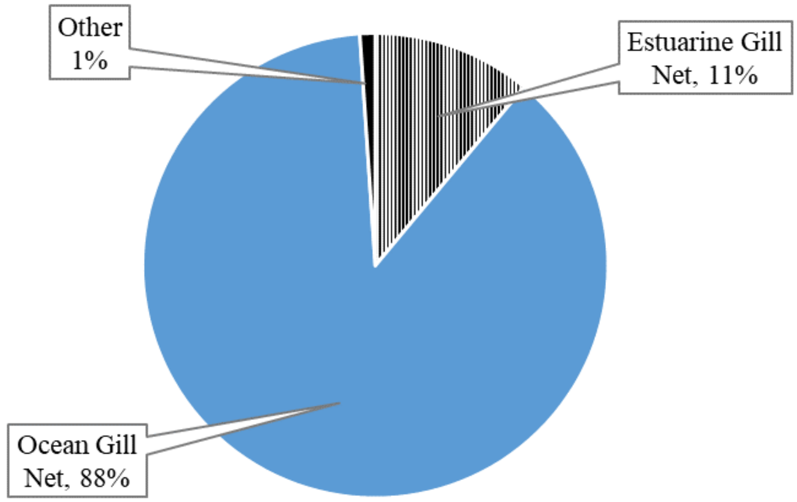

Figure 5. Commercial harvest of Atlantic croaker by gear, 2021. Other gears include swipe net, beach seine, crab pots, haul seines and pound nets.

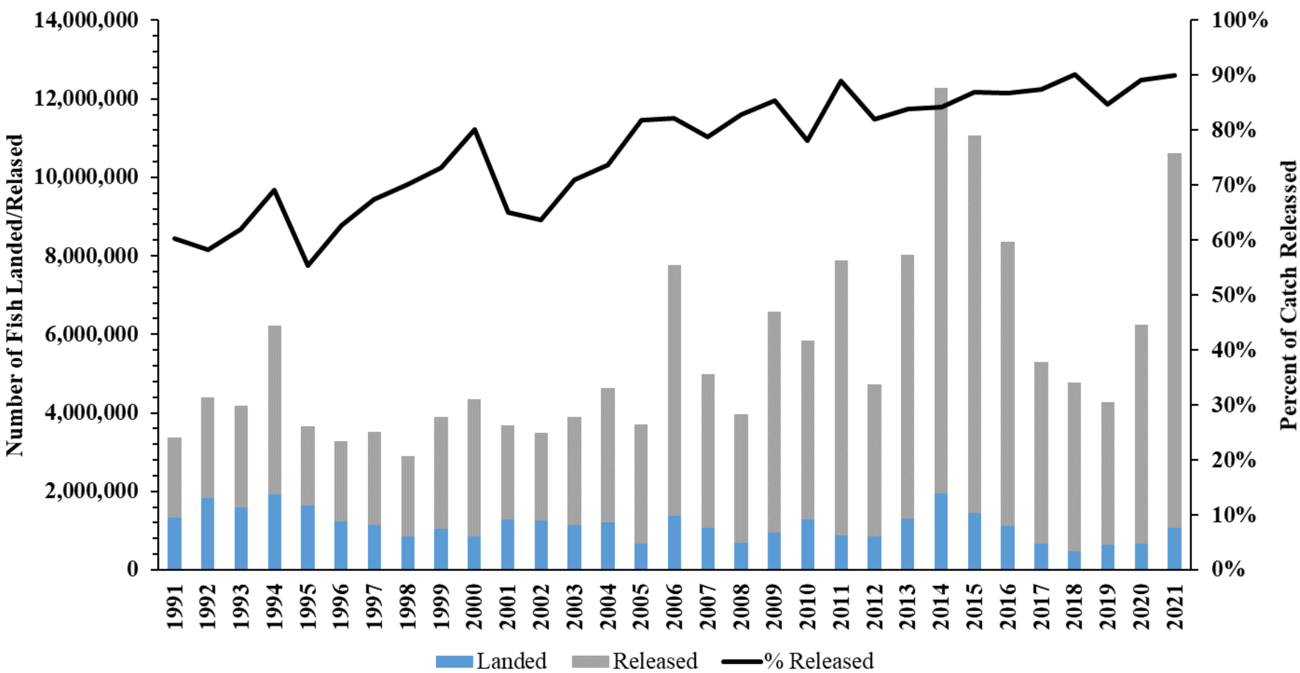

Figure 6. Recreational catch (landings and releases, in numbers) and the percent of catch that is released, 1991–2021 from the MRIP.

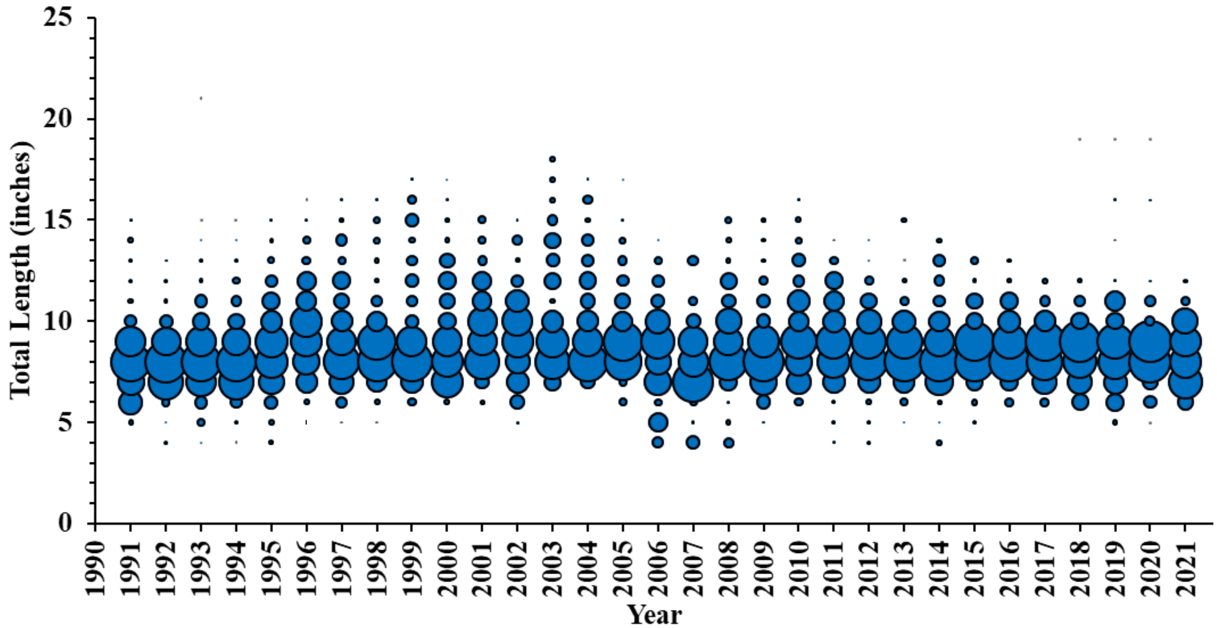

Figure 7. Recreational length frequency (total length, inches) of Atlantic croaker harvested, 1991–2020 (MRIP, n=35,408,568). Bubble represents the proportion of fish at length.

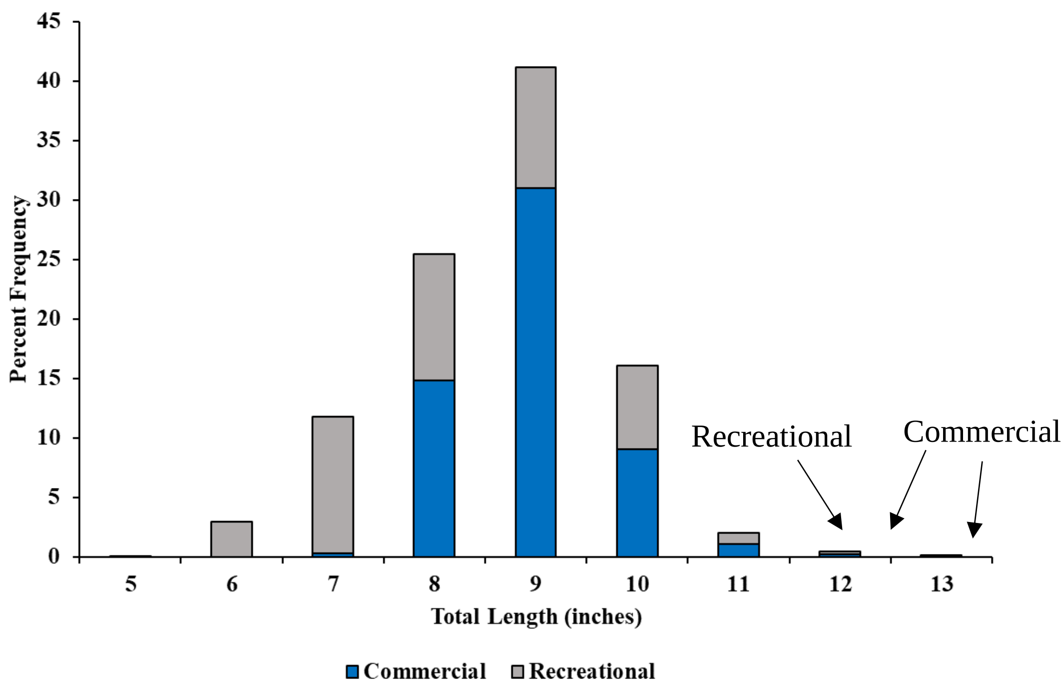

Figure 8. Commercial (n=1,392,477) and recreational (n=1,066,533) length frequency (TL, inches) distribution from Atlantic croaker harvested in 2021.

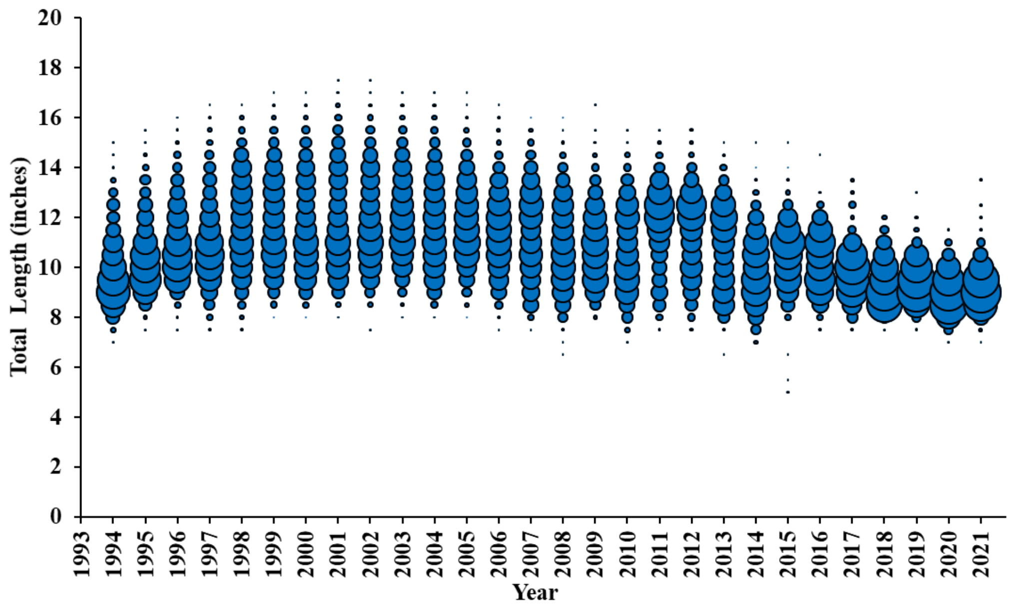

Figure 9. Commercial length frequency (total length, inches) of Atlantic croaker harvested from 1994–2021. Bubble represents the proportion of fish at length. Bait samples not included.

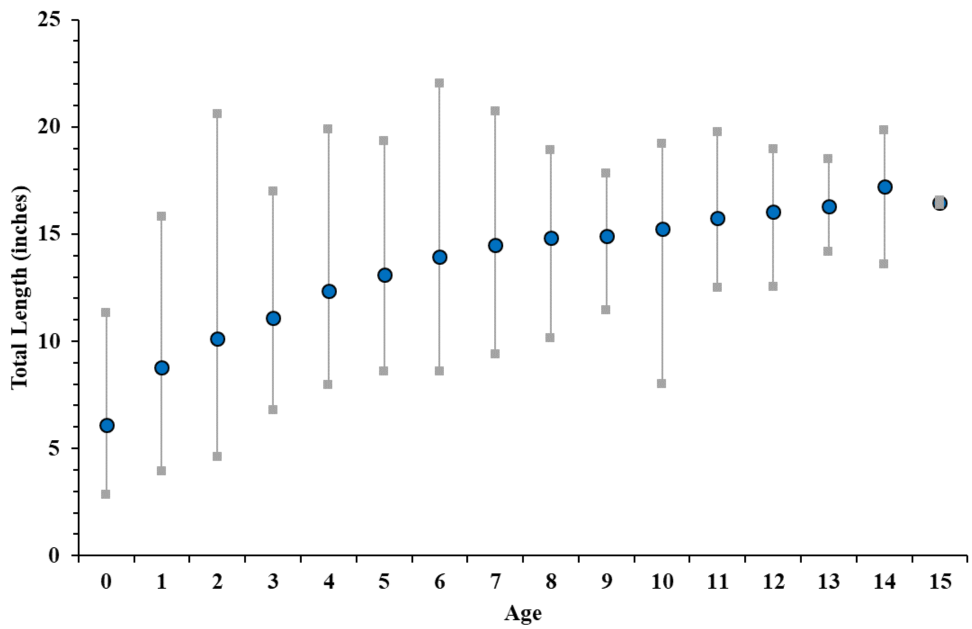

Figure 10. Atlantic croaker length at age based on all age samples collected from 1996 to 2020 (n=17,481). Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

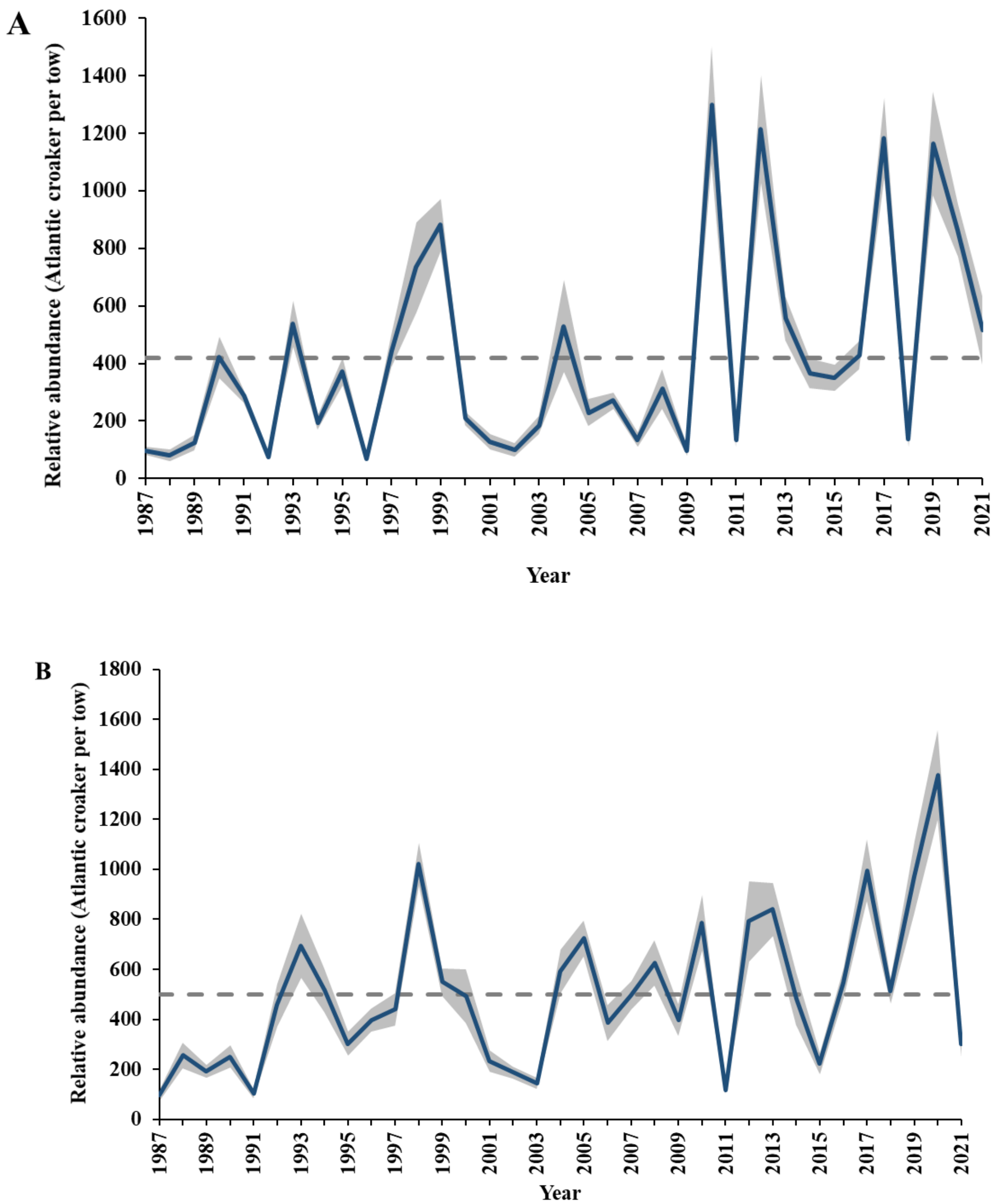

Figure 11. Atlantic croaker weighted juvenile relative abundance (number per tow) for A) June and B) September from the Pamlico Sound Survey, 1987–2021. Shaded area represents standard error and dashed line indicates time series average. Length cutoffs are <160 mm TL (6.3 in) in June and <210 mm TL (8.3 in) in September.

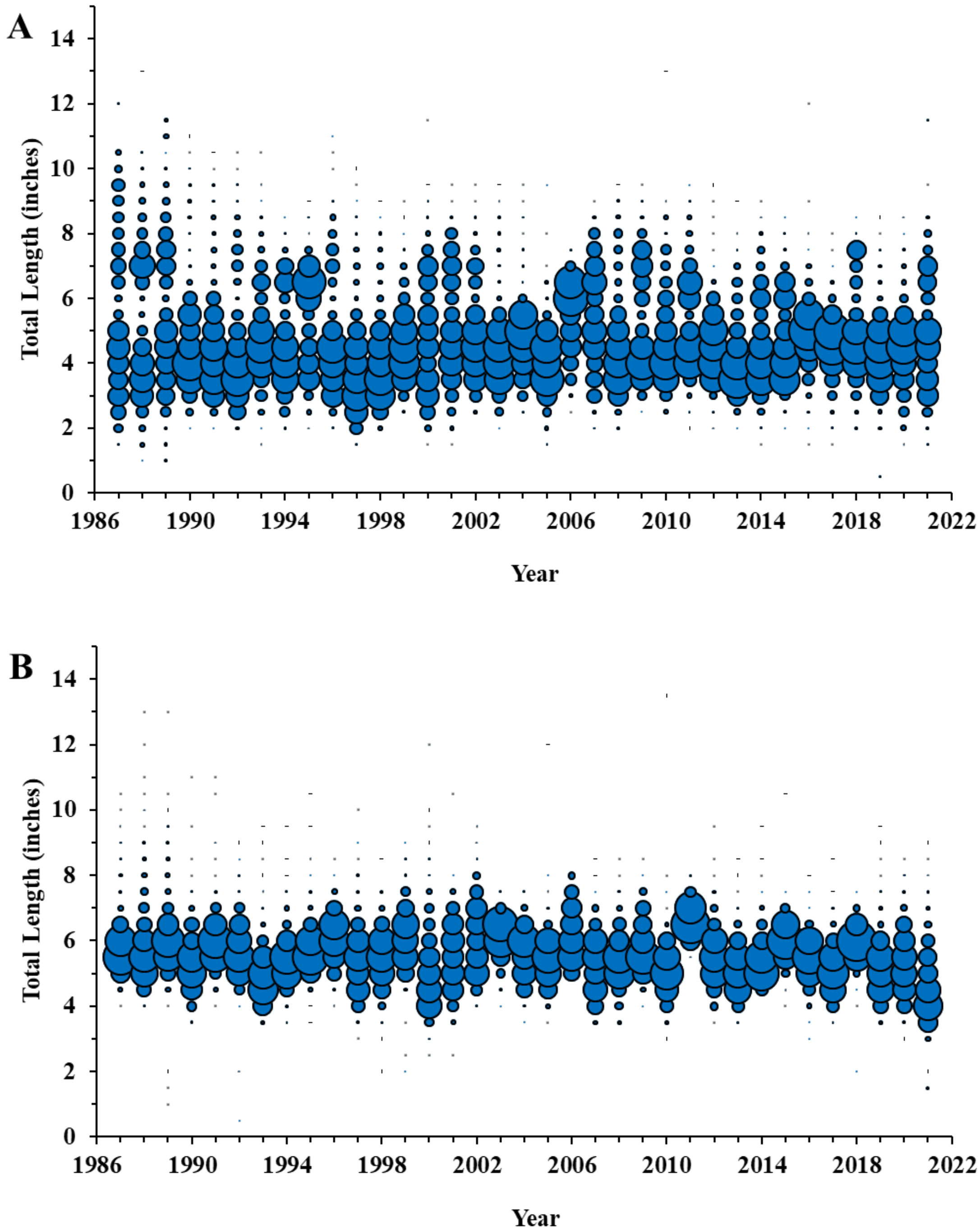

Figure 12. Length frequency (total length, inches) of all Atlantic croaker captured in Pamlico Sound Survey sampling during A) June and B) September 1987–2021.

FISHERY MANAGEMENT PLAN UPDATE
ATLANTIC MENHADEN
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	August 1981		
	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 to the FMP	September 1992	
Supplements:	Supplement to the FMP	October 1986	
Comprehensive Review:	2026		

The first fishery management plan (FMP) for Atlantic menhaden (*Brevoortia tyrannus)* was approved by the Atlantic States Marine Fisheries Commission (ASMFC) in August 1981. The objective of the original plan was to achieve a coastwide 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. A Revision to the FMP was approved in 1992 and was the result of an updated stock assessment. The 1992 FMP also included a suite of objectives intended to improve data collection and increase awareness of the fishery and its research needs. 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 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 (2011–2013). In 2010, the Board tasked the Atlantic Menhaden Technical Committee (TC) to develop alternative reference points. In addition, the ASMFC 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 metric ton (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 coastwide 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 the 2018 and 2019 fishing seasons was set at 216,000 MT (476,198,485 pounds) and maintained that TAC for 2020 with the expectation that it would be set in future years using ERPs. Subsequent years' TAC will be guided by menhaden-specific ERPs. Amendment 3 allocated a baseline quota of 0.5 % to each jurisdiction, and then additional TAC was allocated based on historic 2009–2011 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 the ASMFC Interstate FMP for Atlantic Menhaden, North Carolina also manages this species under the North Carolina FMP for Interjurisdictional Fisheries (IJ FMP). The goal of the IJ FMP is to adopt FMPs, 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) is like the goal 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 2017a).

DESCRIPTION OF THE STOCK

Biological Profile

Atlantic menhaden 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 distributed farther north. During fall and early winter, menhaden migrate south to the North Carolina capes 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 (plankton) while swimming in schools near the surface. Atlantic menhaden are important prey to many species including striped bass, bluefish, birds, dolphins, and whales.

Stock Status

In February 2020, the ASMFC accepted the results of the Atlantic Menhaden Single-Species and Ecological Reference Point Benchmark Stock Assessments and Peer Review Reports for management use. The Single-Species Assessment, acting as a traditional stock assessment, indicates the Atlantic menhaden stock is not overfished or experiencing overfishing relative to the current single-species reference points under Amendment 3 (SEDAR 2020). These reference points used historical performance of the population during the 1960–2012-time frame, representing a period where the population was fished sustainably. Fishing mortality rates have remained below the overfishing threshold (0.6) since the mid–1970s, and below the overfishing target (0.22) since the mid–1990s. Fishing mortality was estimated to be 0.11 in 2017 (terminal year of the assessment). The reference point used to determine the population fecundity is defined as the mature egg production one would expect when the population is being fished at the threshold fishing mortality rate. Population fecundity was highest in the early 1960s and from the 1990s to present. In 2017, fecundity was estimated at 2.60×10^{15} eggs, above the Single-Species Assessment threshold (1.46×10^{15} eggs) and target (1.95×10^{15} eggs).

The Ecological Reference Points Stock Assessment evaluates the health of the stock in an ecosystem context and indicates that the fishing mortality (*F*) reference points for menhaden should be lower to account for menhaden's role as a forage fish (SEDAR 2020). The fishing mortality rate in 2017, terminal year of the assessment, was below both ERP target and threshold, indicating that the stock was not experiencing overfishing. Fecundity (a measure of reproductive capacity) in 2017 was above both the ERP target and threshold, indicating the stock was not overfished.

Stock Assessment

The 2020 Atlantic Menhaden Benchmark Stock Assessments, which were endorsed by an independent panel of fisheries scientists, used the Northwest Atlantic Coastal Shelf Model of Intermediate Complexity for Ecosystems (NWACS-MICE) in combination with the single-species model (Beaufort Assessment Model or BAM) to develop Atlantic menhaden ERPs by evaluating trade-offs between menhaden harvest and predator biomass (SEDAR 2020). The SEDAR 2020 document is comprised of two reports: the 2019 Atlantic Menhaden Single-Species Benchmark Assessment and the Ecological Reference Points Stock Assessment. The Beaufort Assessment Model (BAM), which was used in the previous stock assessment, was used in the single-species assessment. The BAM again incorporated a "fleet as areas" based model configuration, such that the reduction and bait fisheries were divided into northern, mid-Atlantic, and southern regions, creating three fleets. The Single-Species Assessment, acting as a traditional stock assessment, indicates the Atlantic menhaden stock is not overfished or experiencing overfishing relative to the current single-species reference points. The Ecological Reference Points Stock Assessment uses the NWACS-MICE to develop Atlantic menhaden ERPs. NWACS-MICE is an ecosystem model that focuses on four key predator species (striped bass, bluefish, weakfish, and spiny dogfish) and three key prey species (Atlantic menhaden, Atlantic herring, and bay anchovy).

In August 2020, the ASMFC approved the use of ERPs in the management of Atlantic menhaden. Atlantic striped bass was the focal species for the ERP definitions because it was the most sensitive predator fish species to Atlantic menhaden harvest in the model, so an ERP target and threshold that sustained striped bass would likely provide sufficient forage for other predators under current ecosystem conditions. By adopting ERPs, the Board will be accounting for the species' role as an important forage fish. The ERPs for Atlantic menhaden are:

- ERP target: the maximum fishing mortality rate (*F*) on Atlantic menhaden that sustains Atlantic striped bass at their biomass target when striped bass are fished at their *F* target.
- ERP threshold: the maximum *F* on Atlantic menhaden that keeps Atlantic striped bass at their biomass threshold when striped bass are fished at their F target.

- ERP fecundity target and threshold: the long-term equilibrium fecundity that results when the population is fished at the ERP *F* target and threshold, respectively.

Since the stock assessment peer review process was adopted by the ASMFC in 1998, Atlantic menhaden have been assessed several times. Prior to the 2020 Atlantic Menhaden Benchmark Stock Assessments, the most recent peer reviewed benchmark stock assessment was SEDAR 40 (2015), which was updated in 2017 (ASMFC 2017b). The BAM was used to provide management advice during the 2015 benchmark stock assessment and the 2017 update. The 2015 benchmark stock assessment and 2017 update found that Atlantic menhaden were neither overfished nor experiencing overfishing. Stock status was evaluated against the assessment's reference points, which used historical performance of the population during 1960–2012.

The ASMFC will be conducting an update to the 2019 Atlantic Menhaden Single Species Benchmark Stock Assessment in 2022 with data thru 2021. As of August 2022, the update is ongoing and scheduled to be completed by the end of 2022.

DESCRIPTION OF THE FISHERY

Current Regulations

No regulatory changes were made in 2021 that affected menhaden. North Carolina's annual quota is currently 1,840 MT (4,056,588 pounds). 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 Fishery

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, Figure 1). The average landings over the last 10 years is 624,476 pounds. Since 2013, landings have been regulated under the TAC initiated in Amendment 2. North Carolina has landed 10–14% of the state allocated portion of the TAC in the past three years, the majority of which is used for bait in the blue crab and recreational fisheries. The decline in commercial landings is due to the loss of North Carolina's last processing facility in 2005, which in turn led to the North Carolina General Assembly banning purse seines from near shore state waters in 2007 (15A N.C. Admin. Code 3J.0105). Gill nets are now the most common gear used to harvest menhaden throughout the state.

Recreational Fishery

In October 2011, the North Carolina Division of Marine Fisheries (NCDMF) 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 during 2012–2021 recreational annual harvest averaged 189,514 fish harvested and 82,253 fish released (Table 1, Figure 1).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fishing activity is monitored in a variety of NCDMF fishery-dependent sampling programs for compliance with ASMFC. Monitoring includes the ocean sink net fishery, winter trawl fishery, estuarine gill net fishery, long haul seine 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, with the exception of 2020 and 2021 where mean lengths increased (Figure 2).

Fishery-Independent Monitoring

Atlantic menhaden are sampled in a variety of NCDMF independent surveys for compliance with ASMFC requirements. Atlantic menhaden are sampled in the North Carolina Estuarine Trawl Survey (Program 120), Pamlico Sound Survey (Program 195), the Juvenile Anadromous Survey (Program 100), the Albemarle Sound Independent Gill Net Survey (Program 135), and the Fishery Independent Gill Net Survey (Program 915). The Estuarine Trawl Survey (Figure 3) and Fishery Independent Gill Net Survey (Pamlico Sound only, Figure 4) were used as data sources in the 2019 Atlantic Menhaden Single-Species Benchmark Stock Assessment.

The Program 120 relative abundance index for Atlantic menhaden in 2021 was 3.39, which was a 72% increase from 2020 (0.95 Atlantic menhaden per tow). The 2021 relative abundance index was a 32% decrease from the ten-year average (2012–2021, 5.0 Atlantic menhaden per tow). Due to the suspension of the survey, the Program 915 relative abundance index was not calculated for Atlantic menhaden from February 20, 2020, through June 30, 2021. The 2021 relative abundance index was 7.16, is representative of limited sampling (168 units of effort compared to 308 units of effort) and should not be compared with previous years.

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 coastwide 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.

MANAGEMENT STRATEGY

In 2017, the ASMFC set the TAC at 216,000 MT (476,198,485 pounds) for 2018–2019 and maintained that TAC for 2020 with the expectation that it would be set in future years using ERPs. In October 2020, following the adoption of ERPs, the ASMFC approved a TAC of 194,400 MT (428,578,637 pounds) for 2021–2022, which represents a 10% reduction from the 2018–2020 TAC level. Based on projections, the TAC is estimated to have a 58.5% and 52.5% probability of exceeding the ERP *F* target in the first and second year, respectively. One percent of the TAC is set aside for episodic events. The remaining 192,456 MT (424,292,851 pounds) will be made available to the states based on the state-by-state allocation established by Amendment 3 of which North Carolina receives 0.96%. For 2021–2022, North Carolina's annual quota will be set at 1,840 MT (4,056,588 pounds).

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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 Atlantic menhaden from North Carolina, 1991–2021. Recreational weight landed for 2012 through 2021 are based on North Carolina recreational cast net and seine mail survey and an estimated individual fish weight of 0.35 pounds derived from Fishery-Independent sampling. Commercial landings based on North Carolina Trip Ticket Program, 1991–2021.

	Recreational			Commercial	
Year	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1991				110,528,754	110,528,754
1992				57,515,712	57,515,712
1993				64,711,384	64,711,384
1994				73,853,901	73,853,901
1995				58,374,046	58,374,046
1996				53,850,943	53,850,943
1997				97,727,057	97,727,057
1998				57,976,455	57,976,455
1999				42,799,080	42,799,080
2000				56,280,112	56,280,112
2001				56,012,396	56,012,396
2002				69,190,596	69,190,596
2003				48,936,502	48,936,502
2004				50,577,983	50,577,983
2005				13,387,423	13,387,423
2006				962,651	962,651
2007				1,134,208	1,134,208
2008				645,231	645,231
2009				2,124,734	2,124,734
2010				1,299,150	1,299,150
2011				3,530,003	3,530,003
2012	169,926	68,303	59,474	538,792	598,266
2013	221,014	96,004	77,355	454,206	531,561
2014	131,419	64,493	45,997	917,905	963,902
2015	271,824	162,539	95,138	898,322	993,460
2016	278,213	100,998	97,375	398,044	495,419
2017	261,203	96,573	91,421	752,799	844,220
2018	130,441	52,000	45,654	713,978	759,632
2019	152,247	83,285	53,286	551,849	605,135
2020	126,126	60,988	44,144	599,742	643,886
2021	152,722	37,343	53,453	419,127	472,580
Mean	189,514	82,253	66,330	29,924,616	29,946,012

Table 2. Mean, minimum, and maximum lengths (fork length, inches) of Atlantic menhaden measured from the commercial fisheries, 1991–2021.

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1991	6.2	1.9	11.0	3,588
1992	7.0	4.1	76.8	1,832
1993	6.9	3.0	13.8	3,163
1994	7.0	4.3	11.4	1,077
1995	6.5	4.1	12.5	2,045
1996	7.7	3.7	12.9	2201
1997	8.8	3.8	15.6	1,623
1998	8.1	3.4	12.9	1,570
1999	7.4	3.3	14.9	1,702
2000	8.5	4.1	13.5	868
2001	9.6	2.6	15.9	1,266
2002	8.8	4.7	14.0	1,075
2003	9.3	4.4	14.4	621
2004	8.2	3.1	14.2	644
2005	8.5	4.0	13.4	1,197
2006	8.1	3.7	13.7	1,445
2007	8.3	4.3	15.7	1,424
2008	8.0	3.9	12.8	1,063
2009	8.9	3.9	13.5	1,124
2010	8.6	5.8	12.6	210
2011	9.2	3.7	13.7	1,346
2012	8.7	2.8	14.3	705
2013	9.3	5.6	15.2	845
2014	8.8	4.8	12.8	1,477
2015	9.1	4.8	13.7	1,165
2016	8.7	6.3	12.3	760
2017	9.4	5.6	12.4	891
2018	9.3	0.8	12.2	442
2019	8.5	5.6	11.3	179
2020	10.3	6.2	12.7	250
2021	9.9	5.4	12.5	416

FIGURES

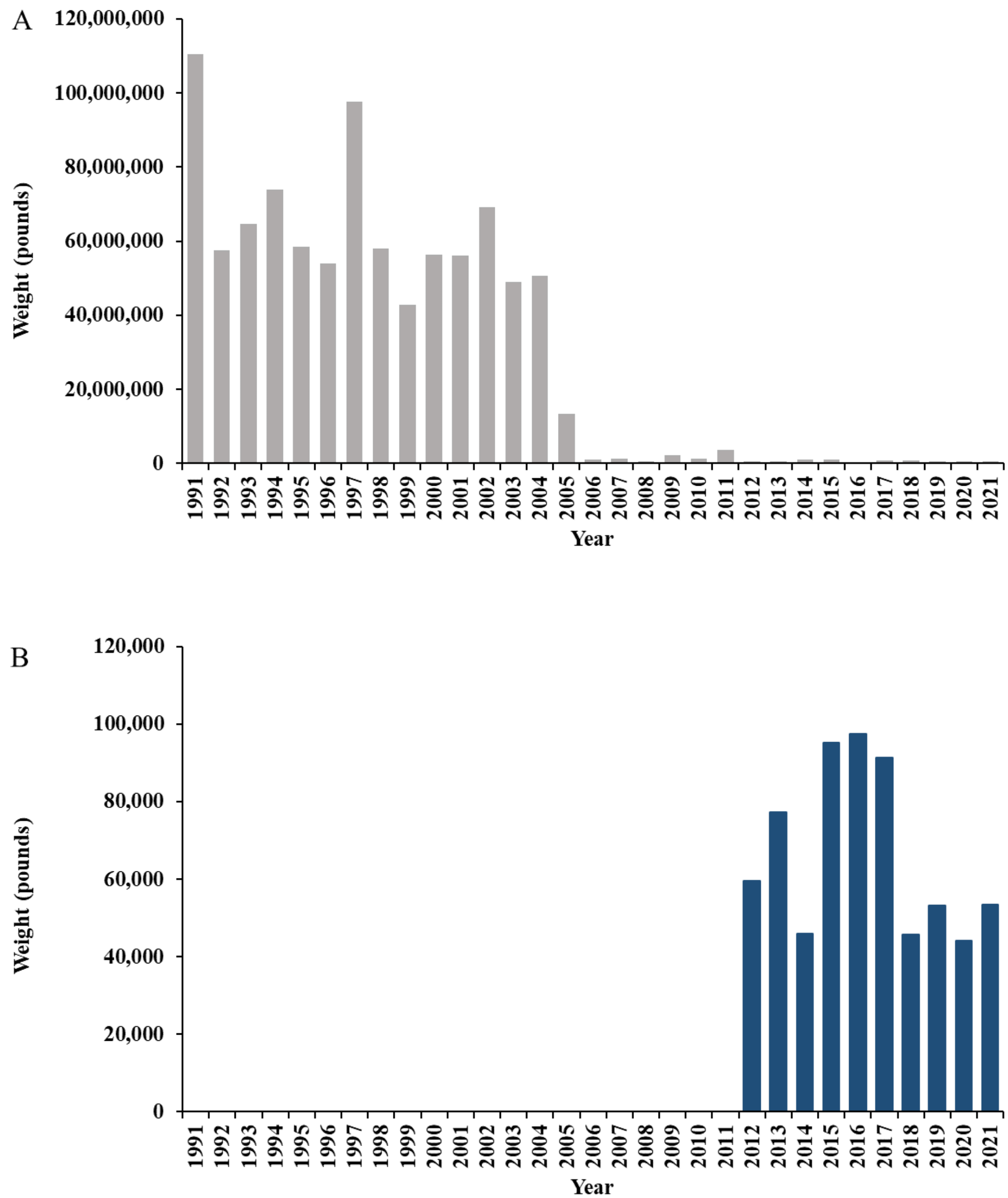

Figure 1. (A) Atlantic menhaden commercial landing (pounds) reported through the North Carolina Trip Ticket Program, 1991–2021, and (B) recreational landings (Type A + B1; pounds) estimated from the North Carolina recreational cast net and seine mail survey, 2012–2021.

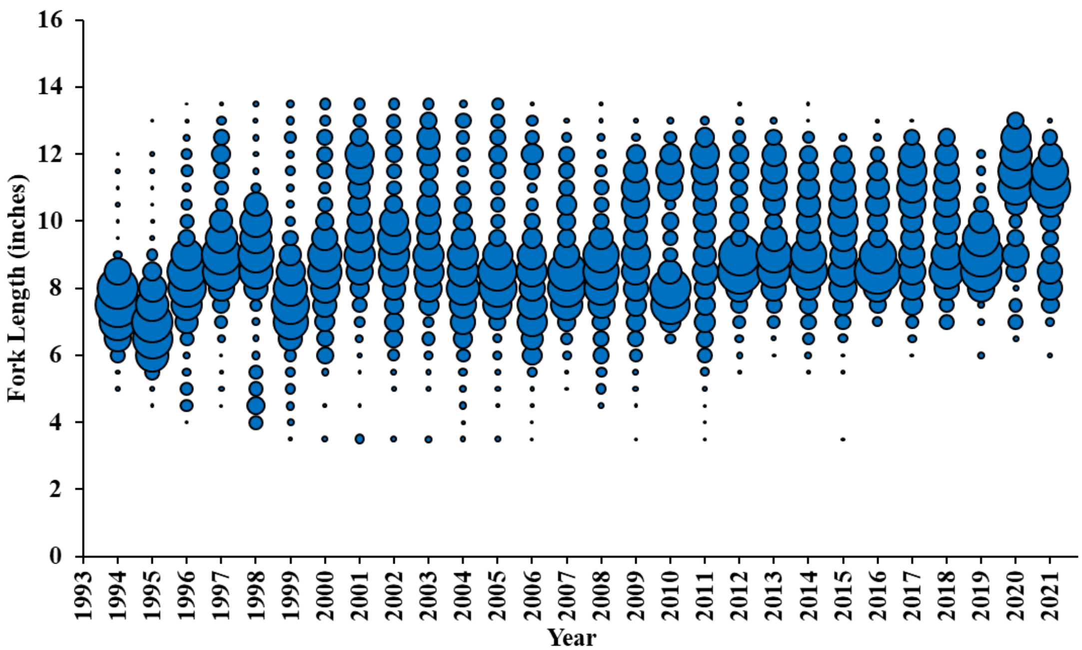

Figure 2. Commercial length frequency (fork length, inches) of Atlantic menhaden harvested from 1994 to 2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

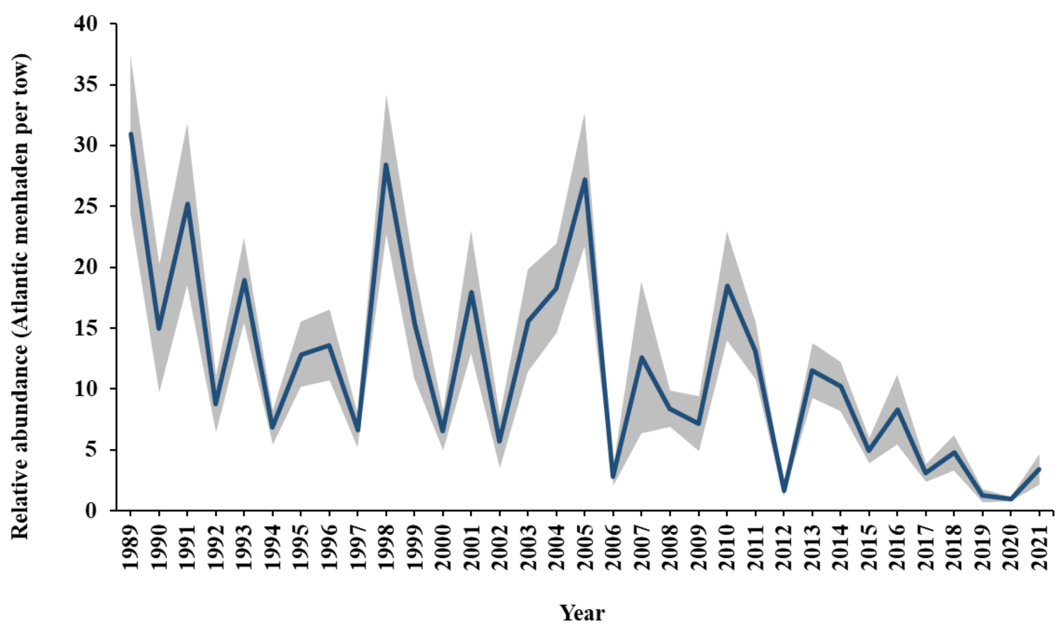

Figure 3. Relative abundance index (fish per tow) of Atlantic menhaden collected from the North Carolina Estuarine Trawl Survey (Program 120) during May and June 1989–2021. Error bars represent ± 1 standard error.

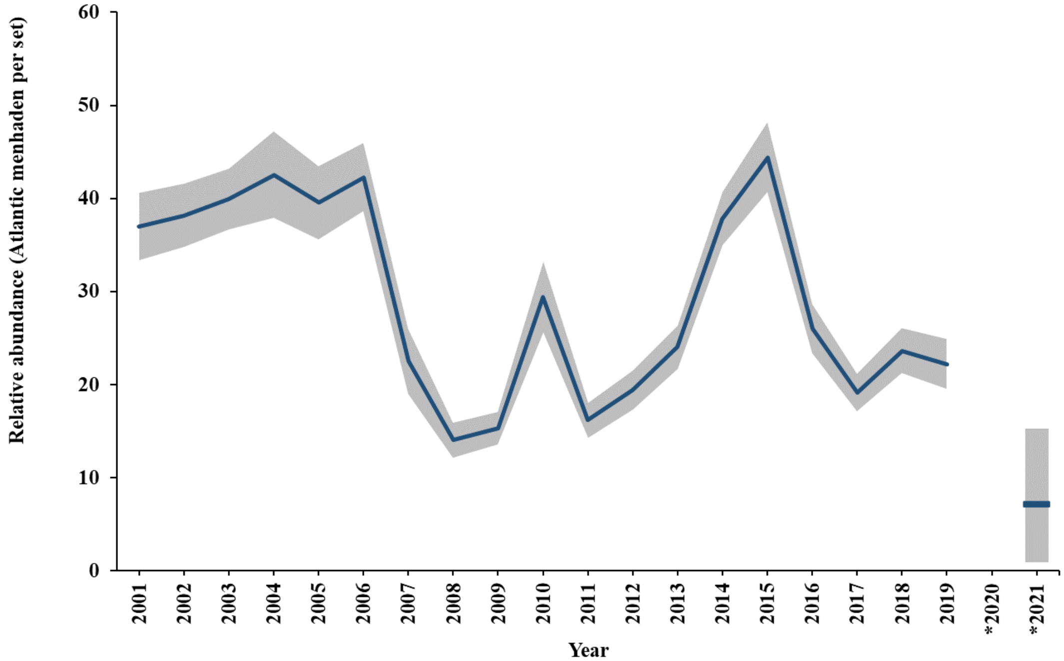

Figure 4. Relative abundance index (fish per set) of Atlantic menhaden collected from the Fishery-Independent Gill Net Survey (Program 915, Pamlico Sound only), 2001–2021. Error bars represent ± 1 standard error. *Survey suspended February 20, 2020, through June 30, 2021.

FISHERY MANAGEMENT PLAN UPDATE
ATLANTIC STURGEON
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	November 1990		
	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
Comprehensive Review:	To Be Determined		

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 that 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 that will provide for sustainable fisheries and ensure viable spawning populations (ASMFC 1998). In order to achieve this goal, the plan sets forth the following objectives:

- Establish 20 protected year classes of females in each spawning stock
- Close the fishery for a sufficient time period to reestablish spawning stocks and increase numbers in current spawning stocks
- Reduce or eliminate bycatch mortality of Atlantic sturgeon
- Determine the spawning sites and provide protection of spawning habitats for each spawning stock
- Where feasible, reestablish access to historical spawning habitats for Atlantic sturgeon
- Conduct appropriate research as needed

DESCRIPTION OF THE STOCK

Biological Profile

The Atlantic sturgeon (*Acipenser oxyrinchus*) is an anadromous species, which means they reside primarily in oceans as adults and migrate 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 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 migrations 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. In NC, adult fish that reproduce in the Roanoke River enter the Albemarle Sound basin during spring. They spend the summer in western Albemarle Sound and lower Roanoke River. Once temperatures begin to decrease around September, the fish ascend the Roanoke River to the rapids near Weldon to spawn. When spawning is complete and as water temperatures decrease further, sturgeon 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 other North Carolina rivers but collection of eggs has not been documented. Additionally, adult sturgeon fitted with radio-telemetry tags 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 Segments 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 coastwide 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 limited data availability, 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 coastwide 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'.

DESCRIPTION OF THE FISHERY

Current Regulations

Coast-wide commercial and recreational moratorium.

Commercial Fishery

No landings recorded since 1991.

Recreational Fishery

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 anchored gill-net fisheries throughout North Carolina.

In July 2014, the NCDMF received an Incidental Take Permit (ITP) to address incidental takes of Atlantic sturgeon (*Acipenser oxyrinchus*) in anchored gill-net fisheries operating in estuarine waters across the state (NMFS 2014). The permit application included analyses using a zero-inflated Poisson general linear model that estimated bycatch in the 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 (Daniel 2014).

During 2003 through 2021, on-board and alternate platform observers documented 484 Atlantic sturgeon caught in anchored gill nets. These sturgeon ranged in size from 5 to 72 inches total length (TL) and averaged 27 inches TL (Table 1). Three-hundred fifty-two of the 484 sturgeon 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 February 2020. Beginning in November 2021 methods remained the same except nets were fished for approximately 12-hours before retrieval. Lengths of sturgeon collected have ranged from 6 to 67 inches Fork Length (FL) and averaged 21 inches FL (Table 2). Twelve fish were collected with a fork length greater than 39 inches, and only seven of 2,563 fish collected were likely adults (>51in fork length). The relative abundance index shows an increasing trend between 1991 and 2020, but annual values are variable (Figure 1). Relative abundance data for 2021 were not available at the time of publication.

The Fishery Independent Assessment Survey (FIAS) is conducted in Pamlico Sound, Neuse, Pamlico and Pungo 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 surveys have been conducted since 2001 and the river surveys since 2003. A total of 56 sturgeon have been collected in Pamlico Sound and an additional 132 have been collected in the Neuse, Pamlico and Pungo, 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 surveys and three adults have been collected in the rivers surveys.

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. Effort has been ongoing since 2008. Additional sampling occurred in the coastal ocean waters off the New and Cape Fear rivers. Two-hundred and seventy yards were fished per sample in these ocean waters. However, sampling in the coastal ocean waters was discontinued on July 1, 2015. Eighteen fish have been collected in the Cape Fear River IGNS and they ranged from 21 to 37 inches FL (Table 5). 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 30 to 69 inches FL and averaged 37 inches FL (Table 6).

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 coastwide level.
- **Expand and improve the genetic stock definitions of Atlantic sturgeon, including developing and updated genetic baseline sample collection at the coastwide, 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 coastwide 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 coastwide 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.

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 anchored 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.

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TABLES

Table 1. Atlantic sturgeon length data (inches) collected from the North Carolina Division of Marine Fisheries Onboard Observer Program, 2001–2021 and Alternate Platform Observer Program (2013-2021).

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Sturgeon With Lengths	Total Sturgeon
2003	*	*	*	0	1
2004	23	13	32	24	25
2005	25	18	32	27	28
2006	24	13	45	38	39
2007				0	0
2008	25	19	33	18	18
2009				0	0
2010				0	0
2011	30	18	55	4	4
2012	26	18	35	8	10
2013	26	19	36	28	30
2014	28	16	65	51	59
2015	28	11	40	63	74
2016	26	15	62	77	82
2017	26	17	41	45	53
2018	28	19	40	22	24
2019	38	21	72	6	8
2020	31	18	47	17	18
2021**	33	20	38	7	11

*Length not recorded
**Based on alternate platform trips only

Table 2. Atlantic sturgeon length data (inches) collected from the Albemarle Sound Independent Gill Net Survey, 1991–2021. Total sturgeon includes recaptures.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Number of Sturgeon Measured	Total Sturgeon
1991	20	10	28	26	26
1992	18	8	23	17	17
1993	18	9	37	13	13
1994	18	10	29	40	41
1995	19	10	30	21	21
1996	17	8	22	27	27
1997	17	9	27	60	61
1998	19	6	29	92	92
1999	21	11	28	55	55
2000	15	7	30	139	139
2001	19	12	27	132	132
2002	21	9	29	29	29
2003	20	10	39	22	22
2004	19	10	31	30	30
2005	20	9	33	48	48
2006	22	9	58	62	63
2007	21	9	30	66	71
2008	21	10	33	124	128
2009	25	15	31	55	56
2010	23	16	32	32	32
2011	24	15	59	47	47
2012	23	12	42	64	65
2013	22	11	55	139	140
2014	24	14	46	70	72
2015	23	14	39	86	86
2016	21	10	37	124	124
2017	22	14	40	173	173
2018	23	15	67	152	155
2019	21	8	52	212	212
2020	22	15	43	148	148
2021	22	13	52	107	107

Table 3. Atlantic sturgeon length data (inches) collected from the Pamlico Sound Independent Gill Net Survey, 2001–2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Number of Sturgeon Measured	Total Sturgeon
2001				0	0
2002	26	26	26	1	1
2003				0	0
2004	20	18	21	5	5
2005	26	23	31	18	18
2006	27	21	31	12	13
2007	33	26	59	5	5
2008	31	25	37	2	2
2009	38	38	38	1	1
2010	24	20	27	2	2
2011				0	0
2012	56	56	56	1	1
2013				0	0
2014				0	0
2015	*	*	*	0	1
2016	30	29	30	2	2
2017	61	61	61	1	1
2018	24	21	27	3	3
2019	38	38	38	1	1
2020**				0	0
2021***				0	0

*Length not recorded
**No sampling occurred
***Limited sampling occurred (July–December)

Table 4. Atlantic sturgeon length data (inches) collected from the Pamlico, Pungo, and Neuse Rivers Independent Gill Net Survey, 2003–2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Number of Sturgeon Measured	Total Sturgeon
2003				0	0
2004	24	19	32	9	9
2005	18	14	31	29	29
2006	25	19	29	4	4
2007	20	16	28	3	3
2008	21	21	21	1	1
2009	28	28	28	1	1
2010				0	0
2011				0	0
2012	25	25	25	1	1
2013				0	0
2014	*	*	*	0	1
2015	24	14	56	23	23
2016	28	18	38	8	8
2017	45	45	45	1	1
2018	34	22	56	5	5
2019	19	13	25	2	2
2020**					
2021***	22	14	38	43	44

*Length not recorded
**No sampling occurred
***Limited sampling occurred (July–December)

Table 5. Atlantic sturgeon length data (inches) collected from the Cape Fear and New Rivers Independent Gill Net Survey, 2008–2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Number of Sturgeon Measured	Total Sturgeon
2008	28	28	28	1	1
2009	22	22	22	1	1
2010	34	34	34	1	1
2011	30	30	30	1	1
2012				0	0
2013				0	0
2014				0	0
2015	26	26	26	1	1
2016	29	25	37	5	5
2017	30	27	37	3	3
2018	25	21	28	3	3
2019	29	25	33	2	2
2020*				0	0
2021**				0	0

*No sampling occurred
**Limited sampling occurred (July–December)

Table 6. 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	Collection Number
2011	38	25	64	45
2012	37	30	69	21
2013	34	24	46	28
Total	37	30	69	94

FIGURES

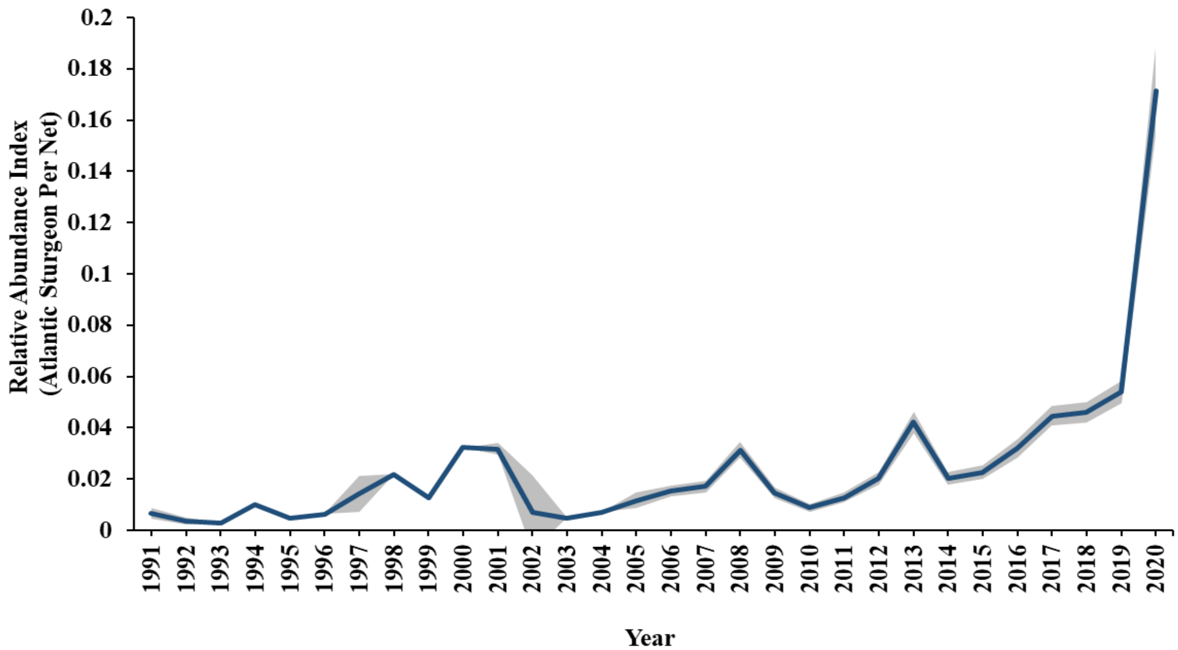

Figure 1. Annual nominal relative abundance index with standard error shaded in gray for Atlantic sturgeon collected from the Albemarle Sound Independent Gill Net Survey from 1991–2020. Data for 2021 were not available by time of publication.

FISHERY MANAGEMENT PLAN UPDATE
BLACK DRUM
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	June 2013	
	Addendum I	May 2018
Information Updates:	December 2021	
Comprehensive Review:	2022	

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 (Proclamation FF-73-2013). The FMP also includes an adaptive management framework to 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 (ASMFC 2015). The ASMFC Interstate Fisheries Management Program Policy Board chose not to make any additional changes to the FMP at the time given the findings of the assessment. A benchmark stock assessment is currently underway and is set to be completed in late 2022.

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 2018). The Black Drum Technical Committee noted 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 2022).

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 (ASMFC 2015).

Goal and Objectives

- The goal of the Black Drum FMP is to provide an efficient management structure to implement coastwide management measures (ASMFC 2013). The objectives of the FMP include:
- Provide a flexible management system to address future changes in resource abundance, scientific information, and fishing patterns among user groups or area.
- 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.
- Manage the black drum fishery to protect both young individuals and established breeding stock.
- 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.

DESCRIPTION OF THE STOCK

Biological Profile

Black drum is the largest member of the drum family (Sciaenidae), reaching sizes of over 46 inches and 120 pounds (Jones and Wells 1998). 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 (Bigelow & Schroeder 1953; Simmons & Breuer 1962). Along the Atlantic Coast, black drum are thought to migrate northward and inshore each spring and southward and offshore by late fall (Jones & Wells 1998). 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 amphipods, polychaetes, mollusks, crustaceans, and small fish, while the adult diet consists primarily of worms, bivalves, mollusks, crustaceans, and fish (Peters & McMichael 1990; Murphy and Muller 1995; Rubio et al. 2018). Spawning is thought to occur in the offshore waters of the mid-Atlantic during the winter and early spring (Richards 1973; Joseph et al. 1964; Wells & Jones 2002; Chesapeake Bay Program 2004). The number of juvenile fish entering the population annually (recruitment) is thought to be highly variable and dependent on natural environmental conditions (Murphey & Muller 1995). Females are sexually mature between the ages of 4 and 6 (25 to 28 inches) and spawn yearly through adulthood (Murphy & Taylor 1989). An average-sized female may spawn 32 million eggs each year (Fitzhugh et al. 1993). At ages 4 and 5 (22 to 25 inches) males are mature (Murphy & Taylor 1989). The species is long-lived, reaching up to 60 years of age (Jones & Wells 1998; Chris Stewart, NCDMF, personal communication). 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 (Murphy & Taylor 1989; Murphy & Muller 1995; Jones & Wells 1998).

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 coastwide 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 (BMSY; 47.26 million pounds; Figure 1). The DB-SRA results determined that black drum is not overfished and not experiencing overfishing based on their life history, indices of abundance, and history of exploitation (ASMFC 2015).

A benchmark stock assessment is currently in development using the recalibrated Marine Recreational Information Program (MRIP) data. The benchmark assessment will provide updated reference points and is expected to be completed in late 2022.

DESCRIPTION OF THE FISHERY

Current Regulations

All harvest is limited to black drum between a 14-inch total length (TL) minimum size and 25-inch TL maximum size for both the recreational and commercial fisheries, except that one black drum over 25-inches TL 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 (Proclamation FF-73-2013).

Commercial Fishery

Since 1994, the North Carolina Trip Ticket Program (NCTTP) has collected data on the commercial harvest of black drum. Black drum is primarily caught as bycatch in several North Carolina commercial fisheries; however, they are predominantly landed in the gill net (76%) and pound net (21%) fisheries (Figure 2). The annual commercial harvest of black drum has been highly variable (Table 1; Figure 3A). On average 118,514 pounds of black drum were landed annually from 1994 to 2021. Commercial landings have ranged from a low of 27,750 pounds in

1998 to a high of 497,479 pounds in 2002. Commercial landings increased 34% from 2020 to 2021. In 2021, 131,724 pounds of black drum were landed in the commercial fishery.

Recreational Fishery

Recreational 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 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 3B). In 2021, 359,481 pounds of black drum were harvested, below the time-series average of 768,856 pounds. The harvest (pounds of fish) decreased 41% from 2020 to 2021. Recreational releases (number of fish) decreased 3% from 2020 to 2021.

The NCDMF offers award citations for exceptional catches of black drum. Prior to 2021, citations were awarded for black drum greater than 35 pounds or fish released greater than 40-inches TL. Released black drum greater than 40 inches TL are now only eligible for an award citation. In 2021, 25 citations were awarded (Figure 4).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fishing activity is monitored through fishery dependent sampling conducted under Title III of the Interjurisdictional Fisheries Act 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-inch slot limit in 2014, as would be expected the mean total length (TL) of commercially harvested black drum has increased. The mean TL has ranged from 10-inches to 19-inches (Table 2). In 2021, the minimum TL was 8-inches, and the maximum TL was 23-inches (Table 2; Figure 5). Undersized black drum continue to be harvested since the implementation of the 14-inch TL minimum size limit established in 2014, likely due to fishermen confusing black drum with sheepshead (Figure 6). The minimum size limit of sheepshead is smaller than the minimum size limit for black drum at 10-inches fork length (FL).

The mean TL of recreational harvested black drum ranged from a low of 10-inches in 2011 and 2011 to a maximum of 17-inches in 2015 and 2016 (Table 3). In 2021, the minimum TL was 9-inches, and the maximum TL was 46-inches (Table 3; Figure 5). Similar to the commercial fishery, undersized black drum continued to be harvested in the recreational fishery since the implementation of the 14-inch TL minimum size limit established in 2014 (Figure 7).

Fishery-Independent Monitoring

A fishery-independent gill net survey (Program 915) 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 and the Neuse, Pamlico, and Pungo rivers. By continuing a long-term database of age composition and developing a relative 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. Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021.

The annual weighted black drum relative index of abundance from the independent gill net survey has ranged from a high of 1.12 in 2016 to a low of 0.32 in 2013 (Table 4; Figure 8). Proportional Standard Error (PSE) has ranged from 12 to 39. In the latter half of 2021, 244 black drum were caught in survey. This survey is used in the 2022 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 2021, 415 black drum were aged. Ages ranged from 0 to 5 years; however, a majority 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 5). The oldest black drum harvested in North Carolina was age-60. Beyond age 3, there is significant overlap in the length at age for black drum (Figure 9).

RESEARCH NEEDS

The 2015 Benchmark Stock Assessment and Peer Review Report (ASMFC 2015) outlines research needs for black drum. The research recommendations 2015 Benchmark Stock Assessment and Peer Review Report for black drum include:

High

- Age otoliths that have been collected and archived. — Ongoing)
- Collect information to characterize the size composition of fish discarded in recreational fisheries. — 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. — Ongoing
- Increase biological sampling in commercial fisheries to better characterize the size and age composition of commercial fisheries by state and gear. — Ongoing
- Increase biological sampling in recreational fisheries to better characterize the size and age composition by state and wave. — Ongoing

- Obtain estimates of selectivity-at-age for commercial fisheries by gear, recreational harvest, and recreational discards. — Ongoing
- Continue all current fishery-independent surveys and collect biological samples for black drum on all surveys. — Ongoing
- Develop fishery-independent adult surveys. Consider long line and purse seine surveys. — Ongoing
- Collect age samples, especially in states where maximum size regulations preclude the collection of adequate adult ages. — Ongoing
- Conduct reproductive studies, including age and size-specific fecundity, spawning frequency, spawning behaviors by region, and movement and site fidelity of spawning adult. — 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. — 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. — Needed
- Conduct studies to estimate catch and release mortality rates in recreational fisheries. — Needed

Medium

- Improve sampling of nighttime fisheries. — 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. — Needed
- Obtain better estimates of harvest from the black drum recreational fishery, especially in states with short seasons. — Ongoing

The ASMFC Black Drum Plan Review Team (PRT) annually reviews and prioritizes the research needs as part of the ASMFC FMP review process. The 2021 Review of the ASMFC FMP for black drum further cites the need to continue and expand the biological collection of age and size composition data, fecundity data, as well as tagging programs (ASMFC 2021). Updated research needs will be available once the 2022 benchmark assessment is complete.

MANAGEMENT STRATEGY

The management program currently in place for black drum has resulted in a stock that has met ongoing management targets. Each year the ASMFC Black Drum PRT 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 2020 fishing year, the PRT determined that all states were compliant with the FMP (ASMFC 2021).

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 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 OFL was set at 4.12 million pounds. The SAS 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 2021).

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.

See Table 6 for current management strategies and implementation status of the ASMFC Black Drum FMP.

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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 spotted seatrout from North Carolina for the period 1991–2021.

Year	Recreational			Commercial	
	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total 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	51,097	831,973
2016	459,078	2,530,596	1,322,547	90,055	1,412,602
2017	355,544	2,336,352	856,081	182,989	1,039,070
2018	134,624	1,450,855	428,273	109,781	538,054
2019	156,401	756,749	404,452	80,049	484,501
2020	213,320	704,357	612,932	98,143	711,075
2021	121,454	681,121	359,481	131,724	491,205
Mean	500,724	675,513	768,856	118,514	887,370

Table 2. Mean, minimum, maximum total length (TL; inches), and total number of black drum measured from North Carolina commercial fish house samples, 1994–2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1994	15	9	18	46
1995	10	8	42	190
1996	14	8	26	203
1997	16	9	23	91
1998	17	6	24	73
1999	14	7	47	645
2000	15	7	29	836
2001	15	7	36	426
2002	14	7	46	2,068
2003	16	7	49	605
2004	16	8	37	203
2005	14	4	44	304
2006	13	6	47	1,402
2007	14	7	50	2,012
2008	14	7	49	2,777
2009	15	7	47	1,044
2010	16	8	48	611
2011	12	7	32	1,300
2012	14	5	37	1,028
2013	15	5	35	777
2014	17	10	47	334
2015	18	9	43	293
2016	17	12	47	750
2017	17	10	29	463
2018	19	14	45	396
2019	17	12	43	405
2020	17	10	31	432
2021	16	8	23	513

Table 3. Mean, minimum, maximum total length (TL; inches), and total number of black drum measured from Marine Recreational Information Program recreational samples, 1989–2021.

Year	Mean Total Length	Minimum Total Length	Maximum Total Length	Total Number Measured
1989	12	26	18	1
1990	7	28	10	6
1991	9	22	11	22
1992	9	19	13	7
1993	8	25	11	61
1989	12	26	18	1
1990	7	28	10	6
1991	9	22	11	22
1994	15	9	32	121
1995	11	7	30	390
1996	12	7	25	339
1997	15	9	33	144
1998	12	7	26	167
1999	13	8	31	248
2000	15	8	24	178
2001	11	8	25	173
2002	14	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
2019	16	10	44	106
2020	16	10	44	215
2021	16	9	46	155

Table 4. Annual weighted black drum index of relative abundance (number per set, all ages combined) from the NCDMF Independent Gill Net Survey (Program 915) in the Pamlico Sound and Neuse, New, Pamlico, and Pungo river systems from 2003–2021. N=number of samples; Index=black drum per gill net set; SE=Standard Error; PSE=Proportional Standard Error. *Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021.

Year	N	Index	SE	PSE
2003	476	0.83	0.21	25
2004	640	0.35	0.07	19
2005	608	0.37	0.09	24
2006	640	0.71	0.07	10
2007	640	0.63	0.13	20
2008	640	1.02	0.14	13
2009	640	0.59	0.11	19
2010	640	0.40	0.13	32
2011	618	0.62	0.10	17
2012	628	0.39	0.06	14
2013	628	0.32	0.05	16
2014	628	0.59	0.12	20
2015	626	0.80	0.29	36
2016	628	1.12	0.15	14
2017	628	0.92	0.18	20
2018	628	0.37	0.05	14
2019	628	0.76	0.12	15
2020*				
2021*	344	0.83	0.17	20

Table 5. Summary of black drum age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources from 2011–2021. Samples collected from partial carcasses were not included.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2011	0	0	60	235
2012	1	0	3	324
2013	2	0	4	190
2014	1	0	31	407
2015	0	0	2	397
2016	1	0	13	667
2017	1	0	42	742
2018	1	0	46	429
2019	1	0	32	444
2020	1	1	4	104
2021	1	0	5	415

Table 6. 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 February 25, 2019	Accomplished (Maryland)

FIGURES

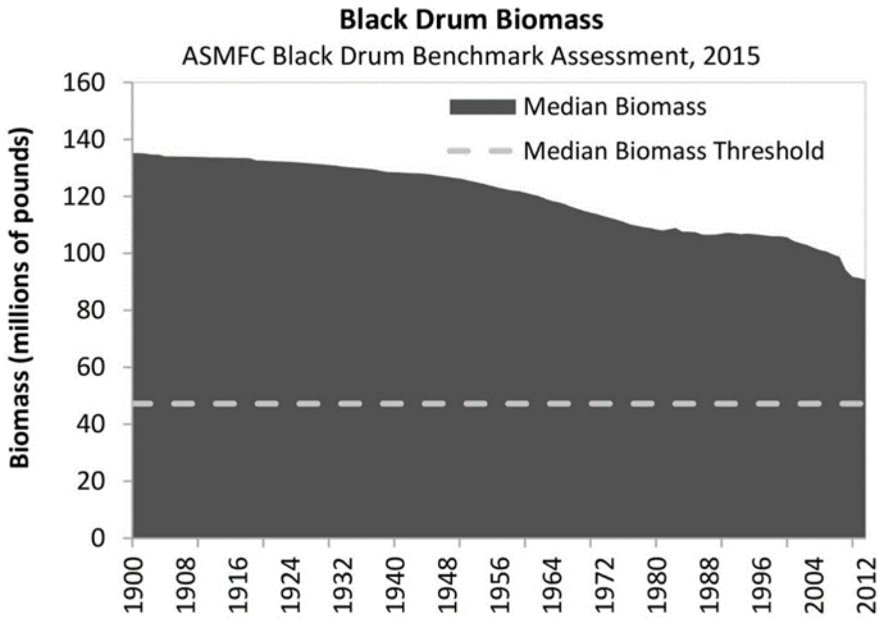

Figure 1. Depletion-Based Stock Reduction Analysis (DB-SRA) median biomass and threshold, 1900–2012 (ASMFC 2015).

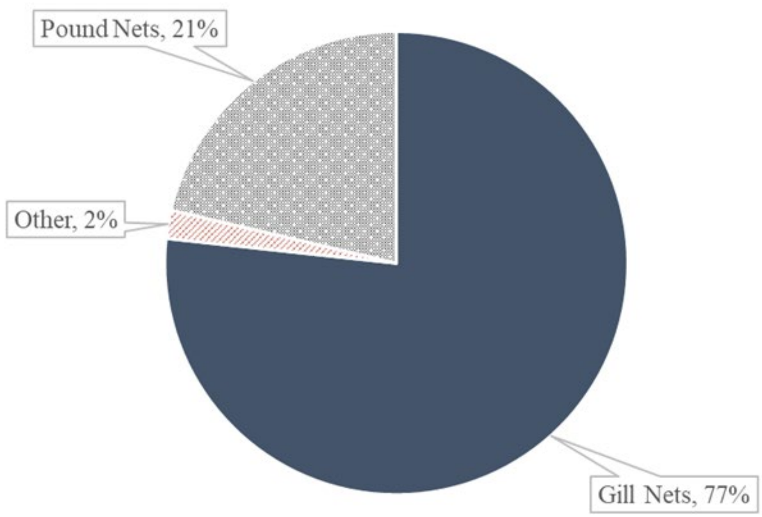

Figure 2. Black drum commercial harvest in 2021 by gear type. "Other" includes haul seines, crab pots, channel nets, and fyke nets.

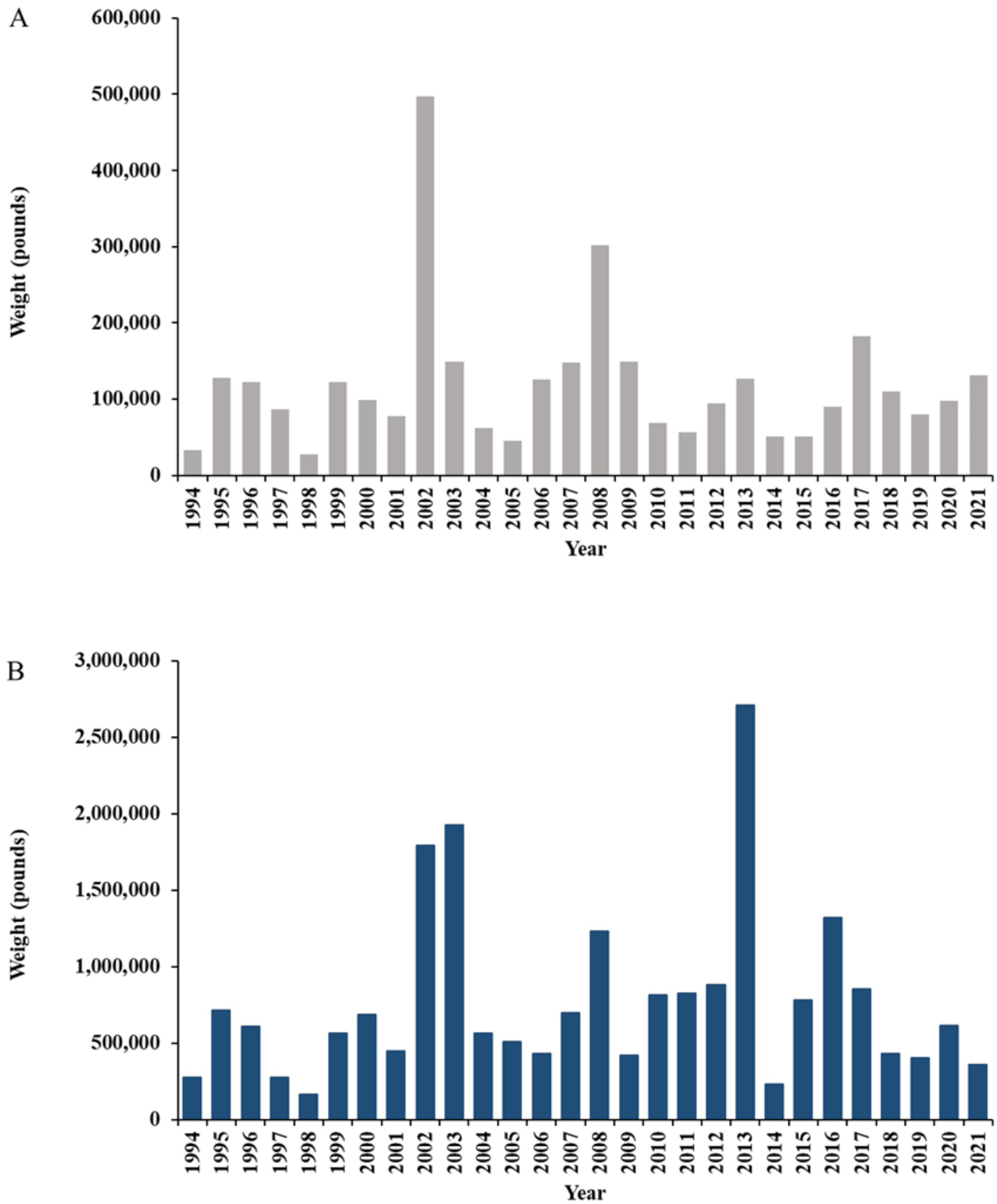

Figure 3. Annual commercial (A) and recreational (B) landings in pounds for black drum in North Carolina from 1994 to 2021.

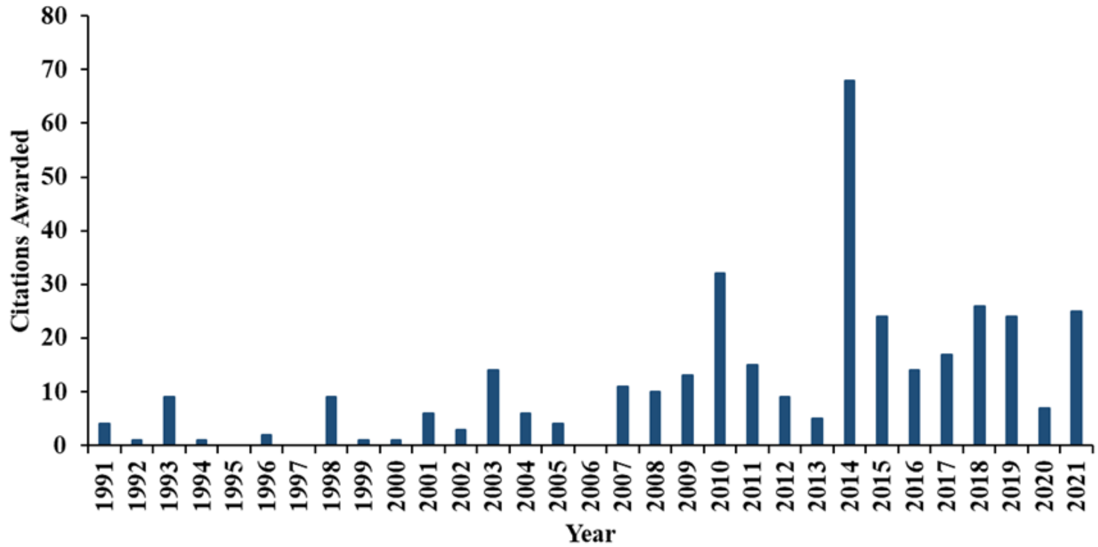

Figure 4. North Carolina Saltwater Fishing Tournament citations awarded for black drum from 1991 to 2021. Citations are awarded for released black drum greater 40 inches total length.

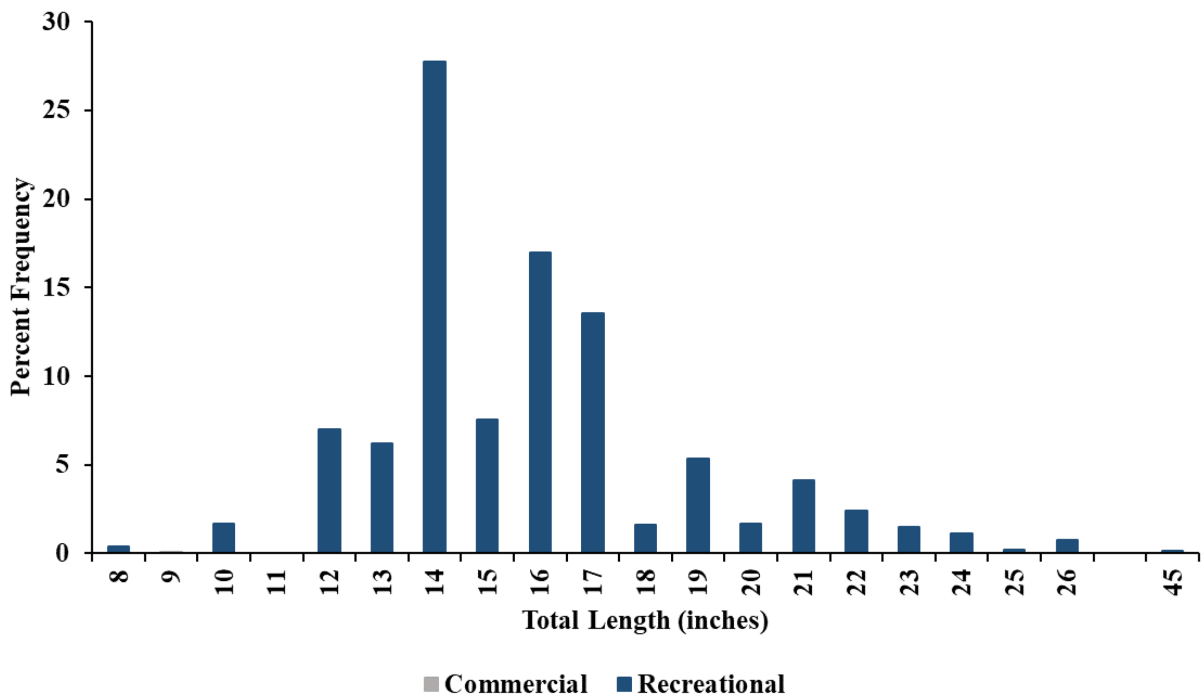

Figure 5. Commercial and recreational length frequency (total length, inches) of black drum harvested in 2021.

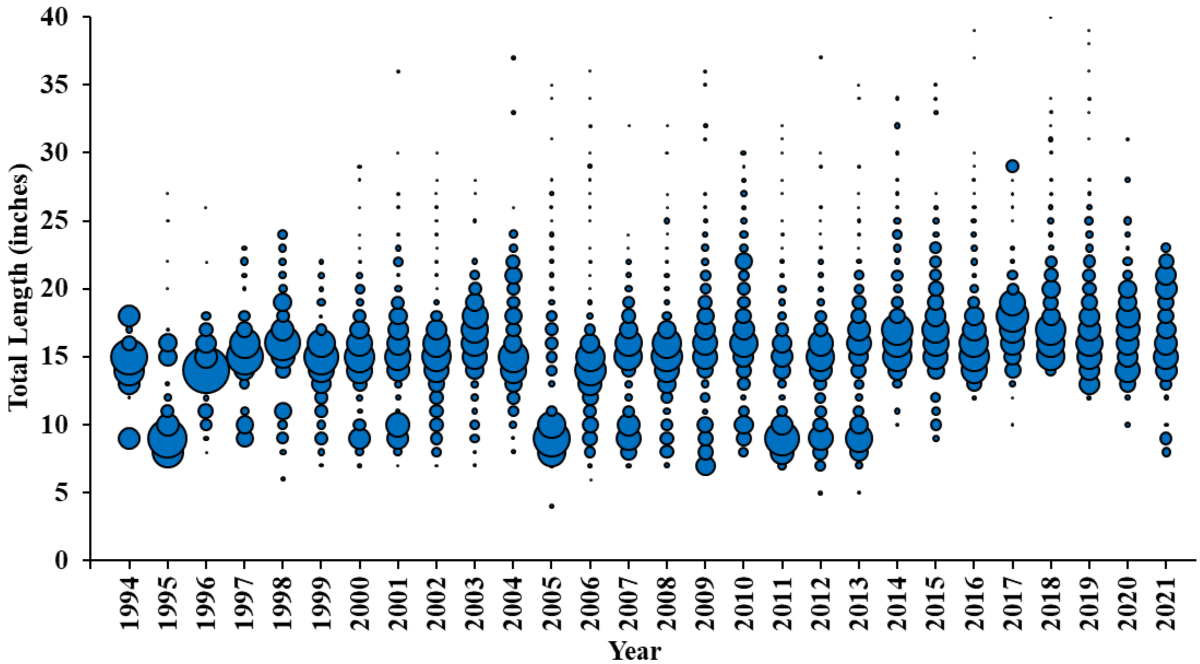

Figure 6. Commercial length frequency (total length, inches) of black drum harvested from 1994 to 2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

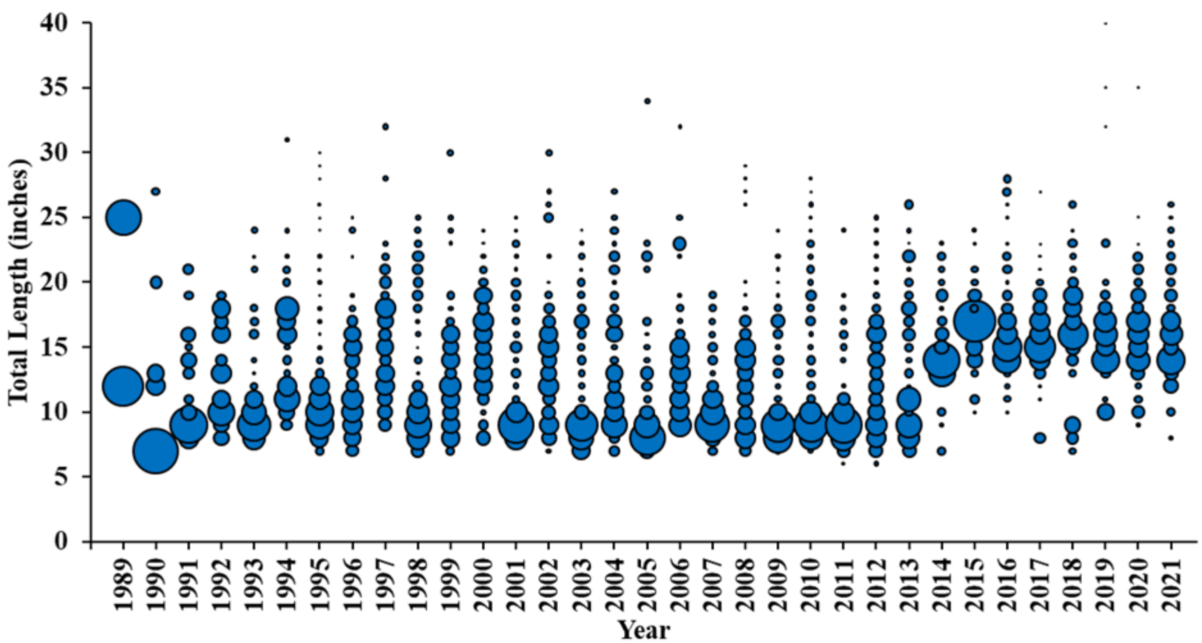

Figure 7. Recreational length frequency (total length, inches) of black drum harvested from 1989 to 2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

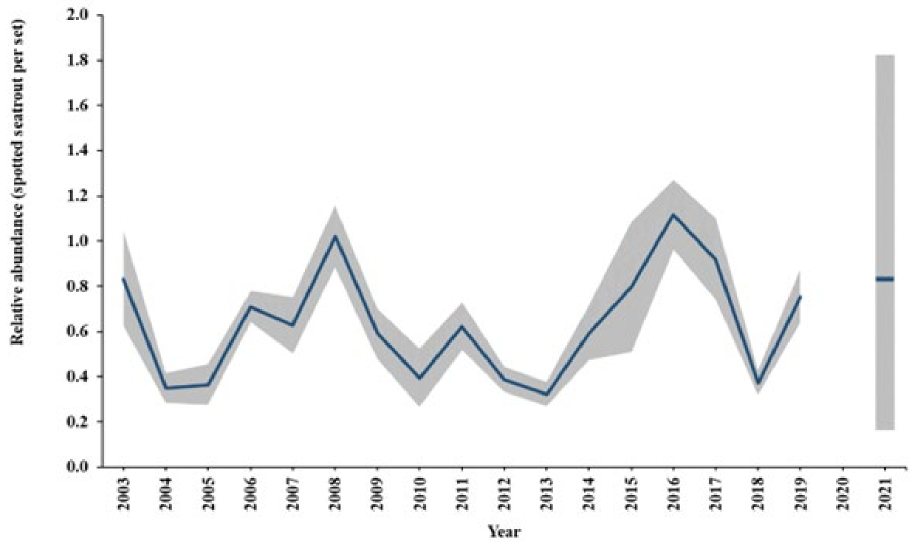

Figure 8. Annual weighted black drum index of relative abundance (number per set) from the NCDMF Independent Gill Net Survey (Program 915) in the Pamlico Sound and Neuse, New, Pamlico, and Pungo river systems from 2003–2021. Shaded area represents + one standard error. Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021.

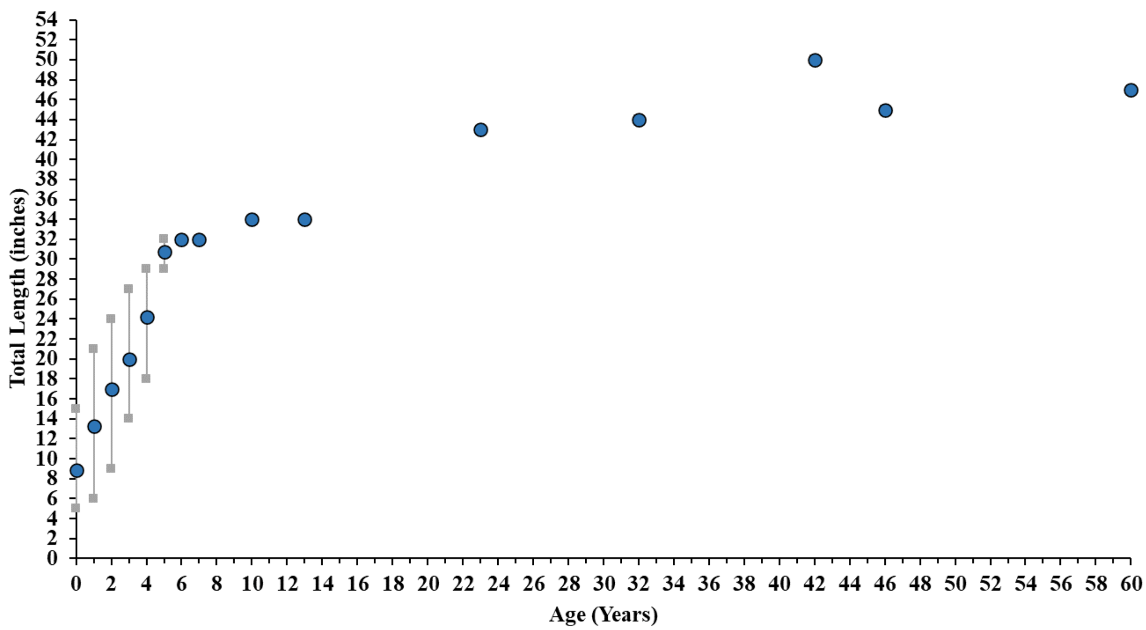

Figure 9. Black drum length (total length, inches) at age based on all age samples collected from 2011 to 2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age. Samples collected from partial carcasses were not included.

FISHERY MANAGEMENT PLAN UPDATE
BLUEFISH
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	1990	
	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
	Framework 4	2020
	Framework 5	2020
	Amendment 7	2021

Comprehensive Review: 2022

The Fishery Management Plan (FMP) for bluefish was developed through a 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. Amendment 1 also established commercial and recreational quota allocations, state-specific commercial allocations, and allowed for the 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 process 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. Amendment 4 modified the accountability measures for the recreational bluefish fishery. Amendment 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 process to specify constant multi-year acceptable biological catches. Framework 4 established a requirement for commercial vessels with federal permits for any species managed by the Mid-Atlantic and New England Councils to submit vessel trip reports electronically within 48 hours after entering port at the conclusion of a trip. Framework 5 modified the Council's ABC control rule and risk policy.

The revised risk policy is intended to reduce the probability of overfishing as stock size falls below the target biomass while allowing for increased risk and greater economic benefit under higher stock biomass conditions. This action also removed the typical/atypical species distinction currently included in the risk policy. Amendment 7, the Bluefish Allocation and Rebuilding Amendment, revised the goals and objectives of the fishery management plan, reallocated quota between the commercial and recreational fisheries, reallocated commercial quota among the states, implemented a rebuilding plan, revised the sector quota transfer process, and revised how management uncertainty is applied during the specifications process. Amendment 7 took effect on January 1, 2022. The bluefish FMP, associated amendment documents, and framework information can be found at https://www.mafmc.org/bluefish.

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 2022).

The MAFMC and ASMFC are also in the process of developing an initiative to consider improvements to management of the recreational fisheries for summer flounder, scup, black sea bass, and bluefish. The Recreational Reform Initiative was initiated in 2019 and is addressing a range of recreational management issues through a joint framework/addendum and a joint amendment.

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 ASMFC bluefish FMP process with the exception of Pennsylvania and the District of Columbia.

Goal and Objectives

Amendment 7 revised the goals and objectives of the bluefish FMP to the following:

- Goal 1: Conserve the bluefish resource through stakeholder engagement to maintain sustainable recreational fishing and commercial harvest.
    - Objective 1.1: Achieve and maintain a sustainable spawning stock biomass and rate of fishing mortality.
    - Objective 1.2: Promote practices that reduce release mortality within the recreational and commercial fishery.

- Objective 1.3: Maintain effective coordination between the National Marine Fisheries Service, Council, Commission, and member states by promoting compliance and to support the development and implementation of management measures.
- Objective 1.4: Promote compliance and effective enforcement of regulations.
- Objective 1.5: Promote science, monitoring, and data collection that support and enhance effective ecosystem-based management of the bluefish resource.

- Goal 2: Provide fair and equitable access to the fishery across all user groups throughout the management unit.
  - Objective 2.1: Ensure the implementation of management measures provides fair and equitable access to the resource across all user groups within the management unit.
  - Objective 2.2: Consider the economic and social needs and priorities of all groups that access the bluefish resource in the development of new management measures.
  - Objective 2.3: Maintain effective coordination with stakeholder groups to ensure optimization of economic and social benefits.

DESCRIPTION OF THE STOCK

Biological Profile

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). 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). Bluefish can exceed 39 inches and 31 pounds (NCDMF 2021). 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

The 2019 operational stock assessment, which included data through 2018, determined that bluefish are overfished but are not experiencing overfishing (NMFS 2019).

Stock Assessment

Estimates from the 2019 operational stock assessment show that spawning stock biomass (SSB) has been decreasing since 2008 and has been below the SSB threshold since 2014 (Figure 1). SSB in 2018 was estimated to be 91,041 MT, which is 46% of the target reference point (NMFS 2019). Based on the 2019 operational assessment, bluefish are overfished, but are not experiencing overfishing.

DESCRIPTION OF THE FISHERY

Current Regulations

In North Carolina, the private recreational (all persons not fishing on a for-hire vessel) bag limit is three bluefish per person per day and the recreational for-hire (all persons fishing on a for-hire vessel) is five bluefish per person per day. These regulations have been in effect since 2020. Commercial fishery landings are monitored and if necessary, trip limits are implemented to prevent exceeding the annual quota. The commercial fishery was opened on January 1, 2021, with no possession limit. In 2021, proclamation authority was used four times to reduce the daily trip limit from no trip limit at the beginning of the year to 50 pounds by the end of November 2021.

Commercial Fishery

Bluefish commercial landings have fluctuated annually since 1972 (Table 1; Figure 2); however, landings in recent years have been lower than average. The commercial quota allocated to North Carolina for 2021 was 887,377 pounds. North Carolina received a total of 195,000 pounds of quota transfer from New Jersey, Maryland, Delaware, and Virginia, which resulted in an adjusted 2021 commercial quota of 1,082,377 pounds. North Carolina’s 2021 commercial bluefish landings totaled 1,051,026 pounds at a dockside value of $663,053. Estuarine and ocean gill nets combined represent the largest commercial landings of bluefish accounting for 96.4% of the harvest in 2021 (Figure 4).

Recreational Fishery

Recreational landings for bluefish have been annually variable but relatively stable for the last few decades (Table 1; Figure 2). Marine Recreational Information Program (MRIP) data collected by the NOAA Fisheries indicates that just under 1 million pounds of bluefish were recreationally harvested in 2021. 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. See https://www.fisheries.noaa.gov/topic/recreational-fishing-data for more information.

The NCDMF offers award citations for exceptional catches of bluefish. Bluefish exceeding 15 pounds are eligible for an award citation. The number of citations awarded was highest in 1991 (n=187), with less citations awarded in the last 20 years, compared to the 1990’s (Figure 3). Since 2017, the NCDMF has offered an additional citation for released bluefish that exceed 34 inches in length. Approximately 66% 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 location, gear type, specifications, soak time, and water depth are recorded. Subsampling of commercial catch to collect biological information on bluefish includes fork length (FL) and aggregate weight (kg) by market grade. Trip ticket information (total weight of catch) is also recorded and reported to NCDMF by licensed dealers. The size of fish harvested recreationally is characterized through the MRIP survey.

A total of 4,203 bluefish were measured from commercial landings in 2021 (Table 2). Mean fork length was 16 inches and ranged from 8 to 34 inches. Size ranges have varied minimally since 1991. The mean length of fish harvested and measured by MRIP in the recreational fishery in 2021 was 12 inches and ranged from 6 to 26 inches fork length (Table 3). 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 1991, the annual length distribution of harvest in both the commercial and recreational fisheries has varied little with most fish harvested ranging from 7 to 16 inches fork length (Figures 6 and 7). Larger bluefish (>20 inches) have been less common in recent years.

Fishery-Independent Monitoring

The Division's Pamlico Sound Independent Gill Net Survey was initiated in May of 2001 and has been sampled continuously through 2019. Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021. 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 coastwide bluefish stock assessment. The relative abundance index, defined as the number of bluefish per set, has ranged from 2.8 in 2015 to 8.6 in 2019 during the 21-year time-series (Figure 8). The relative abundance index in 2021 was 4.95, which is slightly below the time-series average (5.4). It should be noted that the index in 2021 is calculated from samples collected from Jul.-Dec while the index for all other years was calculated for Feb.-Dec.

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. When possible, at least 50 fish should be collected from January-June and 50 fish from July-December. Most years, 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 2021, 793 age samples were collected (Table 4). The maximum age over the time-series is 12 years of age. Bluefish length increases with age, although the size at a given age can be quite variable (Figure 9).

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.

MANAGEMENT STRATEGY

Bluefish in North Carolina are jointly managed by ASMFC and MAFMC under Amendment II of the FMP. Amendment II uses annual catch limits (ACLs) for both the recreational and commercial sectors. The recreational quota is a coast-wide quota while the commercial quota is further divided into state-specific quotas. Amendment II allows quota transfers between states and between sectors. Additionally, daily limits are used to manage recreational harvest and trip limits can be implemented for commercial fishermen if needed in order to prevent exceeding North Carolina's commercial quota.

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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) in North Carolina, 1985–2021.

Year	Recreational			Commercial	
	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (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	3,298,640	4,651,084
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	804,094	4,558,671
2016	4,489,223	6,802,960	3,356,049	1,148,643	4,504,692
2017	3,173,218	8,255,510	3,634,502	1,544,053	5,178,555
2018	3,304,587	7,912,210	2,630,685	910,262	3,540,947
2019	2,752,589	7,162,431	3,011,480	1,108,205	4,119,685
2020	2,108,296	6,557,751	2,124,224	1,113,009	3,237,233
2021	982,389	3,539,333	1,031,760	1,051,026	2,082,786
Mean	3,276,389	3,990,634	4,374,953	2,901,215	7,276,169

Table 2. Summary of fork length (inches) data sampled from all sources of length data (harvest and bait) from the bluefish commercial fishery in North Carolina, 1985–2021.

Year	Mean Fork Length (in)	Minimum Fork Length (in)	Maximum Fork Length (in)	Total Number Measured
1985	15	4	33	5,351
1986	14	4	33	4,220
1987	16	4	33	3,902
1988	16	3	32	4,243
1989	16	4	33	5,701
1990	16	4	33	8,090
1991	14	4	35	6,068
1992	13	4	32	6,771
1993	16	3	35	3,796
1994	15	5	33	2,096
1995	15	3	32	2,095
1996	16	5	33	2,428
1997	14	4	35	4,355
1998	16	5	33	4,693
1999	18	5	34	7,063
2000	18	6	35	8,369
2001	18	4	35	11,748
2002	18	5	35	8,288
2003	19	6	34	7,861
2004	19	6	33	9,608
2005	19	5	33	9,766
2006	18	5	33	10,255
2007	15	6	33	8,856
2008	16	5	33	8,035
2009	18	6	34	7,471
2010	17	6	35	6,721
2011	16	6	33	5,768
2012	14	5	34	7,030
2013	14	6	33	6,928
2014	15	8	34	6,459
2015	14	7	31	6,100
2016	14	3	33	7,616
2017	16	7	35	5,580
2018	15	7	34	3,778
2019	15	8	33	4,812
2020	16	7	35	3,396
2021	16	8	34	4,203

Table 3. Summary of fork length (inches) data sampled from the bluefish recreational fishery in North Carolina, 1985–2021.

Year	Mean Fork Length (in)	Minimum Fork Length (in)	Maximum Fork Length (in)	Total Number Measured
1985	14	6	34	312
1986	18	6	38	420
1987	16	5	40	1,319
1988	7	0	38	1,117
1989	12	5	40	1,633
1990	13	5	34	2,413
1991	14	5	36	1,572
1992	13	7	33	1,044
1993	13	7	36	1,187
1994	14	7	36	1,174
1995	14	4	36	740
1996	15	6	38	1,177
1997	14	6	37	2,404
1998	13	6	40	1,624
1999	12	6	34	1,316
2000	12	6	34	1,356
2001	13	7	31	2,191
2002	13	7	34	999
2003	13	7	34	781
2004	13	6	40	1,149
2005	12	6	35	1,056
2006	12	6	36	1,028
2007	12	6	37	1,048
2008	12	5	35	894
2009	13	7	34	778
2010	12	6	38	1,323
2011	12	6	34	1,784
2012	12	7	35	1,190
2013	11	7	29	563
2014	12	7	29	660
2015	12	7	18	577
2016	11	8	23	732
2017	12	6	35	657
2018	11	6	30	846
2019	13	8	32	910
2020	12	8	32	713
2021	12	6	26	299

Table 4. Summary of bluefish age samples collected in North Carolina from both dependent (commercial and recreational fisheries) and independent (surveys) sources, 1985–2021.

Year	Modal Age	Minimum Age	Maximum Age	Number of Samples
1985	1	0	11	548
1986	1	0	9	437
1987	1	0	9	380
1988	1	0	9	346
1989	1	0	9	320
1990	1	0	9	372
1991	1	0	8	289
1992	1	0	9	704
1993	1	0	10	722
1994	1	0	10	517
1995	1	0	9	634
1996	1	0	10	230
1997	1	0	10	446
1998	1	0	9	658
1999	1	0	10	442
2000	1	0	10	290
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
2019	1	0	8	853
2020	2	0	12	244
2021	1	0	5	793

FIGURES

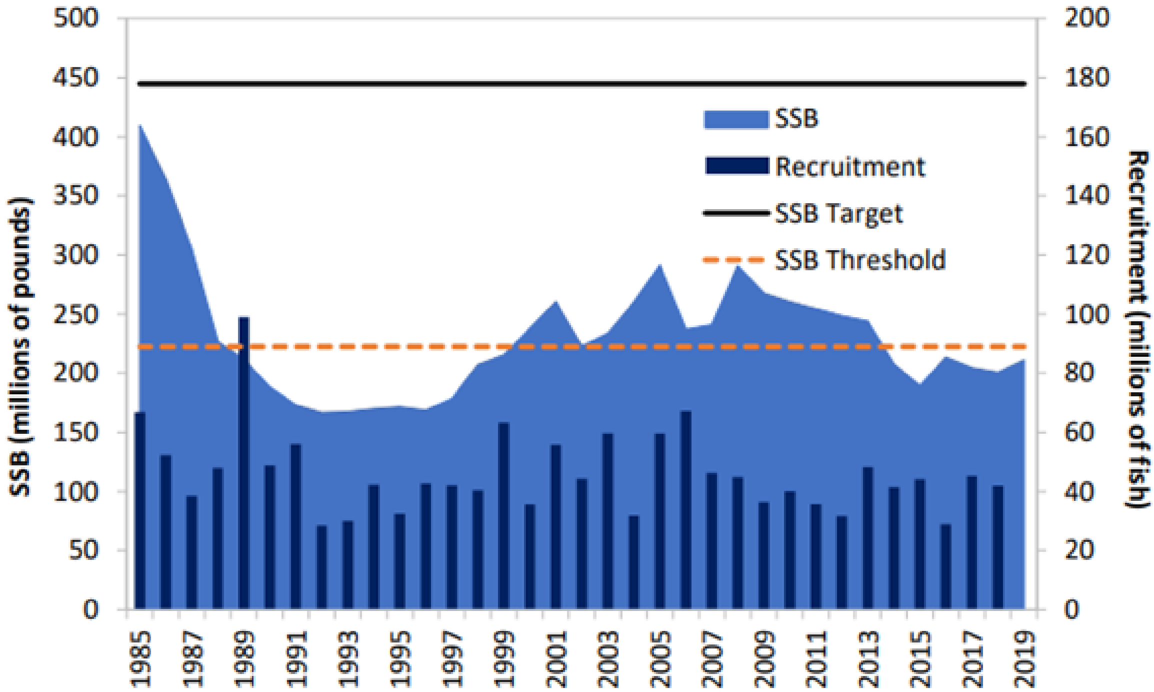

Figure 1. Bluefish spawning stock biomass and recruitment at age 0 by calendar year. The Yellow horizontal dashed line is the updated biomass target SSBMSY Proxy = SSB40% =198,717 mt, and the dotted black line is the SSBthreshold = 99,359 mt. Source: 2019 Bluefish Operational Stock Assessment, NEFSC (NMFS 2019).

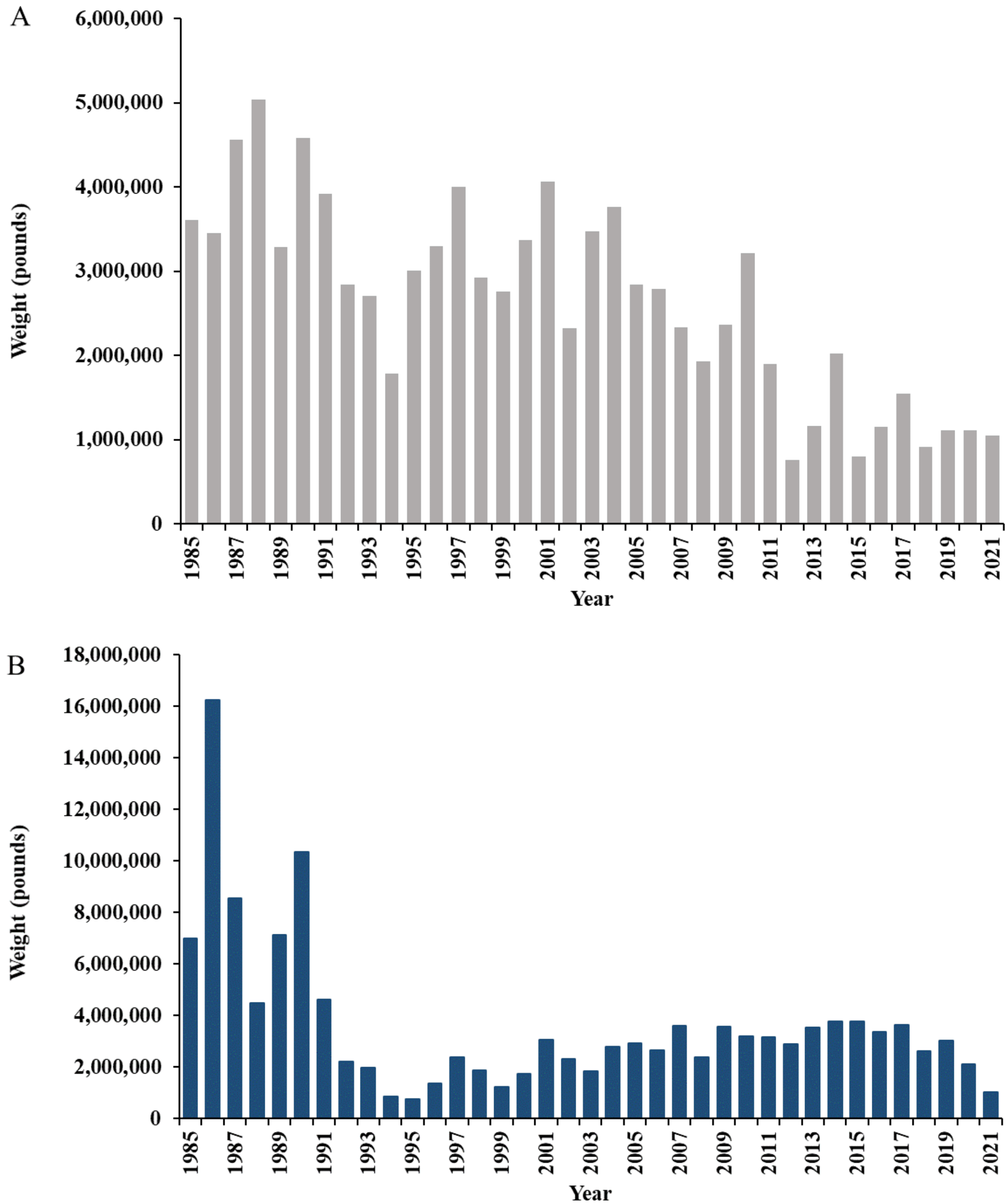

Figure 2. North Carolina commercial (A) and recreational (B) landings of bluefish, 1985–2021.

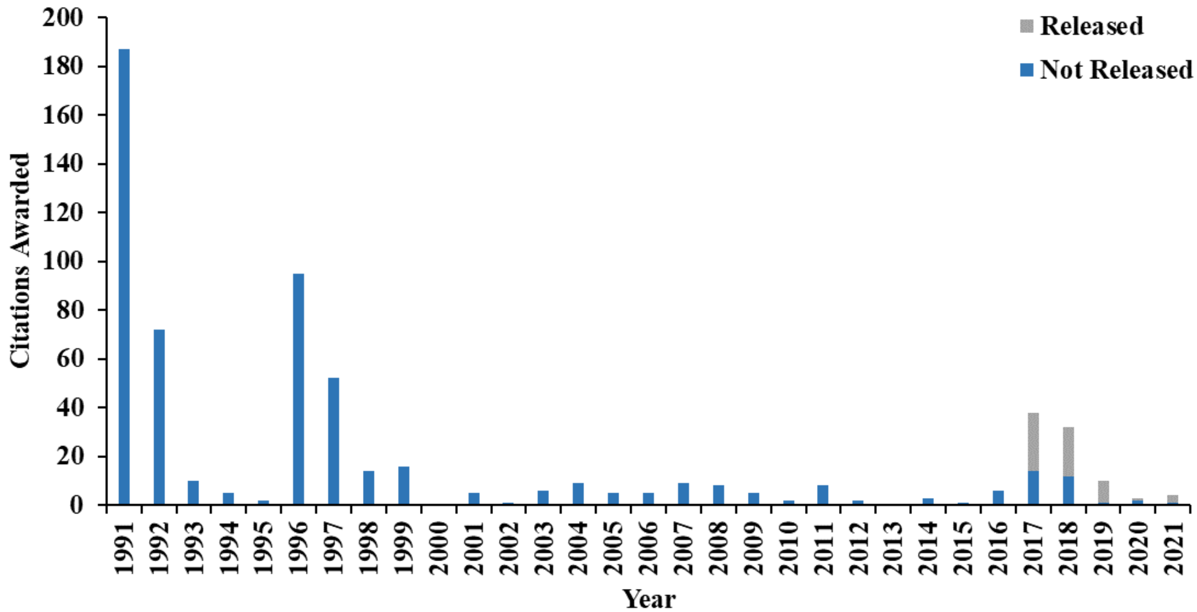

Figure 3. North Carolina recreational award citations for bluefish, 1991–2021.

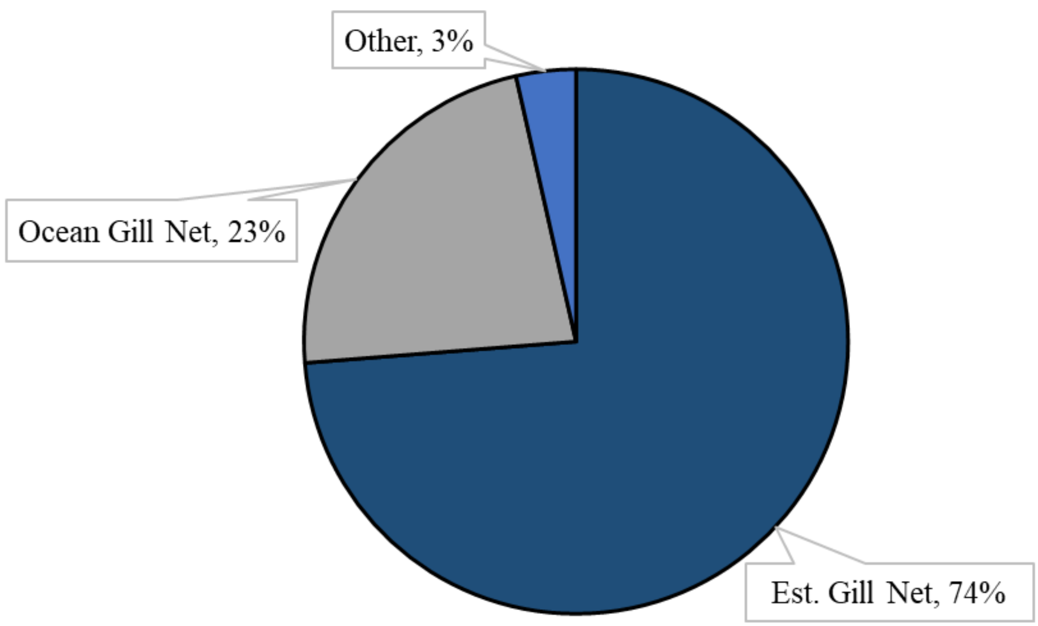

Figure 4. Commercial harvest of bluefish in North Carolina during 2021 by gear type.

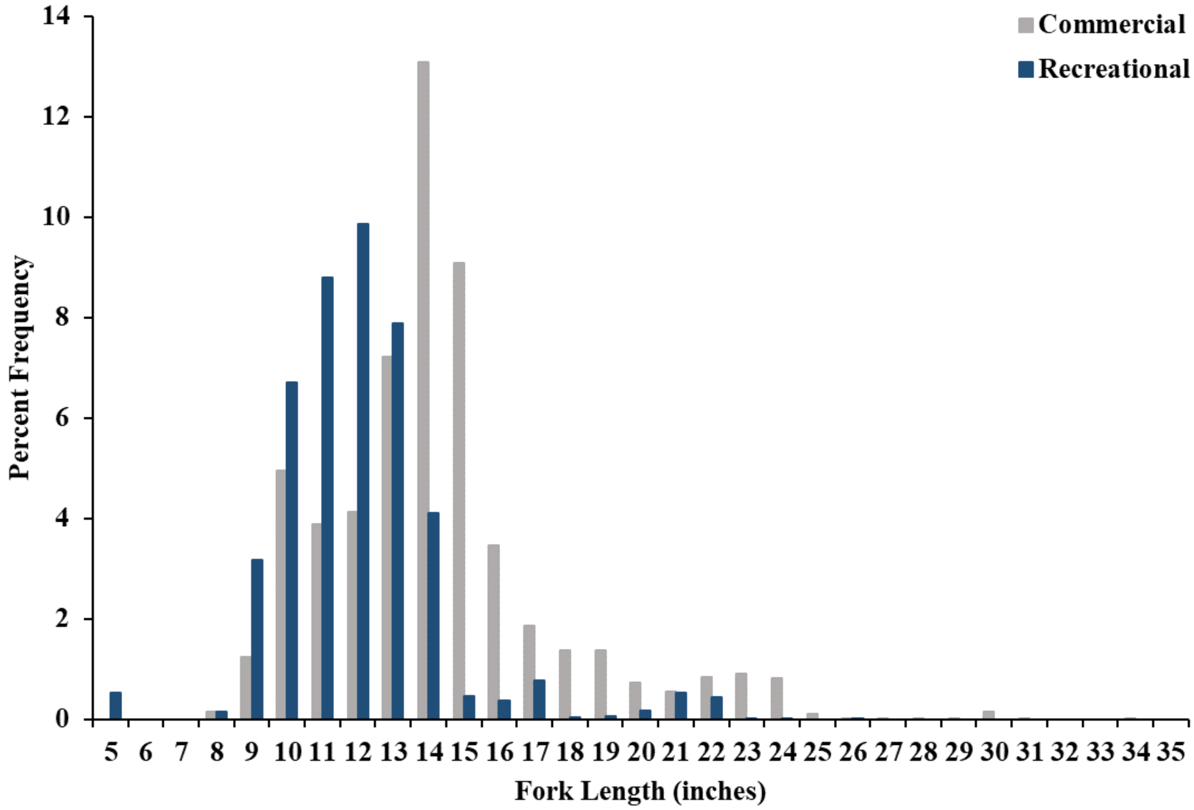

Figure 5. Commercial and recreational length frequency distribution from bluefish harvested in North Carolina, 2021.

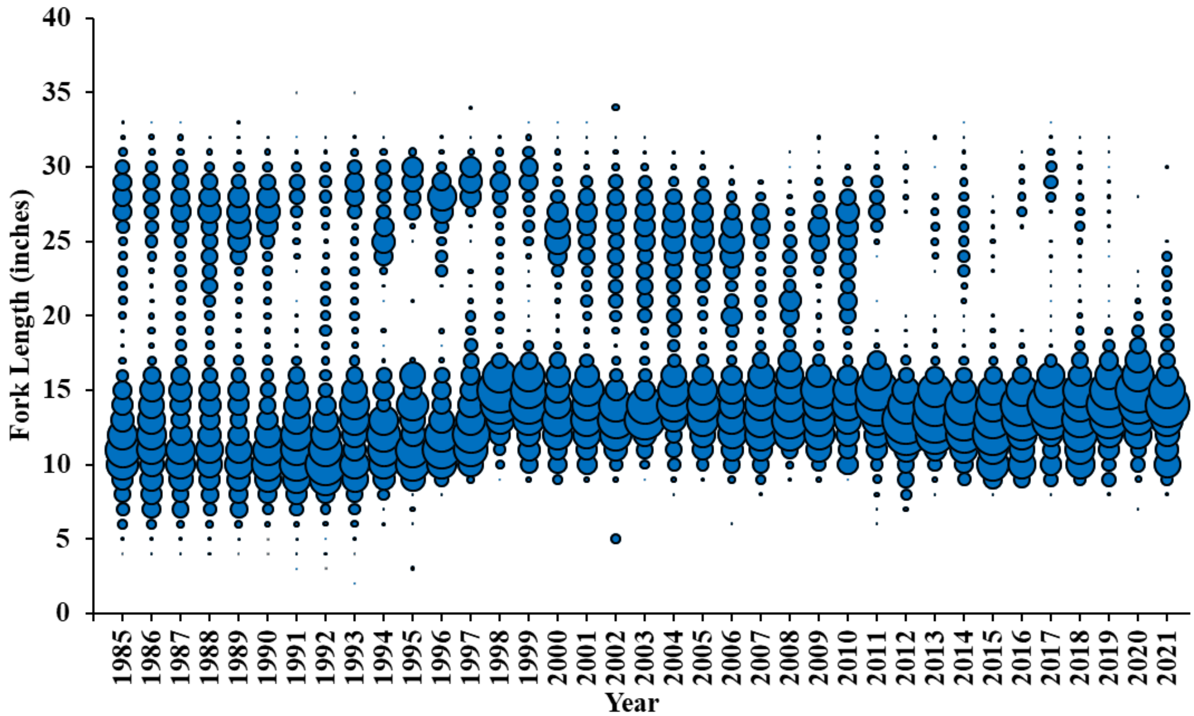

Figure 6. Commercial length frequency of bluefish harvested in North Carolina, 1985–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

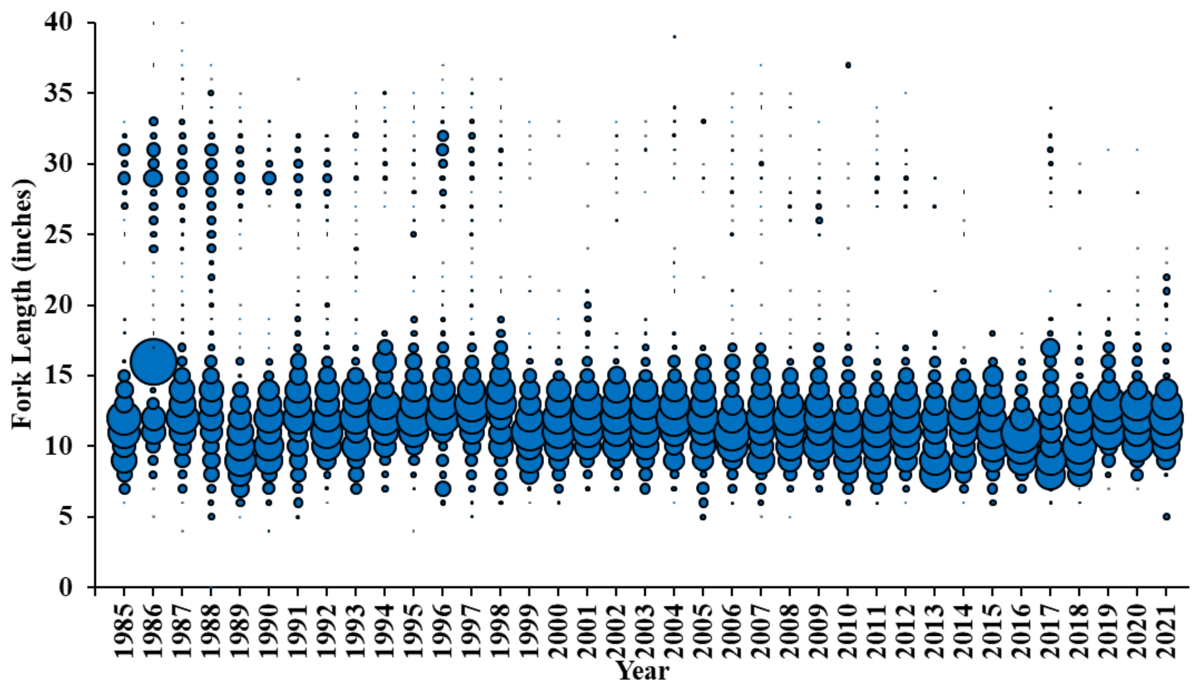

Figure 7. Recreational length frequency (fork length, inches) of bluefish harvested in North Carolina, 1985–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

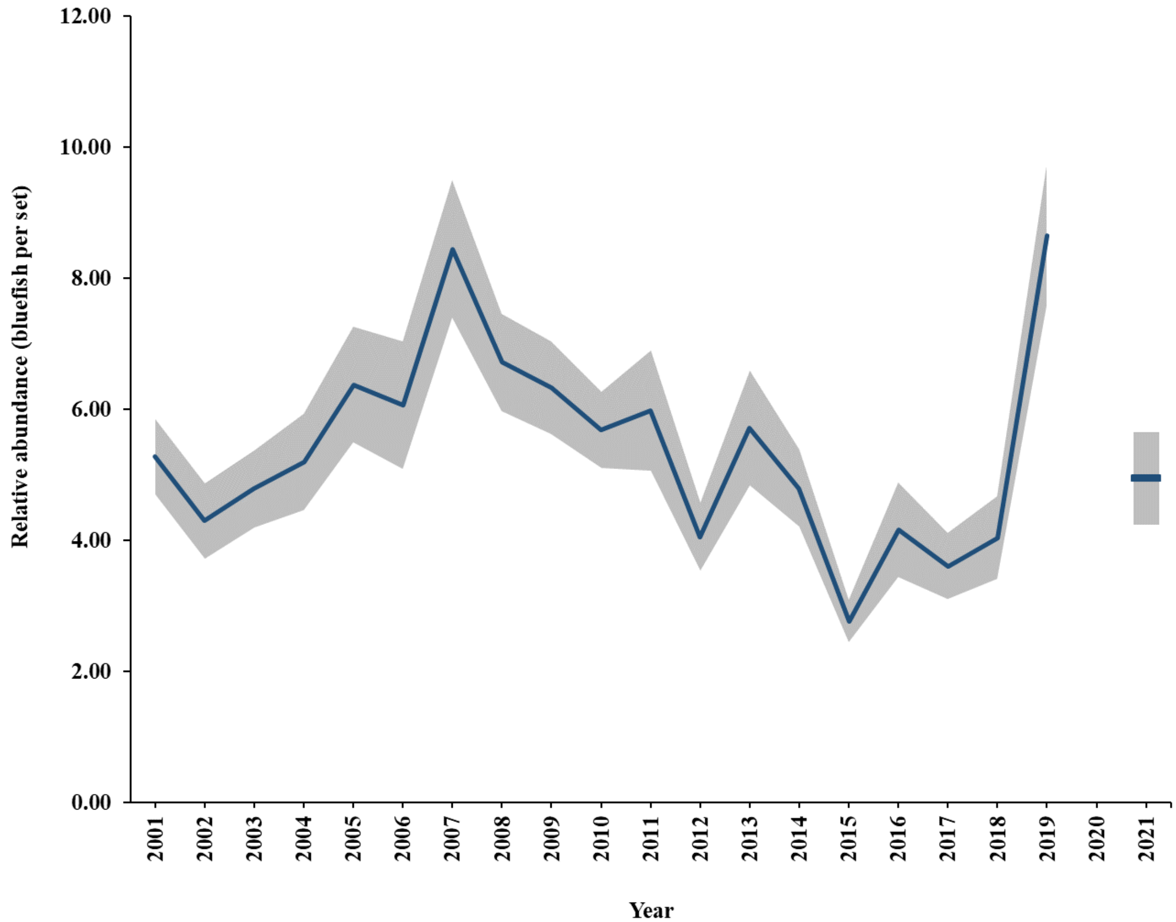

Figure 8. Relative abundance index of bluefish, from the North Carolina Pamlico Sound Independent Gill Net Survey, 2001–2021. Shading represents the standard error about the annual relative abundance index estimates. Pamlico Sound Independent Gill Net Survey sampling did not occur in 2020 and the first half of 2021.

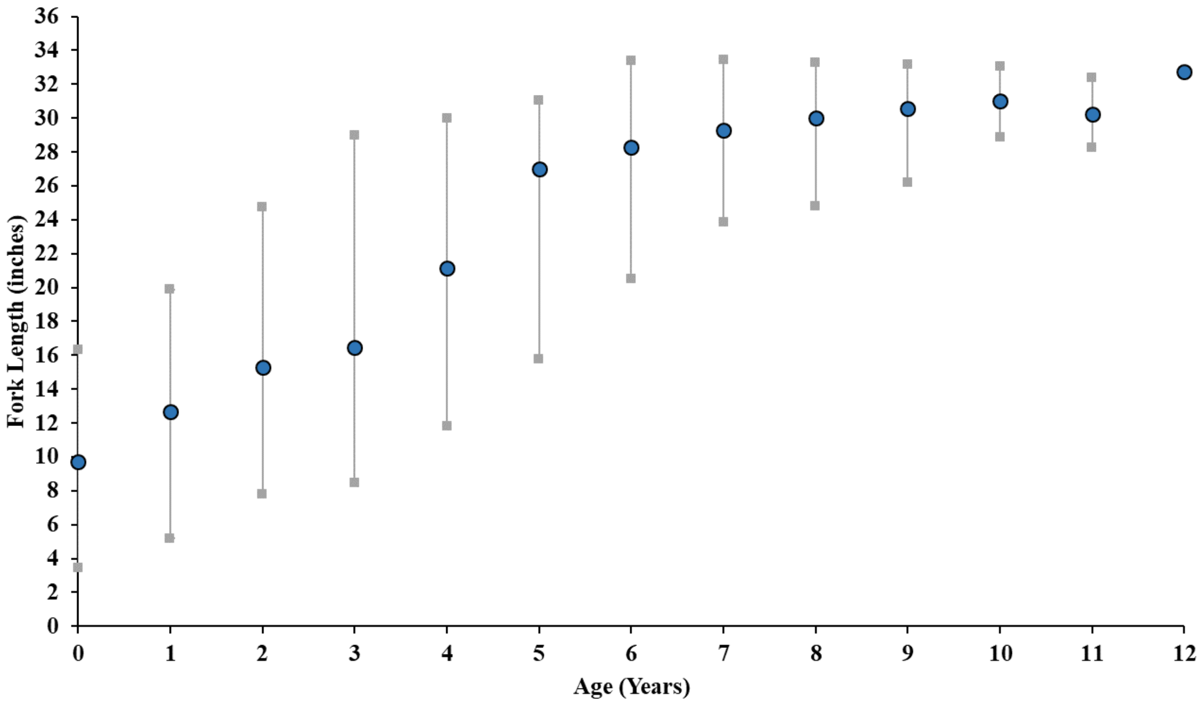

Figure 9. Bluefish length at age based on all age samples collected in North Carolina, 1985–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
SPOT
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	October 1987	
	Omnibus Amendment	August 2012
	Addendum II	August 2014
	Addendum III	February 2020
Comprehensive Review:	2024	

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 the 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.

In August 2011, the South Atlantic State/Federal Fisheries Management Board (hereafter referred to as the Board) approved the Omnibus Amendment for Spot, Spotted Seatrout, and Spanish Mackerel. 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 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.

In August 2014, the Board approved Addendum II to the Omnibus Amendment which 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 for fast-growing, early maturing species like spot, where 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 (ASMFC 2014) replaced the management triggers established in the Omnibus Amendment.

In February 2020, the Board approved Addendum III to the Omnibus Amendment, which revised the TLA's trigger mechanism and management response for the recreational and commercial fisheries (ASMFC 2020). Addendum III incorporated the use of a regional approach (Mid-Atlantic NJ-VA and South Atlantic NC-FL) to better reflect localized fishery trends and changed the TLA to trigger management action if two of the three terminal years exceed threshold levels. State-specific management action is initiated when the proportion of red exceeds specified thresholds

(30% or 60%) for both harvest and abundance. If management action is triggered, the coastwide response includes recreational bag limits and quantifiable measures to achieve percent reductions in commercial harvest. Response requirements vary depending on which threshold is exceeded. Addendum III also defines the mechanism by which triggered management actions may be removed, after abundance characteristics are no longer triggering management action. The TLA is reviewed annually in September. For additional information and links to the above-mentioned FMP, amendments, and addendums please refer to the ASMFC webpage for spot (http://www.asmfc.org/species/spot).

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 and 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. The goals of the North Carolina FMP for Interjurisdictional Fisheries is to adopt FMPs, consistent with North Carolina Law, approved by the Mid-Atlantic Fishery Management Council (MAFMC), South Atlantic Fishery Management Council (SAFMC), or the Atlantic States Marine Fisheries Commission (ASMFC) by reference and implement corresponding fishery regulations in North Carolina to provide compliance or compatibility with approved FMPs and amendments, now and in the future. The goal of the councils and ASMFC plans, established under the Magnuson-Stevens Fishery Conservation Management Act (federal councils) 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 the fisheries (NCDMF 2015).

Management Unit

Delaware through the 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:

- Increase the level of research and monitoring of spot bycatch in other fisheries, and to complete a coast-wide stock assessment.
- Manage the spot fishery to encourage reduced mortality on spot stocks until age 1.

- 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.

DESCRIPTION OF THE STOCK

Biological Profile

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. Spot generally reach maturity by age one or two, rarely living beyond six years. Length at 50 percent maturity is generally between 7- and 11-inches total length. Juvenile and adult spot are bottom feeders, eating mostly worms, small crustaceans, and mollusks. Post-larvae and young-of-the-year spot prey on planktonic organisms (ASMFC 2010).

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 move offshore to spawn during cooler months from late fall to early spring (Hildebrand and Schroeder 1928; Roelofs 1951; Dawson 1958; Hoese 1973). 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). 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

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 II and revised under Addendum III, is reviewed annually in years when an assessment is not already being conducted.

Results from the 2020 TLA (2019 terminal year) indicated harvest indices for both regions and abundance indices for the Mid-Atlantic were above 30% in two of the last three years and thus the TLA for spot triggered at the 30% threshold or moderate concern and management action as outlined in Addendum III was enacted in March 2021 (ASMFC 2020b).

Results of the 2021 TLA included 2020 data for only the harvest composite indices and indicated only the South Atlantic index exceeded the 30% threshold in 2020 (ASMFC 2021a). The Mid-Atlantic index exceeded the 30% threshold in 2018 and 2019 but dropped to about 20% red in 2020. The South Atlantic index has exceeded the 30% threshold since 2016 (ASMFC 2021a; Figure 1). The adult abundance composite characteristic, which combines fishery independent surveys, has exceeded the 30% threshold since 2011 in the Mid-Atlantic region (no 2019-2020 data point as ChesMMAP indices not available) but has not exceeded the 30% threshold in the South Atlantic region since 2007 (no 2019-2020 data point; Figure 2). The South Atlantic index indicates a general increase in adult abundance since 2016 (increasing green portion), primarily driven by higher adult abundance in the SEAMAP index compared to the NCDMF Program 195 index. While not used for management decisions, the composite juvenile abundance index consisting of North Carolina Program 195 trawl survey data is reviewed annually. This index is highly variable and shows a large spike in the red portion in 2020 (Figure 3).

Stock Assessment

The next Spot Benchmark Stock Assessment is scheduled for 2024. The most recent and first benchmark Stock Assessment, completed in 2017, did not pass peer review and will not be used for management (ASMFC 2017, 2020). The assessment was not recommended for management because of concern over uncertainty in assessment results 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 were an improvement, and recommended shrimp trawl discard estimates be incorporated into annual monitoring using the TLA.

DESCRIPTION OF THE FISHERY

Current Regulations

The 2020 TLA review (2019 terminal year) for spot triggered at the 30% threshold and coastwide management action as outlined in Addendum III was enacted in March 2021 (ASMFC 2020b). The management response outlined in Addendum III specifies, non de minimis states are required to implement a 50 fish bag limit for their recreational fishery and must reduce commercial harvest by 1% of the average state commercial harvest from the previous 10 years.

In North Carolina, the 50 fish per person per day recreational bag limit was effective April 15th, 2021 (FF-23-2021). The commercial spot fishery closed December 10th, 2021 through April 4th, 2022 to meet the required 1% reduction (FF-66-2021). The same commercial closure period will occur from December 2022 into April 2023. Management measures will remain in place for at least two years and future TLA updates will determine future management action after this time.

Commercial Fishery

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, beach seines, swipe nets, and crab pots contribute minimally to commercial landings. Commercial landings have fluctuated with higher catches reported in the 1990’s and have generally declined since 2001, averaging 1,562,390 pounds since 1991 (Table 1; Figure 4a). The lowest landings in the time series have occurred over the past seven years. In 2021, commercial landings were 527,468 pounds, which is a slight decrease from 2020. Commercial spot landings in 2020 and 2021 were higher than recreational harvest for the first time since 2000. 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 Fishery

Spot are targeted recreationally by shore-based anglers and those fishing from private vessels during the fall. Harvest data from the Recreational Commercial Gear License (RCGL) were collected from 2002 to 2008. The program was discontinued in 2009 due to a lack of funding. From 2002 to 2008, an average of 203,383 pounds was harvested per year, ranging from 97,753 to 339,077 pounds (NCDMF 2021). Recreational estimates across all years have been updated and are now based on the Marine Recreational Information Program (MRIP) Fishing Effort Survey-based calibrated estimates. For more information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

From 1991 through 2021 recreational harvest of spot in North Carolina ranged from 297,813 and 4,596,119 pounds or between 920,512 and 14,032,650 fish, with the lowest landings in both count and weight occurring in 2020 (Table 1, Figure 4b and 5). Harvest by weight was generally stable prior to 2008 when there was a notable decline in the time series. Harvest in the last seven years has been consistently low including four of the lowest values in the time series. Recreational harvest in 2021 was 1,199,080 fish and 435,231 pounds, a 30% increase in number of fish and a 46% increase in weight from 2020.

The number of recreational releases were relatively low in the first ten years of the time series remaining below 4 million fish. In 2006, there was a noticeable spike in releases of 8,196,592 fish and releases remained relatively high until dropping off in 2016 remaining consistently lower into 2021 (Figure 5). The percentage of released recreational catch has steadily increased over the time series from 14% to 66%. In 2021, anglers released 2,357,567 fish or 66% of all catches. This spike in discard percentage may be the result of the bag limit enacted in 2021.

The number of spot measured during MRIP sampling has generally declined since 2011, only 67 individuals were measured in 2021 which is the lowest in the time series (Table 2). Mean fork length (FL) in 2021 was 8.0 inches and there has been little fluctuation since 1991 ranging from 7.6 to 9.2 inches. Maximum FL has remained 10.1 inches for the past three years, while minimum FL dropped slightly in 2021 to 4.7 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 6). However, in the ‘90s and early 2000s, a wider range of lengths was harvested in the recreational fishery. Primarily, spot over 12 inches FL have not been observed in the recreational fishery for the past 10 years. Length distribution from 2021 recreational catches ranged from 4.0 to 10.0 inches and when compared to commercial catches had greater representation of smaller size classes (Figure 7). The modal length in the recreational harvest was 8.0 inches with 44 percent of the recreational catch within this size class

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

In 2021, 3,082 spot lengths were obtained from commercial fish house sampling with a mean FL of 8.0 inches, and lengths ranging from 4.9 to 12.1 inches. Mean FL has been consistent since 2019 and relatively stable across the time series ranging from 6.7 to 8.9 inches. The number of spot lengths obtained from commercial fish house sampling has generally decreased since 1994 ranging from 2,241 to 15,614 (Table 3). Bait samples are included in minimum, maximum, and mean length calculations.

Modal length generally increased from 1994 to the early 2000's (Figure 8). The range of lengths harvested narrowed in the late 2000s with little change since. Size trends in 2021 commercial samples indicate a dominance of 7.0- and 8.0-inch fish (Figure 7). When compared to the recreational fishery, the commercial fishery harvested a narrower range of sizes.

Fishery-Independent Monitoring

The number of spot aged in North Carolina's comprehensive life history program (P930) using otoliths from 1997 through 2021 has ranged from 230 to 783 (Table 4). In 2021, 783 spot were aged and preliminary data indicates the modal age was one and maximum age was five, a notable increase from the past eight years with a maximum age of three. Modal age was one in every year except 2004 when modal age was two and 2016 when modal age was zero. Minimum age was zero in every year, while maximum age ranged from two to six and is most frequently three. There is substantial overlap in length at age for ages zero through three with length at age becoming less variable after age four (Figure 9).

The Pamlico Sound Survey (Program 195) samples 54 randomly selected 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. Length cutoffs for juvenile spot were updated in 2022 after analyzing length distribution of age-0 and age-1 spot in P930. Juvenile spot are defined as fish <140 mm TL (5.5 inches) in June, and fish <190 mm TL (7.5 inches) in September.

The COVID pandemic impacted sampling in 2020 and 2021. Executive Order (EO) 116, issued on March 10, 2020, declared North Carolina under a State of Emergency and was soon followed by EO 120 which implemented a statewide Stay at Home Order for all non-essential State employees. In 2020, sampling was limited to 28 stations sampled in June and 35 stations sampled in September. A total of 35 stations were sampled in June 2021 and 32 stations were sampled in September 2021. Limited sampling likely impacted abundance indices calculated from Sound Survey data. An initial analysis of this impact was conducted for the 2020 spot abundance indices and concluded the magnitude of abundance may be overestimated slightly but limited sampling was likely able to capture the general abundance trends.

The spot weighted JAI from the Pamlico Sound Survey is highly variable in both June and September with a time series average of 460 and 393 respectively (Figure 10). Throughout the time series, large peaks tend to be followed by large declines. JAI reached a peak of 1,285 individuals per tow in June 2008 and 774 individuals per tow in September 2005. June JAI has been declining since 2018, dropping below the time series average in 2020 at 254 individuals per tow and 255 individuals per tow in 2021. September JAI has also declined since 2018 and dropped below the time series average in 2021 at 244 individuals per tow.

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 around 3.0 inches FL (age-0), and the other is around 6.0 inches FL (age-1 or greater; Figure 11). Modal length from the September portion of the Pamlico Sound Survey is more variable than June ranging from 2.0 to 5.0 inches FL with a wider range of lengths captured. Frequency of smaller size classes has increased in both months over the past five years.

RESEARCH NEEDS

There are no research or monitoring programs required of the states except for the submission of an annual compliance report. The top three recommendations are reported below (ASMFC 2021b). Additional research and monitoring recommendations can be found in the 2017 Spot Stock Assessment Peer Review Report (ASMFC 2017).

- Expand collection of life history data (age, growth, and reproduction data) from fishery dependent sources while maintaining these collections from ongoing state level fishery independent sources as well as multistate monitoring surveys. In addition, identification of coastal stocks and their movement through tagging and genetic studies.
- Increase efforts to characterize commercial discards through expanded observer coverage, particularly within the shrimp trawl fishery, and develop a standardized bycatch protocol with collection of lengths and ages of discards and by-catch. Other sources for discard mortality studies include scrap and bait fisheries, commercial gears and recreational gear, and direct research and engagement of commercial harvesters.
- Investigate environmental impacts of temperature shifts, climate change and large scale oceanic cycles (e.g., Atlantic Multi-Decadal Oscillation, AMO, and El Nino Southern Oscillation, El Nino) on recruitment SSB, stock distribution and maturity schedules for incorporation into stock assessment models.

MANAGEMENT STRATEGY

The TLA established under Addendum II and revised under Addendum III (approved February 2020) to the Omnibus Amendment is used as a precautionary management framework for spot. The TLA provides guidance in lieu of a current stock assessment. Addendum III incorporated the use of a regional approach (Mid-Atlantic NJ-VA and South Atlantic NC-FL) to better reflect localized fishery trends. 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 any two of the three most recent years, then management action is required. The harvest composite triggered at the 30% threshold in both regions in 2019. The adult abundance composite exceeded the 30% threshold in the Mid-Atlantic region but not in the South Atlantic region. Since both population characteristics were above the 30 percent threshold in at least two years (2017-2019), management actions were implemented in March 2021.

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TABLES

Table 1. Spot recreational harvest and number released (Marine Recreational Information Program), commercial harvest (North Carolina Trip Ticket Program), and total harvest, 1991–2021. All weights are in pounds.

	Recreational			Commercial	
Year	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1991	9,894,562	3,454,466	3,066,857	3,047,305	6,114,162
1992	5,043,969	2,908,974	1,431,733	2,826,138	4,257,871
1993	6,877,688	1,445,961	2,879,162	2,672,164	5,551,326
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	377,028	1,210,418
2016	1,928,716	1,831,415	558,799	241,044	799,843
2017	2,418,331	1,902,281	909,796	415,465	1,325,261
2018	2,068,865	2,062,163	597,511	167,696	765,207
2019	2,822,884	2,356,120	851,998	392,206	1,244,204
2020	920,512	1,673,676	297,813	542,870	840,683
2021	1,199,080	2,357,567	435,231	527,468	962,699
Mean	6,274,898	3,023,123	2,304,420	1,562,390	3,866,810

Table 2. Mean, minimum, maximum fork length (inches), and total number of spot measured by Marine Recreational Information Program (MRIP) sampling in North Carolina, 1989–2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Number Measured
1991	7.6	4.0	13.3	3,022
1992	7.6	3.2	11.7	1,193
1993	8.4	4.9	13.5	1,385
1994	8.2	5.7	35.5	2,633
1995	8.5	4.3	19.4	2,040
1996	8.5	4.9	11.6	2,376
1997	8.7	5.7	15.6	1,762
1998	8.6	6.3	12.4	1,632
1999	9.1	5.5	11.5	1,159
2000	8.6	5.5	20.5	1,223
2001	8.8	5.4	13.9	1,627
2002	8.3	6.3	12.0	860
2003	8.7	4.6	14.2	1,403
2004	9.2	4.8	12.8	2,034
2005	8.4	5.2	16.2	1,286
2006	8.9	4.8	13.5	1,216
2007	9.1	5.7	12.0	1,243
2008	8.3	5.0	12.2	1,344
2009	8.4	5.0	10.8	682
2010	8.1	5.8	12.0	1,096
2011	8.2	5.9	11.1	1,534
2012	7.9	5.6	11.7	611
2013	7.9	4.5	11.5	484
2014	8.2	4.8	11.9	344
2015	8.1	6.1	11.9	214
2016	8.0	6.3	11.0	107
2017	8.1	6.3	10.6	98
2018	8.4	5.7	10.9	125
2019	7.7	5.0	10.1	276
2020	8.1	5.0	10.1	131
2021	8.0	4.7	10.1	67

Table 3. Mean, minimum, maximum fork length (inches), and total number of spot measured from North Carolina commercial fish house samples, 1994–2021. Bait samples are included in calculation of mean, minimum and maximum length.

Year	Mean Length	Minimum Length	Maximum Length	Number Measured
1994	6.7	3.9	11.9	9,183
1995	6.8	3.9	15.4	11,136
1996	7.3	3.9	11.8	14,139
1997	7.4	3.9	13.3	15,574
1998	7.4	3.9	12.2	11,815
1999	7.7	3.9	11.7	9,188
2000	7.9	3.9	17.6	15,614
2001	8.5	3.9	12.4	15,584
2002	8.4	3.9	17.8	13,029
2003	8.6	3.9	13.9	12,907
2004	8.8	3.9	15.0	12,370
2005	8.9	4.0	13.1	15,535
2006	8.3	4.1	13.2	13,517
2007	7.9	3.9	12.0	13,889
2008	7.9	3.9	13.3	10,744
2009	8.1	3.9	11.7	9,087
2010	8.1	3.9	11.6	7,491
2011	8.1	4.3	13.1	8,906
2012	8.0	4.1	19.1	4,461
2013	8.3	4.2	13.3	4,699
2014	8.2	4.1	13.1	6,650
2015	8.3	4.3	12.8	4,543
2016	8.0	4.9	12.8	2,250
2017	8.3	4.4	11.7	2,643
2018	7.9	4.2	10.9	2,241
2019	8.0	4.4	16.1	3,719
2020	8.0	5.0	12.5	3,200
2021	8.0	4.9	12.1	3,082

Table 4. Modal, minimum, maximum age, and total number of spot aged in North Carolina from fishery dependent and fishery independent sampling, 1997–2021. Includes otolith ages only. Age data from 2014 and 2021 are preliminary.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1997	1	0	3	263
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	365
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	516
2019	1	0	3	440
2020	1	0	3	452
2021	1	0	5	783

FIGURES

Figure 1. Annual harvest composite TLA color proportions for South Atlantic region (NC-FL) spot recreational and commercial landings, 1989–2020 (ASMFC 2021a). The reference period is 2002–2012.

Figure 2. Annual abundance composite TLA color portions for the South Atlantic region (NC-FL) adult spot (age 1+) from fishery independent indices (SEAMAP and NCDMF Program 195), 2002–2019 (no 2020 data point due to limited sampling; ASMFC 2021a). The reference period is 2002–2012.

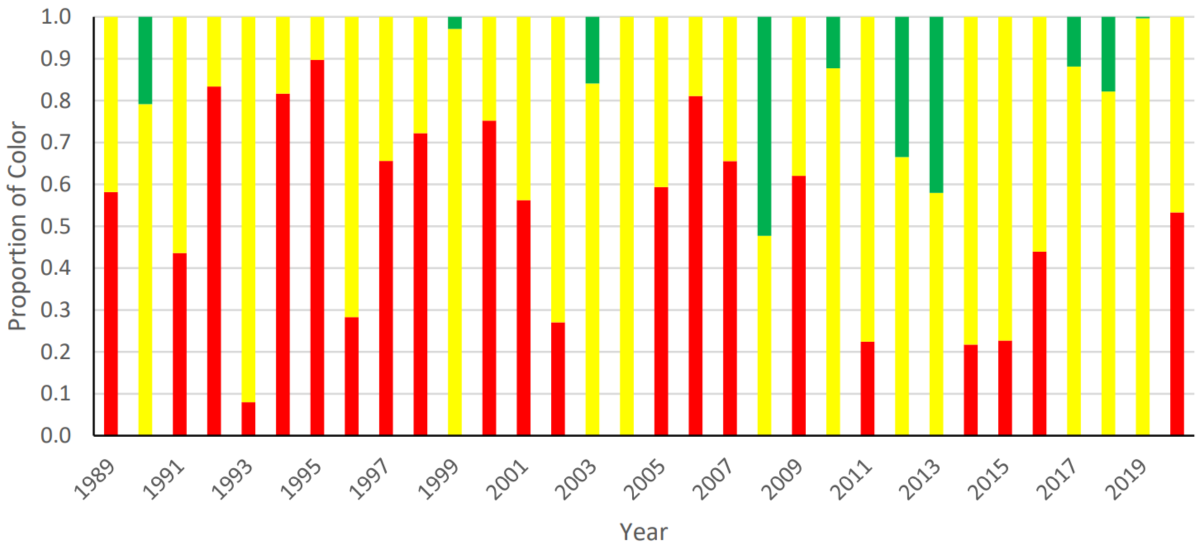

Figure 3. Annual TLA color proportions for the South Atlantic region abundance composite for juvenile spot (age 0) from the NCDMF Pamlico Sound Survey, 1989–2020 (ASMFC 2021a). Juvenile index does not trigger management action. Reference period is 2002–2012.

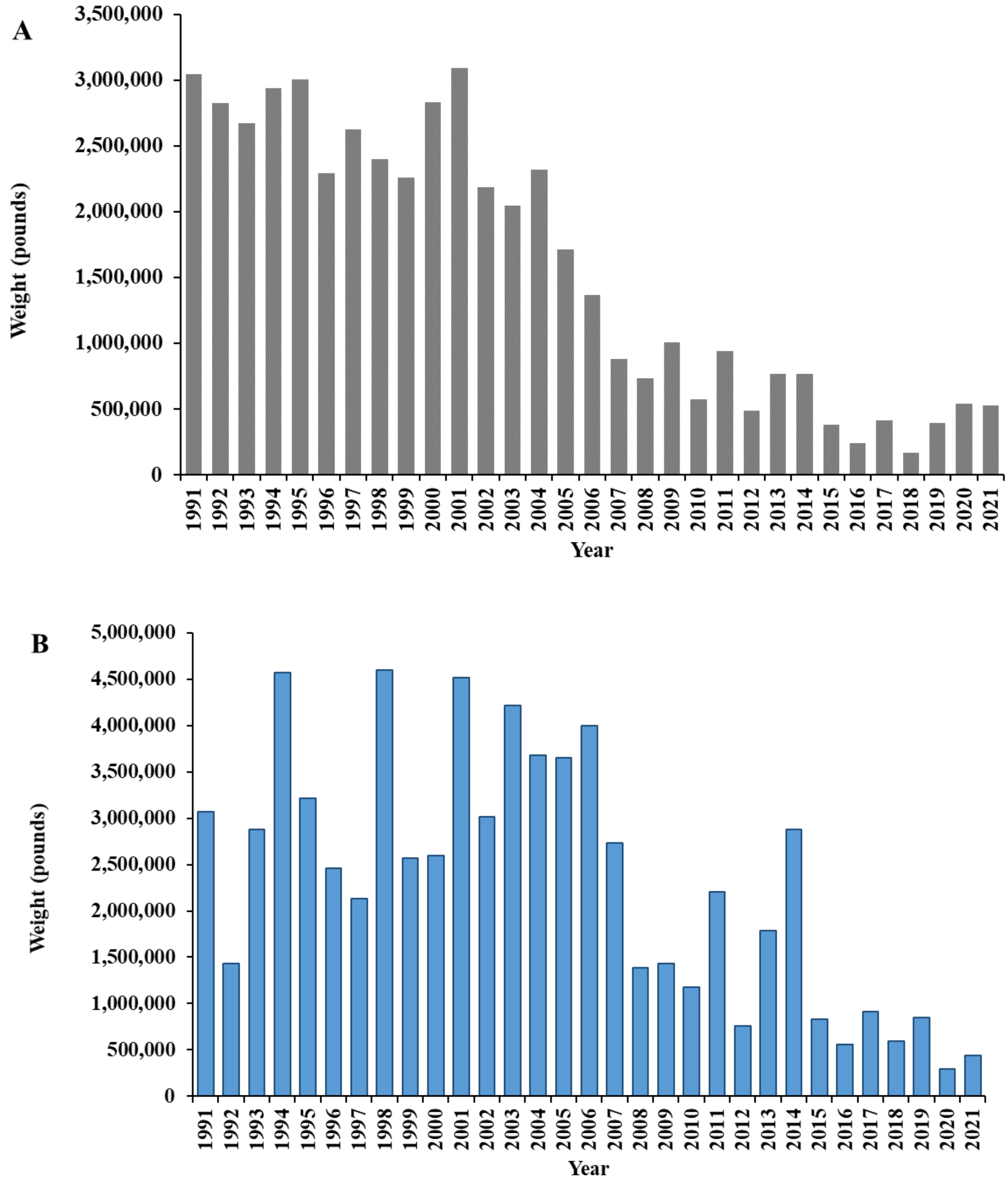

Figure 4. Annual A) commercial landings (North Carolina Trip Ticket Program) and B) recreational harvest (Marine Recreational Information Program) in pounds for spot in North Carolina, 1991–2021.

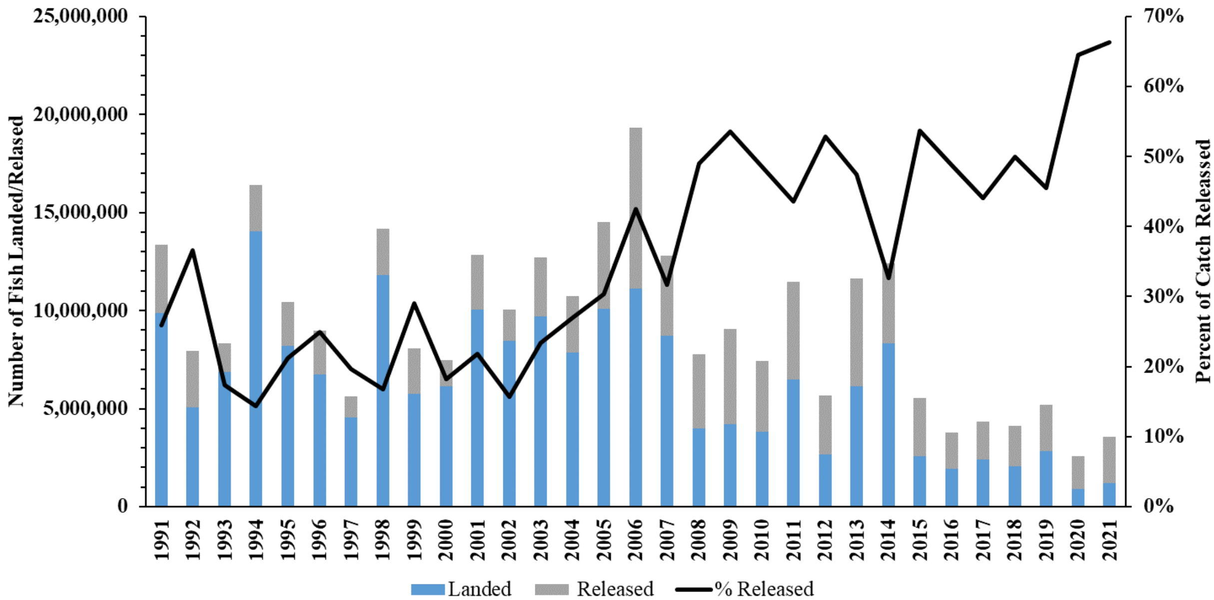

Figure 5. Recreational catch (landings and releases, in numbers) and the percent of catch that is released, 1991–2021 from the MRIP.

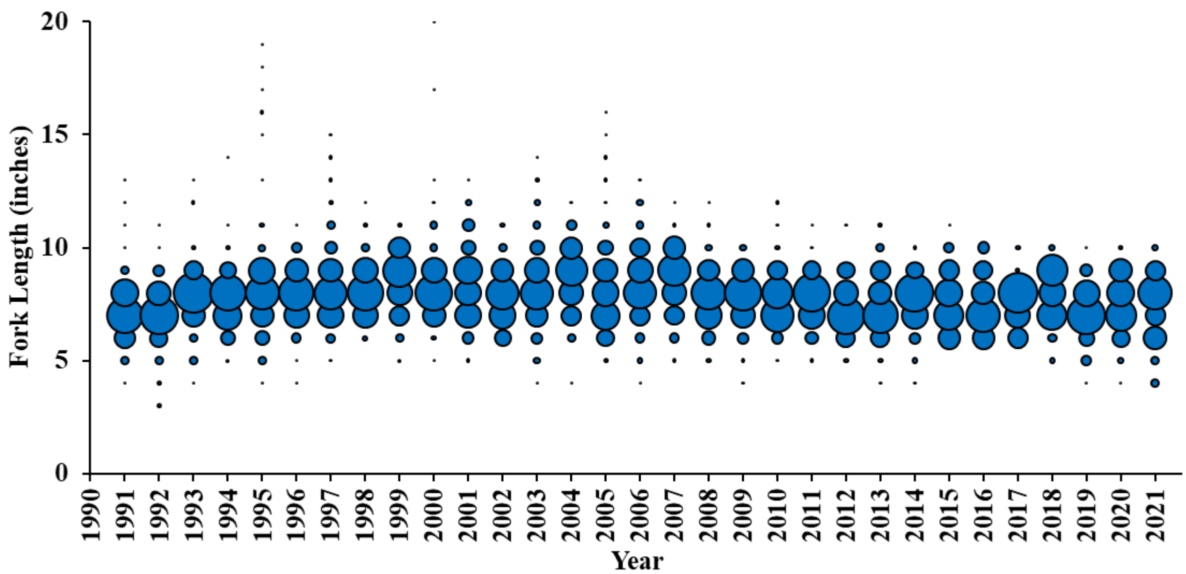

Figure 6. Recreational length frequency (fork length, inches) of spot harvested in North Carolina, 1991–2021 (MRIP, n=194,521,845). Bubble represents the proportion of fish at length.

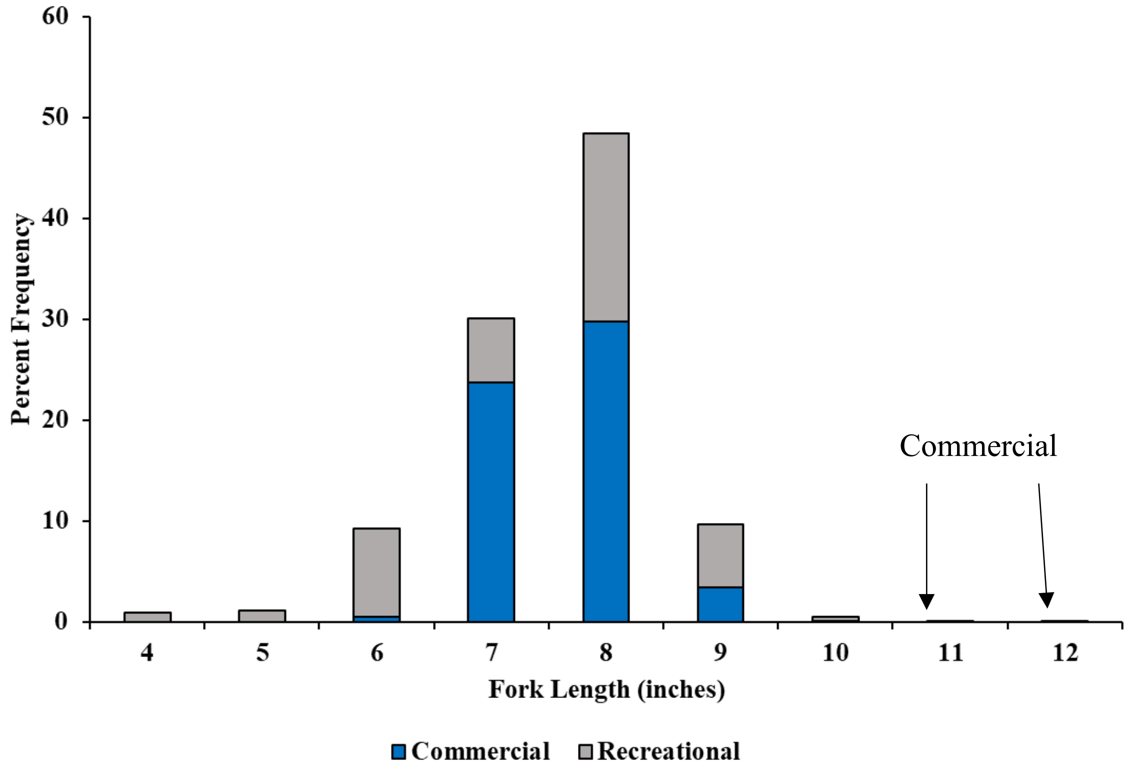

Figure 7. Commercial (n=1,625,386) and recreational (n=2,824,466) length frequency distribution for spot harvested in North Carolina, 2021.

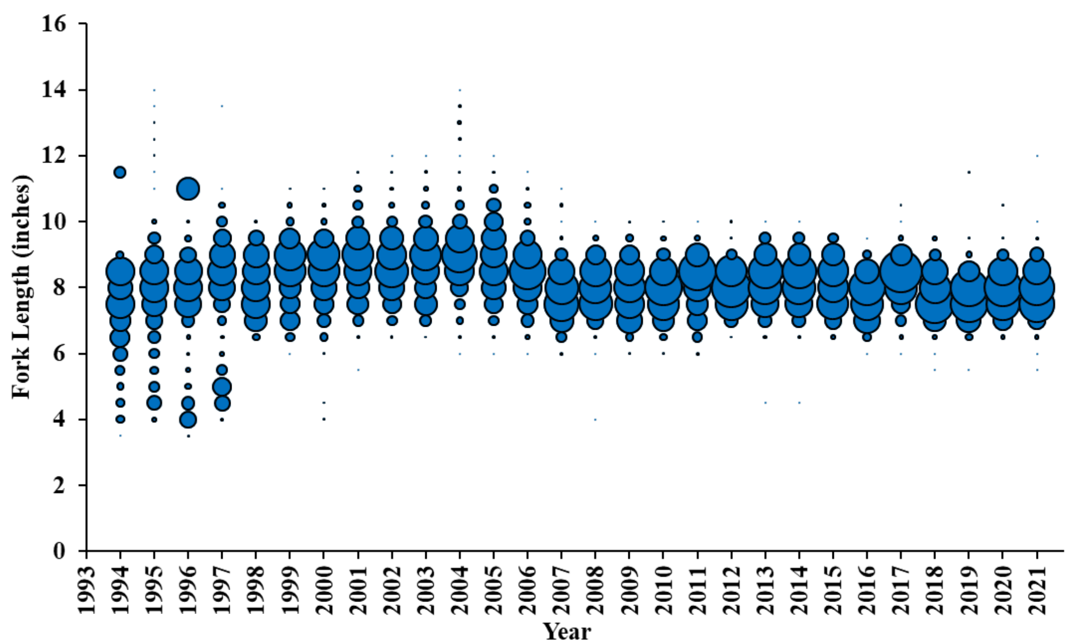

Figure 8. Commercial length frequency (fork length, inches) of spot harvested from 1994 to 2021. Bubble represents the proportion of fish at length. Bait samples not included.

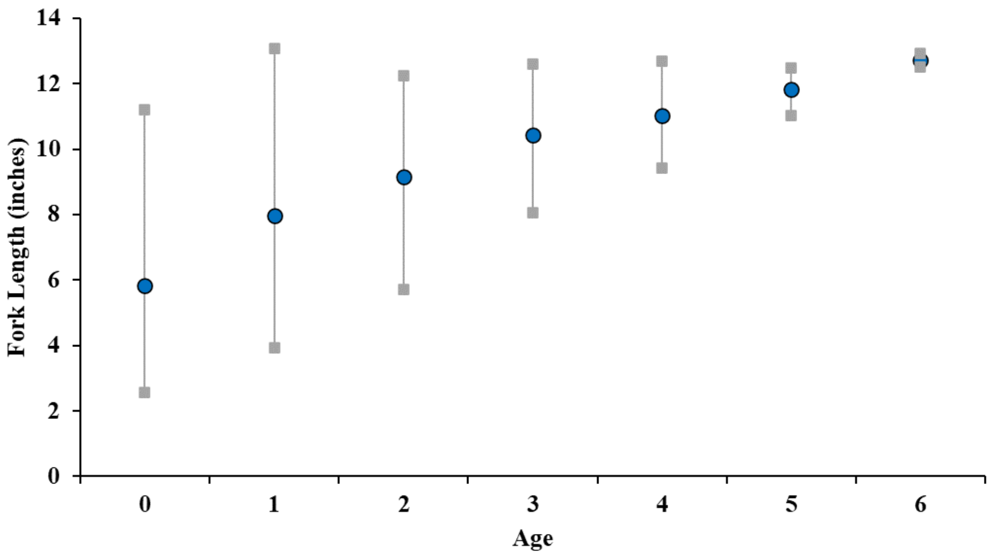

Figure 9. Spot length at age based on all otolith age samples collected from 1997 to 2020 (n=10,444). Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size at age.

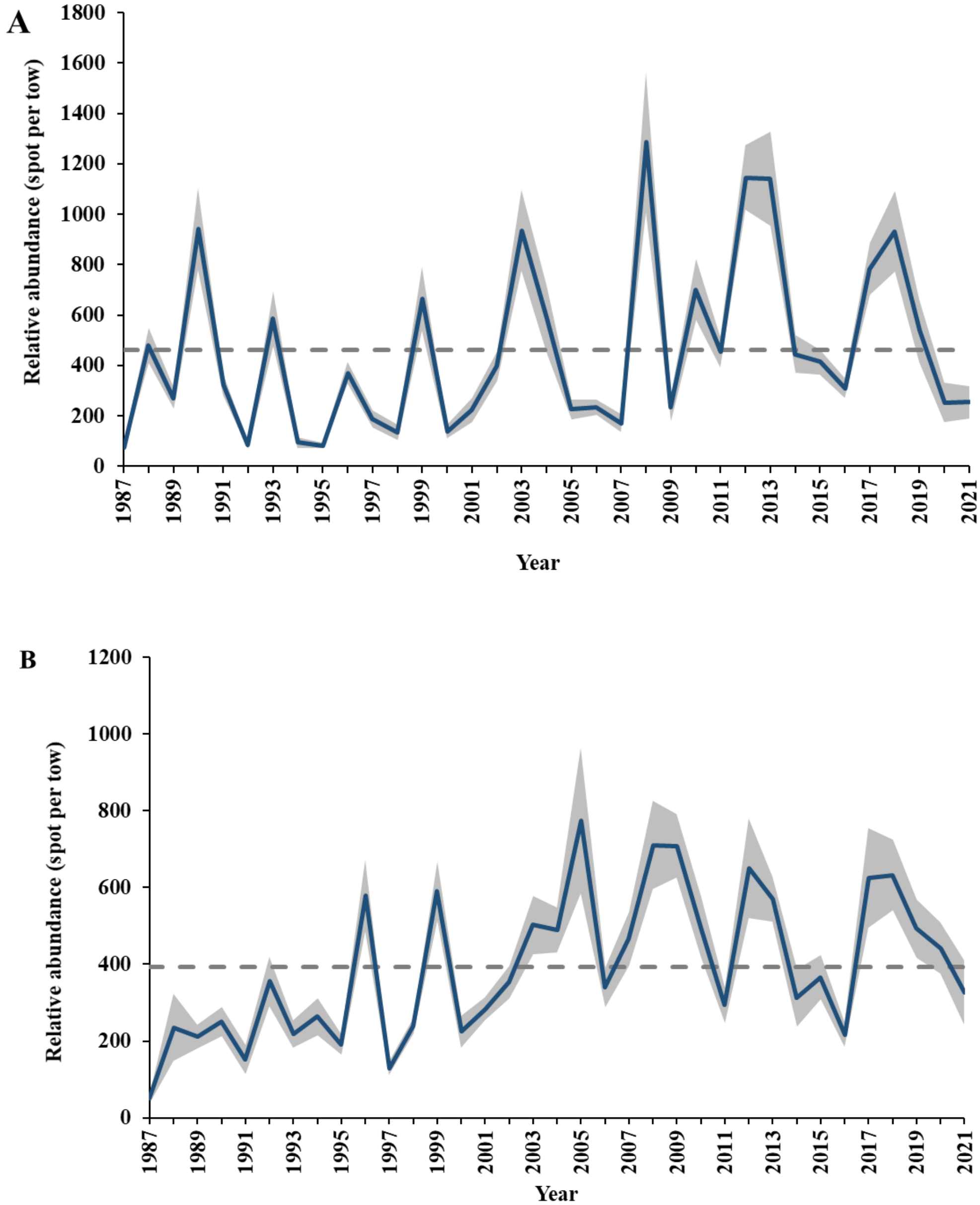

Figure 10. Spot juvenile weighted abundance index (number per tow) for A) June and B) September from the Pamlico Sound Survey, 1987–2021. Shaded area represents standard error and dashed line indicates time series average. Length cutoffs are <140 mm FL (5.5 in) in June and <190 mm TL (7.5 in) in September.

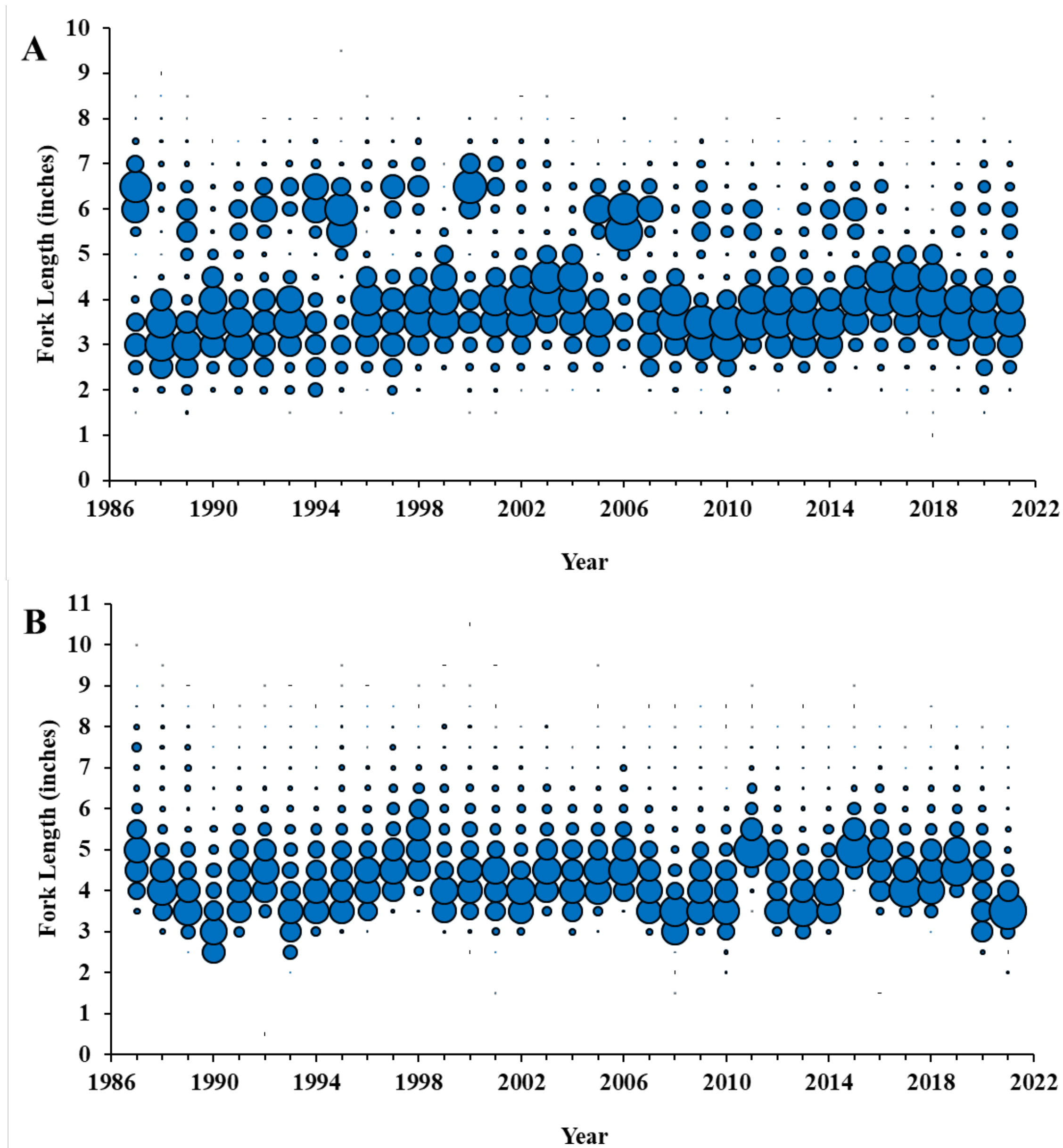

Figure 11. Length frequency (Fork Length, inches) of all spot captured in Pamlico Sound Survey sampling during A) June and B) September, 1987–2021. Bubble represents the proportion of fish at length.

FISHERY MANAGEMENT PLAN UPDATE
SUMMER FLOUNDER
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	Adopted by the ASMFC in 1982 and the MAFMC in 1988	
	Amendment 1	1991
	Amendment 2	1993
	Amendment 3	1993
	Amendment 4	1993
	Amendment 5	1993
	Amendment 6	1994
	Amendment 7	1995
	Amendment 10	1997
	Amendment 11	1998
	Amendment 12	1999
	Framework 1	2001
	Framework 2	2001
	Addendum III	2001
	Addendum IV	2001
	Framework 5	2004
	Addendum VIII	2004
	Addendum XIV	2004
	Addendum XV	2004
	Addendum XVI	2005
	Addendum XVII	2005
	Framework 6	2006
	Addendum XVIII	2006
	Framework 7	2007
	Addendum XIX	2007
	Amendment 16	2007
	Amendment 15	2011
	Amendment 19 (Recreational Accountability Amendment)	2013
	Addendum XXV	2014
	Amendment 17	2015
	Addendum XXVI	2015
	Amendment 18	2015
	Addendum XXVII	2016
	Addendum XXVIII	2017
	Amendment 20	2017
	Framework 10	2017
	Framework 11	2018
	Framework 13	2018

Addendum XXXI	2018
Addendum XXXII	2018
Framework 14	2019
Framework 15	2020
Amendment 21	2020
Framework 16	2020

Comprehensive Review: 2021

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.

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 equivalence 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 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 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.

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.

Framework 14 gives the Council the option to waive the federal recreational black sea bass measures in favor of state measures through conservation equivalency; implements a transit zone for commercial and recreational summer flounder, scup, and black sea bass fisheries in Block Island Sound; and allows for the use of a maximum size limit in the recreational summer flounder and black sea bass fisheries.

Framework 15 established a requirement for commercial vessels with federal permits for all species managed by the Mid-Atlantic and New England Councils to submit vessel trip reports electronically within 48 hours after entering port at the conclusion of a trip.

Amendment 21 modified the summer flounder commercial state quota allocation system and FMP goals and objectives.

Framework 16 modified MAFMC's ABC control rule and risk policy. The revised risk policy is intended to reduce the probability of overfishing as stock size falls below the target biomass while allowing for increased risk and greater economic benefit under stock biomass conditions. This action also removed the typical/atypical species distinction currently included in the risk policy.

Specific details for each amendment under development include:

Summer Flounder, Scup, and Black Sea Bass Commercial/Recreational Allocation Amendment was jointly approved in December 2021 and selected preferred alternatives for each species. The Council is preparing this amendment for submission to NMFS for review and rulemaking.

The Recreational Harvest Control Rule Framework/Addenda is under the public hearing stage. The Draft Addenda proposes five possible approaches for setting recreational measures. Key differences between the options include the information considered when setting measures and the circumstances under which measures would change. These differences have implications for how often measures would change and the magnitude of those changes. Taking final action on these addenda will not implement any specific bag, size, or season limits but will modify the specification process for setting specific measures. In February 2021, the Council and Policy Board agreed to focus on the Harvest Control Rule through a joint framework/addendum. In August and October of 2021, the Council and Policy Board reviewed and provided feedback on a draft range of alternatives. In February 2022 the Council and Policy Board approved a range of alternatives which are currently going through the public hearing process.

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 2022).

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

Amendment 21 in 2020 approved the proposed revised FMP Goals and Objectives for Summer Flounder and are as follows:

- Goal 1: Ensure the biological sustainability of the summer flounder resource in order to maintain a sustainable summer flounder fishery.
    - Objective 1.1: Prevent overfishing and achieve and maintain sustainable spawning stock biomass levels that promote optimum yield in the fishery.
- Goal 2: Support and enhance the development and implementation of effective management measures.
    - Objective 2.1: Maintain and enhance effective partnership and coordination among the Council, Commission, Federal partners, and member states.
    - Objective 2.2: Promote understanding, compliance, and the effective enforcement of regulations.
    - Objective 2.3: Promote monitoring, data collection, and the development of ecosystem-based science that support and enhance effective management of the summer flounder resource.
- Goal 3: Optimize economic and social benefits from the utilization of the summer flounder resource, balancing the needs and priorities of different user groups to achieve the greatest overall benefit to the nation.
    - Objective 3.1: Provide reasonable access to the fishery throughout the management unit. Fishery allocations and other management measures should balance responsiveness to changing social, economic, and ecological conditions with historic and current importance to various user groups and communities.

DESCRIPTION OF THE STOCK

Biological Profile

Summer flounder are estuarine-dependent members of the left eyed flounder family (*Paralichthyidae*) 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. The 2021 management track stock assessment indicated that the summer flounder stock status has not changed.

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 beginning in 2019. The 2021 management track assessment indicated that the spawning stock biomass (SSB) was at approximately 86% of the SSB target, fishing mortality was below the threshold, and recruitment still remains below average. The stock assessment report can be found on the summer flounder page on the ASMFC website for further information.

DESCRIPTION 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 replaced harvest limits to provide additional opportunities to land the quota, which are established by proclamation [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 for shrimp trawls during closed flounder trawl harvest periods. A license to land flounder from the Atlantic Ocean is required to land more than 100 pounds per trip.

Recreational: Season closures are currently in effect for North Carolina. The recreational closure effects all flounder species in North Carolina and was implemented in accordance with Amendment 3 to the North Carolina Southern Flounder Fishery Management Plan. The 2022 season is scheduled to be open September 1 through September 30 for internal and ocean waters of the state. During the open season, a 15-inch total length minimum size limit and 1-fish creel limit will be in effect.

Commercial Fishery

All landings reported as caught in the Atlantic Ocean are considered to be summer flounder by the North Carolina Trip Ticket Program. Since 2019, summer flounder have only been allowed to be harvested by trawls from the Atlantic Ocean (Figure 1). Although in history's past other gears were also comparable in summer flounder landings coming from the Atlantic Ocean. Commercial allocations were modified via Amendment 21, which became effective on January 1, 2021. The revised allocation system modifies the state-by-state commercial quota allocations in years when the annual coastwide commercial quota exceeds the specified trigger of 9.55 million pounds. North Carolina has an allocation of 27.4% (baseline quota) and an additional allocation of 12.375% if the 9.55 million pounds of coastwide commercial quota is triggered. In recent years, landings peaked in 2004 and have been generally stable since 2007, aside from 2012 and 2013, when landings were lower than average (Table 1, Figure 2). 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. Since 2014, more winter trawl vessels returned to North Carolina to land catches, mainly in the Beaufort and Washington areas.

Recreational Fishery

Summer flounder harvest is reported through the NOAA Marine Recreational Information Program (MRIP). Recreational estimates across all years have been updated and are now based on the new MRIP Fishing Effort Survey-based calibrated estimates. For more information on MRIP, see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Recreational harvest of summer flounder has varied annually but has seen a decline over the years (Table 1, Figure 2). Some of this decline in landings is likely the result of increases in size limits and the lack of these larger summer flounder being prevalent in this area. The limited harvest opportunities and closed and shortened seasons in accordance with Amendment 2 to the North Carolina Southern Flounder FMP have also contributed to the decline in landings.

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 commercial 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 the North Carolina Carcass Collection Program.

From 1991 to 2021, annual mean length in the commercial fishery increased from 17 to 20 inches total length (TL) (varying through the years) and the mean number of fish measured from 1991 to 2021 was 19,063 (Table 2). Summer flounder harvested commercially during 2021 ranged from 12 to 32 inches TL with 25% being the mode at 15 inches TL (Figure 3). From 1991 to 2021, summer flounder harvested commercially ranged from 12 to 35 inches TL (Table 2, Figure 4).

As for recreational fishery length data from 1982 to 2021, annual mean lengths increased overtime as size limits have been implemented. The number of fish measured from 1982 to 2021 were variable (Table 3). Summer flounder harvest recreationally during 2021 ranged from 14 to 19 inches TL with the mode being 17 inches TL (Figure 3). From 1982 to 2021, summer flounder harvested recreationally ranged from 5 to 29 inches TL (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 and use 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 TL during 1987 through 2019 (Table 4). During 2020 and 2021, sampling was impacted during scheduled sampling months due to staffing issues and the COVID pandemic. Executive Order (EO) 116, issued on March 10, 2020, declared North Carolina under a State of Emergency and was soon followed by EO 120 which implemented a statewide Stay at Home Order for all non-essential State employees. During this time, sampling did not occur in 2020 and incomplete sampling in 2021. Data from 1999 is also 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 2018 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) sources throughout the year. While scales were used to determine the age of summer flounder historically, otoliths are now preferred and have been collected exclusively since 2016. In 2021, 628 summer flounder otoliths were aged yielding a range in age from 1 to 12 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 2021 (Table 5). The age data suggests that summer flounder grow very quickly during their first year of life with an average TL of 13 inches at age 1. They continue to grow to an average TL of 28 inches by age 14 (Figure 7).

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, biological reference points, 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).

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 each year. Amendments to the FMP are undertaken as issues arise that require action. 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 percent) and recreational (40 percent) fisheries. Beginning in 2023, revised allocations will be implemented and transitioning to catch-based allocations with 55 percent being commercial and 45 percent being recreational. 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. North Carolina has several specific management strategies for summer flounder (Table 6).

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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 summer flounder from North Carolina for the period 1982 – 2021.

Year	Recreational			Commercial	
	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (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	4,844,118	5,311,987
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
2014	150,201	1,478,527	215,294	2,911,750	3,127,044
2015	99,263	856,849	157,437	2,878,743	3,036,180
2016	65,494	664,388	110,392	2,071,100	2,181,492
2017	91,193	977,285	147,426	1,572,707	1,720,133
2018	57,913	440,676	92,032	1,654,569	1,746,601
2019	34,895	467,942	52,872	2,025,401	2,078,273
2020	24,699	705,247	37,935	1,779,861	1,817,796
2021	13,863	1,187,109	27,492	2,093,366	2,120,858
Mean	577,905	1,258,898	627,132	3,746,169	4,373,300

Table 2. Summer flounder length (total length, inches) data from commercial fish house samples in North Carolina, 1990-2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum Length (in)	Total Number Measured
1990	17	12	29	16,275
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
2019	20	13	33	18,964
2020	20	12	35	14,768
2021	19	13	32	17,884

Table 3. Summer flounder length (total length, inches) data from NOAA Marine Recreational Information Program recreational samples in North Carolina, 1982-2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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	39	1,454
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
2019	16	13	19	65
2020	16	8	24	38
2021	17	15	19	13

Table 4. Summer flounder length (total length, inches) data from Program 195 (Pamlico Sound Survey) samples in North Carolina, 1987-2021. *Note: Data for 2020 and 2021 not usable due to staffing issues and insufficient sampling during COVID-19.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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
2019	6	3	15	400
2020*	7	4	13	56
2021*	8	3	14	30

Table 5. Summer flounder age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources in North Carolina from 1991-2021.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1991	2	0	8	635
1992	2	0	7	359
1993	2	0	6	401
1994	2	0	7	552
1995	2	0	7	535
1996	2	1	9	476
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	1,128
2015	6	0	17	890
2016	7	0	18	998
2017	4	0	19	1,179
2018	5	0	19	882
2019	5	0	19	925
2020	4	0	17	761
2021	4	1	12	628

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 percent 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

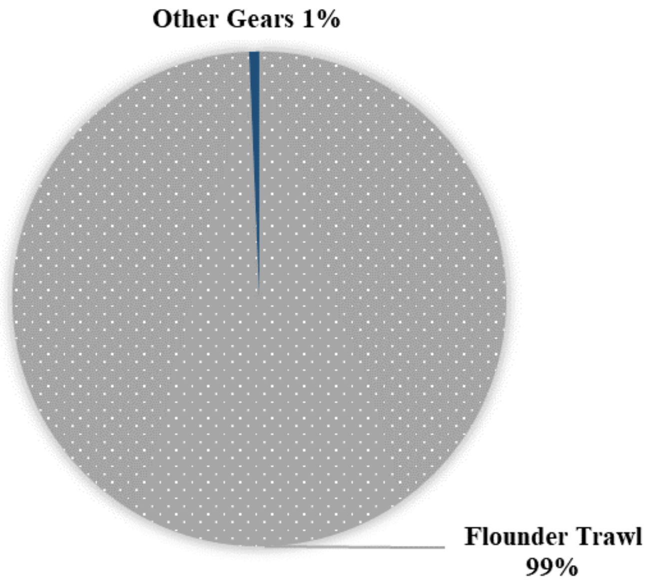

Figure 1. Commercial harvest of summer flounder in North Carolina by gear type in 2021.

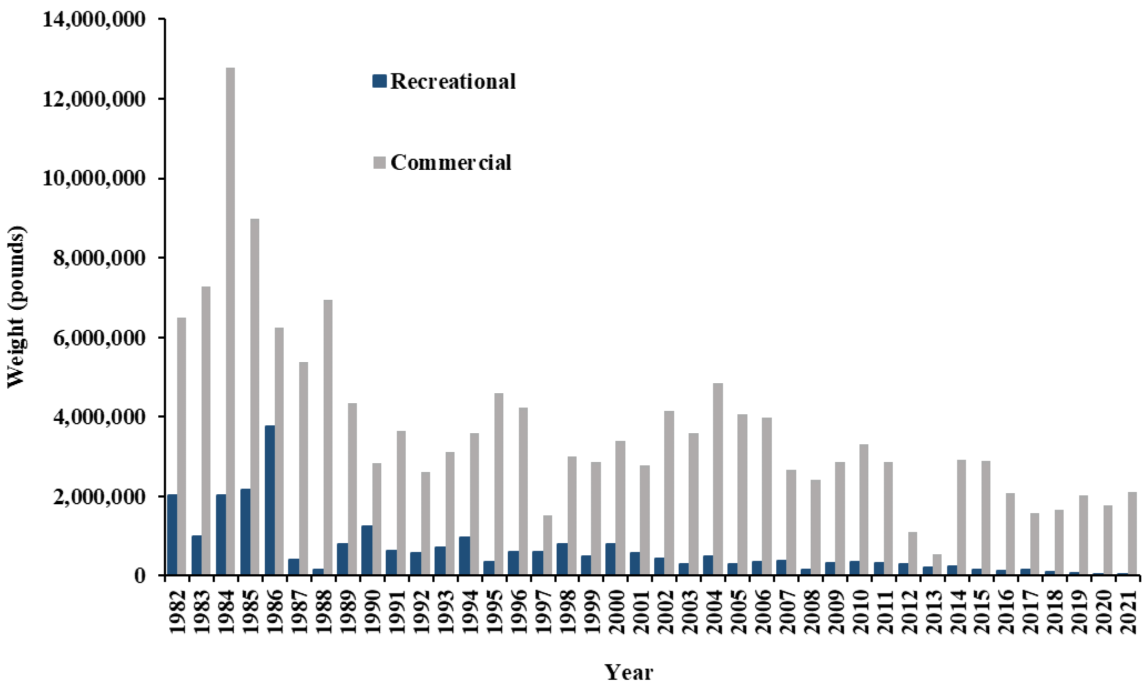

Figure 2. Annual commercial and recreational landings in pounds for summer flounder in North Carolina from 1982-2021.

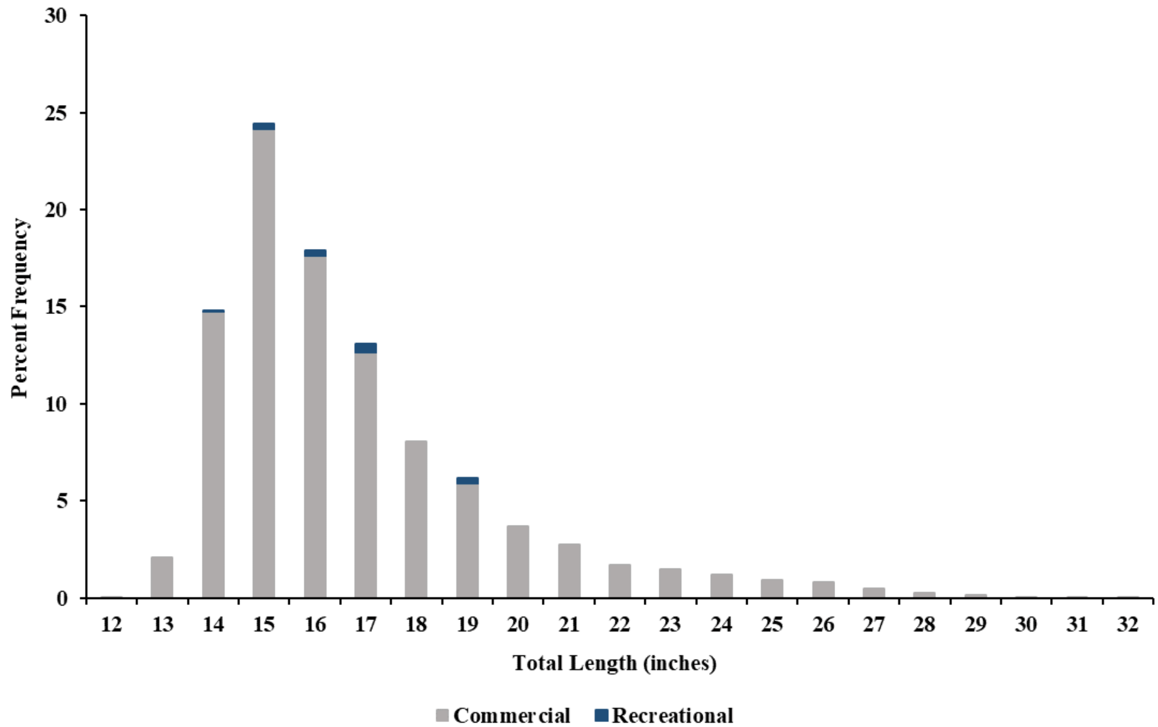

Figure 3. Commercial and recreational length frequency distribution from summer flounder harvested in North Carolina in 2021.

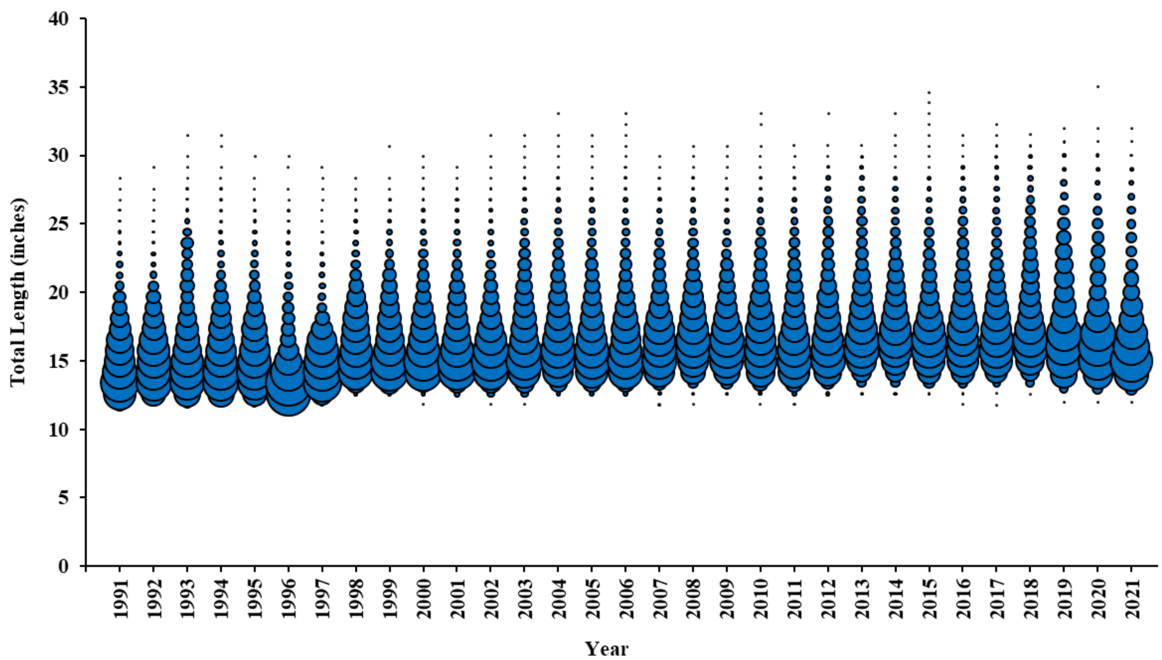

Figure 4. Commercial length frequency (total length, inches), of summer flounder harvested in North Carolina from 1991-2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

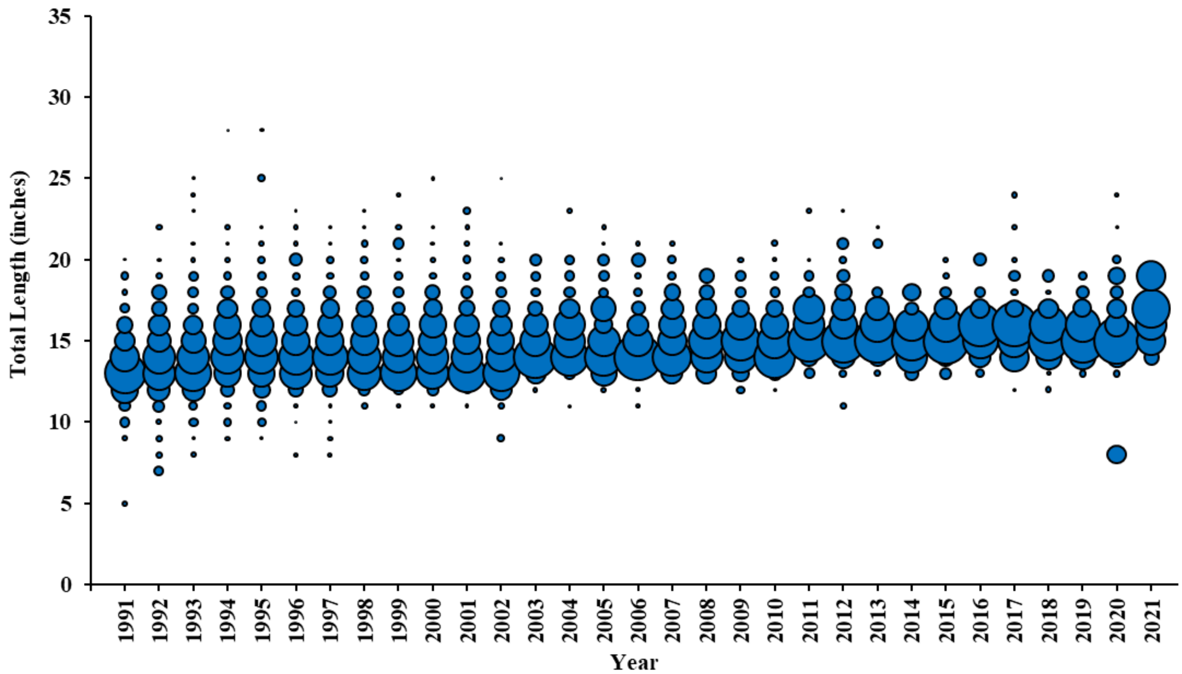

Figure 5. Recreational length frequency (total length, inches), of summer flounder harvested in North Carolina from 1991-2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

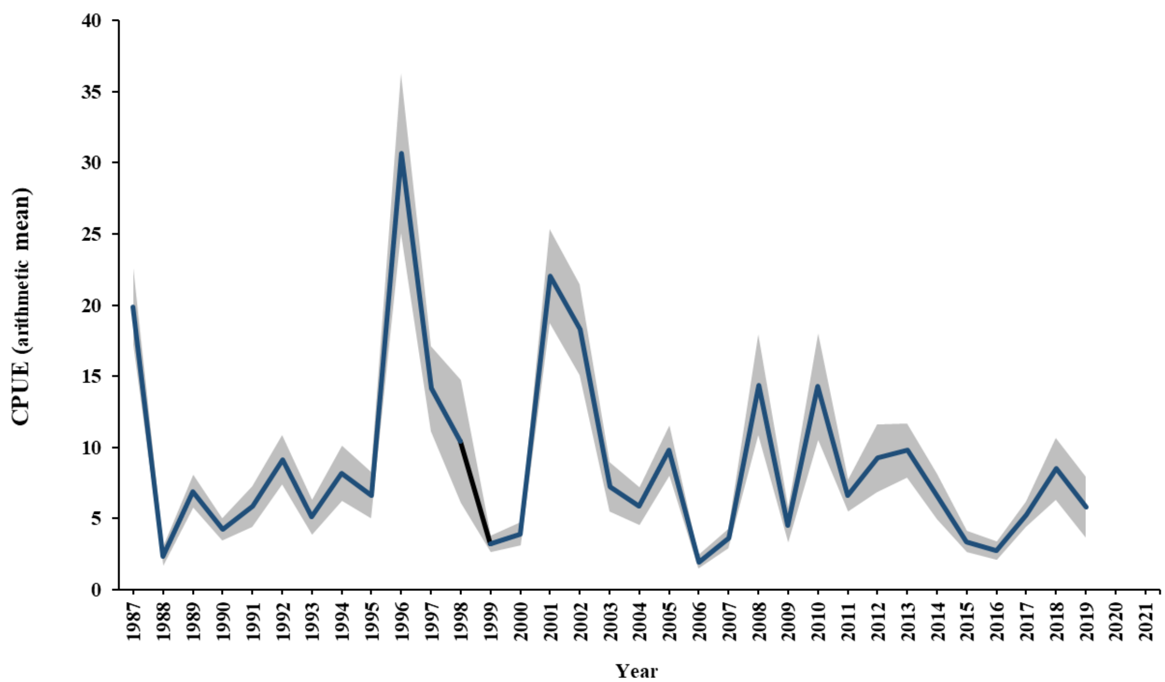

Figure 6. The annual summer flounder juvenile abundance index with standard error shaded in the gray from the North Carolina Program 195 (Pamlico Sound Survey) Survey for the period of 1987-2019. Data from 2020 and 2021 will not be used due to staffing issues and incomplete sampling corresponding with the COVID-19 pandemic.

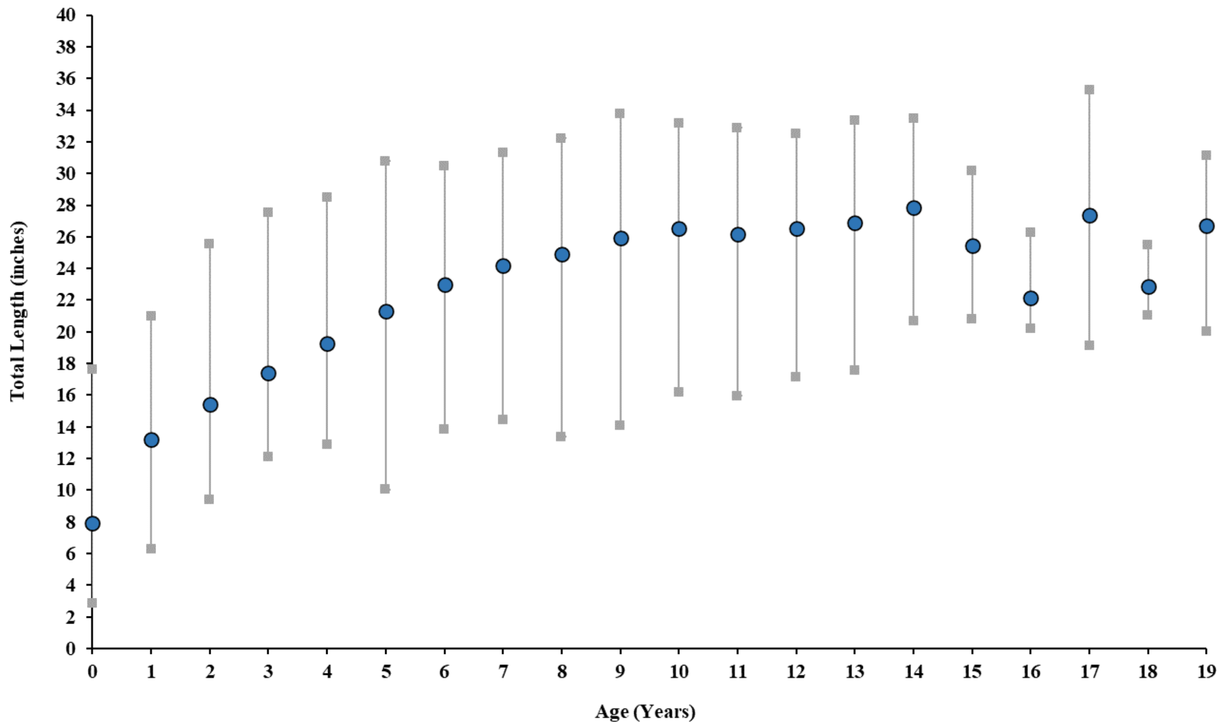

Figure 7. Summer flounder length at age based on age samples collected in North Carolina from 1991-2021. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
WEAKFISH
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	ASMFC – October 1985	
	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

Comprehensive Review: To be determined

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 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 to extend the existing management program until the Weakfish Management Board could approve Amendment 4 (ASMFC 2000).

Weakfish are currently managed under the management program contained in Amendment 4 (ASMFC 2002, 2003) 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 weakfish were in a severely depleted state (NEFSC 2009a and 2009b) 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 weakfish are depleted and 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 no new management action was warranted.

An update to the peer-reviewed 2016 assessment was completed in 2019 (ASMFC 2019) and presented at the 2019 ASMFC Fall Meeting. Results of the assessment update show the weakfish stock is depleted and has been since 2003. Estimates of recruitment, spawning stock biomass, and total abundance remain low in recent years. Estimates of fishing mortality were moderately high in recent years, although not as high as the time-series highs of the mid- to late-2000's or the earliest years, and natural mortality remained high. The Board reviewed the results of the assessment update at their October 2019 meeting and decided no new management action was warrented. The management program implemented under Addendum IV remains in effect.

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:

- 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.
- Restore the weakfish age and size structure to that necessary for the restoration of the fishery.
- Return weakfish to their previous geographic range.
- Achieve compatible and equitable management measures among jurisdictions throughout the fishery management unit, including states' waters and the federal EEZ.
- Promote cooperative interstate research, monitoring and law enforcement necessary to support management of weakfish.
- Promote identification and conservation of habitat essential for the long-term stability in the population of weakfish.
- Establish standards and procedures for both the implementation of Amendment 4 and for determination of states' compliance with provisions of the management plan

DESCRIPTION OF THE STOCK

Biological Profile

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 2019 stock assessment update, spawning stock biomass (SSB) in 2017 was 4.24 million pounds, well below the SSB threshold of 30% (13.6 million pounds), indicating the stock is depleted (Figure 1; ASMFC 2019). The weakfish Technical Committee recommended total mortality (Z) benchmarks, which includes fishing and natural mortality. Total mortality in 2017 was 1.45, which was above both the 20% target (1.03) and the 30% threshold (1.43), indicating total mortality was too high (Figure 2). However, fishing mortality in 2017 (0.62) was above the 20% target but below the 30% threshold (0.97), indicating the stock is not overfished.

Stock Assessment

The assessment completed in 2016 and updated in 2019 employed a spatially structured forward projecting statistical catch at age model with time-varying natural mortality, with a terminal year of 2017. 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 15 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 13.6 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. Despite SSB showing a slight increasing trend in recent years, SSB was 4.24 million pounds in 2017 (Figure 1), which is well below the threshold. The model indicated natural mortality has been increasing since the mid-1990s, from approximately 0.17 at the beginning of the time-series to an average of 0.92 from 2007-2017 (Figure 2). The weakfish population has been experiencing very high levels of total mortality which has prevented the stock from recovering. Fishing mortality has increased in recent years but was below the threshold in 2017.

DESCRIPTION OF THE FISHERY

Current Regulations

The NCDMF allows 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 pound daily limit and 12-inches total length minimum size 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 Fishery

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 decreased in 2021 to 59,534 pounds from the previous year (87,645 pounds) and were the lowest since 2018 (35,134 pounds; Table 1; Figure 3).

Recreational Fishery

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 MRIP's 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 has 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 79,630 pounds and has varied from a high of 157,269 pounds in 2015 to a low of 29,924 in 2018. Recreational harvest increased in 2019 to 43,252 pounds (or 39,061 fish) and increased again in 2020 to 105,729 pounds (82,124 fish), the highest observed since 2015 (157,269 pounds; Table 1; Figure 3). Harvest in 2021 was similar to 2020 with 103,449 pounds harvested. The number of weakfish released has remained relatively stable since 2017, varying between 300,195 fish in 2017 and 386,364 fish in 2020 but increased dramatically in 2021 to 1,030,829 fish, the highest since 2016 (1,097,615 fish).

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 49 citations (greater than 5 pounds landed) and thirty release citations (greater than 24 inches total length) were issued for weakfish in 2021 (Table 2; Figure 4). This is the highest number of weakfish citations since 2003 and the second highest number of citations in the time series (1991-2021).

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 ocean fisheries as well as estuarine fisheries. The ocean sink net fishery and estuarine gill net fishery dominate the catches of weakfish accounting for 96% of the overall commercial catch in 2021.

Mean 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 mean length has been approximately 14 inches fork length. 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 (2011-2021).

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 in recent years, the average maximum observed length is smaller in the recreational fishery by approximately 9 inches (Table 3; Figure 7). The maximum observed length in the recreational fishery in 2021 (23 inches) was the same as the previous year (23 inches).

The recreational modal length decreased to 13 inches in 2021 (Figure 5). However, the commercial modal length decreased from 14 inches in 2019 to 12 inches in 2021. In addition, in 2021, 78% of the commercial fishery harvest and 80% of the recreational fishery harvest was between 12 and 16 inches (Figure 5).

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 relative abundance index calculated from the September stations and an age-1+ 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). During 2021, sampling was impacted during June and September due to the COVID pandemic. Not all stations were able to be sampled as only day trips were permitted. In June, only 35 of the 54 stations were sampled, and in September, only 33 of the 54 stations were sampled. Thus, the relative abundance indices from this year should be viewed with caution. The 2021 age-0 (1.0 fish per tow) relative abundance index was the lowest in the time series (1990-2021). The 2021 age 1+ (41.8 fish per tow) relative abundance index increased from the previous year and was just above the time series average (38.3 fish per tow).

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 relative abundance index from the Pamlico Sound portion is used in the ASMFC stock assessment and had been showing a declining trend since the beginning of the time series, but it has remained relatively stable since 2015 (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. During 2020 no index of abundance was available for weakfish from the fishery-independent assessment (Program 915). Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021. The relative abundance index for 2021 was 0.32 fish per set and was similar to indices for 2015 through 2019. The 2021 relative abundance index should be used with caution as just over 50% of the samples were completed for the year.

Weakfish age samples (otoliths) are collected through both fishery dependent and independent sampling. Sampling for weakfish has been ongoing since 1995. Age samples are collected from all possible gears and during all months. The number of samples collected yearly has ranged from 170 to 1,319, for a total of 15,321 otoliths aged to date. Ages have ranged from 0 to 15 years with a mean 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). The maximum age of the weakfish sampled in 2019 (age 6) was the highest since 2009 (Table 4). However, the maximum age of weakfish sampled in 2020 decreased to four; since 2010, the maximum age of weakfish has fluctuated between four and six.

RESEARCH NEEDS

High

- Increase observer coverage to identify the magnitude of discards for all commercial gear types from both directed and non-directed fisheries.
- Moderate
- Continue studies on temperature, size, and depth specific recreational hook and release mortality rates, particularly catches from warm, deep waters. Investigate methods to increase survival of released fish.
- Continue studies on mesh size selectivity, particularly trawl fisheries.
- Improve methods to estimate commercial bycatch. Refine estimates of discard mortality based on factors such as distance from shore and other geographical differences for all sizes including below minimum size.
- Evaluate predation of weakfish with a more advanced multispecies model (e.g., the ASMFC MSVPA or Ecopath with Ecosim).
- Develop a bioenergetics model that encompasses a broader range of ages than Hartman and Brandt (1995) and use it to evaluate diet and growth data.
- Analyze the spawner-recruit relationship and examine the effects of the relationship between adult stock size and environmental factors on year class strength.
- Develop a coast-wide tagging program to identify stocks and determine migration, stock mixing, and characteristics of stocks in over wintering grounds. Determine the relationship between migratory aspects and the observed trend in weight-at-age.
- Monitor weakfish diets over a broad regional and spatial scale, with emphasis on new studies within estuaries.
- Continue to investigate the geographical extent of weakfish hybridization.
- Estimate weakfish mortality through independent approaches (e.g., alternative models, tagging) to corroborate trends in mortality from the assessment model.

- Conduct a meta-analysis of all factors likely to influence changes in natural mortality to see if the aggregate effect shows stronger statistical likelihood of occurrence than the significance shown by each individual driver effect on its own.
- Improve implementation of the process for organizing and collecting data from different agencies and sources to assure timely and high-quality data input into the model.

Moderate

- Identify and delineate weakfish spawning habitat locations and environmental preferences to quantify spawning habitat.
- Compile data on larval and juvenile distribution from existing databases to obtain preliminary indications of spawning and nursery habitat location and extant.
- Examine geographical and temporal differences in growth rate (length and weight-at-age).
- Determine the impact of power plants and other water intakes on larval, post larval, and juvenile weakfish mortality in spawning and nursery areas. Calculate the resulting impact on adult stock size.
- Monitor predation on weakfish from both fish and marine mammal species.
- Determine the impact of scientific monitoring surveys on juvenile weakfish mortality. Calculate the resulting impact on adult stock size.
- Assemble socioeconomic data as it becomes available from ACCSP.

Low

- Determine the onshore versus offshore components of the weakfish fishery.
- 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 and further north.
- Develop latitudinal, seasonal, and gear specific age length keys coast wide. Increase sample sizes for gear specific keys.
- Define restrictions necessary for implementation of projects in spawning and over wintering areas and develop policies on limiting development projects seasonally or spatially.

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 on results from the 2016 assessment, the Weakfish TC recommended a 30% SSB threshold be used as a reference point to determine if the stock is depleted. The TC also noted there is no long-term stable equilibrium population of weakfish due to time varying natural mortality, so they recommended managing the stock using Z-based (total mortality) targets and thresholds of 20%

and 30%. In addition, total mortality (Z) benchmarks are used to prevent an increase in fishing pressure when F is low but M is high. Although the total mortality of the stock in the terminal year of the assessment update (2017) was above both the Z target and threshold, the TC recommended, and the board approved no new management measures at this time given how highly restrictive the weakfish management program already is.

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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 weakfish from North Carolina for the period 1982–2021.

Year	Recreational			Commercial	
	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (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	85,462	141,406
2018	30,935	300,195	29,924	35,134	65,058
2019	39,061	366,518	43,252	115,665	158,917
2020	82,124	386,364	105,729	91,374	197,103
2021	91,032	1,030,829	103,449	59,534	162,983
Mean	200,889	610,632	347,256	1,896,081	2,093,604

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 199–2021.

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
2019	8	3	38
2020	10	3	30
2021	49	30	61

+ 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 1982–2021. Commercial lengths include both marketable and scrap finfish.

Year	Commercial				Recreational			
	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
2019	14.1	8.7	26.3	1,923	14.5	9.8	18.1	62
2020	14.0	9.0	26.0	1,004	15.0	9.8	22.9	65
2021	13.9	10.2	24.3	870	14.4	8.7	22.7	70

Table 4. Modal age, minimum age, maximum age, and number aged for weakfish collected through NCDMF sampling programs from 1995 through 2021.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1995	1	0	5	898
1996	4	0	6	1,319
1997	3	0	7	1,059
1998	3	0	7	703
1999	3	0	8	659
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	752
2007	2	0	6	560
2008	1	0	5	480
2009	1	0	15	263
2010	2	0	5	507
2011	2	0	4	378
2012	3	0	4	497
2013	2	0	5	546
2014	1	0	4	508
2015	3	0	4	425
2016	1	0	5	570
2017	1	0	5	353
2018	2	0	4	170
2019	2	0	6	551
2020	2	0	4	724
2021	1	0	6	1006

FIGURES

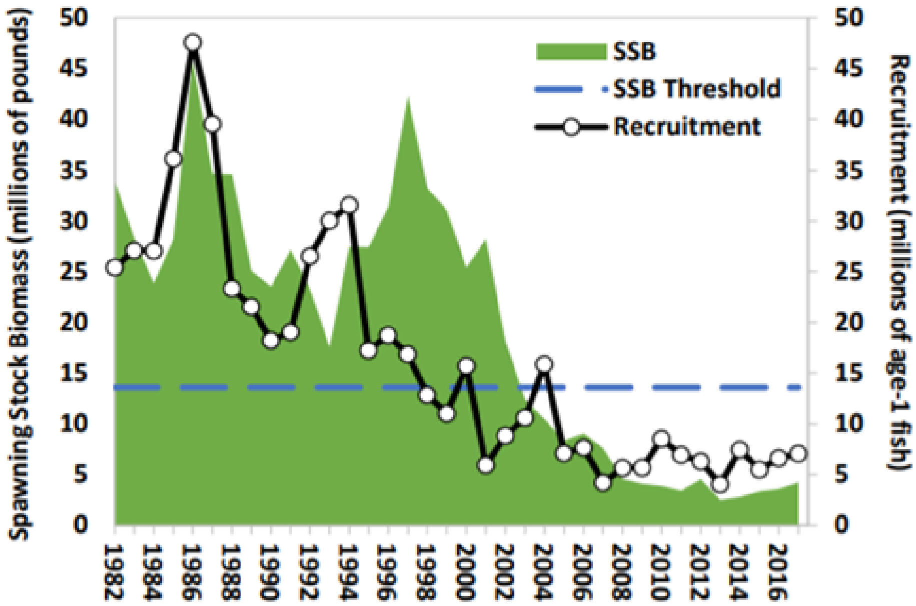

Figure 1: Spawning stock biomass (SSB) and recruitment of age-1 weakfish estimated along the U.S. Atlantic coast from 1982 to 2017 (ASMFC 2019). Dashed line represents the 30% spawning stock biomass (SSB) threshold of 13.6 million pounds.

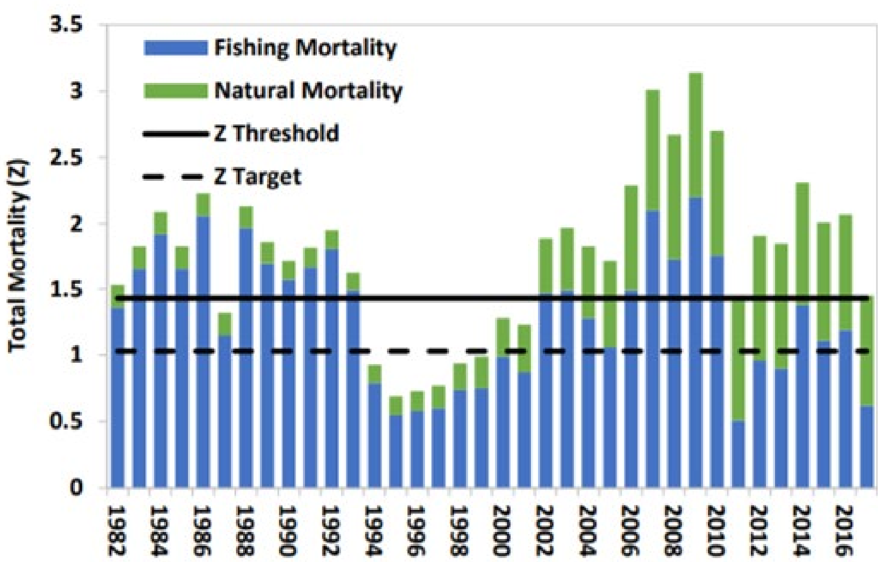

Figure 2. Natural mortality (M) and fishing mortality (F) estimated for all weakfish along the U.S. Atlantic east coast, 1982 to 2017 (ASMFC 2019). Solid and dashed lines represent total mortality target (Z30% = 1.03) and threshold (Z20% = 1.43) used to determine if the stock is being overfished.

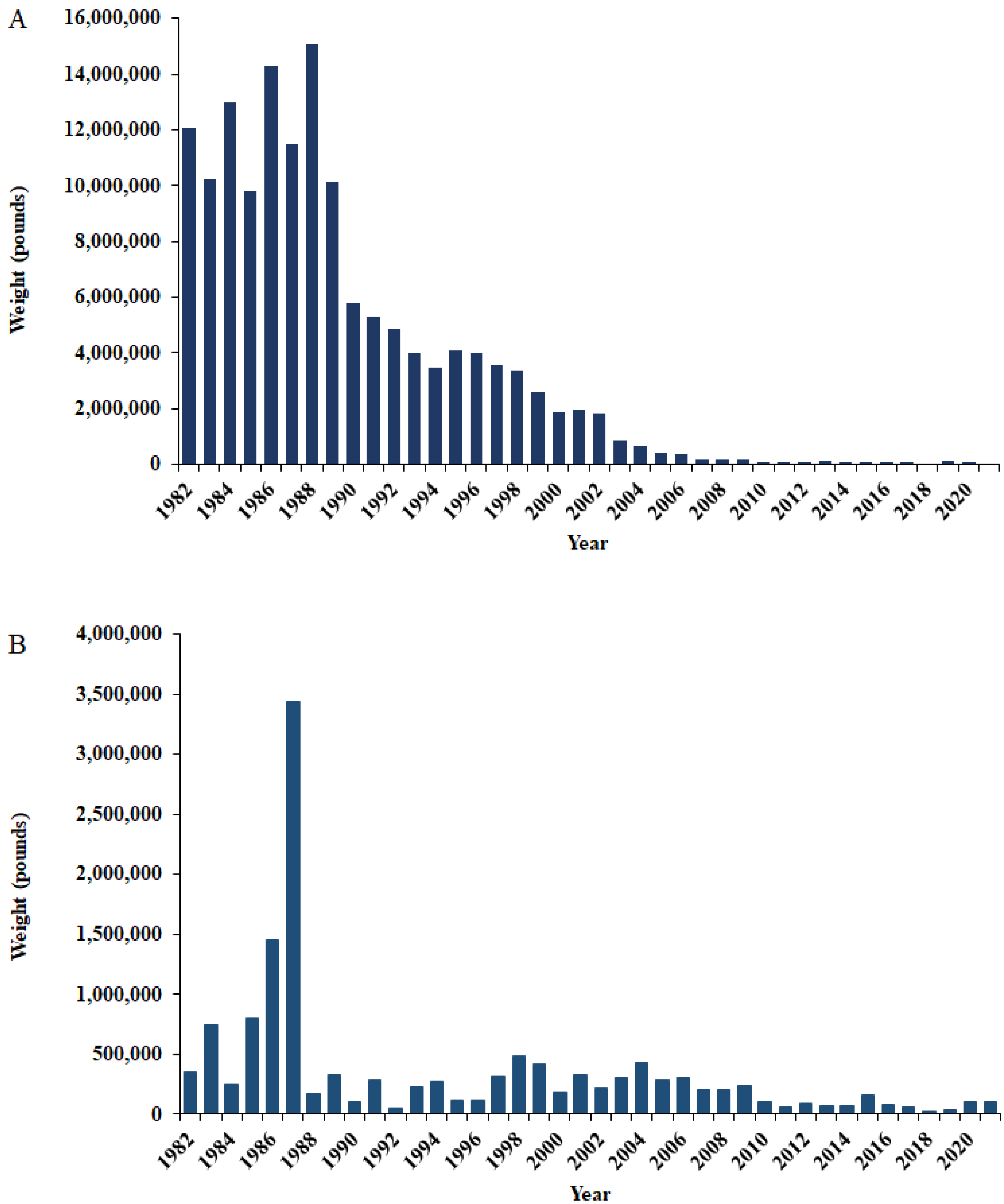

Figure 3. Annual commercial (A) and recreational (B) landings in pounds for weakfish in North Carolina from 1982 to 2021.

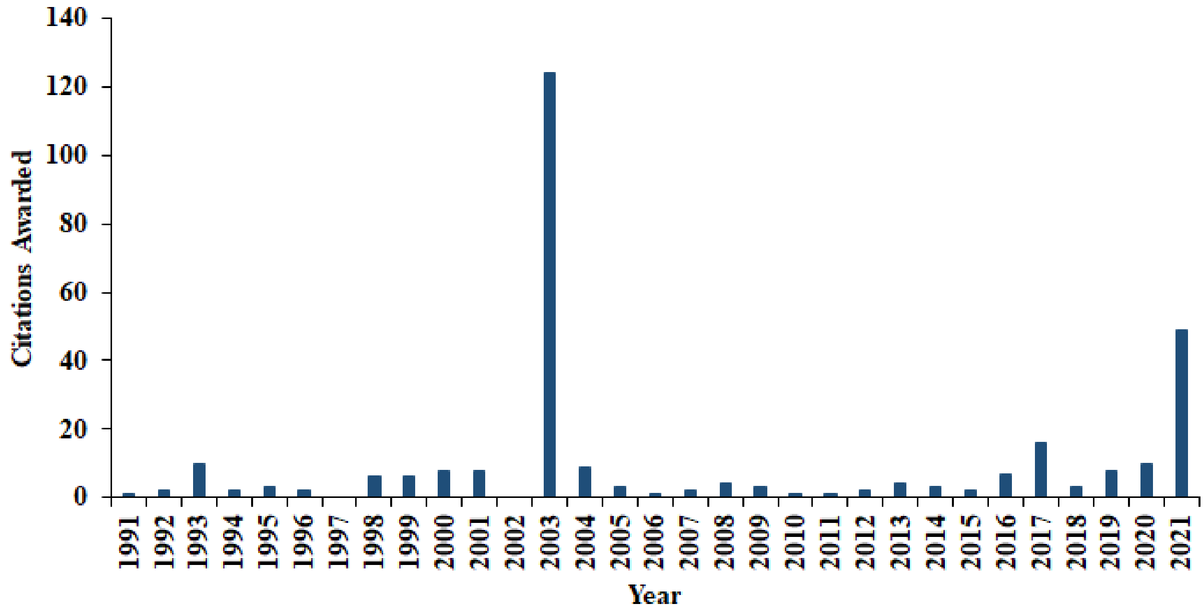

Figure 4. North Carolina Saltwater Fishing Tournament citations awarded for weakfish from 1991 to 2021. Citations are awarded for weakfish greater than 24 inches total length released or greater than 5 pounds landed.

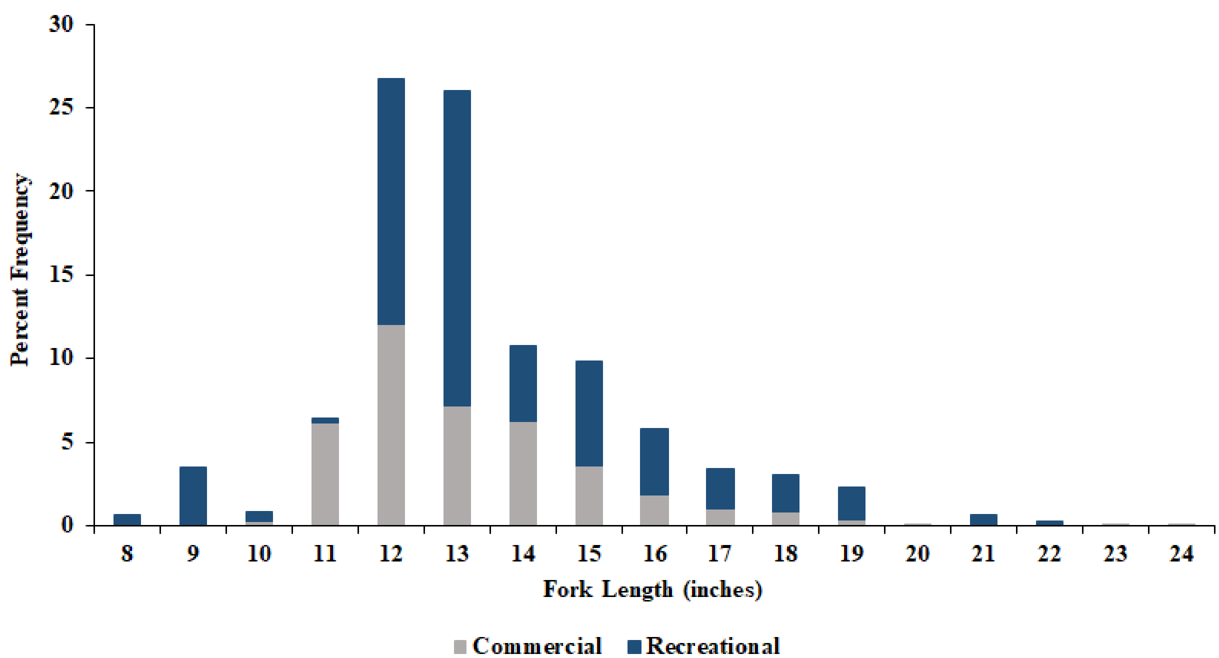

Figure 5. Commercial and recreational length frequency distribution from weakfish harvested in 2021.

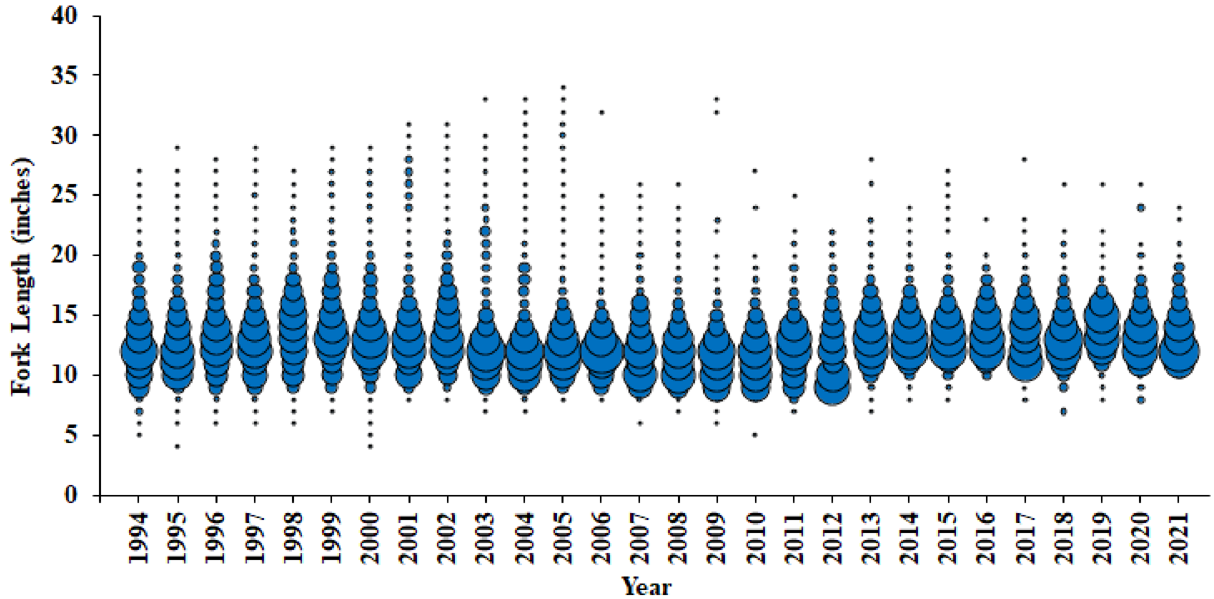

Figure 6. Commercial length frequency (fork length, inches) of weakfish harvested from 1994-2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

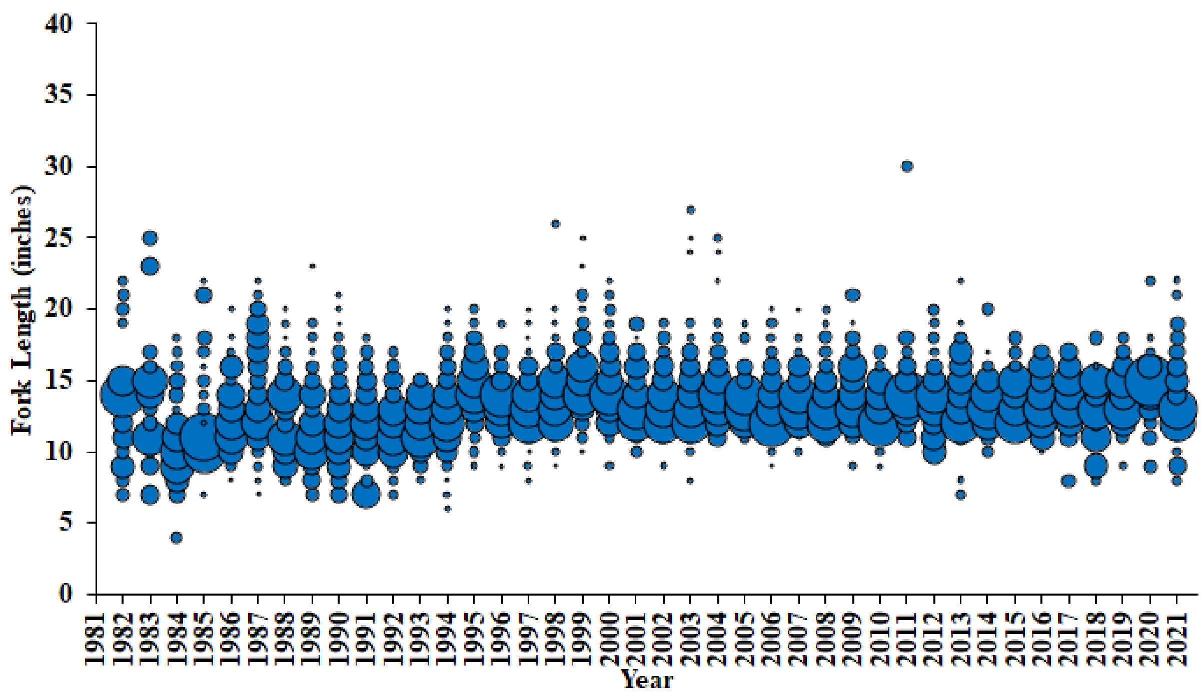

Figure 7. Recreational length frequency (fork length, inches) of weakfish harvested from 1982-2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

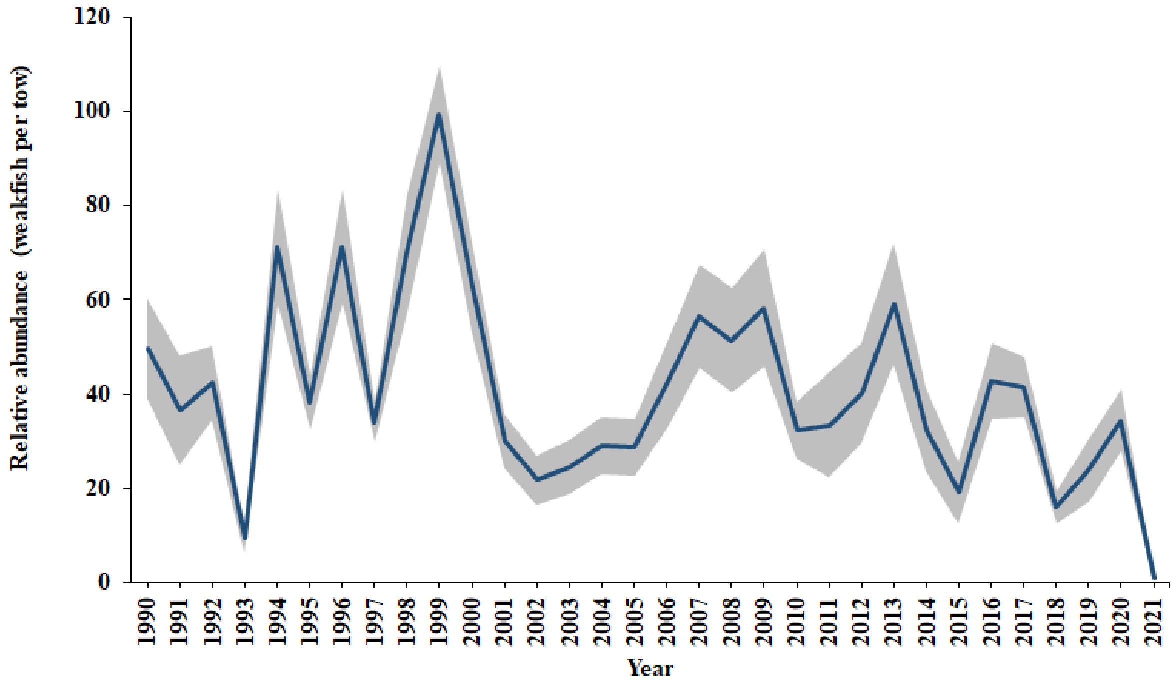

Figure 8. Relative abundance index (fish per tow) from the Pamlico Sound Survey (Program 195) in North Carolina of Age-0 weakfish collected during September with a total length less than 200 mm from 1990 through 2021. Error bars represent ± one standard error (SE). *Not all samples were completed in 2020 and 2021.

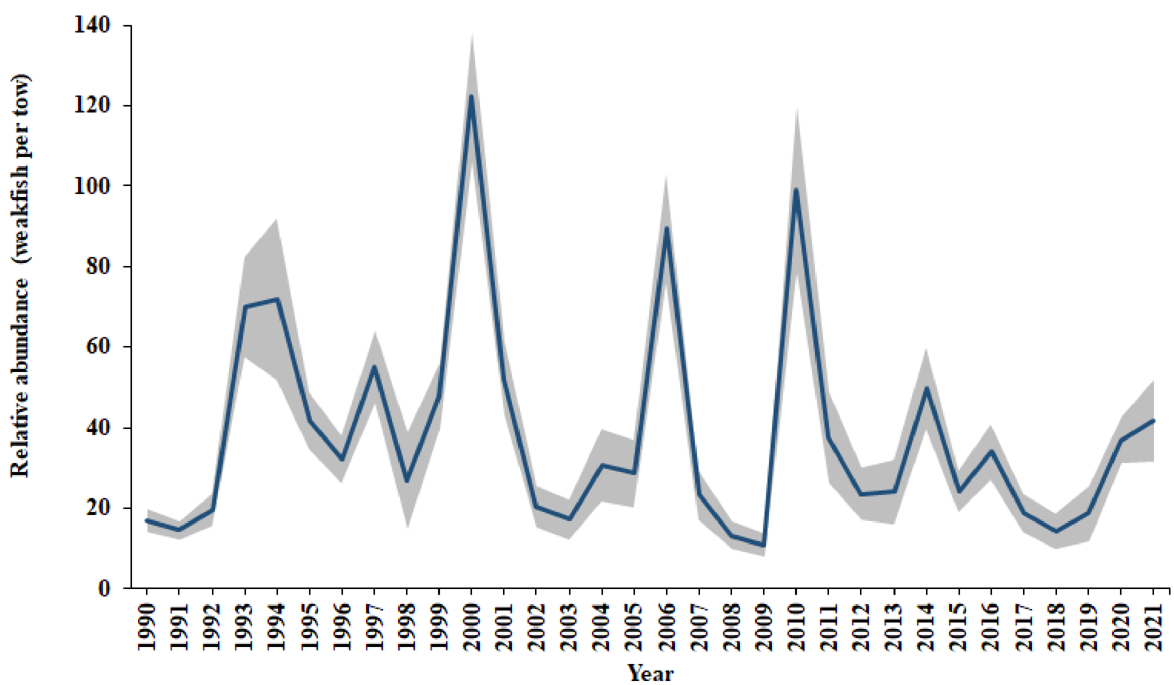

Figure 9. Relative abundance index (fish per tow) from the Pamlico Sound Survey (Program 195) in North Carolina of Age-1+ weakfish collected during June with a total length of 140 mm and greater from 1990 through 2021. Error bars represent ± one standard error (SE). *Not all samples were completed in 2020 and 2021.

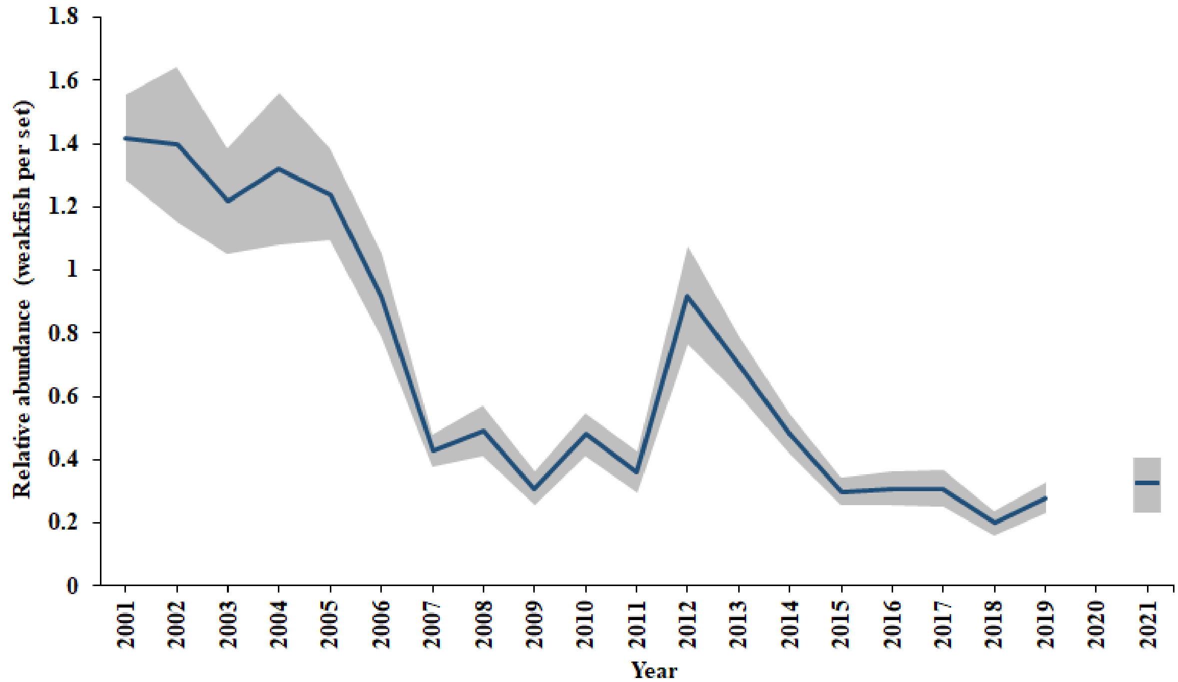

Figure 10. Relative abundance index (fish per station set) from the Pamlico Sound portion of the Independent Gill Net Survey (Program 915) in North Carolina, 2001 - 2021. Error bars represent ± one standard error (SE). *Sampling not conducted in 2020, not all samples completed in 2021.

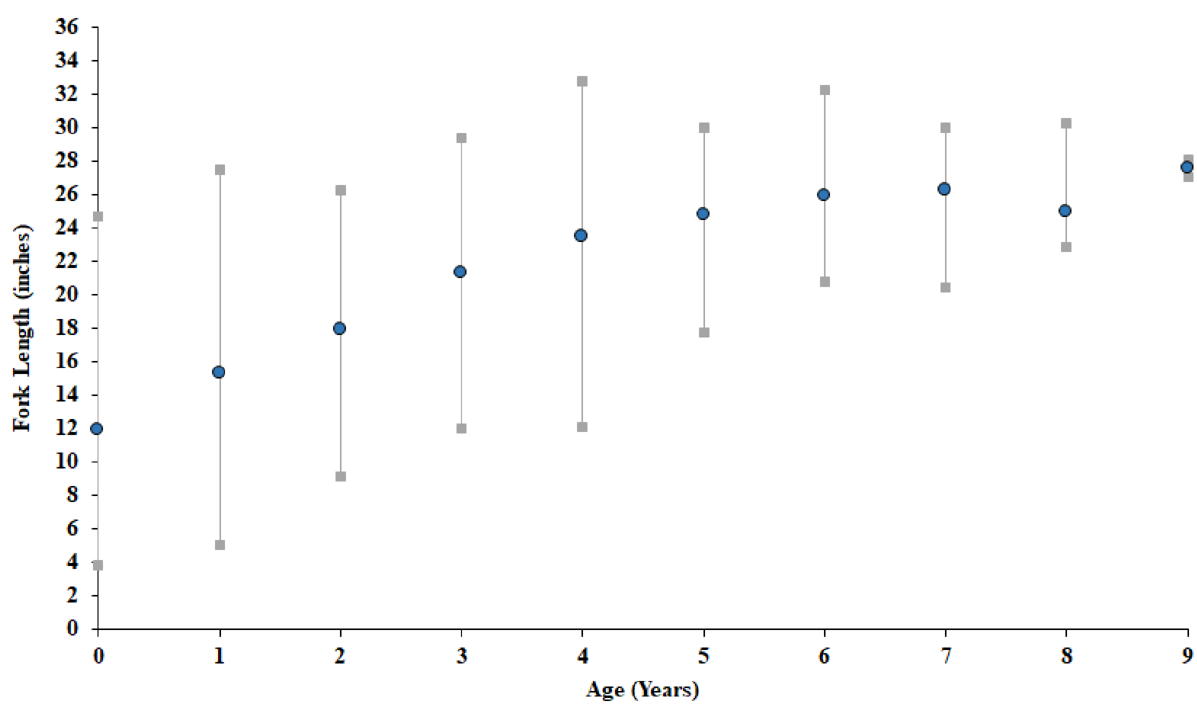

Figure 11. Weakfish length at age based on all age samples collected from 1995 to 2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
BLACK SEA BASS NORTH OF CAPE HATTERAS
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation: Incorporated into the Summer Flounder FMP through Amendment 9 in 1996

Amendment 9	1996
Amendment 10	1997
Amendment 11	1998
Amendment 12	1999
Framework 1	2001
Addendum IV	2001
Addendum VI	2002
Amendment 13	2003
Framework 5	2004
Addendum XII	2004
Addendum XIII	2004
Addendum XVI	2005
Amendment 16	2007
Framework 7	2007
Addendum XIX	2007
Addendum XX	2009
Amendment 15	2011
Addendum XXI	2011
Addendum XXII	2012
Amendment 19	2013
Addendum XXIII	2013
Addendum XXV	2014
Amendment 17	2015
Framework 8	2015
Amendment 18	2015
Addendum XXVII	2016
Amendment 20	2017
Framework 10	2017
Addendum XXX	2018
Framework 11	2018
Framework 13	2018
Addendum XXXI	2018
Addendum XXXII	2018
Framework 14	2019
Framework 15	2020
Framework 16	2020

Addendum XXXIII 2021

Comprehensive Review: 2021

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. Black sea bass went through preliminary FMP development from 1978-1993 by the MAFMC. In 1996 NMFS requested that black sea bass regulations be incorporated into another FMP to reduce the number of separate fisheries regulations. As a result, the black sea bass FMP was incorporated into the summer flounder FMP as Amendment 9.

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 coastwide 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 coastwide allocations into state-by-state management for 2012 only.

Amendment 19 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 Council 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.

Framework 14 gives the Council the option to waive the federal recreational black sea bass measures in favor of state measures through conservation equivalency; implements a transit zone for commercial and recreational summer flounder, scup, and black sea bass fisheries in Block Island Sound; and allows for the use of a maximum size limit in the recreational summer flounder and black sea bass fisheries.

Framework 15 established a requirement for commercial vessels with federal permits for all species managed by the Mid-Atlantic and New England Councils to submit vessel trip reports electronically within 48 hours after entering port at the conclusion of a trip.

Framework 16 modified MAFMC's ABC control rule and risk policy. The revised risk policy is intended to reduce the probability of overfishing as stock size falls below the target biomass while allowing for increased risk and greater economic benefit under stock biomass conditions. This action also removed the typical/atypical species distinction currently included in the risk policy.

Addendum XXXIII modifies the allocation of the coastwide black sea bass commercial quota among the states, which were originally implemented in 2003 through Amendment 13 and extended indefinitely through Addendum XIX. The revised allocation addresses the significant change in the distribution of black sea bass that have occurred since the original allocations were implemented in 2003.

Specific details for each amendment and addendum under development include:

Summer Flounder, Scup, and Black Sea Bass Commercial/Recreational Allocation Amendment was jointly approved in December 2021 and selected preferred alternatives for each species. The Council is preparing this amendment for submission to NMFS for review and rulemaking.

The Recreational Harvest Control Rule Framework/Addenda is under the public hearing stage. The Draft Addenda proposes five possible approaches for setting recreational measures. Key differences between the options include the information considered when setting measures and the circumstances under which measures would change. These differences have implications for how often measures would change and the magnitude of those changes. Taking final action on these addenda will not implement any specific bag, size, or season limits but will modify the specification process for setting specific measures. In February 2021, the Council and Policy Board agreed to focus on the Harvest Control Rule through a joint framework/addendum. In August and October of 2021, the Council and Policy Board reviewed and provided feedback on a draft range of alternatives. In February 2022 the Council and Policy Board approved a range of alternatives which are currently going through the public hearing process.

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 2022).

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 for the Black Sea Bass FMP are to:

- Reduce fishing mortality in the black sea bass fisheries to assure that overfishing does not occur.
- Reduce fishing mortality on immature black sea bass to increase spawning stock biomass.
- Improve the yield from these fisheries.
- Promote compatible management regulations between state and federal jurisdictions.
- Promote uniform and effective enforcement of regulations.
- 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.

DESCRIPTION OF THE STOCK

Biological Profile

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 2019 black sea bass operational stock assessment included data through 2018 and incorporated new recreational harvest estimates. It indicated that the stock was not overfished, and overfishing was not occurring in 2018 relative to newly revised reference points. The 2021 management track stock assessment indicated that the black sea bass stock status has not changed.

Stock Assessment

The 2019 black sea bass operational stock assessment estimated fishing mortality and stock sizes using an 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. An updated black sea bass management track assessment was peer reviewed in July 2021, comparisons between assessments indicated that the trends in spawning stock biomass, recruitment and fishing mortality have been consistent between the 2016 benchmark assessment and 2021 update. Stock assessment reports can be found on the black sea bass page on the ASMFC website for further information.

DESCRIPTION OF THE FISHERY

Current Regulations

Commercial: 11-inch total length minimum size limit in Atlantic Ocean and internal coastal waters north of Cape Hatteras. Harvest periods 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: 12½-inch total length minimum size limit and a 15-fish creel limit in Atlantic Ocean and internal coastal waters north of Cape Hatteras. The season for the recreational fishery is typically May 15 to December 31.

Commercial Fishery

All black sea bass landings are reported through the North Carolina Trip Ticket Program. The majority of black sea bass landings from north of Cape Hatteras were from trawls, while fish pots and flynets caught much smaller numbers (Figure 1). Landings generally declined from 1994 through 2012 but have increased notably since 2013 (Table 1; Figure 2). The low landings in 2012 and 2013 were partly due to shoaling at Oregon Inlet making passage by large vessels (such as trawlers) unsafe and the consequent transfer of large portions of North Carolina’s black sea bass quota allocation to Virginia and other states. During 2014 through 2021, more winter trawl vessels returned to North Carolina (mainly Beaufort and Washington areas) to land catches rather than transferring quota to Virginia and other states.

Recreational Fishery

Recreational estimates across all years have been updated and are now based on the new National Ocean and Atmospheric Administration (NOAA) Marine Recreational Information Program (MRIP) Fishing Effort Survey-based calibrated estimates. For more information on MRIP, see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. 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 2019, above average harvest occurred in 2020, and lower than average harvest in 2021 (Table 1; Figure 2).

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 2021. Annual mean lengths were fairly consistent for the time-series. The number of measurements collected totaled 3,542 in 2021 (Table 2). Otoliths have been collected from commercial fisheries since 2013 and are currently in the process of aging, although these data are not currently used in the coastwide stock assessments.

Length data in the recreational fishery was variable and sample size was low from 1994 through 2021. Mean lengths have gradually increased over the time-series but tend to be variable given low sample size. The number of measurements decreased compared to the last two years (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 are encountered 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 estuarine 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.

RESEARCH 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

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 2019 operational stock assessment are being used to guide management. 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 percent) and recreational (51 percent) fisheries. Beginning in 2023, revised allocations will be implemented and transitioning to catch-based allocations with 45 percent being commercial and 55 percent being recreational. 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 coastwide basis in federal waters. The commercial quota is divided into state-by-state quotas. Projections based on stock assessments are used to set the coastwide quota level each year. Amendments to the FMP are undertaken as issues arise that require action.

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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 black sea bass north of Cape Hatteras from North Carolina for the period 1994 – 2021.

	Recreational			Commercial	
Year	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1994	13,464	127,309	14,746	244,767	259,513
1995	52,181	279,414	25,298	142,508	167,806
1996	17,373	53,235	14,948	287,347	302,295
1997	17,249	102,069	22,482	247,603	270,085
1998	19,229	315,269	25,353	218,655	244,008
1999	44,785	386,011	48,213	121,199	169,412
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	374,880	377,411
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	388,865	422,286
2018	6,762	96,604	9,494	315,983	325,477
2019	6,268	159,129	11,638	279,008	290,646
2020	44,475	104,177	74,149	218,756	292,905
2021	4,171	252,992	6,564	200,565	207,129
Mean	17,292	219,549	22,714	221,859	244,573

Table 2. Black sea bass (north of Cape Hatteras) length (total length, inches) data from commercial fish house samples in North Carolina, 1994-2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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
2019	15	9	24	4,124
2020	15	9	23	3,244
2021	16	10	24	3,542

Table 3. Black sea bass (north of Cape Hatteras) length, (total length, inches) data from NOAA Marine Recreational Information Program recreational samples in North Carolina, 1994-2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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
2019	17	12	21	32
2020	15	9	21	52
2021	16	13	20	22

FIGURES

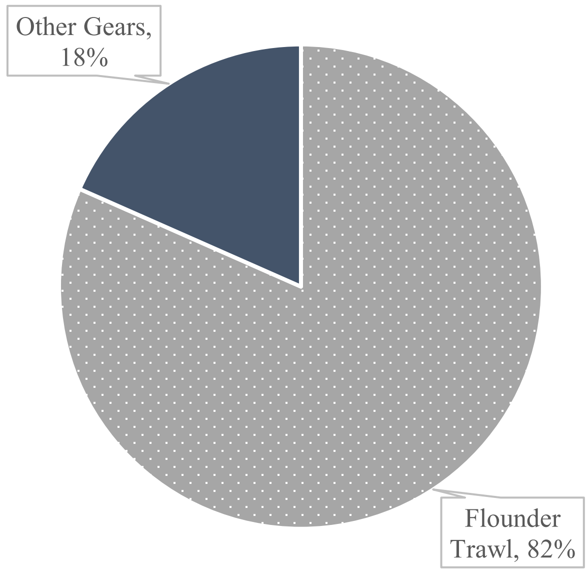

Figure 1. Commercial harvest of black sea bass (north of Cape Hatteras) in North Carolina by gear type in 2021. Note: data for Other Gears are confidential data.

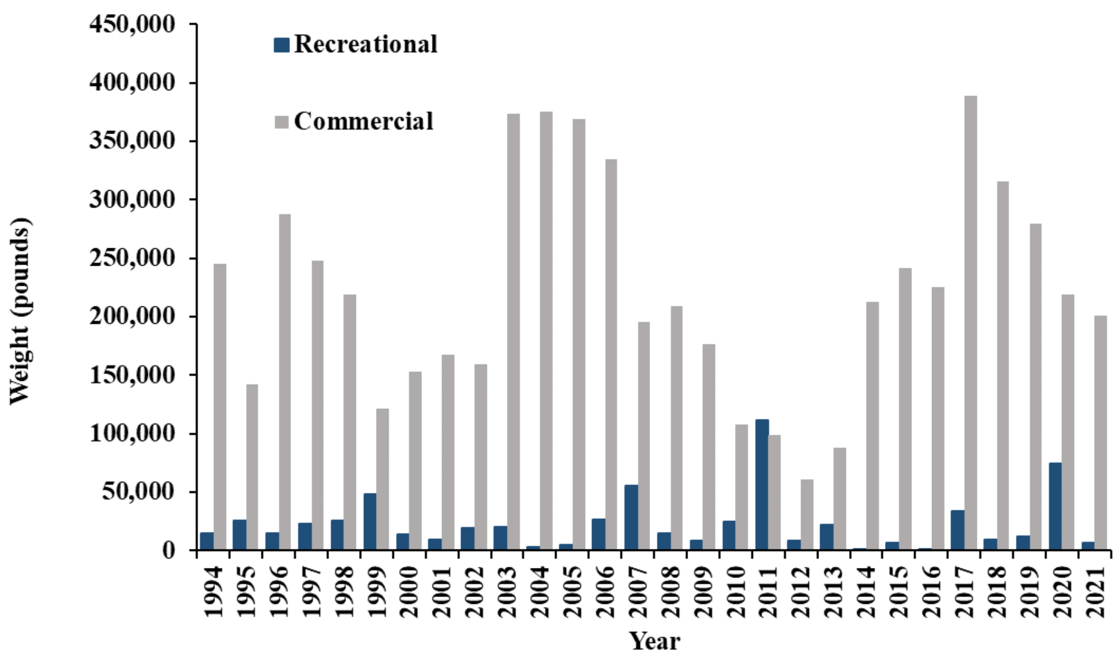

Figure 2. Annual commercial and recreational landings in pounds for black sea bass (north of Cape Hatteras) in North Carolina from 1994-2021.

FISHERY MANAGEMENT PLAN UPDATE
COBIA
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	SAFMC FMP	February 1983
	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 FMP	November 2017
	Amendment 1	August 2019
	Addendum 1	October 2020

Comprehensive Review: 2027

The Gulf of Mexico Fishery Management Council (GMFMC) and the South Atlantic Fishery Management Council (SAFMC) approved and implemented the Fishery Management Plan (FMP), Final Environmental Impact Statement, Regulatory Impact Review and Final Regulations for the Coastal Migratory Pelagic (CMP) 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 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 was established for the Fishery Conservation Zone (FSC), which is analogous to the Exclusive Economic Zone (EEZ) of today, 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 (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 prohibited drift gill nets as a gear that could be used to harvest coastal pelagic species (GMFMC/SAFMC 1987b).

Amendment 5 addressed the issue of average annual catches from 1981-1986 exceeding the established MSY level and defined the overfishing limit for the cobia stock, as well as set the procedure for rebuilding if the stock was found to be overfished (GMFMC/SAFMC 1990). Cobia were added to the annual stock assessment procedures for the councils, and a bag and possession limit was established for both commercial and recreational sectors in an effort to control harvest. Amendment 6 (GMFMC/SAFMC 1992) removed the total length minimum size limit, specifying that the only minimum size for cobia was fork length (FL) and increased Maximum Sustainable Yield (MSY) based on results stock assessment analyses done for, and at the recommendation of, the Mackerel Stock Assessment Panel (Isely 1992; MSAP 1992).

In 1998, Amendment 8 extended the management area for cobia through the Mid-Atlantic Fishery Management Council's (MAFMC) jurisdiction which also extended the bag limit and 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 separated cobia into two stocks at the jurisdiction boundary between the GSFMC and the SAFMC (GMFMC/SAFMC 2011). 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 2013) to the Florida-Georgia state line. A new ACL was set at 690,000 pounds for the 2015 fishing season and 670,000 pounds for every year after, with sector allocations shifting appropriately. 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 was met or projected to be met rather, measures were 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 was 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 required an in-season closure if the commercial ACL was met or projected to be met. If the stock was 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 increased the recreational minimum size limit of cobia to 36 inches FL, reduced the bag limit to one fish per person per day and implemented a vessel limit. The recreational AM were modified to allow for a reduction in vessel limit before a season reduction was implemented. The framework amendment also maintained the existing commercial minimum size limit and established 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 removed the Atlantic migratory group cobia (Georgia through New York) from federal management under the Magnuson-Stevens Act and transfered sole management of Atlantic cobia to the Atlantic States Marine Fisheries Commission (ASMFC). The amendment also implemented 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 was no lapse in the management of the stock.

The ASMFC approved the Interstate FMP 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 (SAFMC 2016). State landings will be evaluated against the RHLs every three years to ensure that management measures are constraining coastwide harvest to the Federal ACLs.

To accommodate the removal of Atlantic cobia from federal management, ASMFC approved Amendment 1 in August 2019. Amendment 1 changes several portions of the Commission's FMP that were previously dependent on the CMP FMP and institutes a long-term strategy for managing in the absence of a federal plan (ASMFC 2019). Several of these changes establish processes for the Commission to carry out management responsibilities previously performed by the South Atlantic Council, including setting of harvest quotas and sector allocations, and defining stock status criteria. Amendment 1 recommends to NOAA Fisheries that fishing in federal waters be regulated according to the state of landing. Amendment 1 changes the units used to measure and evaluate the recreational fishery from pounds to numbers of fish. Additionally, Amendment 1 transitions responsibilities of monitoring and closing commercial harvest to the Commission and establishes *de minimis* criteria for the commercial fishery (ASMFC 2019).

When SEDAR 58 was accepted for management, the ASMFC South Atlantic Board approved an increase in the annual total harvest based on the assessment results and harvest projections (SEDAR 2020). Addendum 1 to Amendment 1 was initiated after approval of the assessment. The Board approved the Addendum in October 2020. Addendum 1 modifies the sector allocations from a 92% recreational:8% commercial split to 96% recreational:4% commercial, respectively (ASMFC 2020). The change was primarily based on new recreational catch estimates that resulted from changes in survey methodology by the Marine Recreational Information Program; estimates were, on average, two times higher than previously estimated. The new commercial allocation allows the fishery to operate at the current level with some room for landings to increase as the stock range expands further north. Additionally, Addendum 1 modifies the calculation of the commercial trigger to determine when an in-season coastwide commercial closure occurs and modified *de minimis* measures including an adjustment to the commercial allocation set aside and the recreational regulations (ASMFC 2020).

To ensure compliance with interstate requirements, North Carolina also manages this species under the North Carolina Interjurisdictional Fisheries Management Plan (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 2022).

Management Unit

The management unit for Atlantic cobia is defined as all waters north of the Florida-Georgia line through New York from coastal estuarine waters eastward to the offshore boundaries of the EEZ (ASMFC 2019; Figure 1).

Goal and Objectives

The goal of Amendment 1 to the Interstate FMP (ASMFC 2019) is to provide for an efficient management structure that implements coastwide management measures, providing equitable and sustainable access to the Atlantic cobia resource throughout the management unit in a timely manner.

The following objectives are intended to support the goal of Amendment 1.

- Provide a flexible management system to address future changes in resource abundance, scientific information, and fishing patterns among user groups or area.
- Implement management measures that allow stable, sustainable harvest of Atlantic cobia in both state and federal waters.
- Establish a harvest specification procedure that will allow flexibility to respond quickly to stock assessment results or problems in the fishery, while also providing opportunities for public input on potential significant changes to management.
- Promote continued, cooperative collection of biological, economic, and social data required to effectively monitor and assess the status of the Atlantic cobia resource and evaluate management efforts.
- Manage the Atlantic cobia fishery to protect both young individuals and established breeding stock.
- Develop research priorities that will further refine the Atlantic cobia management program to maximize the biological, social, and economic benefits derived from the Atlantic cobia population.

DESCRIPTION OF THE STOCK

Biological Profile

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 2018). 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 are most abundant in nearshore coastal waters from Virginia south through the Gulf of Mexico. They migrate in the spring and fall from inshore and offshore habitats, as well as up and down the Atlantic coast (Perkinson et al. 2019; Crear et al. 2020; Gallagher 2020). Recent tagging and genetics studies have shown there is the potential for a resident sub-stock off Virginia and northern North Carolina (Darden et al. 2014; Perkinson et al. 2019; Gallagher 2020)

Spawning along the Atlantic coast occurs from April through July, peaking during May and June around inlets and in high salinity estuarine waters (Brown-Peterson et al. 2001). In North Carolina, spawning peaks in June, coinciding with water temperatures of 20 – 25°C (Smith 1995; Lefebrve and Denson 2012; Perkinson et al. 2019). 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

Results of the 2020 assessment indicate that cobia are not overfished, and overfishing is not occurring (SEDAR 2020; Figures 2 and 3).

Stock Assessment

Cobia were assessed during South East Data, Assessment, and Review (SEDAR) 58 using data through 2017 (SEDAR 2020); this was a benchmark assessment. SEDAR 58 began with a stock identification workshop in April 2018. The workshop maintained the Florida-Georgia state line as the stock boundary since this border is within a transition zone that occurs from the southern boundary of Brevard County, FL to Brunswick, GA (SEDAR 2018).

SEDAR 58 assessed the Atlantic stock of cobia using data from 1986 – 2017 (SEDAR 2020). This assessment included several modifications from the previous assessment (SEDAR 2013). Though more years of data were added to the end of the assessment, overall, the time series was shorted such that the model was started in the year when the best data became available.

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 the headboat logbook index. 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 ($SSB_{2017}/SSB_{40\%}$ = 1.41; Figure 2) and overfishing was not occurring ($F_{2015\text{-}2017}/F_{40\%}$ = 0.29; 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 the sole index used in the model was from a fishery-dependent source. Because the fishery operates in such a way that a trip consists of very few fish, the reliability of fishery-dependent indices as a true indicator of the stock should be approached with caution since they may not track actual abundance well and issues can be exacerbated by management measures. For SEDAR 58, the fishery-dependent index was not extended past 2015 due to seasonal closures. The spawner-recruit relationship was also not well defined and annual recruitment was based on a fixed value. MSY-based management quantities rely heavily on this value, so results should be considered with this uncertainty in mind.

Overall, the model estimated little trend in SSB, though the terminal year was the lowest of the time series (Figure 2). The last strong year class in the model was predicted to have occurred around 2010. Predicted recruitment in the last four years (2014-2017) was below the time series average. If recruitment remains low, the decline in the stock as seen in the last several years of the assessment, will continue.

DESCRIPTION OF THE FISHERY

Current Regulations

Under the Interstate Plan, North Carolina must implement seasons and/or vessel limits that constrain harvest to the RHL. State landings will be evaluated against the RHL by averaging landings over a three-year period. The acceptance of SEDAR 58 in 2020 for management meant an increase in the amount of fish available for harvest, and the shift of harvest allocation to the recreational sector through Addendum 1. North Carolina's RHL increased to 29,302 fish with a shared coastwide commercial quota of 73,116 pounds.

For the 2020 – 2022 fishing years, North Carolina implemented a 36-inch FL minimum 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 were set to two fish per vessel from May 1 to 31 and one fish per vessel from June 1 to December 31. Due to the increase in the RHL through Addendum 1, North Carolina re-submitted the cobia implementation plan to ASMFC, and was approved to extend the two fish vessel limit for private vessels through June 30 each year starting in 2021. 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 36-inch FL minimum size limit and two fish per person per day possession limit, not to exceed six fish per vessel.

North Carolina was not the only state to implement new management measures in 2021. Based on a recommendation from the Technical Committee to the Coastal Pelagics Board at the spring 2022 meeting, the Board changed the fishing years to 2021 – 2023 to better align with management. New specifications for the 2024 – 2026 fishing years will be decided in 2023.

Commercial Fishery

Commercial landings of cobia in North Carolina are available from 1950 to the present. However, monthly landings were not available until 1972. 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. Since 1986, landings have ranged from 14,898 pounds (1989) to 52,684 pounds (2015), averaging 34,083 pounds over the last 10 years (Table 1; Figure 4A). In 2021, 29,301 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 primarily landed out of the haul seine fishery. Most landings that occurred during the 1980s came from the pelagic troll and hook-and-line fisheries with modest landings from the haul seine and anchored gill net fisheries. From 1994 – 2020, most landings have occurred from the anchored gill net, pelagic troll, and hook-and-line fisheries with gill nets being the top gear during most of those years. In 2021, gill nets accounted for 73% of the landings, while 21% of the landings were from the hook-and-line and pelagic troll fisheries combined (Table 2; Figure 5). From 2017-2019 gill-net landings decreased as the cobia season closed in early September. As the result of an increase in quota in 2020 due to SEDAR 58, gill-net landings have increased the last couple of years as fishermen have been able to land cobia incidentally caught during the fall king mackerel fishery. From 2012- 2017, landings in the pound net fishery increased, accounting for up to 12% of the total landings dependent on the year; however, since 2017, pound nets landings have contributed less than 5% to the overall landings (Table 2).

Recreational Fishery

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 estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information see: https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Cobia is enthusiastically pursued by recreational anglers in North Carolina, and recreational harvest can be up to 98% of the total harvest. Over the last 10 years, recreational harvest has averaged 93% of the total harvest. Recreational harvest of cobia in North Carolina has ranged from a low of 81,833 pounds (1987) to a high of 1,925,762 pounds (2015) with average landings of 376,390 pounds over the 36-year time series. Recently, landings have ranged from 102,077 pounds (2012) to 1,925,762 pounds (2015), averaging 707,018 pounds over the last 10-year period (Table 1; Figure 4B). In 2021, North Carolina landed 356,340 pounds of cobia in the recreational fishery. 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. Cobia are landed mostly in the spring and summer months corresponding with their spring spawning migration (Smith 1995; Brown-Peterson et al. 2001). Peak landings occur during the latter part of May into June and quickly diminish thereafter. However, recreational landings of cobia can occur through October. By fishing mode, most recreational landings of cobia in North Carolina occur from private vessels (75%) with charter vessels (8%) and shore-based modes (17%) accounting for the rest.

The North Carolina Division of Marine Fisheries (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 (prior to May 1, 2021) or 36 inches FL (currently), are eligible for an award citation. Since 1991, just over 10,500 citations have been awarded for cobia. On average, 10% of citations have been from released fish; in 2021, approximately 7% 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. Ten cobia were measured from the commercial fishery in 2021 with an average FL of 39 inches (Table 3). Mean FL has ranged from 37 to 43 inches since 1986. Cobia landed in the commercial fishery have ranged from 15 to 61 inches FL (Table 3; Figure 7).

Nine cobia were measured by MRIP in 2021 with an average FL of 43 inches (Table 4). Mean size has ranged from 27 to 48 inches FL over the time series. Cobia harvested in the recreational fishery have ranged from 9 to 68 inches FL (Table 4; Figure 8). Additionally, a total of 28 cobia were measured through the carcass collection program in 2021, with a average FL of 41 inches. Donated carcass lengths tend to be similar to what is measured by MRIP (Table 4). The number of commercial and recreational fish sampled is low and is most likely affected by low possession limits and seasonal nature of the fishery. Size trends in commercially landed fish for most years appear to correspond with sizes observed in the recreational fishery though at lower frequencies (Tables 3 and 4). However, the length distribution of the recreational fishery was larger than that of the commercial fishery in 2021 (Figure 9). This is possibly due to the timing of the fisheries, and differences in gear selectivity between the sectors; these differences may be hyper-inflated by the lower than normal sample sizes for both sectors in 2021.

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. Through 2018, 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 2021, 47 cobia were collected for aging, but 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 (Program 915). 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 half-inch increments). A total of 146 cobia have been captured in the Pamlico Sound Independent Gill Net Survey from 2001 – 2021. Cobia ranged from 6 to 38 inches FL and had a mean size of 19 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.

Additionally, cobia have been caught by the independent gill net survey sampling south of Pamlico Sound. The 'Rivers' portion of the survey (Neuse, Pamlico, Tar, and Pungo rivers) was initiated in 2003, the 'Southern' portion (Cape Fear and New rivers) in 2008, and the 'Central' portion (White Oak River through Back Sound) in 2018. Seventy-two cobia have been caught in this sampling, ranging in size from 8 to 22 inches FL, with a mean size of 15 inches FL.

While this data cannot be used to create an index of abundance, this sampling program is one of the few programs on the Atlantic coast that catches smaller cobia, providing important life history information that may not otherwise be obtained.

For the 2020, data are not available for cobia from the Fishery-Independent Gill-Net Survey (Program 915) due to the COVID pandemic. Sampling in this program was suspended in February 2020 due to COVID-19 restrictions and protected species interactions but resumed July 2021.

RESEARCH NEEDS

Current research needs for cobia can be found in the most recent SEDAR 58 stock assessment report (SEDAR 2020) and the Amendment 1 to the Interstate FMP (ASMFC 2019). Below is a list of state prioritized research needs based off the recommendations from SEDAR 58, Amendment 1 to the Interstate Plan, and input from NCDMF lead staff.

- Institute fisheries independent sampling programs to obtain estimates of cobia abundance

- 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
- Obtain more precise and timely estimates of harvest from the Atlantic cobia recreational fishery.
- Investigate release mortality and fishing mortality within the commercial and recreational fisheries
- Increase reporting of recreational harvest and better characterize the recreational and for-hire fisheries

MANAGEMENT STRATEGY

As of March 2019, cobia is managed solely under the ASMFC Interstate Plan requirements. The interstate plan, including Amendment 1 and Addendum 1 to the FMP, aim to maintain SSB above a threshold which allows for surplus recruitment to the stock.

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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, 1986 – 2021. All weights are in pounds.

	Recreational			Commercial	
Year	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
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
2019	10,090	38,285	254,963	21,553	276,516
2020*	15,067	51,158	407,883	38,344	446,227
2021	10,970	40,136	356,340	29,301	385,641
Mean	12,504	26,082	376,390	27,114	403,505

*2020 recreational data contains imputed data as a result of impacts from COVID on sampling during this year.

Table 2. Commercial harvest (weight in pounds) by gear, 2012 – 2021. (Source: North Carolina Trip Ticket Program)

Year	Gear					Total
	Gill Nets	Hook & Line	Trolling	Pound Nets	Other*	
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
2019	9,417	7,752	3,221	473	690	21,553
2020	29,202	3,175	3,780	1,294	894	38,344
2021	21,451	4,146	2,078	1,060	567	29,301

*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, 1986 – 2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1986	38	24	52	21
1987	39	28	50	42
1988	40	21	57	52
1989	38	24	48	28
1990	38	15	53	108
1991	39	31	46	19
1992	39	32	47	19
1993	37	32	46	10
1994	38	31	45	4
1995	40	33	48	14
1996	35	17	42	5
1997	38	33	43	4
1998				0
1999	37	25	45	8
2000	41	33	61	7
2001	37	30	42	8
2002	38	33	41	5
2003	40	30	46	13
2004	38	26	49	24
2005	40	31	54	18
2006	39	32	49	23
2007	40	31	52	24
2008	39	18	57	29
2009	39	30	44	15
2010	43	35	52	19
2011	38	34	46	13
2012	38	29	50	34
2013	38	33	46	16
2014	36	30	53	32
2015	39	32	48	34
2016	39	33	51	13
2017	42	36	46	9
2018	40	33	48	11
2019	39	34	49	12
2020	39	33	47	14
2021	39	34	47	10

Table 4. Mean, minimum, and maximum lengths (fork length, inches) of cobia sampled from the recreational fisheries (MRIP) and the NCDMF Carcass Collection Program from North Carolina, 1986 – 2021. It should be noted that the NCDMF Carcass Collection Program started in 2016.

	MRIP				NCDMF Carcass Collection			
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1986	43	20	50	7				
1987	27	9	48	13				
1988	37	16	50	9				
1989	34	11	55	16				
1990	34	11	53	28				
1991	35	11	60	20				
1992	41	22	52	19				
1993	41	31	51	16				
1994	39	18	52	18				
1995	43	31	54	25				
1996	36	17	61	37				
1997	42	35	51	17				
1998	45	35	55	28				
1999	47	41	55	5				
2000	41	26	58	8				
2001	43	33	59	11				
2002	48	34	59	16				
2003	42	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	44	36	63	12
2017	43	36	58	27	41	33	48	38
2018	41	33	57	60	37	23	47	39
2019	40	34	57	30	45	35	57	42
2020	41	33	57	67	41	34	49	9
2021	43	31	50	9	41	35	49	28

Table 5 Summary of cobia age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources, 2008 – 2021.

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
2019**			80
2020**			34
2021**			47

**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 yet read.*

FIGURES

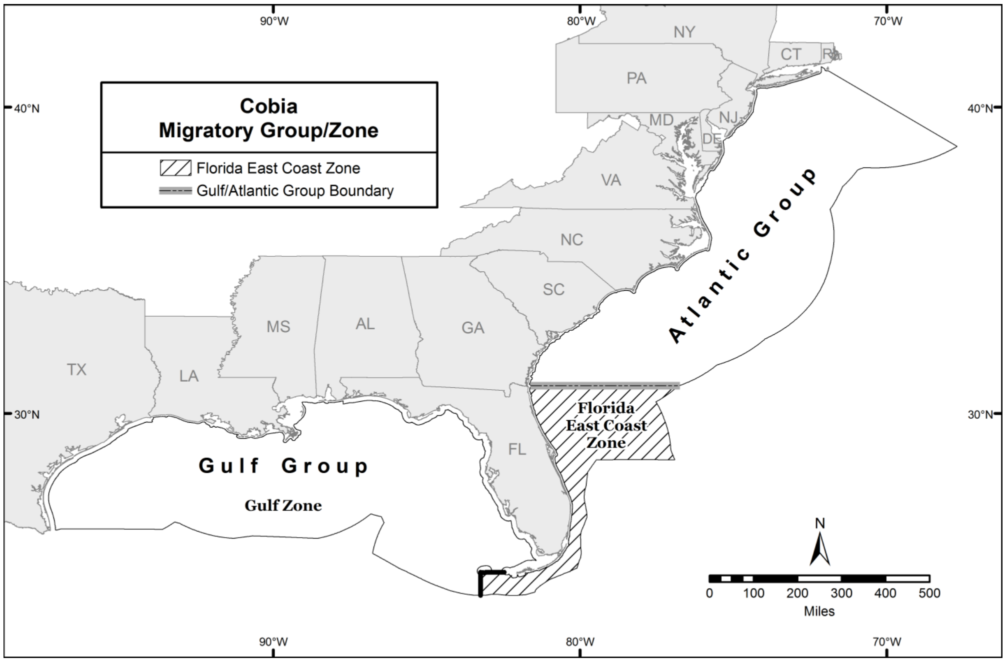

Figure 1. Zone splits for Gulf and Atlantic Migratory Group cobia established in Coastal Migratory Pelagics Fishery Management Plan Amendment 20b (Source: GMFMC/SAFMC 2014).

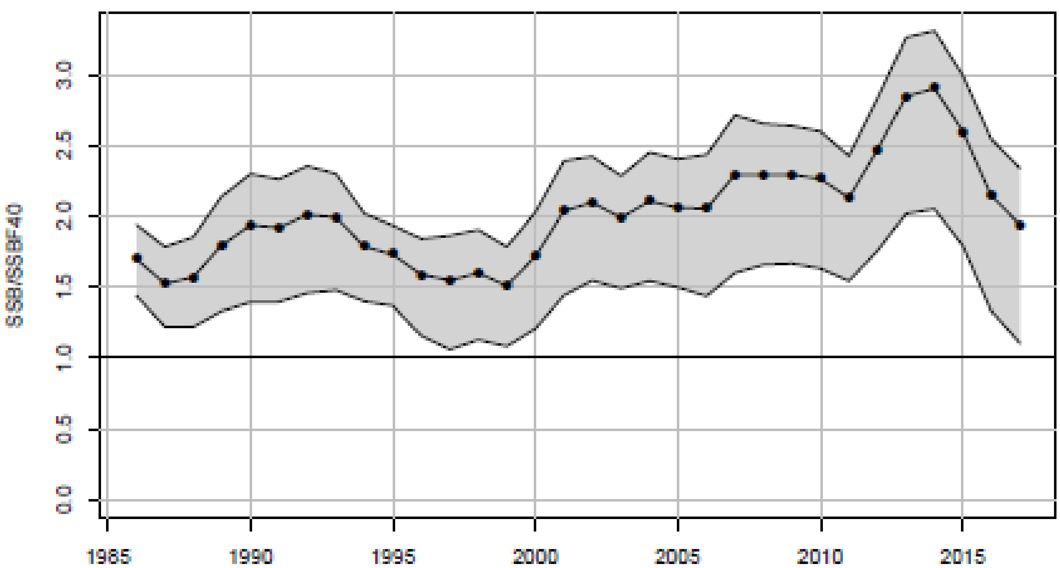

Figure 2. Spawning Stock Biomass (SSB) relative to established reference point SSBF40% for cobia from SEDAR 58 (SEDAR 2020). The shaded gray error bands indicate 5th and 95th percentiles of the Monte Carlo Bootstrap trials.

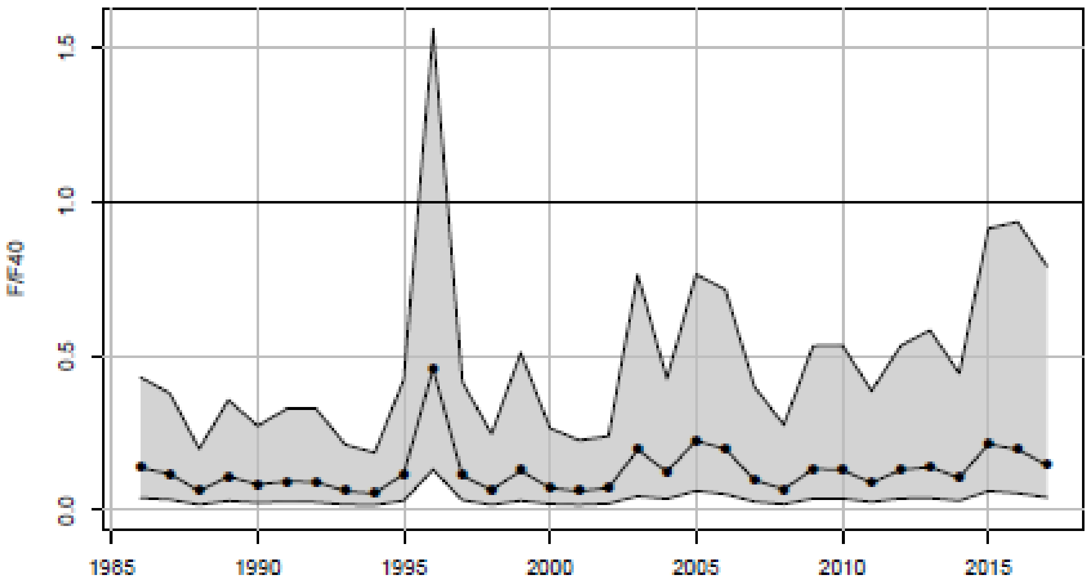

Figure 3. Fishing mortality (*F*) relative to established reference point $F_{40\%}$ for cobia from SEDAR 58 (SEDAR 2020). The shaded gray error bands indicate 5th and 95th percentiles of the Monte Carlo Bootstrap trials.

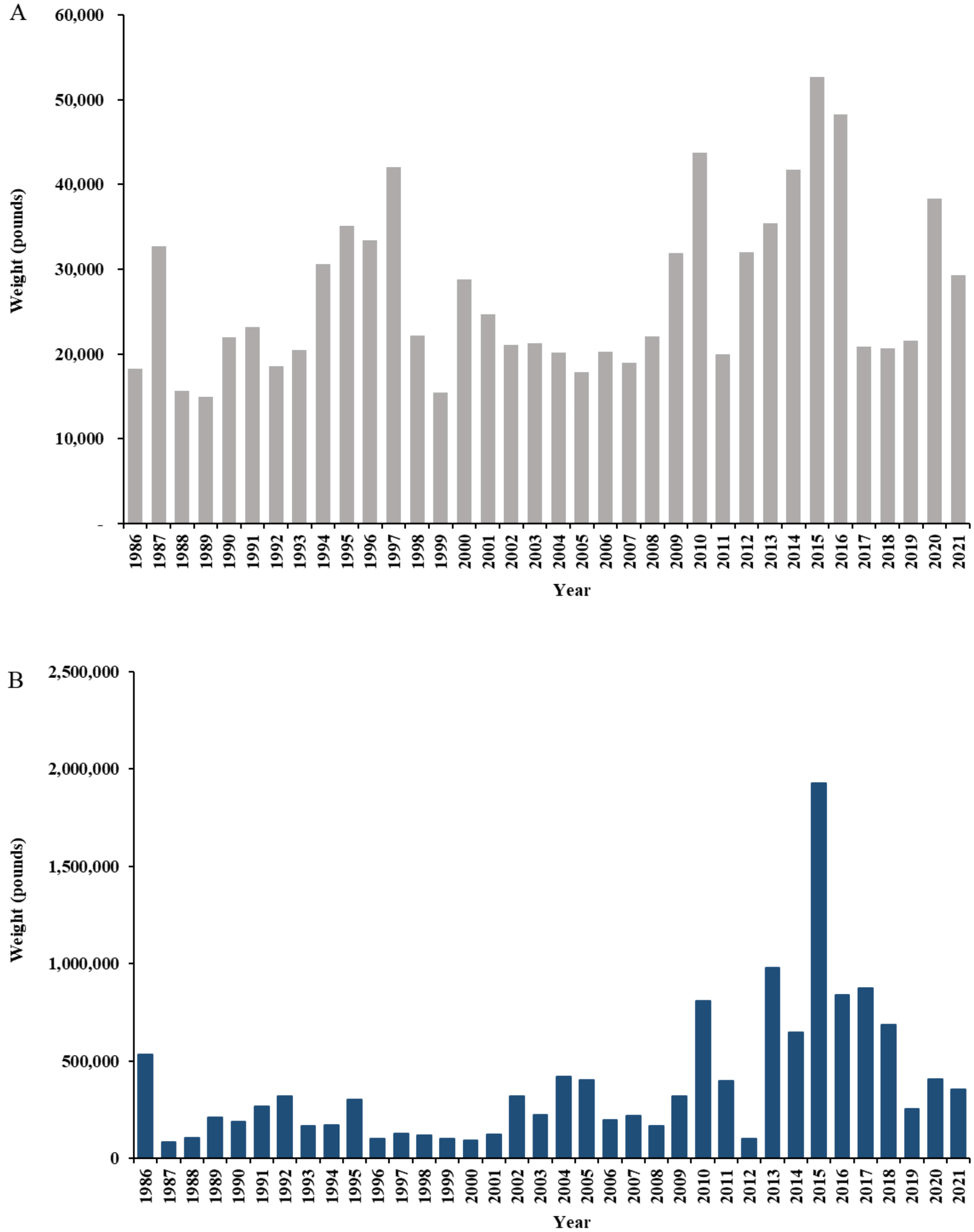

Figure 4. Annual (A) commercial (Atlantic Coastal Cooperative Statistics Program and N.C. Trip Ticket Program) and (B) recreational (MRIP) landings in pounds for cobia in North Carolina from 1986 – 2021.

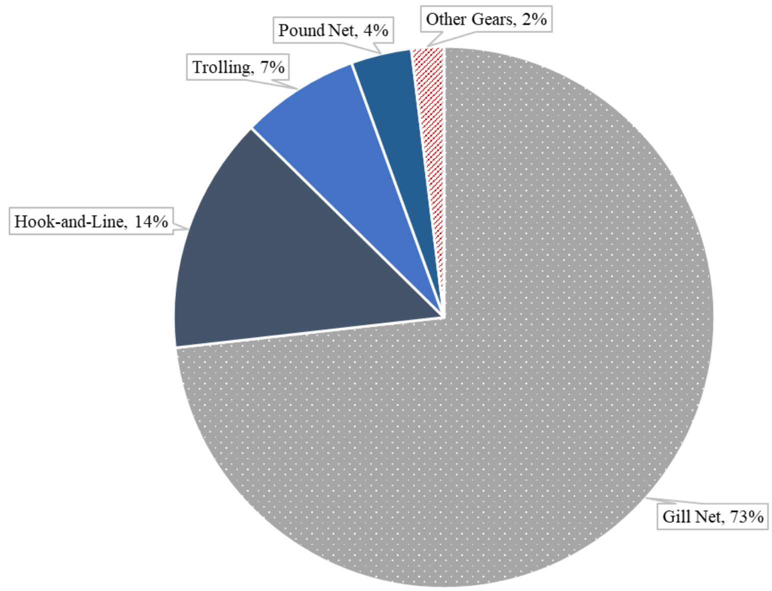

Figure 5. Commercial harvest in 2021 by gear type. Other gears can include beach seines, trawls, crab and fish pots, flynets, fyke nets, spears, longlines, and haul seines.

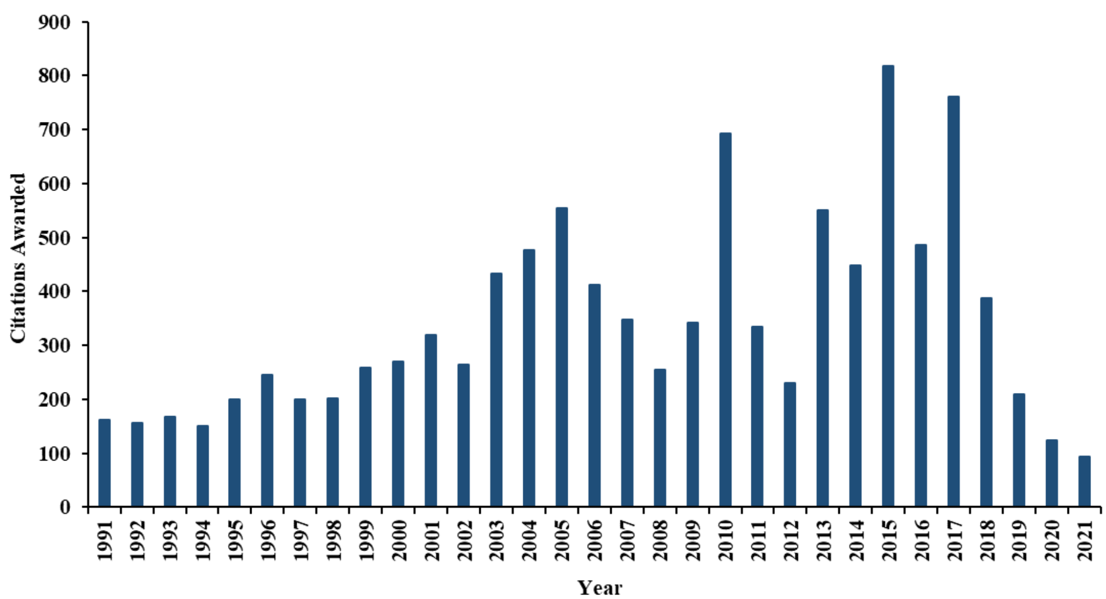

Figure 6. North Carolina Saltwater Fishing Tournament citations awarded for cobia from 1991 – 2021.

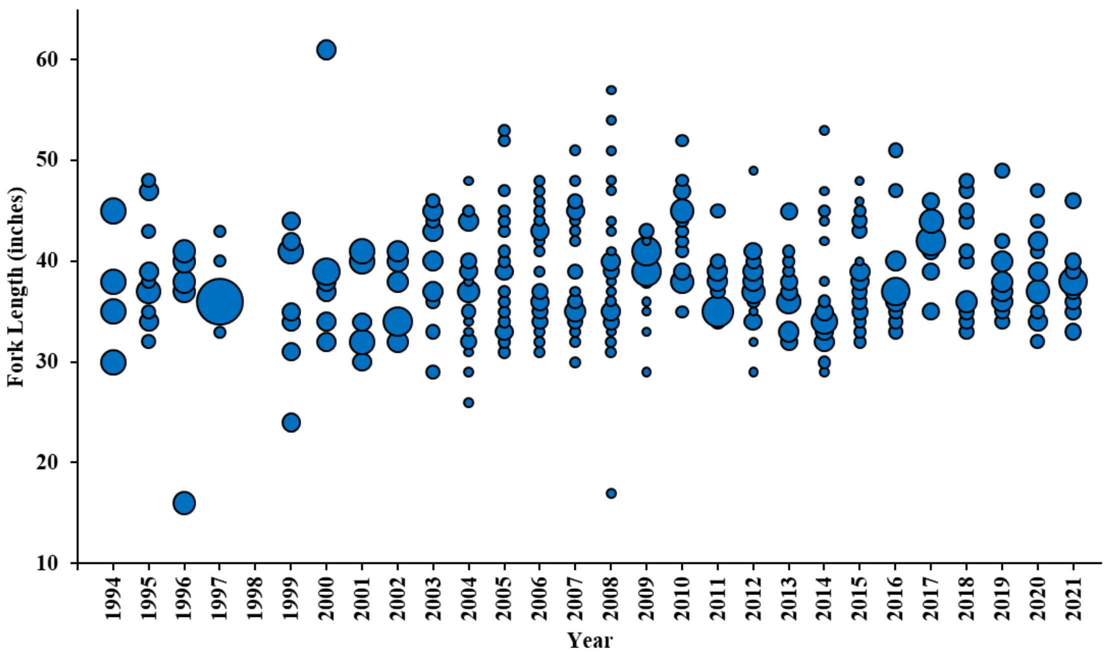

Figure 7. Commercial length frequency (fork length, inches) of cobia harvested from 1994 – 2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

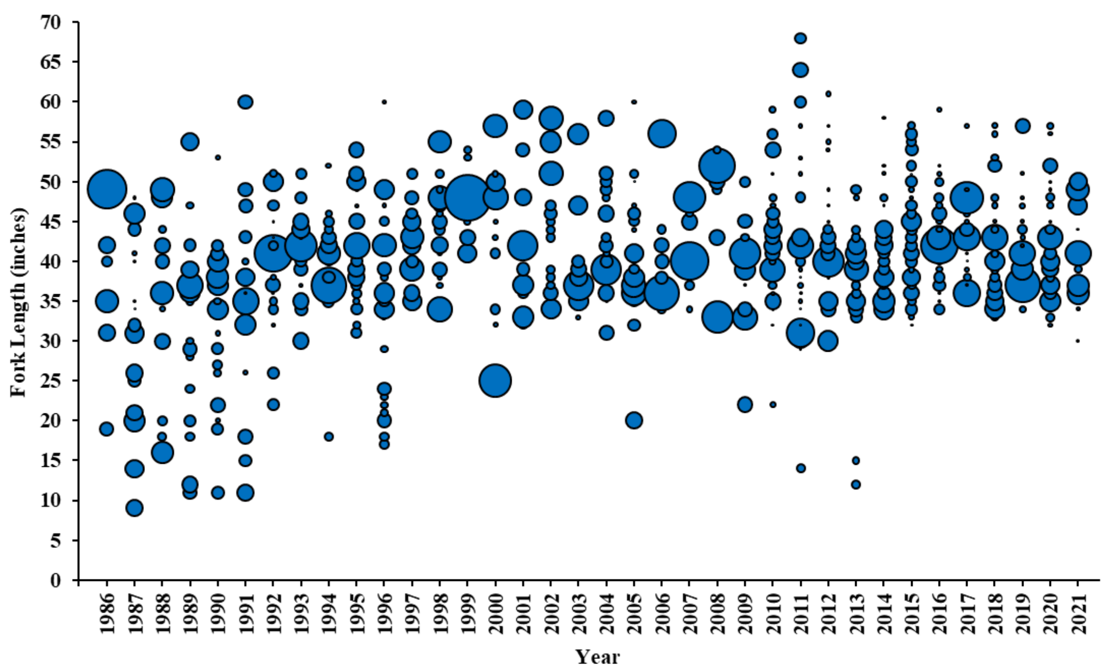

Figure 8. Recreational length frequency (fork length, inches) of cobia harvested from 1986 – 2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

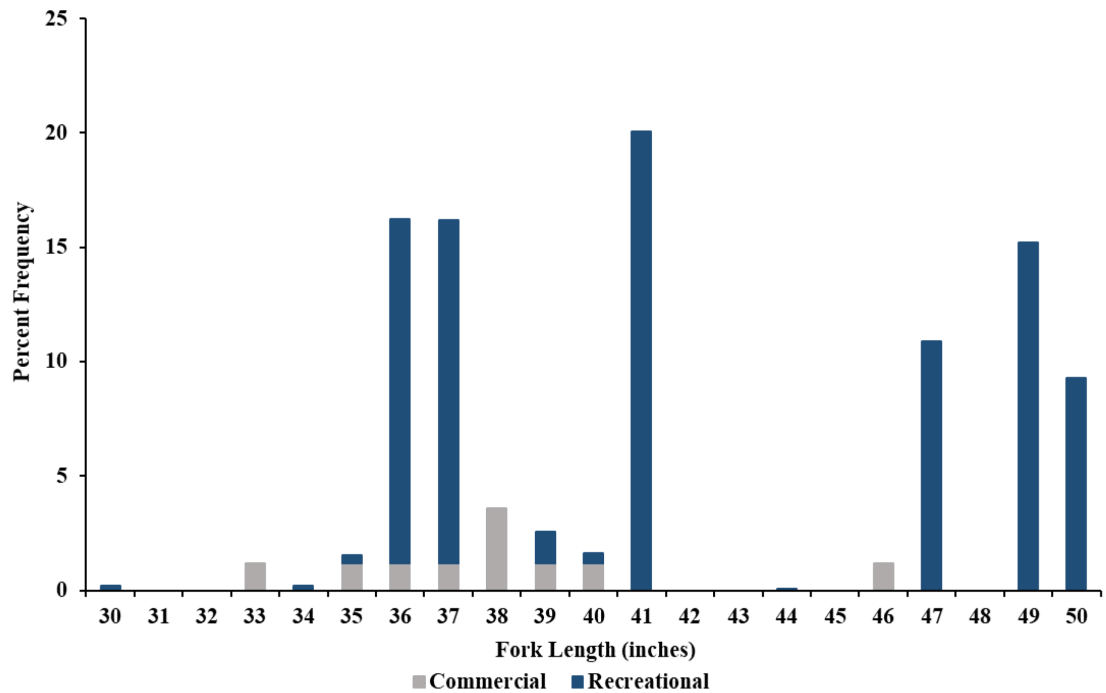

Figure 9 Commercial and recreational length frequency distribution from cobia harvested in 2021.

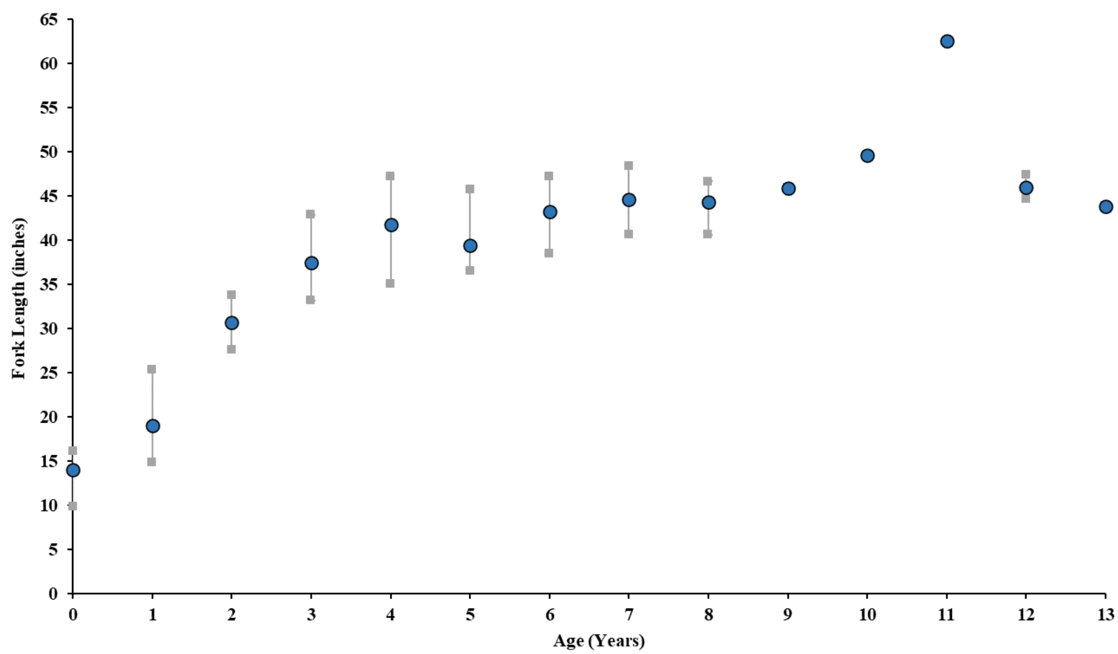

Figure 10. Cobia length at age based on all age samples collected from 2008 – 2017. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age. Otoliths from 2018-2021 are not included in this figure as they have not yet been aged.

FISHERY MANAGEMENT PLAN UPDATE
DOLPHIN
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	June 2004	
	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
	Amendment 12	June 2021
	Amendment 10	May 2022

Comprehensive 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), 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 (MRIP). 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 filets 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, established 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.

Amendment 12 was approved by the Council at its September 2020 meeting and became effective June 6, 2021 (SAFMC 2020). Amendment 12 adds bullet mackerel and frigate mackerel to the Dolphin Wahoo Fishery Management Plan and designates them as ecosystem component species. Amendment 10 was approved by the Council at its September 2021 meeting and became effective May 2, 2022 (SAFMC 2020). Amendment 10 includes actions that accommodate updated recreational data from the MRIP by revising the annual catch limits and sector allocations for dolphin and wahoo. The amendment also contains actions that implement other management changes in the fishery including revising accountability measures, accommodating possession of dolphin and wahoo on vessels with certain unauthorized gears onboard, removing the operator card requirement, and reducing the recreational vessel limit for dolphin and wahoo.

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:

- 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.
- 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.
- 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.
- 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.
- 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.
- Direct research to evaluate the role of dolphin and wahoo as predator and prey in the pelagic ecosystem.
- Direct research to enhance collection of biological, habitat, social, and economic data on dolphin and wahoo stocks and fisheries.

DESCRIPTION OF THE STOCK

Biological Profile

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 (BMSY) and the species can withstand a relatively high rate of exploitation (Prager 2000).

Stock Assessment

A stock assessment is not available for this species.

DESCRIPTION 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 54 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. Commercially harvested dolphin must be at least 20 inches fork length. 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 Fishery

Commercial landings of dolphin are reported through the mandatory NCDMF Trip Ticket program. Landings since 1986 have fluctuated with a low of 26,112 pounds in 2021 and a high of 611,962 pounds in 2009 (Table 1; Figure 1). Commercial landings in 2021 (26,112 pounds) were much lower than the time series average (198,695 pounds), and the lowest landings of the time series.

Recreational Fishery

Recreational landings of dolphin are estimated from the MRIP. Recreational estimates across all years have been updated and are now based on the MRIP's new Fishing Effort Survey-based calibrated estimates. For more information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

From 1981 to 2009, recreational dolphin landings had been steadily increasing. Subsequently, from 2010 to present, dolphin landings have slowly declined. After peaking in 2009 (6,380,552 pounds), landings of dolphin fluctuated between highs in 2015 (5,610,008 pounds) and 2016 (5,099,647 pounds) and lows in 2017 (2,223,509 pounds), 2020 (2,149,038 pounds), and 2021 (1,971,454 pounds; Table 1; Figure 2). It is likely the decline in dolphin landings in 2021, in addition to a decline in citations (see below), was due to fewer for-hire trips taking place in North Carolina because of COVID-19.

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 observed from 2013-2018 (Table 2; Figure 2). Although the total number of citations awarded through the North Carolina Saltwater Fishing Tournament increased in 2019 (181 citations), citations declined in 2020 (94 citations) and 2021 to the lowest number recorded in the time series (68 citations; 1991-2020).

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 (Offshore Live Bottom Fishery) and 439 (Coastal Pelagic). The number of commercial dolphin lengths collected in 2021 (194 samples) was above time series average of 186 samples (Table 3; Figure 3). The average size of dolphin sampled from the commercial fishery increased in 2021 (32.1 inches fork length) from the previous year (26.0 inches fork length) and was above the time series average (27.8 inches fork length; Table 3; Figure 4). The maximum size of dolphin sampled from the commercial fishery also increased in 2021 (59.8 inches fork length) from 2020 (43.5 inches fork length) to the largest in the time series (Table 3; Figure 4).

Length and weight information for the recreational fishery are collected through the MRIP dockside sampling. The average size of dolphin sampled from the recreational fishery decreased from 28.0 inches fork length in 2020 to 26.1 inches fork length in 2021, but overall has remained relatively constant throughout the time series (Table 3; Figure 5). The minimum size of dolphin sampled from the recreational fishery in 2021 (13.7 inches fork length) was slightly below the time series average from 1981-2021, and the maximum size sampled in 2021 (55.1 inches fork length) slightly below the previous year (55.3 inches fork length) and the time series average of 53.4 inches fork length.

The modal length for the commercial fishery (26 inches fork length) was much greater than the recreational fishery (21 inches fork length) in 2021 (Figure 3; Figure 5). However, the recreational fishery harvests larger dolphin than the commercial fishery (Figure 3; Figure 5); the maximum length of dolphin sampled from the recreational fishery was 67.9 inches fork length in 2010, compared to a maximum length of 59.8 inches fork length by the commercial fishery in 2021 (Table 3; Figure 5).

Fishery-Independent Monitoring

Currently, NCDMF does not have any fishery-independent sampling programs that target or catch dolphin in great numbers.

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:

- What is the areal and seasonal abundance of pelagic Sargassum off the southeast U.S.?
- Develop methodologies to remotely assess Sargassum using aerial or satellite technologies (e.g., Synthetic Aperture Radar).
- What is the relative importance of pelagic Sargassum weedlines and oceanic fronts for early life stages of dolphin?
- Are there differences in dolphin abundance, growth rate, and mortality?
- 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?
- Is pelagic Sargassum mariculture feasible?
- Determine the species composition and age structure of species associated with pelagic Sargassum when it occurs deeper in the water column.
- Additional research on the dependencies of pelagic Sargassum productivity on the marine species using it as habitat.
- Quantify the contribution of nutrients to deepwater benthic habitat by pelagic Sargassum.
- 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.
- 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.
- 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.
- 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:

- 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.
- Additional data are needed to develop and/or improve estimates of growth, fecundity, etc.
- 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.
- Trophic data should be considered in support of an ecosystem management approach.
- Essential fish habitats for dolphin and wahoo need to be identified.
- An overall design should be developed for future tagging work. In addition, existing tagging databases should be examined.
- Long-term work should continue and expand on current research investigating genetic variability of dolphin populations in the western central Atlantic.
- 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 bio profile data (size, sex, hard parts for aging, etc.).
- High levels of uncertainty in inter-annual variation in abundance of dolphin should be investigated through an examination of oceanographic and other environmental factors.
- Release mortality should be investigated as a part of the evaluation of the effectiveness of current minimum size limits in the dolphin fishery.
- Establish a list serve for dolphin and wahoo which would facilitate research and the exchange of information.

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), Amendment 12 (SAFMC 2020), Amendment 10 (SAFMC 2021) and Regulatory Amendment 1 (SAFMC 2016).

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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, 1986–2021.

Year	Recreational			Commercial	
	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight Landed (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
2019	458,086	35,286	3,147,384	208,385	3,355,769
2020	262,372	26,902	2,149,038	51,994	2,201,032
2021	268,012	25,108	1,945,342	26,112	1,971,454
Mean	364,545	11,916	2,981,874	193,901	3,175,776

Table 2. Total number of awarded citations for dolphin (>35 pounds landed) annually from the North Carolina Saltwater Fishing Tournament, 1991–2021.

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
2019	181
2020	94
2021	68

Table 3. Mean, minimum, and maximum lengths (fork length, inches) of dolphin collected from the commercial and recreational fisheries, 1986–2021.

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
2019	29.3	14.1	45.3	143	25.7	10.3	58.1	877
2020	26.0	17.6	43.5	64	28.0	13.1	55.3	1,092
2021	32.1	15.7	59.8	194	26.1	13.7	55.1	396

FIGURES

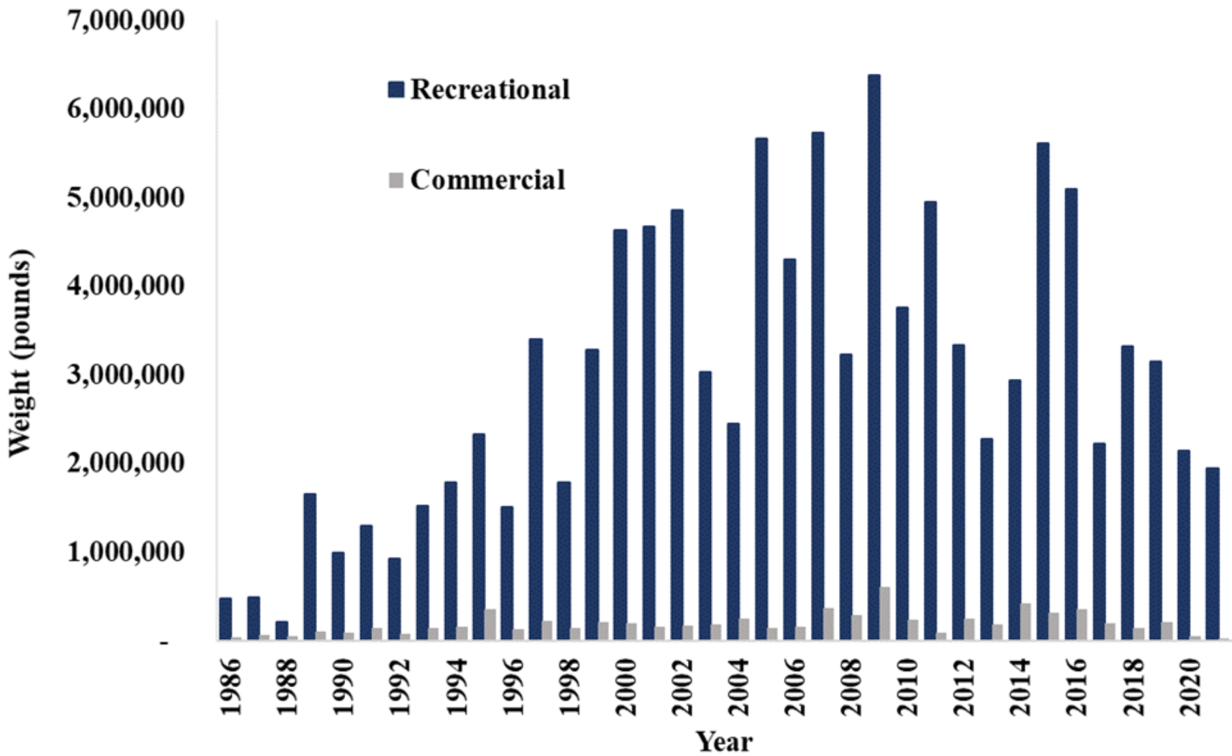

Figure 1. Annual commercial and recreational landings in pounds of dolphin in North Carolina, 1986–2021.

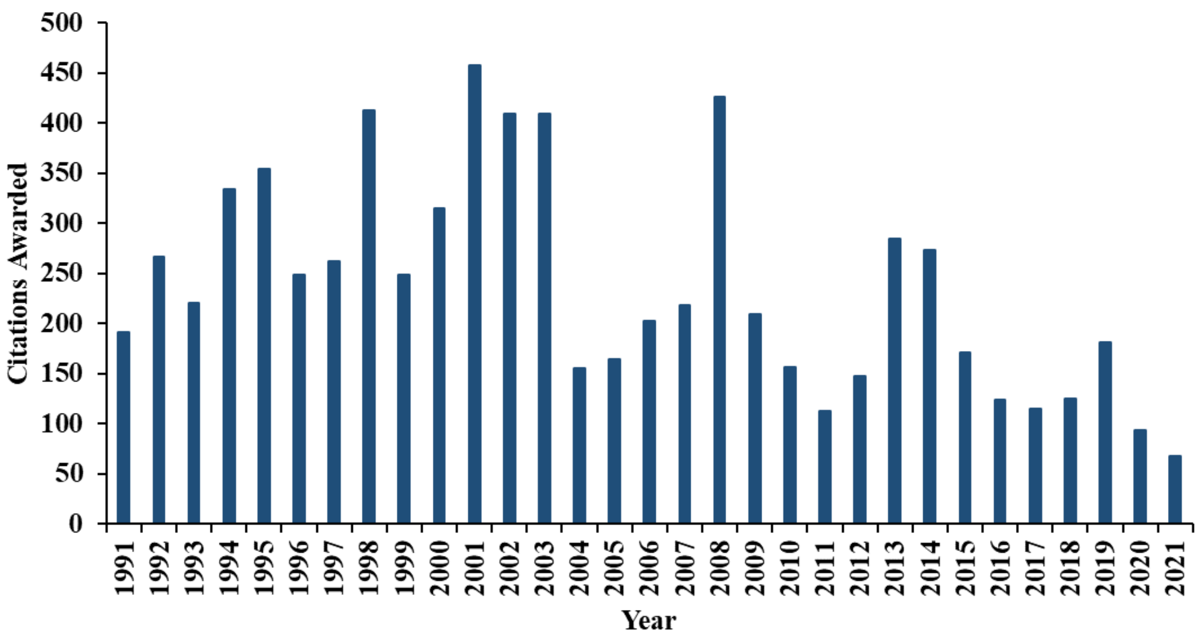

Figure 2. Total number of awarded citations for dolphin (>35 pounds landed) annual from the North Carolina Saltwater Fishing Tournament, 1991–2021.

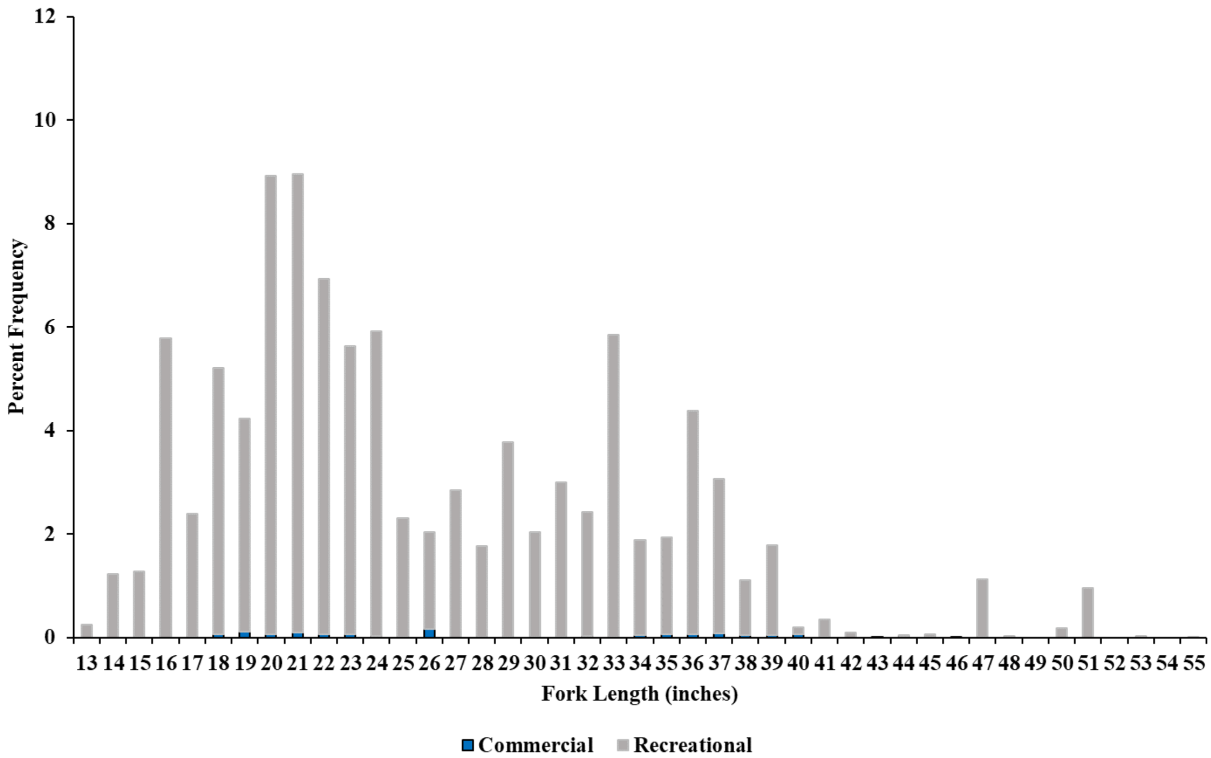

Figure 3. Commercial and recreational length frequency distribution for dolphin harvested in 2021.

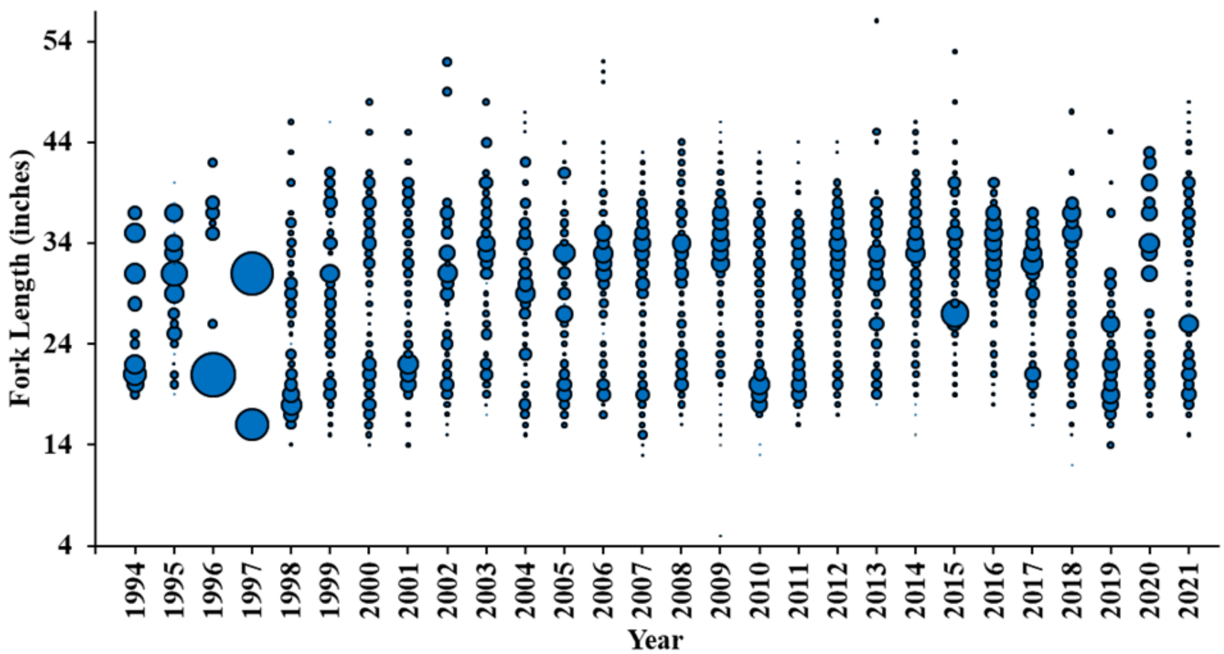

Figure 4. Commercial length frequency (fork length, inches) of dolphin harvested from 1994 to 2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length in that year.

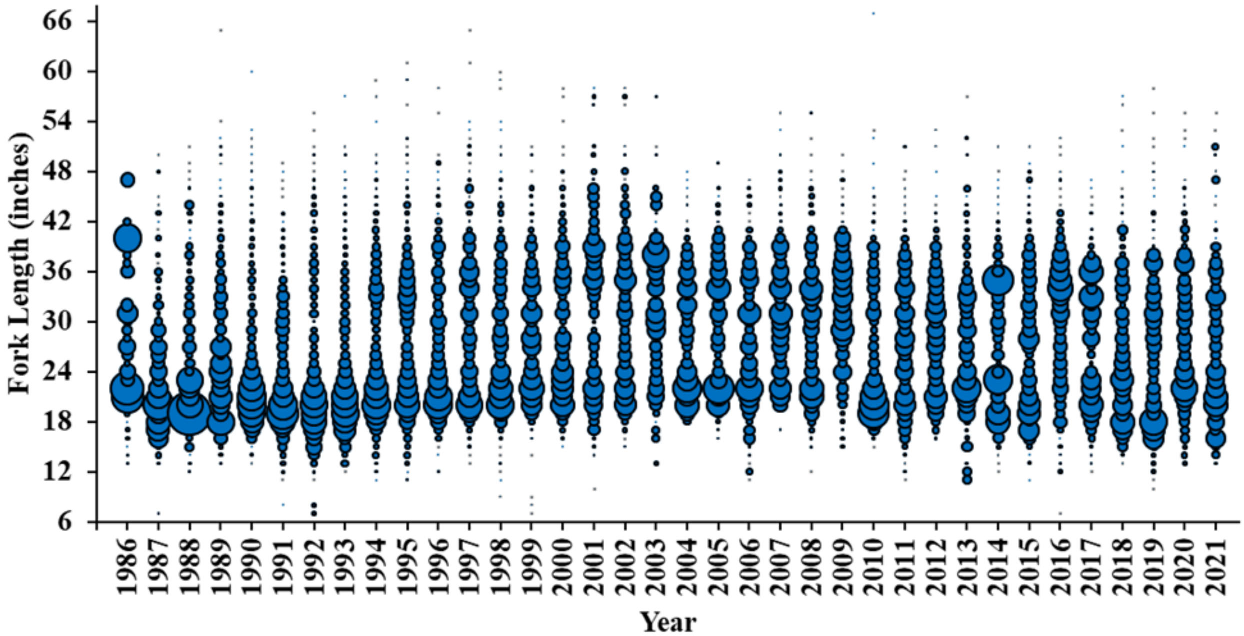

Figure 5. Recreational length frequency (fork length, inches) of dolphin harvested from 1986 to 2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length in that year.

FISHERY MANAGEMENT PLAN UPDATE
KING MACKEREL
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	February 1983	
	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

Comprehensive Review: 2020

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 (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 1989). 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 fork length (FL) or 14 inches total length (TL) for king mackerel and included a definition of "conflict".

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, (e) allow setting zero bag limits, and (f) 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%t 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 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 1998b).

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 2002a). 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 2002b). 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 2004). 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 (SAFMC 2002b).

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 (SAFMC 2011).

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 2010).

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 2013a). 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 2014a). 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 2013b).

Amendment 23 (SAFMC 2013c) 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 (SAFMAC 2014b).

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.

Framework Amendment 6 (effective 2018) modifies the commercial trip limit for Atlantic migratory group king mackerel in the exclusive economic zone from the North Carolina/South Carolina line to the Miami-Dade/Monroe County line (Atlantic Southern Zone) (SAFMC 2018).

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 2022).

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:

- 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.
- 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.
- To provide necessary information for effective management and establish a mandatory reporting system.
- To minimize gear and user group conflicts.
- 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.
- To minimize waste and bycatch in the fishery.
- To provide appropriate management to address specific migratory groups of king mackerel.
- To optimize the social and economic benefits of the coastal migratory pelagic fisheries.

DESCRIPTION OF THE STOCK

Biological Profile

King mackerel (*Scomberomorus cavalla*) 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 FL, but most recreational catches are between 35- and 45-inches fork length. 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 2020, the Atlantic king mackerel stock was assessed and peer reviewed through the Southeast Data, Assessment and Review (SEDAR 38 Update). 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 3, was used to assess the stock (SEDAR 2014) in a benchmark assessment (SEDAR 2014). The SEDAR 38 assessment was updated in 2020 (SEDAR 2020). 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 (CPUE) indices. Total biomass and spawning stock biomass estimates increased steadily since 2013. All fishery indicators (fleet CPUEs and scientific survey) showed positive trends since SEDAR 38. Stock Synthesis estimated a recent period (2013 to 2016) of above average age-0 recruitments, contrasting the period prior (2008 to 2012) of below average recruitments first detected during SEDAR 38. Two particularly high recruitment years were estimated for 2015 and 2016, supported by the juvenile survey observations in 2016 (SEAMAP trawl survey), as well as fleet length compositions. Observations by stakeholders may help validate the model predictions, given the distinct change in signal from five-years of low recruitment up to SEDAR 38 to four years of recent high recruitment. The fish would have entered the fisheries beginning in fishing year 2015, with relatively high abundance beginning in fishing year 2017, particularly of fish between 24 and 36 inches FL.

DESCRIPTION OF THE FISHERY

Current Regulations

The North Carolina Division of Marine Fisheries complements the management measures of the Coastal Migratory Pelagic FMP through rule (NCMFC Rule 15A NCAC 03M .0512) and proclamation authority (NCMFC Rule 15A NCAC 03M .0512). Current regulations include a recreational bag limit of three king mackerel per person per day and 24-inch FL 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 Fishery

In 2021, commercial landings were 430,868 pounds (Table 1; Figure 1A) and 86% of the king mackerel harvest was taken by hook and line while the remaining 14% was harvested in gill nets (Table 2; Figure 2). The commercial fishery has declined since 2008 and the 2021 landings were lower than the 488,243 pound 10-year average (2012-2021).

Recreational Fishery

Recreational landings of king mackerel are estimated from the Marine Recreational Information Program (MRIP). Recreational 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 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 563,082 pounds of king mackerel in 2021, which is 59% lower than 2020 harvest and 45% lower than the 10-year average of 1,014,603 pounds (Table 1 and Figure 1B).

The NCDMF offers award citations for exceptional catches of king mackerel. King mackerel greater than 30 pounds or 45 inches FL are eligible for an award citation. In 2021, 319 citations were awarded, eleven of which were released alive (Figure 6).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Length-frequency information for the commercial king mackerel fishery in North Carolina is collected through the Division Program 434 (Ocean Gill Net Fishery), Program 437 (Long Haul Seine Fishery), Program 438 (Offshore Live Bottom Fishery), Program 439 (Coastal Pelagic), and Program 461 (Estuarine Gill Net and Seine Sampling)]. Through these programs, 549 king mackerel were measured with a mean length of 29.1 inches (Table 4; Figures 3 and 5). 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 (Figures 4 and 5).

Fishery-Independent Monitoring

Currently, the division does not have any fishery-independent sampling programs that target or catch king mackerel in great numbers.

RESEARCH NEEDS

From SEDAR 38 (2014) and SEDAR 38 Update (2020):

- 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 age-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.
- Research aimed at improving the documentation of data series formatting, including index standardization, for Stock Synthesis 3 would improve modeling efficiency. This includes statistical coding for consistent database querying and data processing.
- Evaluation of alternative age references, or age-specific time series, for the SEAMAP fishery independent survey was recommended by the data providers and noted by the analyst for future assessments. An analysis of the effect of excluding sublegal fish size observations on the assessment should be undertaken. Information on the age-composition of discarded fish from all fleets is needed to validate the assumption of exclusively age-0 discards. The conditional age-at-length data had a significant influence on recent recruitment estimates.

MANAGEMENT STRATEGY

King mackerel is included in the North Carolina FMP for Interjurisdictional Fisheries, which defers, to SAFMC's management plan compliance requirements. Current management measures were established under recent Amendments 20A (SAMFC 2013a), 20B (SMAFC 2014b), and 26 (SAMFC 2016) to the Coastal Migratory Pelagics FMP. 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 SAFMC completed Amendment 26 (SAFMC 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.

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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 king mackerel from North Carolina, 1994–2021.

Year	Recreational			Commercial	
	Number Harvested	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1994	177,608	5,792	1,709,740	849,909	2,559,649
1995	135,796	7,544	1,240,901	1,013,319	2,254,220
1996	119,418	15,465	1,097,226	793,467	1,890,693
1997	206,601	57,739	1,797,936	1,558,439	3,356,375
1998	112,383	9,155	1,163,739	1,143,342	2,307,081
1999	104,483	120,296	1,034,465	1,082,693	2,117,158
2000	196,979	26,009	2,250,512	1,045,554	3,296,066
2001	145,290	12,381	2,046,022	839,107	2,885,129
2002	104,631	20,811	1,242,058	778,427	2,020,485
2003	153,339	33,774	1,388,145	764,831	2,152,976
2004	191,584	184,384	2,276,035	955,002	3,231,037
2005	175,070	101,507	1,349,536	1,246,088	2,595,624
2006	177,369	45,568	1,805,814	1,185,534	2,991,348
2007	339,278	53,549	3,099,801	1,059,107	4,158,908
2008	164,719	41,283	1,379,450	1,036,852	2,416,302
2009	168,558	23,639	1,822,673	777,585	2,600,258
2010	58,311	9,734	580,505	328,806	909,311
2011	31,589	851	367,896	408,162	776,058
2012	55,529	6,385	613,903	297,423	911,326
2013	48,000	8,868	521,153	345,177	866,330
2014	72,288	35,075	1,213,096	549,981	1,763,077
2015	95,705	16,877	1,168,255	391,315	1,559,570
2016	108,151	43,909	963,139	420,869	1,384,008
2017	110339	94655	1261775	629,703	1,891,478
2018	102,675	75,614	1,018,459	506,933	1,525,392
2019	184,962	115,350	1,446,939	698,252	2,145,191
2020	146,423	70,879	1,376,229	610,718	1,986,947
2021	58,174	24,069	563,082	430,868	993,950
Mean	133,759	45,042	1,349,946	776,738	2,126,641

Table 2. North Carolina commercial harvest of king mackerel with landings in pounds by gear type, 1994–2021.

	Gear Type			
Year	Hook and Line	Gill Net	Other	Total
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
2019	616,273	81,944	13	698,229
2020	518,010	92,509	199	610,718
2021	368,767	61,987	113	430,868

Table 3. Total number measured, mean, minimum, and maximum length (inches) of king mackerel measured by MRIP sampling in North Carolina, 1981–2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1981	38.5	25.0	46.0	47
1982	33.9	15.7	44.1	90
1983	30.1	5.7	36.0	33
1984	31.1	12.2	44.3	71
1985	32.9	22.0	42.5	67
1986	33.1	19.7	48.9	257
1987	31.4	12.6	55.9	1,041
1988	13.5	14.2	58.5	646
1989	33.8	12.2	53.9	765
1990	31.3	12.2	59.5	1,169
1991	31.8	10.1	57.9	1,057
1992	31.1	14.6	57.9	1,037
1993	32.3	12.8	58.3	772
1994	32.2	20.1	65.4	829
1995	31.2	14.6	53.5	959
1996	31.3	20.1	56.0	670
1997	30.5	12.6	54.6	1,814
1998	32.4	13.9	57.8	1,062
1999	32.9	18.3	50.2	452
2000	33.7	19.3	69.6	831
2001	37.0	22.4	59.1	800
2002	34.6	22.7	54.2	218
2003	32.8	20.2	55.0	268
2004	32.2	13.2	55.5	247
2005	29.6	21.7	53.3	277
2006	32.0	19.2	59.2	269
2007	31.1	21.3	49.3	320
2008	30.1	20.6	47.9	317
2009	32.7	21.0	46.9	168
2010	32.5	25.0	50.0	83
2011	34.1	28.0	51.0	36
2012	32.9	23.5	51.0	74
2013	32.6	23.5	54.8	38
2014	38.7	23.9	53.1	106
2015	33.3	22.2	52.9	93
2016	30.4	12.2	60.0	213
2017	31.9	13.4	48.9	278
2018	30.3	14.6	60.4	365
2019	29.7	10.2	49.8	369
2020	31.6	10.4	54.4	363
2021	31.7	17.8	48.4	306

Table 4. King mackerel length (fork length, inches) data from commercial fish house samples, 1997–2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork 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
2019	29.5	16.0	49.8	1,136
2020	30.2	15.7	46.9	439
2021	29.1	17.2	47.2	917

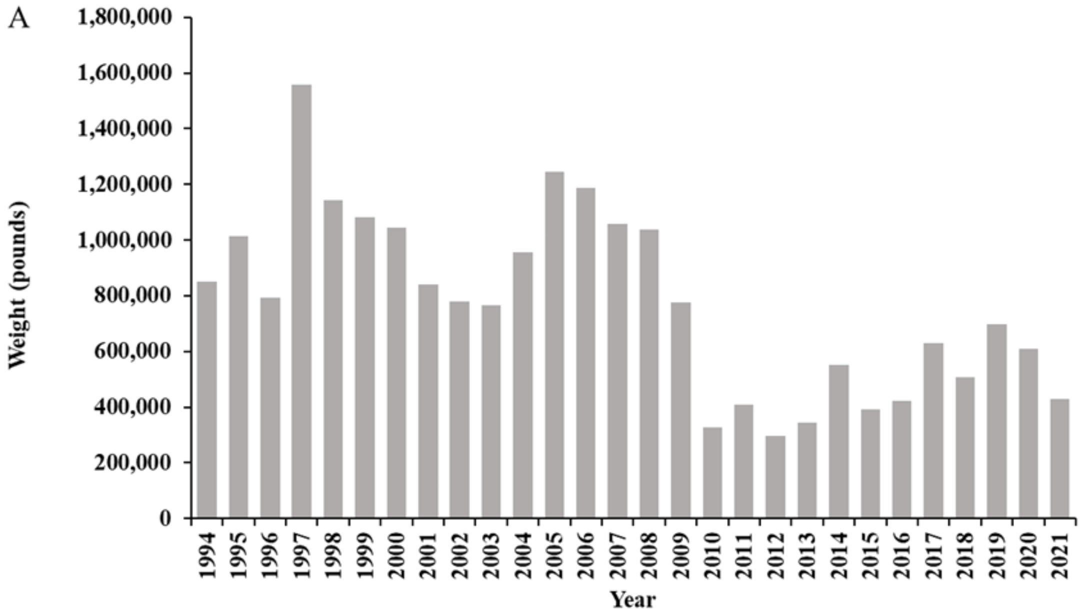
Table 5. King mackerel length (fork length, inches) fishery-dependent data collected by NCDMF for ageing by the NOAA Southeast Fisheries Science Center, 1997–2021.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork 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
2019	35.5	17.5	56.3	695
2020	36.2	19.5	56.5	520
2021	36.9	15.9	57.1	549

Table 6. Summary of N.C. Marine Fisheries Commission management strategies for king mackerel.

Management Strategy	Implementation Status
Prohibits Purse Gill Nets when taking king or Spanish mackerel	Rule 15A NCAC 03M .0512
24-inch fork length minimum size limit. Three fish recreational creel limit. Commercial Vessel Permit requirements. Commercial trip limit of 3,500 pounds of king, Spanish, or aggregate. Charter vessels or head boats with Commercial Vessel Permit must comply with possession limits when fishing with more than three persons 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-238-2022

FIGURES



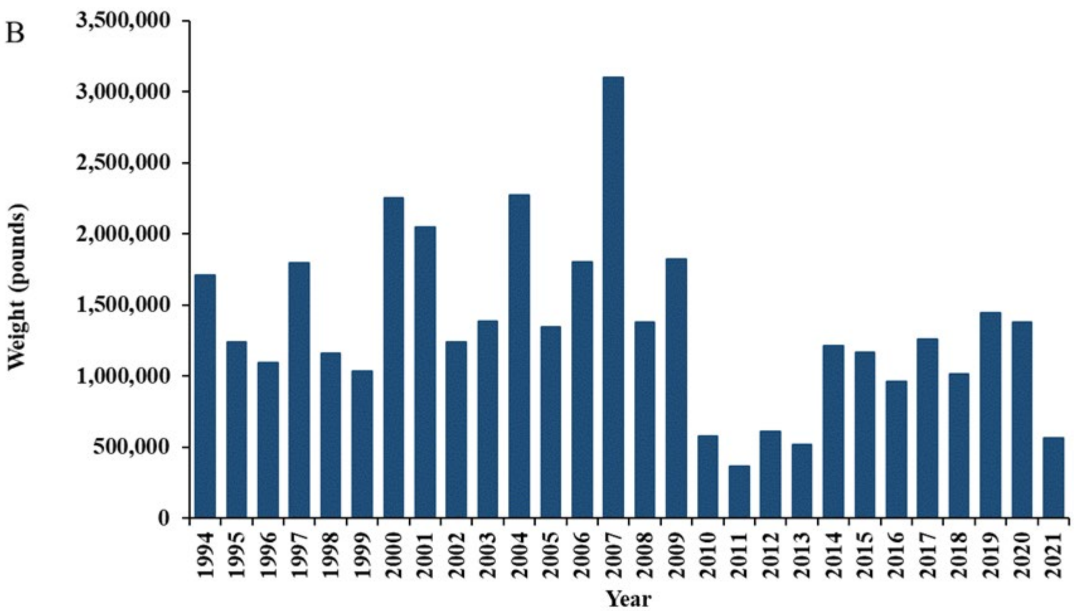


Figure 1. Annual commercial (A) and recreational (B) landings in pounds for king mackerel in North Carolina, 1994–2021.

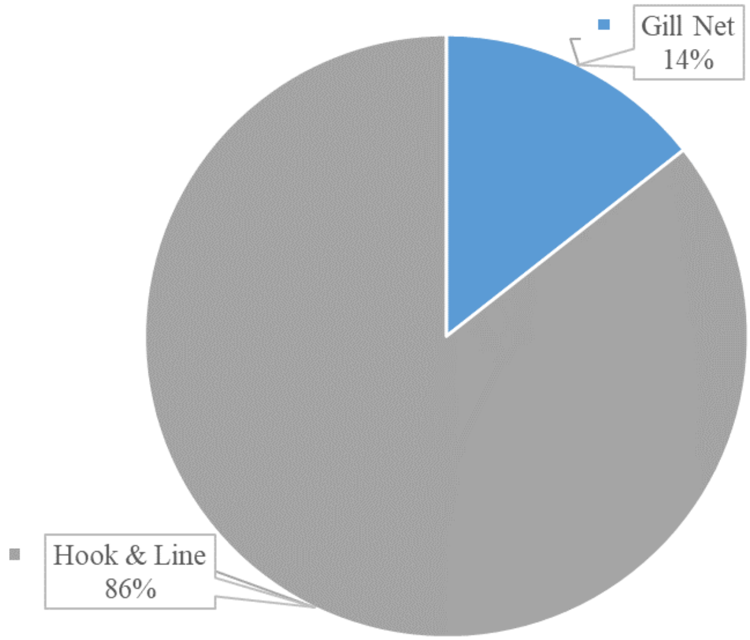


Figure 2. Commercial harvest of king mackerel by gear, 2021.

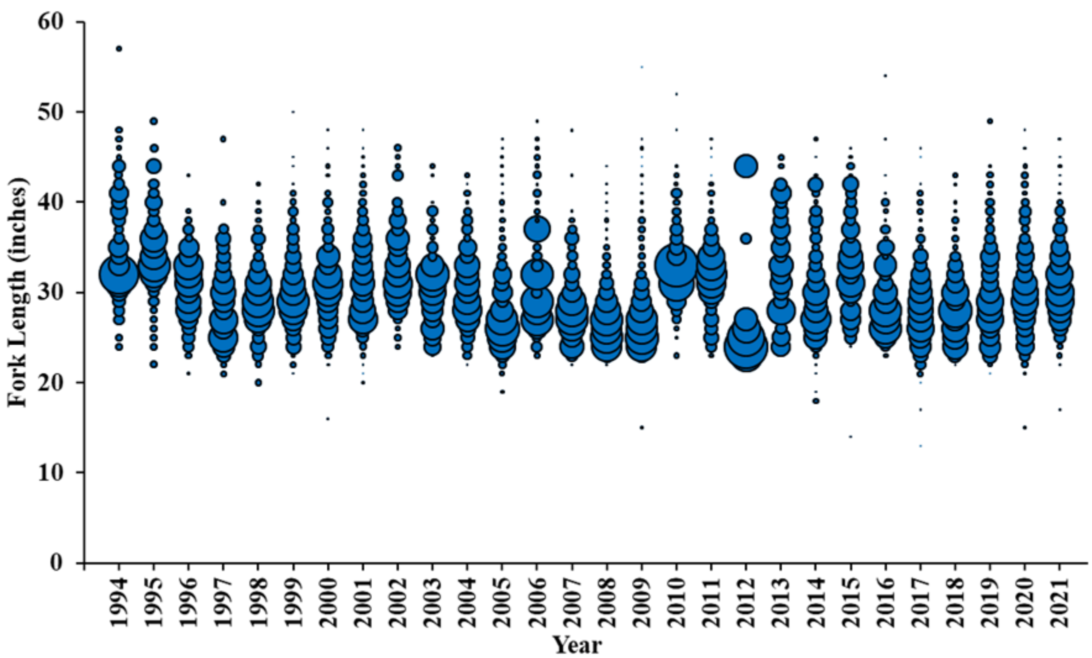


Figure 3. Commercial length frequency (fork length, inches) of king mackerel, 1994–2021. Bubbles represents fish harvest at length and the size of the bubble represents the proportion of fish at that length in that year.

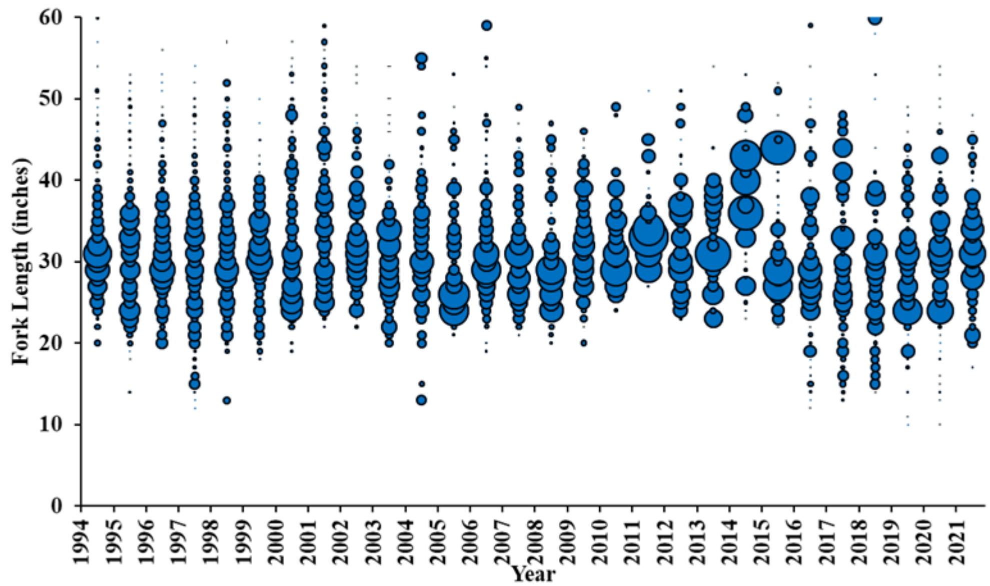


Figure 4. Recreational length frequency (fork length, inches) of king mackerel, 1994–2021. Bubbles represents fish harvest at length and the size of the bubble represents the proportion of fish at that length in that year.

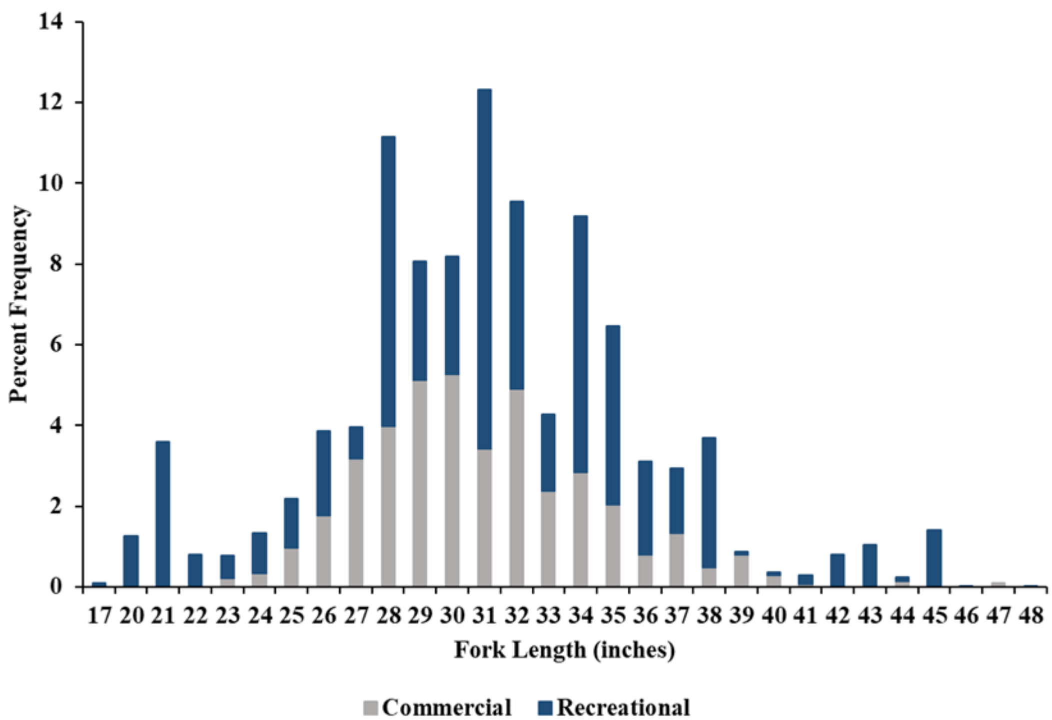


Figure 5. Commercial and recreational length frequency distribution from king mackerel harvested in 2021.

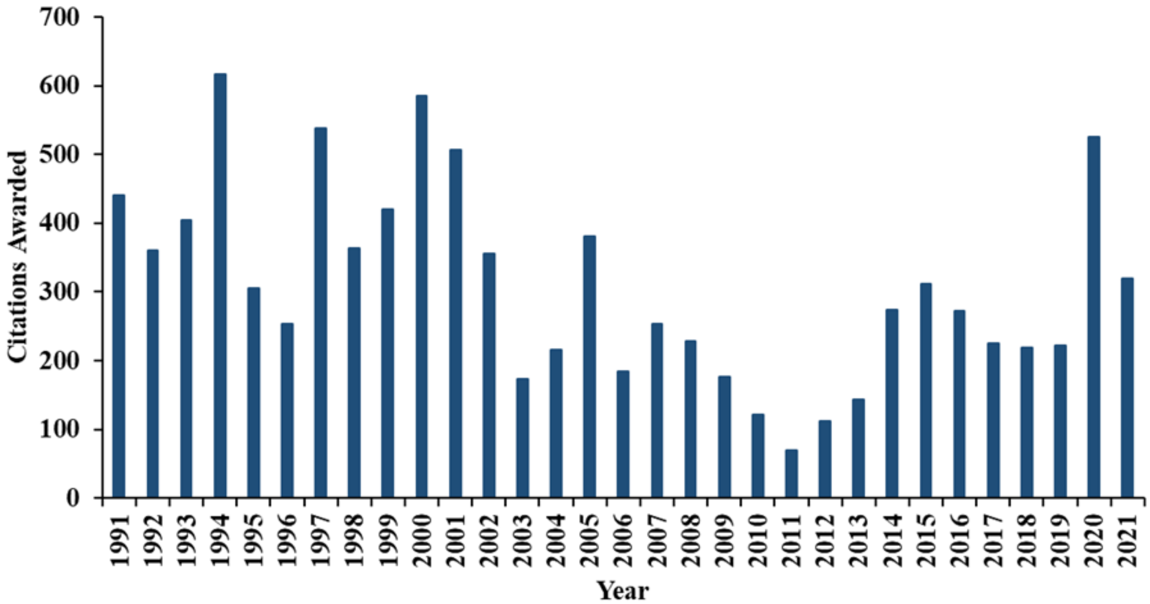


Figure 6. North Carolina Saltwater Fishing Tournament citations awarded for king mackerel, 1991–2021. Citations are awarded for king mackerel greater 30 pounds or 45 inches fork length.

FISHERY MANAGEMENT PLAN UPDATE
SCUP NORTH OF CAPE HATTERAS
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation: Incorporated into the Summer Flounder FMP through Amendment 8 in 1996

Amendment 8	1996
Regulatory Amendment	1996
Amendment 10	1997
Amendment 11	1998
Amendment 12	1999
Framework 1	2001
Addendum III	2001
Addendum IV	2001
Addendum V	2002
Addendum VII	2002
Framework 3	2003
Framework 4	2003
Addendum IX	2003
Addendum X	2003
Amendment 13	2003
Framework 5	2004
Addendum XI	2004
Addendum XIII	2004
Addendum XVI	2005
Framework 7	2007
Addendum XIX	2007
Amendment 14	2007
Amendment 16	2007
Addendum XX	2009
Amendment 15	2011
Amendment 19	2013
Amendment 17	2015
Amendment 18	2015
Framework 9	2016
Amendment 20	2017
Addendum XXIX	2017
Framework 10	2017
Framework 11	2018
Framework 12	2018
Framework 13	2018
Framework 14	2019

Framework 15	2020
Framework 16	2020

Comprehensive Review: 2021

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. Scup went through preliminary FMP development from 1978-1993 by the MAFMC. In 1995 MAFMC and ASMFC adopted the scup FMP but sequentially NMFS requested that the scup regulations be incorporated into another FMP to reduce the number of separate fisheries regulations. As a result, the scup FMP was incorporated into the summer flounder FMP as Amendment 8.

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 coastwide recreational harvest limit, allow states to customize scup recreational management measures to deal with burden issues associated with the implementation of coastwide 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 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 Council 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.

Framework 14 gives the Mid-Atlantic Council the option to waive the federal recreational black sea bass measures in favor of state measures through conservation equivalency; implements a transit zone for commercial and recreational summer flounder, scup, and black sea bass fisheries in Block Island Sound; and allows for the use of a maximum size limit in the recreational summer flounder and black sea bass fisheries.

Framework 15 established a requirement for commercial vessels with federal permits for all species managed by the Mid-Atlantic and New England Councils to submit vessel trip reports electronically within 48 hours after entering port at the conclusion of a trip.

Framework 16 modified MAFMC's ABC control rule and risk policy. The revised risk policy is intended to reduce the probability of overfishing as stock size falls below the target biomass while allowing for increased risk and greater economic benefit under stock biomass conditions. This action also removed the typical/atypical species distinction currently included in the risk policy.

Specific details for each Amendment under development include:

Summer Flounder, Scup, and Black Sea Bass Commercial/Recreational Allocation Amendment was jointly approved in December 2021 and selected preferred alternatives for each species. The Council is preparing this amendment for submission to NMFS for review and rulemaking.

The Recreational Harvest Control Rule Framework/Addenda is under the public hearing stage. The Draft Addenda proposes five possible approaches for setting recreational measures. Key differences between the options include the information considered when setting measures and the circumstances under which measures would change. These differences have implications for how often measures would change and the magnitude of those changes. Taking final action on these addenda will not implement any specific bag, size, or season limits but will modify the specification process for setting specific measures. In February 2021, the Council and Policy Board agreed to focus on the Harvest Control Rule through a joint framework/addenda. In August and October of 2021, the Council and Policy Board reviewed and provided feedback on a draft range of alternatives. In February 2022 the Council and Policy Board approved a range of alternatives which are currently going through the public hearing process. taken out to public hearings.

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 2022).

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 Scup FMP are to:

- Reduce fishing mortality in the scup fisheries to assure that overfishing does not occur.
- Reduce fishing mortality on immature scup to increase spawning stock biomass.
- Improve the yield from these fisheries.
- Promote compatible management regulations between state and federal jurisdictions.
- Promote uniform and effective enforcement of regulations.
- 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.

DESCRIPTION OF THE STOCK

Biological Profile

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 2019 scup operational stock assessment included data through 2018 and indicated that the stock was not overfished, and overfishing was not occurring in 2018. The 2021 management track stock assessment indicated that the scup stock status has not changed.

Stock Assessment

The 2019 scup operational 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. Spawning stock biomass was estimated to be 2 times above biomass reference points. The 2019 stock assessment report can be found on the scup page on the ASMFC website for further information.

DESCRIPTION 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 coastwide 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; 8-inch fork length minimum size, 50-fish creel limit in federal Atlantic Ocean waters north of Cape Hatteras. Season is year-round.

Commercial Fishery

All scup landings are reported through the North Carolina Trip Ticket Program. Flounder trawl is the main gear landing scup from north of Cape Hatteras (Figure 1). Annual landings were variable from 1994 through 2021 with very low landings during 2012, 2013 and 2020 (Table 1, Figure 2). Landings in 2021 increased slightly since 2020. Low landings in 2012 to 2013 were partly due to shoaling at Oregon Inlet limiting access 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 2021, winter trawl vessels returned to North Carolina (mainly Beaufort and Washington areas) to land catches rather than landing in Virginia and other states.

Recreational Fishery

All scup harvest is reported through the National Oceanic and Atmospheric Administration (NOAA) Marine Recreational Information Program. Recreational estimates across all years have been updated and are now based on the new Marine Recreational Information Program (MRIP) Fishing Effort Survey-based calibrated estimates. For more information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Recreational harvest of scup north of Cape Hatteras was only reported 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 2021. Annual mean lengths have been fairly consistent since 2001 and 2021 was consistent with past years. The number of scup measured in 2021 increased since 2020 (Table 2). Recreational harvest length data were only collected in 1994, 2000 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 as ASMFC has not requested it.

Fishery-Independent Monitoring

NCDMF currently does not have independent sampling programs in the Atlantic Ocean or internal estuarine waters north of Cape Hatteras that encounter scup.

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 unknow 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 on accurately 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 unknow at this time
- The commercial discard mortality rate was assumed to be 100 percent 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 unknow at this time

MANAGEMENT STRATEGY

Scup stock assessments are completed by the NMFS Northeast Fisheries Science Center (NEFSC). Results from the 2019 stock assessment update are used to guide management. Data are analyzed from the previous year based on decisions made for the benchmark assessment. 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 percent) and recreational (22 percent) fisheries. Beginning in 2023, catch-based allocations will continue, and revised allocations will be implemented with 65 percent being commercial and 35 percent being recreational. 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 coastwide measures in federal waters. The commercial quota is coastwide during the winter seasons (January-April; October-December) and state specific during the summer season (May-September).

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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 scup (north of Cape Hatteras) from North Carolina for the period 1994 – 2021. Note: * represents confidential data.

Year	Recreational			Commercial	
	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1994	827	1,231	365	304,350	304,715
1995	0	0	0	23,872	23,872
1996	0	1,267	0	58,559	58,559
1997	0	0	0	1,292	1,292
1998	0	0	0	14,718	14,718
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
2019	0	0	0	216,632	216,632
2020	0	0	0	38,719	38,719
2021	0	0	0	54,118	54,118
Mean	184	89	58	129,702	129,760

Table 2. Scup (north of Cape Hatteras) length (fork length, inches) data from commercial fish house samples in North Carolina, 1994-2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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	6	5	7	3
2000	7	5	12	25
2001	10	8	14	35
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
2019	11	6	17	3,037
2020	11	8	15	891
2021	11	7	16	1,628

Table 3. Scup (north of Cape Hatteras) length (fork length, inches) data from NOAA Marine Recreational Information Program recreational samples in North Carolina, 1994-2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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
2019	0	0	0	0
2020	0	0	0	0
2021	0	0	0	0

FIGURES

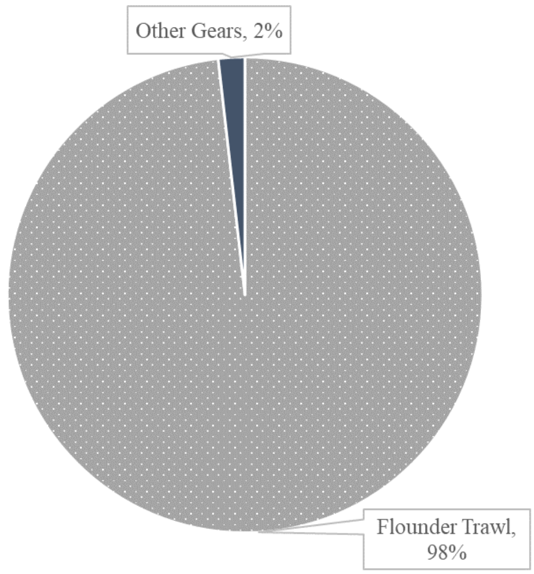

Figure 1. Commercial harvest of scup (north of Cape Hatteras) in North Carolina by gear type in 2021. Note: data for Other Gears are confidential data.

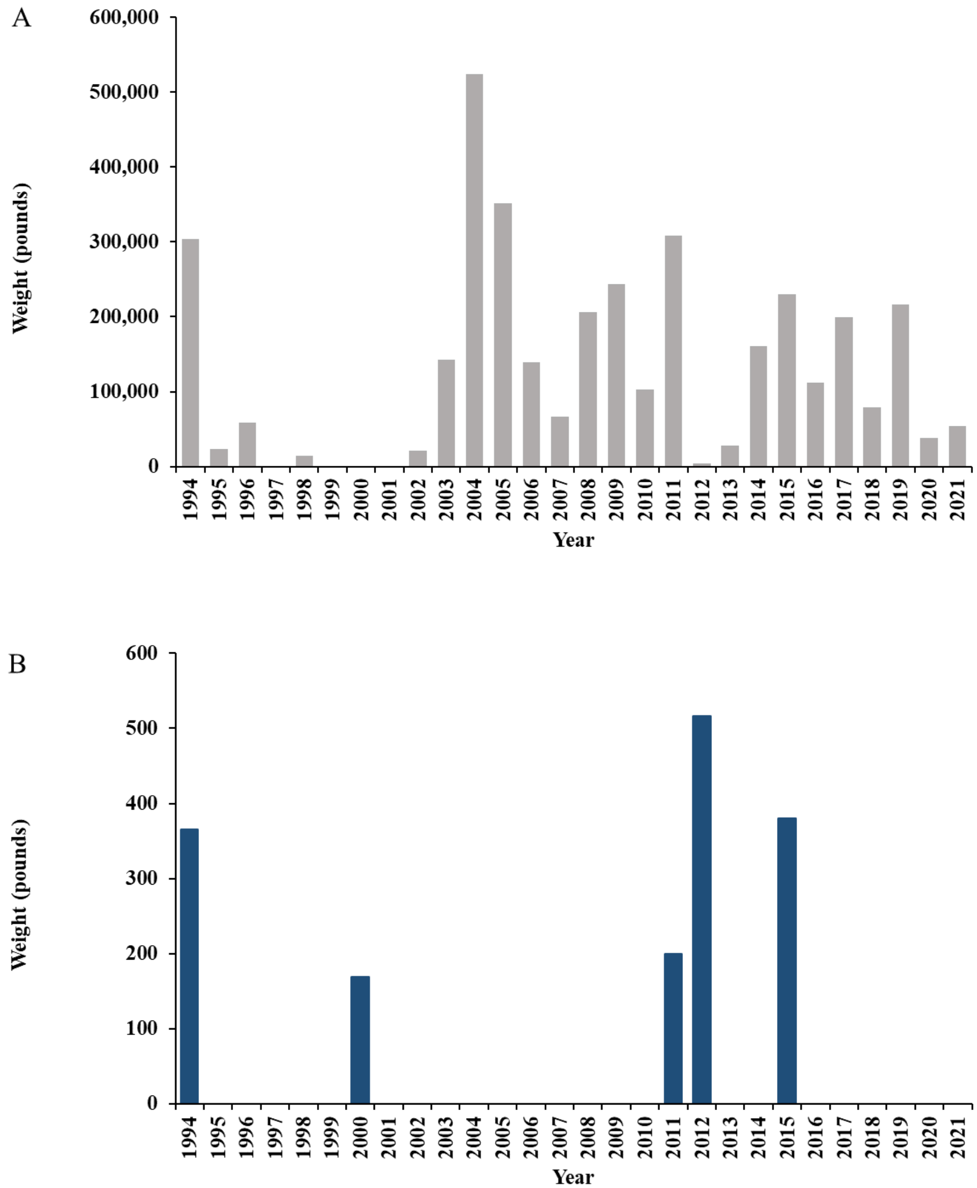

Figure 2. Annual commercial (A) and recreational (B) landings in pounds for scup (north of Cape Hatteras) in North Carolina from 1994-2021.

FISHERY MANAGEMENT PLAN UPDATE
COASTAL SHARKS
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	August 2008	
	Addendum I	September 2009
	Addendum II	May 2013
	Addendum III	October 2013
	Addendum IV	August 2016
	Addendum V	October 2018
Comprehensive Review:	2023: Blue shark (ICCAT)	
	2023: Hammerhead sharks Complex (SEDAR 77)	

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. Prior to the ASMFC FMP, sharks were domestically managed exclusively under National Marine Fisheries Service (NMFS) FMPs (NOAA Fisheries 1993; NOAA Fisheries 1999; NOAA Fisheries 2006). Atlantic HMS are also managed internationally by the International Commission for the Conservation of Atlantic Tunas (ICCAT). The ASMFC 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 NMFS openings and closures for all shark management groups.

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 weight 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 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 North Carolina 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 2022).

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. The management units for pelagic sharks and sandbar sharks (Shark Research Fishery) are not split by region; the respective management units are the Atlantic and Gulf of Mexico combined.

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:

- Reduce fishing mortality to rebuild stock biomass, prevent stock collapse, and support a sustainable fishery.
- Protect essential habitat areas such as nurseries and pupping grounds to protect sharks during particularly vulnerable stages in their life cycle.
- Coordinate management activities between state and federal waters to promote complementary regulations throughout the species' range.

- Obtain biological and improved fishery related data to increase understanding of state water shark fisheries.
- Minimize endangered species bycatch in shark fisheries.

DESCRIPTION OF THE STOCK

Biological Profile

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 rates are 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 (2–25) of 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 individual species when sufficient data is available (Table 1). For species that are data-limited, they are either assessed at the species complex level or have not been assessed. 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; NOAA Fisheries 2022). These reports are required under the Magnuson-Stevens Fishery Conservation and Management Act and provide the public with information on the latest updates in Atlantic HMS management.

Stock Assessment

Stock status varies between species and species groUup (Table 1). In 2015 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 Coastal 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 (NOAA Fisheries 2013). The dusky shark stock assessment was updated in 2016 and resulted in a determination of the population being overfished with overfishing occurring (SEDAR 2016). In 2017, a new sandbar shark stock assessment was conducted through SEDAR and the same status as the 2011 assessment was determined that the population was overfished but overfishing was not occurring (SEDAR 2017).

The 2007 SEDAR 13 assessed the SCS complex, finetooth (*Carcharhinus isodon*), Atlantic sharpnose (*Rhizoprionodon terraenovae*), and bonnethead (*Sphyrna tiburo*) sharks (SEDAR 2007). 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 (SEDAR 2013). Atlantic sharpnose status remained as not overfished or undergoing overfishing. Based on SEDAR 34, bonnethead were not overfished or undergoing overfishing. However, the assessment combined the Gulf of Mexico stock and the Atlantic stock for the assessment. Because data shows that they are in fact two separate stocks, the results of the assessment were rejected and the status of the Atlantic stock is officially considered unknown.

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. A new stock assessment for Atlantic blacktip sharks was completed in December 2020 (SEDAR 65) and the stock assessment concluded that the stock in not overfished and overfishing is not occurring.

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 (ICCAT 2017). The next stock assessment is scheduled for 2024.

Porbeagle sharks (*Lamna nasus*) were assessed by ICCAT in 2009 (ICCAT 2009). 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 most recent porbeagle shark stock assessment, which was completed in 2020, came to the same determination as the 2009 stock assessment; the northwest Atlantic stock is overfished but overfishing is not occurring (ICCAT 2020; NOAA Fisheries 2021).

The most recent blue shark stock assessment was completed in 2015 ICCAT (ICCAT 2015). The assessment found that domestically, the north Atlantic stock is not over fished and overfishing is not occurring. The international north Atlantic stock is not likely overfished and overfishing in not likely occurring. The next stock assessment is scheduled for 2023.

A 2009 stock assessment for the Northwest Atlantic and Gulf of Mexico populations of scalloped hammerhead sharks (*Sphyrna lewini*) indicated the stock is overfished and experiencing overfishing (Hayes et al. 2009). This assessment was reviewed by NOAA Fisheries and deemed appropriate to serve as the basis for U.S. management decisions (SEFSC 2010). In response to the assessment findings, NOAA Fisheries established a scalloped hammerhead rebuilding plan that will end in 2023. Since the assessment, research has determined that a portion of animals considered scalloped hammerheads in the US Atlantic are actually a cryptic species, recently named the Carolina hammerhead (*Sphyrna gilberti*; Quattro et al. 2013). Little to no species-specific information exists regarding the distribution, abundance, and life history of the two species. Therefore, both species are currently managed under the name scalloped hammerhead. The stocks of the species in the hammerhead complex (scalloped, Carolina, great, smooth) will be assessed through SEDAR 77. Completion is scheduled for spring 2023 (SEDAR 2021).

DESCRIPTION OF THE FISHERY

Current Regulations

All non-prohibited shark management groups opened in North Carolina on January 1, 2021 (Table 2) reflecting NOAA Fisheries openings. Commercial fishing shark management groups are outlined in Table 3. NOAA Fisheries closes the management groups' fisheries 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 is 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 (dw) of smooth dogfish carcasses landed or found onboard a vessel. It is unlawful for a vessel to retain, transport, 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 five inches) 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). In March 2019, NOAA HMS implemented final measures to address the overfishing and overfished condition of Atlantic shortfin mako under Amendment 11 to the HMS FMP (NOAA Fisheries 2019). 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. Additionally in 2019, the Board moved to require non-offset circle hooks for the recreational shark fishery in state waters with an implementation date of July 1, 2020. The Board chose to do so after NOAA Fisheries requested that the states implement a circle hook requirement for the recreational fishery consistent with the measures approved in HMS Amendment 11. Species authorized for recreational harvest are listed in Table 4 based on management group and recreational size and bag limits are described in Table 5.

Commercial Fishery

Table 2 summarizes preliminary coast-wide Atlantic commercial landings data from 2021. Shark management groups with Atlantic region quotas are LCS, hammerhead, non-blacknose SCS, blacknose, and smoothhound. Commercial landings of LCS totaled 304,054 pounds, dressed weight (lb, dw) in 2021, which was a decrease of 79,911 lb, dw from 2020. Total commercial landings of hammerhead sharks were 88,686 lb, dw in 2021, which was an increase from 76,990 lb, dw reported in 2020. Commercial landings of non-blacknose SCS shark species in 2021 totaled 427,103 lb, dw, a slight increase from 410,988 lb, dw landed in 2020. The commercial landings total of blacknose sharks south of 34º N latitude (Kure Beach, North Carolina) in 2021 was 20,890 lb, dw. Commercial retention of blacknose sharks is prohibited north of 34º N latitude. Commercial landings of smoothhound sharks in 2021 were 1,119,655 lb, dw, which was an increase from the 886,233 lb dw landed in 2020. Shark management groups with no regional quotas are sandbar (shark research fishery), blue, porbeagle, and other pelagics. There are no reported landings for porbeagle or blue sharks in 2021. Other pelagic shark landings were 122,289 lb, dw. The shark research fishery landed 41,388 lb, dw of sandbar sharks.

In North Carolina, total shark commercial landings steadily decreased since 2012 (Figure 1; Table 6). Smoothhound shark landings have steadily decreased from 980,285 lb dw in 2012 to 42,147 lb, dw in 2021. Peak harvest of pelagic sharks was highest in 2014 (424,531 lb, dw) and there has been an overall decreasing trend. In 2021, 44,648 b, dw of pelagic sharks were landed. While total shark landings have decreased, landings for the SCS and Hammerhead management groups have increased. LCS (non-hammerhead) harvest has fluxuated annually but has been fairly consistent over the last ten years. In 2021, LCS landings totaled 165,005 lb, dw.

Recreational Fishery

Recreational harvest estimates for SCS in North Carolina has fluctuated in the past 10 years from a low of 2,545 pounds in 2017 to a peak in harvest of 106,765 pounds in 2019 (Table 7). The 2021 landings (24,241 pounds) was similar to the 10-year average (27,086 pounds). Recreational harvest for LCS in North Carolina tends to be less than for SCS. Annual harvest was 594 pounds in 2021 and averaged 7,853 pounds from 2012 to 2021 (Table 8). Recreational harvest of pelagic sharks in North Carolina is highly variable. Harvest was 0 pounds in 2020 and has ranged from 0 to 479,443 pounds from 2012 to 2021 (Table 9). Recreational harvest of smooth dogfish in North Carolina is variable and often low, although releases are common. Harvest for smoothhound ranged from 0 to 186,261 (Table 10). Recreational landing estimates for all shark species across all years have been updated and are now based on the Marine Recreational Information Program (MRIP) new Fishing Effort Survey-based calibrated estimates. Due to small sample sizes and the relatively rare occurrence of landings, the percent standard errors (PSE) is high for many years of recreational shark landings. For more information on MRIP methodology and changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

North Carolina does not collect individual lengths for sharks other than spiny dogfish; sharks arrive at the dock dressed (i.e. gutted with head and tail removed). Landings in pounds dw are recorded by the Trip Ticket Program.

Fishery-Independent Monitoring

The North Carolina Division of Marine Fisheries (NCDMF) established a fishery-independent adult red drum longline survey in 2007 (P365) that operates in Pamlico Sound from July to October. Atlantic coastal shark species captured in the survey are measured, tagged, and released. No sharks were captured during this survey in 2021. NCDMF has conducted a fishery-independent gill net survey (P915) which has been conducted in Pamlico Sound since 2001 and has been sampled continuously through 2019. In 2020 and part of 2021, sampling for this survey was suspended due to impacts from the COVID Pandemic and permit issues. Sampling resumed July 1, 2021. 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 2021, a total of 11 individual coastal sharks were captured in P915 (Table 11), which is less than the project's annual average of 134 individual sharks.

RESEARCH NEEDS

The review of the ASMFC FMP (ASMFC 2021) for coastal sharks lists the following research needs:

Species-Specific Priorities

- Investigate the appropriateness of using vertebrae for aging adult sandbar sharks. If appropriate, implement a systematic sampling program that gathers vertebral samples from entire size range for annual aging 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.
- Investigate sex- and life stage-specific movements of blacktip sharks to determine if migratory behaviors change based on maturity or reproductive condition. Additionally blacktip sharks should be tagged throughout their range, including the northern extent of the population range off New York, to gain a more complete understanding of migratory and residency patterns.

General Priorities

- 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 genetics and 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.

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 and management groups. The ASMFC adopts NOAA Fisheries regulations in state waters.

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TABLES

Table 1. 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	2020: Rebuilding ends in 2108
Blue	No	No	2015
Shortfin Mako	Yes	Yes	2017
All other pelagic species	Unknown	Unknown	
Large Coastal Sharks			
Blacktip	No	No	2020:
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	Unknown	Unknown	2013
Finetooth	No	No	2007
Hammerhead			
Scalloped	Yes	Yes	2009: Rebuilding ends in 2023
Blacknose			
Blacknose	Yes	Yes	2011: Rebuilding ends in 2043
Smoothhound			
Smooth Dogfish	No	No	2015
Research			
Sandbar	Yes	No	2017: Rebuilding ends 2070
Prohibited			
Dusky	Yes	Yes	2016: Rebuilding ends in 2107
All other prohibited species	Unknown	Unknown	

Table 2. Preliminary 2021 coast-wide Atlantic coastal shark commercial fishery landings (Atlantic Coastal Cooperative Statistics Program, ACCSP) and annual quota.

Management Group	Region	2021 Quota (lb dw)	Season Opening	Season Closing	2021 Landings (lb dw)
Aggregated LCS	Atlantic	372,552	1/1/21	12/31/21	304,054
Hammerhead		59,736			88,686
Non-Blacknose SCS		582,333			427,103
Blacknose (South of 34° N. latitude only)		37,921			20,890
Smoothhound		3,973,902			1,119,655
Sandbar (shark research fishery)	No Regional Quotas	199,943			41,388
Blue		601,856			0
Porbeagle		3,748			0
Other pelagics		1,075,856			122,289

Table 3. List of commercial shark management groups.

Management Group	Species Within Group
Prohibited	Sand tiger, bigeye sand tiger, whale, basking, white, dusky, bignose, Galapagos, night, reef, narrowtooth, Caribbean sharpnose, smalltail, Atlantic angel, longfin mako, bigeye thresher, sharpnose sevengill, bluntnose sixgill, and bigeye sixgill sharks
Research	Sandbar sharks
Non-Blacknose Small Coastal	Atlantic sharpnose, finetooth, and bonnethead sharks
Blacknose	Blacknose sharks
Aggregated Large Coastal	Silky, tiger, blacktip, spinner, bull, lemon, and nurse
Hammerhead	Scalloped hammerhead, great hammerhead, and smooth hammerhead
Pelagic	Shortfin mako, common thresher, oceanic whitetip, *porbeagle, and *blue sharks
Smoothhound	Smooth dogfish (referred to as smoothhound throughout this report)

*Although porbeagle and blue sharks are in the Pelagic Management Group, they each have their own quota.

Table 4. 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 5. Recreational size and bag limits (as of June 13, 2022). Non-listed species are prohibited.

RECREATIONAL SIZE / BAG LIMITS and SEASONS			
Species*	Minimum Size (FL, inches)	Trip Bag Limit/Calendar Day	Season
Atlantic sharpnose	None	1 per person of each species	Jan. 1 – Dec. 31
Bonnethead	None		
Smooth dogfish	None	None	
Hammerheads (Great, Smooth and Scalloped)	78”	1 per vessel <u>OR</u> 1 per person for shore-anglers	
Shortfin mako**	71” males 83” females		
Non-Hammerhead LCS, Tiger, Pelagic, Blacknose, and Finetooth Sharks	54”		

*Check NCDMF proclamations for most current regulations
**Further restrictions anticipated for shortfin makos in 2022

Table 6. Summary of North Carolina commercial landings (pounds) for large coastal sharks (LCS), small coastal sharks (SCS), hammerheads, smoothhound, and pelagics, 2012–2021. In this table, sandbar shark landings are included with the LCS and SCS includes blacknose landings.

Year	LCS (non-hammerhead)	SCS	Hammerhead	Smoothhound	Pelagics	Total
2012	121,674	279,442	15,404	980,285	243,121	1,639,926
2013	157,340	140,798	14,428	783,053	220,872	1,316,491
2014	340,708	204,572	28,264	498,904	424,531	1,496,978
2015	197,948	375,026	41,768	268,429	176,882	1,060,053
2016	288,081	371,140	62,135	178,694	224,746	1,124,796
2017	216,142	359,486	40,743	154,440	240,128	1,010,939
2018	201,146	430,382	55,004	209,760	125,993	1,022,285
2019	263,269	479,484	65,104	102,592	69,182	979,631
2020	209,939	318,268	75,339	49,286	99,468	752,300
2021	165,005	297,193	85,966	42,147	44,648	634,959

Table 7. North Carolina small coastal sharks recreational harvest, discards, and percent standard error (PSE) (including blacknose), 2012–2021.

Year	Number Harvested	PSE	Weight (lb)	PSE	Number Released	PSE
2012	2,082	47.5	11,804	48.4	7,733	43.5
2013	2,171	45.9	13,474	48.0	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	57.0
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
2019	13,736	70.8	106,765	75.8	34,952	36.1
2020	5,074	70.2	21,114	56.0	16,563	50.9
2021	3,556	57.7	24,241	53.9	21,045	44.9

*PSE higher than 50 indicates a very imprecise estimate

Table 8. North Carolina large coastal sharks recreational harvest, discards, and percent standard error (PSE), 2012–2021. Blank indicates years with estimated harvest of zero.

Year	Number Harvested	PSE	Weight (lb)	PSE	Number Released	PSE
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
2019	60	72.1	3,745	72.1	30,032	40.5
2020	26	74.6	551	100.8	8,567	36.0
2021	6	100.8	594	100.8	22,576	97.5

*PSE higher than 50 indicates a very imprecise estimate

Table 9. North Carolina pelagic sharks recreational harvest, discards, and percent standard error (PSE), 2012–2021. Blank indicates years with estimated harvest of zero.

Year	Number Harvested	PSE	Weight (lb)	PSE	Number Released	PSE
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
2019					888	65.7
2020						
2021	111	98.1			20	96.9

*PSE higher than 50 indicates a very imprecise estimate

Table 10. North Carolina recreational harvest, discards, and percent standard error (PSE) of smoothhound, 2012–2021. Blank indicates years with estimated harvest of zero.

Year	Number Harvested	PSE	Weight (lb)	PSE	Number Released	PSE
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
2019	2,856	95.6	6,926	95.6	15,301	73.6
2020	1,289	98.9	3,125	98.9	479,933	49.4
2021	0	.	0	.	10,815	89.9

*PSE higher than 50 indicates a very imprecise estimate

Table 11. Shark species captured in the NCDMF 2021 Pamlico Sound Independent Gill Net Survey (P915).

Species	Total Number Measured	Mean Total Length (inches)	Minimum Total Length (inches)	Maximum Total Length (inches)
Bull shark	7	26.3	21.6	31.9
Bonnethead	3	35.2	28.6	42.2
Requiem/unidentified	1	28.9	28.9	28.9

FIGURES

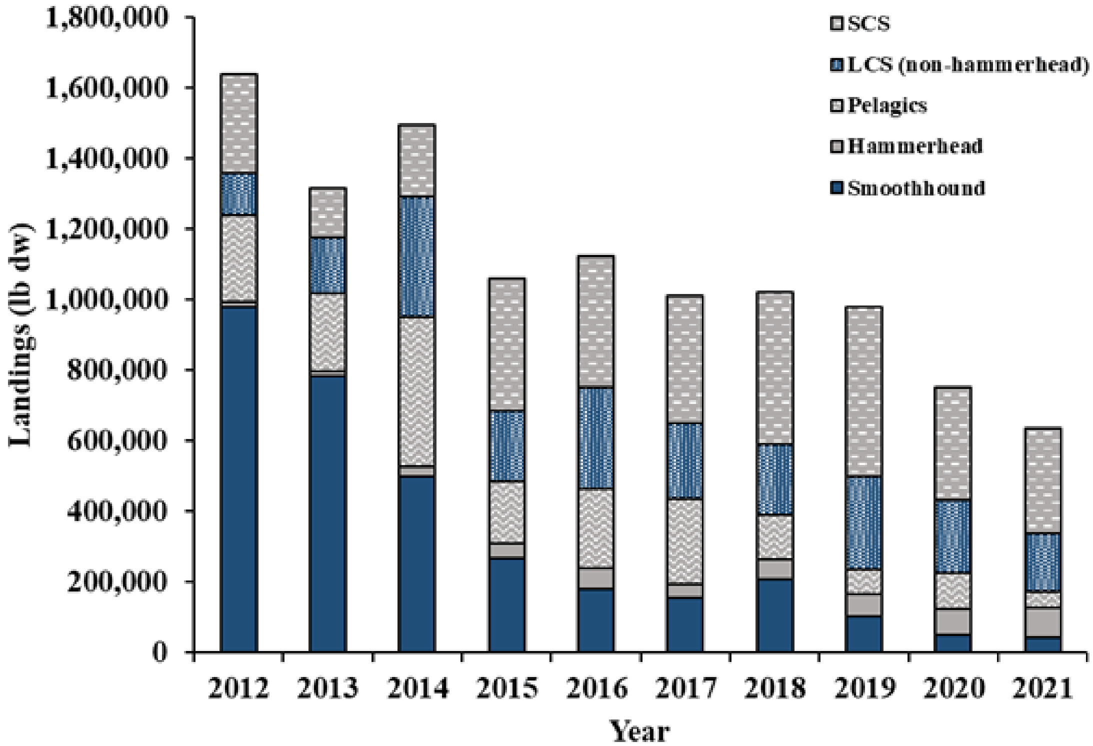

Figure 1. North Carolina commercial shark landings by management group, 2012–2021. In this figure, sandbar shark landings are included with the LCS and SCS includes blacknose landings.

FISHERY MANAGEMENT PLAN UPDATE
SNAPPER GROUPER COMPLEX
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation: August 1983 (SAFMC 1983a, b; 48 FR 39463)

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
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
Amendment 42	January 2020
Regulatory Amendment 27	February 2020
Regulatory Amendment 30	March 2020
Regulatory Amendment 26	March 2020
Regulatory Amendment 29	July 2020
Abbreviated Framework Amendment 3	August 2020
Regulatory Amendment 33	November 2020
Amendment 39	January 2021
Regulatory Amendment 34	May 2021

Comprehensive Review: None

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 1990s 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 degrees and 30 degrees 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 deep-water 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 deep-water closure (240 feet seaward) for deep-water 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 deep-water 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 were 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.

Amendment 42 (SAFMC 2019a; FR 84 67236) modified the sea turtle handling and release gear requirements for the snapper grouper fishery, clarified the requirements for other release gears, and modified the FMP framework procedure to implement newly approved devices and handling requirements for sea turtles and other protected resources.

Regulatory Amendment 27 (SAFMC 2019b; FR 85 4588) modified the commercial trip limits for blueline tilefish, greater amberjack, red porgy, and vermilion snapper; established commercial split seasons for snowy grouper, greater amberjack, and red porgy; established a commercial trip limit for the “other” jacks complex; established a minimum size limit for almaco jack; and removed the minimum size limits for silk, queen , and blackfin snappers; and reduced the minimum size limit for gray triggerfish in the EEZ off the east coast of Florida.

Regulatory Amendment 30 (SAFMC 2019c; FR 85 6825) revised the rebuilding schedule for red grouper based on the most recent stock assessment and modified the spawning season closure for the commercial and recreational sectors in the EEZ off North Carolina and South Carolina, and established a 200 pound commercial trip limit.

Regulatory Amendment 26 (SAFMC 2019d; FR 85 11307) removed the recreational minimum size limits for silk snapper, queen snapper, and blackfin snapper, reduced the recreational minimum size limit for gray triggerfish in the EEZ off the east coast of Florida, and modified the snapper grouper aggregate bag limit for the 20-fish aggregate.

Regulatory Amendment 29 (SAFMC 2020c; FR 85 36166) modified gear requirements for South Atlantic snapper grouper species. Actions include requirements for descending and venting devices, and modifications to requirements for circle hooks and powerheads.

Abbreviated Framework Amendment 3 (SAFMC 2020d; FR 85 43145) increased the commercial and recreational ACLs and increased the recreational ACT for blueline tilefish in the South Atlantic EEZ based on updated information from a SEDAR benchmark assessment that was completed for the Atlantic stock of blueline tilefish, using data through 2015 (SEDAR 50).

Regulatory Amendment 33 (SAFMC 2020b; FR 85 64978) removed the four-day minimum season length requirement for South Atlantic red snapper (commercial or recreational) to improve access to South Atlantic red snapper, particularly for the recreational sector.

Amendment 39 (SAFMC 2020e; FR 85 10331) established new, and revised existing, electronic reporting requirements for federally permitted charter vessels and headboats, in certain Atlantic fisheries to increase and improve fisheries information collected from federally permitted for-hire vessels in the Atlantic.

Regulatory Amendment 34 (SAFMC 2020a; FR 86 17318) created 34 special management zones (SMZs) around artificial reefs in the EEZ off North Carolina and South Carolina to designate new SMZs and to restrict fishing gear with greater potential to result in high exploitation rates.

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 Interjurisdictional Fisheries Fishery Management Plan (IJ FMP). The goal of the IJ FMP is to adopt FMPs, consistent with N.C. law, approved by the Mid-Atlantic Fishery Management Council, SAFMC, or the Atlantic States Marine Fisheries Commission (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 2022).

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).

Goal and Objectives

The following are the FMP 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).

- Prevent overfishing.
- Collect necessary data.
- Promote orderly utilization of the resource.

- Provide for a flexible management system.
- Minimize habitat damage.
- Promote public compliance and enforcement.
- Mechanism to vest participants.
- Promote stability and facilitate long-run planning.
- Create market-driven harvest pace and increase product continuity.
- Minimize gear and area conflicts among fishermen.
- Decrease incentives for overcapitalization.
- Prevent continual dissipation of returns from fishing through open access.
- Evaluate and minimize localized depletion.

DESCRIPTION OF THE STOCK

Biological Profile

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 ontogenetic (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: https://safmc.net/fishery-management-plans/snapper-grouper/.

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 gag grouper, red grouper, red porgy, red snapper, hogfish (east Florida), and snowy grouper. Stocks experiencing overfishing are blueline tilefish, gag grouper, red snapper, snowy grouper, speckled hind, and Warsaw grouper.

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.

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 at: https://www.fisheries.noaa.gov/national/population-assessments/fishery-stock-status-updates.

DESCRIPTION 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 TL (commercial)
- Red porgy: 14-inch TL
- Vermilion, gray, cubera and yellowtail 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
- Almaco jack: 20-inch FL (commercial)

All species have sector ACLs and recreational bag limits and/or commercial trip limits. See the SAFMC (https://safmc.net/regulations/) or NCDMF (http://portal.ncdenr.org/web/mf/proclamations-current) 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' landings and/or catch data
- January-April shallow water grouper spawning closure (commercial and recreational); Red grouper remains closed through May in North and South Carolina
- 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 recreational fishery open May 1- August 31
- Blueline tilefish recreational fishery open May 1 – July 26

Temporary closures may result for a species if the ACL is met or projected to be met. NOAA Fisheries monitors the landings for species managed by the 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 Fishery

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 deep-water 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 1994-2021 was 1,963,069

pounds with a dockside value of $4,026,698[1] (Table 3). In 2021, 977,318 pounds of snapper grouper species were caught commercially in North Carolina. The highest landings from the past 28 years were in 2008, after which landings dropped; landings have been under two million pounds for the last ten years (Figure 1A). The decline in landings over the past ten years is most likely due to the removal of species from the complex, as well as the changes to ACLs and trip limits and implementation of a seasonal spawning closure by the SAFMC.

Over the last five years, landings have been dominated by six main aggregates; black 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 Fishery

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 1,909,068[2] pounds for 1994-2021. Since 2008, the total amount of fish landed declined steadily until 2013 (Table 5, Figure 1B). The number of fished harvested declined roughly 60% from 2017 to 2018 and harvest weight decreased 48%. As no major management changes to the recreational sector contributed to this decrease in landings, it is likely due to the impacts of Hurricane Florence on coastal North Carolina. The number of fish harvested decreased 42% from 2020 to 2021 and harvest weight decreased 42%. Recreational landings (by weight) have dropped roughly 79% since a 28-year high (4,773,359 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 50% 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 2021, the dominant species (by pounds) landed were groupers, snappers, jacks, triggerfish, tilefish, and grunts (Table 6). This pattern mainly holds true for the last five years; however, other species are occasionally more dominant.

MONITORING PROGRAM DATA

Fishery-dependent and fishery-independent data collected by NCDMF from the snapper grouper fishery is provided to NOAA Fisheries. In 2006, the division received a Marine Fisheries Initiative Program (MARFIN) grant to collect ageing structures of the snapper grouper species, determine the age structure of the black sea bass stock south of Cape Hatteras, and estimate release mortality of the of the commercial snapper grouper fishery. Funding for the grant ended in 2014. Data collected for this grant is summarized in the final 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 2021, NCDMF recorded 7,615 lengths from individual fish from the snapper grouper fishery of which 1,156 were black sea bass south of Cape Hatteras (Table 7). In 2021, 104 black sea bass were measured from the recreational fishery with an average total length (TL) of 14 inches (Table 8, Figure 2). Total length has ranged from 4 inches to 21 inches since 1994 (Table 8, Figure 4). In 2021, 510 black sea bass south of Cape Hatteras were measured from the commercial fishery with an average TL of 14 inches (Table 7, 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 2021 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 2021, NCDMF collected 4,811 age structures from the snapper grouper fishery of which 490 came from black sea bass (Table 7). Since 2004, the modal age of black sea bass collected each year is 4 with the exception of 2011, 2018, 2019 and 2021 where the modal age was 3, 5, 6 and 5 (Table 9). 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.

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

MANAGEMENT STRATEGY

The snapper grouper complex is managed under the various amendments of the SAFMC FMP. 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.

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TABLES

Table 1. Amendments under consideration/review by the South Atlantic Fishery Management Council (SAFMC). Summaries of the issues the amendment addresses are included; documentation is provided as available.

Amendment	Issue addressed	Where in process	Documentation
Amendment 50	Red porgy catch levels, allocations and rebuilding	Under development by Council	SAFMC 2021a
Amendment 49	Greater amberjack catch levels and allocations	Under development by Council	SAFMC 2021b
Regulatory Amendment 31	Revisions to snapper grouper recreational accountability measures	Work on hold	SAFMC 2019e
Amendment 46	Private recreational reporting and permitting	Amendment on hold	SAFMC 2017g
Amendment 35	Release mortality issues in the snapper grouper fishery and modifications to red snapper catch levels	Scoping	SAFMC 2022a
Amendment 53	Gag grouper rebuilding, catch levels, and allocations	Scoping	SAFMC 2022b
Amendment 52	Golden tilefish allocations and blueline tilefish bag limit and accountability measures	Scoping	SAFMC 2022c
Amendment 51	Snowy grouper catch levels, sector allocations, management measures, and accountability measures	Scoping	SAFMC 2022d
Amendment 44	Yellowtail snapper catch levels	Scoping	SAFMC 2022e
Amendment 46	Private recreational reporting and permitting	Pre-scoping	SAFMC 2022f
Amendment 45	Modifies the Acceptable Biological Catch (ABC) Control Rule to address scientific uncertainty, management risk, and rebuilding stocks. Specifies criteria and procedures for phase-in of ABC changes and carry-over of unused portions of annual catch limits	Scoping	SAFMC 2022g
Amendment 54	Reporting requirements for commercial logbooks in the snapper grouper, coastal migratory pelagics, and dolphin-wahoo fisheries.	Pre-scoping	SAFMC 2022h

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 North Carolina Division of Marine Fisheries due to the nature of the fishery.

Family (species aggregate)	Species	Overfishing?	Overfished?	Documentation
Serranidae (Sea basses and groupers)	Gag (*Mycteroperca microlepis*)	Yes	Yes	SEDAR 71 (SEDAR 2021a); NMFS 2020
	Red grouper (*Epinephelus morio*)	No	Yes	SEDAR 53 (SEDAR 2017a); NMFS 2021
	Scamp (*Mycteroperca phenax*)	No	Unknown	NMFS 2021
	Black grouper (*Mycteroperca bonaci*)	No	No	SEDAR 19 (SEDAR 2010); NMFS 2021
	Rock hind (*Epinephelus adcensionis*)	Unknown	Unknown	NMFS 2021
	Red hind (*Epinephelus guttatus*)	Unknown	Unknown	NMFS 2021
	Graysby (*Cephalopholis cruentata*)	Unknown	Unknown	NMFS 2021
	Yellowfin grouper (*Mycteroperca venenosa*)	Unknown	Unknown	NMFS 2021
	Coney (*Cephalopholis fulva*)	Unknown	Unknown	NMFS 2021
	Yellowmouth grouper (*Mycteroperca interstitialis*)	Unknown	Unknown	NMFS 2021
	Goliath grouper (*Epinephelus itajara*)	No (Permanent closure)	Unknown	SEDAR 47 (SEDAR 2016d); NMFS 2021
	Nassau grouper (*Epinephelus striatus*)	No (Permanent closure)	Unknown	NMFS 2021
	Snowy grouper (*Epinephelus niveatus*)	Yes	Yes	SEDAR 36 Update (SEDAR 2020c); NMFS 2021
	Yellowedge grouper (*Epinephelus flavolimbatus*)	Unknown	Unknown	NMFS 2021
	Warsaw grouper (*Epinephelus nigritus*)	Yes (Permanent closure)	Unknown	SG Amendment 17b (SAFMC 2010b); NMFS 2021
	Speckled hind (*Epinephelus drummondhayi*)	Yes (Permanent closure)	Unknown	SG Amendment 17b (SAFMC 2010b); NMFS 2021
	Misty grouper (*Epinephelus mystacinus*)	Unknown	Unknown	NMFS 2021
	Black sea bass (*Centropristis striata*)	No	No	SEDAR 56 (SEDAR 2018b); NMFS 2021
	Bank sea bass (*Centropristis ocyurus*)*	N/A	N/A	N/A
	Rock sea bass (*Centropristis philadelphica*)*	N/A	N/A	N/A
Polyprionidae (Wreckfish)	Wreckfish (*Polyprion americanus*)	No	No	Rademeyer and Butterworth 2014; NMFS 2021

** 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**
Lutjanidae (Snappers)	Queen snapper (*Etelis oculatus*)	Unknown	Unknown	NMFS 2021
	Yellowtail snapper (*Ocyusus chrysurus*)	No	No	SEDAR 27A (SEDAR 2012b); NMFS 2021
	Gray snapper (*Lutjanus griseus*)	Unknown	Unknown	NMFS 2021
	Mutton snapper (*Lutjanus analis*)	No	No	SEDAR 15A Update (SEDAR 2015); NMFS 2021
	Lane snapper (*Lutjanus synagris*)	Unknown	Unknown	NMFS 2021
	Cubera snapper (*Lutjanus cyanopterus*)	Unknown	Unknown	NMFS 2021
	Vermilion snapper (*Rhomboplites aurorubens*)	No	No	SEDAR 55 (SEDAR 2018a); NMFS 2021
	Red snapper (*Lutjanus campechanus*)	Yes	Yes	SEDAR 73 (SEDAR 2021b); NMFS 2021
	Silk snapper (*Lutjanus vivanus*)	Unknown	Unknown	NMFS 2021
	Blackfin snapper (*Lutjanus buccanella*)	Unknown	Unknown	NMFS 2021
Sparidae (Porgies)	Red Porgy (*Pagrus pagrus*)	No	Yes	SEDAR 60 (SEDAR 2020a); NMFS 2021
	Knobbed porgy (*Calamus nodosus*)	Unknown	Unknown	NMFS 2021
	Jolthead porgy (*Calamus bajonado*)	Unknown	Unknown	NMFS 2021
	Scup (*Stenotomus chrysops*)	Unknown	Unknown	NMFS 2021
	Whitebone porgy (*Calamus leucosteus*)	Unknown	Unknown	NMFS 2021
	Saucereye porgy (*Calamus calamus*)	Unknown	Unknown	NMFS 2021
	Longspine porgy (*Stenotomus caprinus*)*	N/A	N/A	N/A
Haemulidae (Grunts)	White grunt (*Haemulon plumieri*)	Unknown	Unknown	NMFS 2021
	Margate (*Haemulon album*)	Unknown	Unknown	NMFS 2021
	Tomtate (*Haemulon aurolineatum*)	Unknown	Unknown	NMFS 2021
	Sailor's choice (*Haemulon parra*)	Unknown	Unknown	NMFS 2021
	Cottonwick (*Haemulon melanurum*)*	N/A	N/A	N/A

** 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
Carangidae (Jacks)	Greater Amberjack (*Seriola dumerili*)	No	No	SEDAR 59 (SEDAR 2020b); NMFS 2021
	Almaco jack (*Seriola rivoliana*)	Unknown	Unknown	NMFS 2021
	Banded rudderfish (*Seriola zonanta*)	Unknown	Unknown	NMFS 2021
	Bar jack (*Caranx ruber*)	Unknown	Unknown	NMFS 2021
	Lesser Amberjack (*Seriola fasciata*)	Unknown	Unknown	NMFS 2021
Malacanthidae (Tilefishes)	Golden tilefish (*Lopholatilus chamaeleonticeps*)	No	No	SEDAR 66 (SEDAR 2021c); NMFS 2021
	Blueline (or gray) tilefish (*Caulolatilus microps*)	Yes**	No	SEDAR 50 (SEDAR 2017b); NMFS 2021
	Sand tilefish (*Malacanthus plumier*)	Unknown	Unknown	NMFS 2021
Balistidae (Triggerfishes)	Gray triggerfish (*Balistes capriscus*)	No	Unknown	SEDAR Assessment 41 (SEDAR 2016c); NMFS 2020
	Ocean triggerfish (*Canthidermis sufflamen*)*	N/A	N/A	N/A
Labridae (Wrasses)	Hogfish (*Lachnolaimus maximus*)	Unknown (Carolinas); No (Florida)	Unknown (Carolinas); Yes (Florida)	SEDAR 37 (SEDAR 2013b); NFMS 2021
Eppiphidae (Spadefishes)	Atlantic spadefish (*Chaetodipterus faber*)	Unknown	Unknown	NMFS 2021

* *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, 1994–2021. Sheepshead were removed from the fishery in 2012 and therefore not included past 2011.

Year	Weight of harvested fish (lb)	Value of Landings (USD)
1994	2,933,341	$4,085,919
1995	2,785,388	$3,844,162
1996	2,587,459	$3,601,700
1997	2,748,156	$4,053,647
1998	2,501,675	$3,931,486
1999	2,372,662	$3,981,057
2000	2,151,795	$3,762,290
2001	2,178,180	$3,652,941
2002	2,356,065	$3,930,591
2003	1,953,932	$3,375,178
2004	2,014,492	$3,522,424
2005	1,889,095	$3,567,882
2006	2,140,639	$4,332,986
2007	2,324,605	$5,247,798
2008	2,748,626	$5,990,474
2009	2,625,280	$5,263,009
2010	2,281,867	$4,877,050
2011	1,613,928	$3,911,719
2012	1,651,545	$4,169,682
2013	1,445,346	$3,918,164
2014	1,427,568	$3,845,196
2015	1,161,861	$3,324,493
2016	1,246,432	$3,715,347
2017	1,259,683	$3,825,047
2018	1,250,750	$3,887,827
2019	1,315,444	$4,452,724
2020	1,022,800	$3,398,422
2021	977,318	$3,278,321
Mean	1,963,069	$4,026,698

Table 4. Landings (in pounds) of snapper grouper, by aggregate groups, for the commercial fishery, 1994–2021. Aggregate groups are those used by the South Atlantic Fishery Management Council 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 and the Mid-Atlantic Fisheries Management Council. Wreckfish landings are confidential and are excluded.

Year	Black sea bass	Grouper	Snapper	Porgies	Grunts	Jacks	Tilefish	Triggerfish	Hogfish	Spadefish	Unclassified
1994	456,086	775,414	450,221	344,074	202,983	151,984	231,584	271,503	19,133	23,347	7,011
1995	348,077	773,372	403,499	355,210	184,799	171,510	160,860	304,540	33,507	40,873	9,142
1996	489,883	651,105	350,206	338,242	106,851	139,669	158,586	277,741	13,841	55,890	5,445
1997	518,260	719,513	366,482	264,012	131,974	178,310	149,402	342,134	14,010	57,384	6,676
1998	523,253	745,591	352,020	269,092	108,162	101,739	67,770	274,641	12,037	38,994	8,375
1999	491,434	758,059	441,783	178,690	95,008	129,245	76,697	150,387	12,405	34,320	4,634
2000	414,282	636,942	510,897	143,212	81,338	127,116	85,467	88,277	7,727	46,235	10,303
2001	477,123	558,626	523,742	148,513	94,422	121,966	106,674	87,628	8,203	41,994	9,290
2002	432,332	699,579	490,591	145,394	102,158	120,644	220,331	90,934	10,637	38,400	5,067
2003	476,511	651,941	269,230	108,931	65,379	135,991	87,102	117,396	9,135	28,519	3,797
2004	506,376	584,722	339,453	127,543	81,075	106,507	78,126	136,211	8,902	44,521	1,055
2005	321,858	579,194	432,829	101,936	90,364	122,361	44,014	145,639	7,877	35,445	7,578
2006	443,567	708,823	345,071	130,363	118,234	101,722	138,090	126,354	7,296	19,623	1,496
2007	277,454	827,622	550,617	175,215	118,545	133,519	58,218	155,261	7,112	19,567	1,476
2008	275,764	785,429	602,838	204,349	91,292	160,769	404,295	198,724	13,035	11,694	438
2009	437,969	637,438	374,081	231,478	74,054	153,099	469,293	215,759	10,839	20,636	635
2010	292,879	561,753	320,260	242,520	47,219	128,466	430,394	225,682	13,046	18,827	821
2011	173,681	408,332	326,371	211,792	33,451	72,797	133,824	220,204	10,793	21,535	1,149
2012	194,778	381,929	279,368	83,969	49,734	124,325	361,094	143,114	8,256	24,238	739
2013	241,367	311,056	276,533	72,966	44,718	90,122	217,079	160,861	7,847	20,369	2,429
2014	316,421	299,555	251,087	82,918	39,333	193,049	91,074	116,782	9,767	22,761	4,822
2015	226,337	261,031	232,030	54,496	32,702	146,584	45,354	131,536	8,238	15,997	7,556
2016	198,595	257,743	280,043	47,326	39,953	139,061	111,788	135,545	9,195	15,231	11,952
2017	243,356	223,383	286,861	54,531	42,392	128,125	88,754	152,958	15,776	18,834	4,713
2018	180,623	239,135	323,276	59,007	37,269	142,459	68,509	174,075	13,755	9,838	2,803
2019	106,249	302,728	422,970	49,135	44,752	104,756	90,118	165,126	14,486	12,262	2,862
2020	53,583	199,123	277,175	31,842	35,002	152,977	115,601	126,655	11,640	15,007	4,194
2021	53,226	186,897	224,168	28,462	25,051	230,049	119,269	67,353	13,147	27,489	2,207

Table 5. Landings of all snapper grouper species for the recreational fishery, 1994–2021. Sheepshead were removed from the fishery in 2012 and therefore not included past 2011.

Year	Number Harvested	Weight Harvested (lb)	Number Released	Percent Released
1994	1,122,704	1,536,118	2,085,119	36
1995	760,710	1,272,346	1,017,649	34
1996	520,600	1,035,700	516,966	39
1997	758,210	1,275,604	982,893	39
1998	462,922	638,255	1,180,941	37
1999	512,259	1,115,025	1,279,859	40
2000	814,533	1,875,322	2,070,305	40
2001	885,512	1,951,012	1,793,595	35
2002	763,191	2,119,881	1,385,078	31
2003	1,120,047	2,335,324	1,327,321	29
2004	1,153,460	2,731,095	2,578,785	33
2005	1,157,612	2,736,693	2,562,520	35
2006	885,567	3,378,064	3,380,922	34
2007	1,230,325	4,245,321	3,463,009	49
2008	1,328,295	4,773,359	2,778,672	49
2009	1,179,139	3,986,022	2,519,259	40
2010	933,735	2,803,945	2,763,289	47
2011	611,220	1,361,512	3,132,003	50
2012	592,316	1,375,815	4,942,686	45
2013	383,259	1,004,917	3,413,860	43
2014	527,044	1,119,307	5,665,011	55
2015	585,640	1,236,957	5,585,899	43
2016	629,119	1,354,061	7,792,792	57
2017	851,774	1,659,890	6,795,091	47
2018	342,750	859,989	2,485,376	44
2019	434,400	885,120	3,346,307	63
2020	551,571	1,767,713	3,096,666	44
2021	320,255	1,019,528	3,034,845	59

Table 6. Recreational landings (in pounds), by aggregate groups, 1994–2021. Aggregate groups are those used by the South Atlantic Fishery Management Council 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 Atlantic States Marine Fisheries Council and Mid-Atlantic Fishery Management Council.

Year	Black sea bass	Groupers	Snappers	Porgies	Grunts	Jacks	Tilefish	Triggerfish	Hogfish	Spadefish	Wreckfish
1994	255,936	192,300	86,864	348,920	405,116	142,011	-	96,569	256	8,146	-
1995	192,882	120,308	55,390	484,602	112,911	147,991	27,907	25,071	83,710	21,574	-
1996	222,898	44,050	31,717	289,437	77,503	276,636	540	77,012	-	15,907	-
1997	225,333	175,595	48,080	396,527	77,153	186,042	71,038	72,236	1,146	22,454	-
1998	154,986	60,962	9,577	250,646	37,113	89,045	-	25,188	-	10,738	-
1999	59,202	83,222	14,977	773,977	31,670	71,471	2,332	26,159	-	52,015	-
2000	373,028	52,463	23,294	820,377	9,520	548,623	3,724	26,184	-	18,109	-
2001	401,777	193,874	53,284	722,015	162,741	242,933	22,253	81,602	-	70,533	-
2002	183,634	348,809	143,786	865,924	337,495	159,670	7,290	54,879	11,499	6,895	-
2003	300,241	309,336	54,508	1,055,668	237,379	220,407	20,207	62,147	1,719	73,712	-
2004	507,359	1,022,259	170,615	558,545	266,540	94,406	29,313	64,317	1,300	16,441	-
2005	447,869	883,330	213,954	431,621	345,702	119,282	132,444	56,314	19,319	86,858	-
2006	175,048	1,671,117	54,160	476,295	235,456	316,341	330,140	64,556	19,365	35,586	-
2007	246,920	1,348,151	37,518	1,542,134	277,955	194,892	361,745	127,338	-	108,668	-
2008	104,582	1,946,062	114,550	1,139,132	302,233	468,560	404,734	269,507	1,813	22,186	-
2009	158,882	1,435,703	125,579	678,816	182,410	699,654	161,626	450,795	5,043	87,514	-
2010	206,765	325,422	50,327	1,016,739	84,349	567,382	51,649	257,445	8,658	235,209	-
2011	151,366	190,108	21,234	541,299	67,802	237,212	31,528	107,820	2,431	10,712	-
2012	219,859	215,213	78,050	42,963	171,618	262,534	65,879	221,703	24,243	73,281	472
2013	101,797	98,178	17,303	29,682	44,549	470,545	42,557	146,636	7,116	46,554	-
2014	562,393	28,173	25,717	21,247	86,365	154,373	45,541	102,145	-	93,353	-
2015	448,876	102,038	60,137	26,547	76,945	402,160	8,128	76,733	-	35,393	-
2016	301,334	79,379	46,391	19,455	86,926	356,481	282,035	165,279	466	16,315	-
2017	506,489	55,465	42,040	52,667	60,245	234,338	125,497	397,002	45,064	141,083	-
2018	107,331	9,227	29,406	8,012	16,762	357,661	116,891	178,928	383	35,388	-
2019	208,739	109,848	50,678	11,947	91,273	136,613	121,689	134,476	433	19,424	-
2020	120,950	28,013	83,330	12,831	83,906	361,133	833,910	230,521	305	12,814	-
2021	72,631	107,991	117,205	21,748	34,696	306,312	190,012	130,101	141	38,691	-

Table 7. Number of lengths and aging structures collected by NCDMF Program 438 (Offshore Live Bottom Fishery dependent sampling) for all species landed by the commercial and recreational sectors combined of the snapper grouper fishery in 2021. Many species included in this table are not part of the South Atlantic Snapper Grouper Management Complex but are landed as incidental catch during the prosecution of the fishery.

Species	Number Measured	Number of Aging Structures
African Pompano	22	3
Almaco Jack	606	0
Atlantic Bonito	11	2
Atlantic Chub Mackerel	1	0
Atlantic Cutlassfish	2	0
Banded Rudderfish	3	0
Bank Sea Bass	68	0
Barrelfish	5	0
Bigeye	14	0
Black Drum	2	2
Black Grouper	1	1
Black Sea Bass	1,156	492
Blackbar Drum	15	0
Blackbar Soldierfish	7	0
Blackbelly Rosefish	22	0
Blackfin Snapper	153	153
Blackline Tilefish	7	7
Blue Runner	1	0
Blueline Tilefish	190	147
Carribean Red Snapper	3	3
Cobia	12	1
Coney	1	1
Conger Eels	2	0
Cottonwick	49	0
Creole-fish	5	5
Cubbyu	1	0
Dolphinfish	72	0
Gag	242	232
Goldface Tilefish	29	29
Gray Snapper	10	5
Gray Triggerfish	285	274
Graysby	46	46
Great Barracuda	14	0
Greater Amberjack	168	3
Greater Soapfish	1	0
Hogfish	66	6
Jolthead Porgy	1	0
King Mackerel	127	5
Knobbed Porgy	62	5
Lesser Amberjack	20	0
Little Tunny	65	2
Littlehead Porgy	1	1
Marbled Grouper	2	2
Misty Grouper	1	1
Mutton Snapper	14	14
Ocean Sunfish	1	0
Ocean Triggerfish	1	1
Painted Wrasse	3	0

Table 7. (continued)

Permit	1	0
Porgies	1	1
Queen Triggerfish	9	9
Rainbow Runner	4	0
Red Grouper	27	25
Red Hake	2	0
Red Hind	5	5
Red Lionfish	1	0
Red Porgy	375	372
Red Snapper	165	165
Reticulate Moray	3	0
Rock Hind	16	15
Saddle Bass	13	0
Sand Perch	21	0
Sand Tilefish	113	0
Scamp	157	152
Scup	13	0
Sheepshead	11	6
Short Bigeye	47	0
Silk Snapper	601	601
Skipjack Tuna	5	4
Snowy Grouper	576	567
Spanish Flag	5	0
Spanish Mackerel	6	4
Spinycheek Scorpionfish	24	0
Spotfin Hogfish	9	0
Spottail Pinfish	168	0
Spotted Moray	3	0
Squirrelfish	43	0
Stout Moray	1	0
Striped Grunt	1	0
Swordfish	1	0
Tautog	1	0
Tilefish	1	1
Tomtate	131	0
Vermilion Snapper	1,191	1,185
Wahoo	1	0
White Grunt	238	238
Whitebone Porgy	11	0
Yellow Jack	1	0
Yellowcheek Wrasse	3	0
Yellowedge Grouper	11	10
Yellowfin Grouper	2	2
Yellowfin Tuna		1
Yellowmouth Grouper		6
Grand Total	7,615	4,811

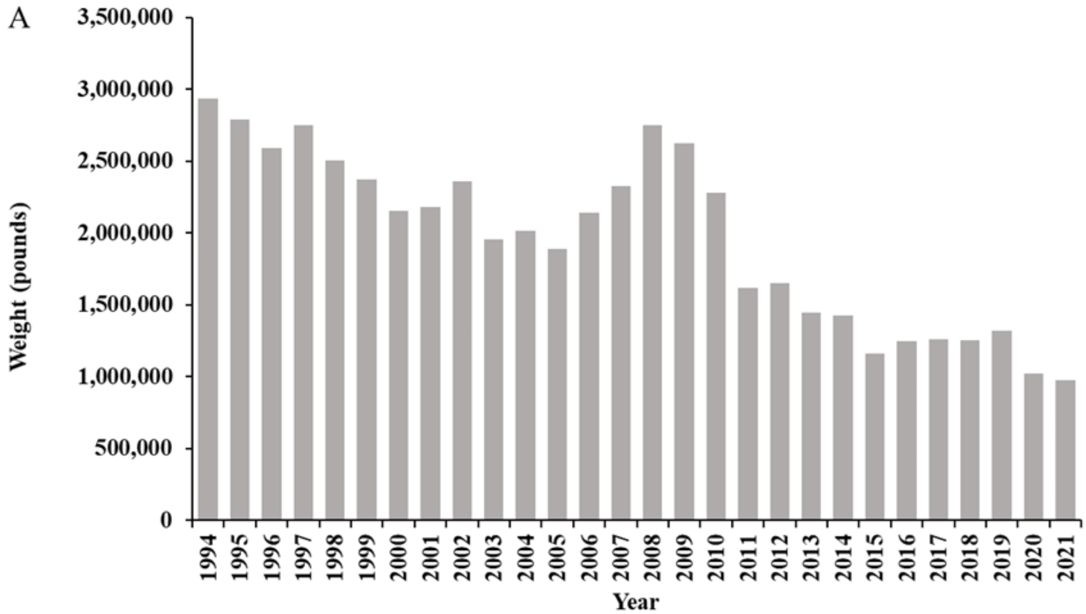
Table 8. Black sea bass south of Cape Hatteras length (total length, inches) data from Marine Recreational Information Program recreational samples, 1994–2021.

Year	Mean Length	Minimum Length	Maximum 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
2019	14	12	18	117
2020	14	11	18	152
2021	14	11	18	90

Table 9. Summary of black sea bass south of Cape Hatteras age samples collected from both fishery dependent (commercial and recreational fisheries) and fishery-independent (surveys) sources, 2004–2021.

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	1837
2008	4	2	10	1452
2009	4	2	8	1473
2010	4	1	8	900
2011	3	1	8	798
2012	4	2	10	1116
2013	4	1	7	1251
2014	4	1	8	1546
2015	4	2	9	1039
2016	4	1	8	708
2017	4	1	7	1025
2018	5	2	7	964
2019	6	2	7	592
2020	4	2	7	314
2021*	5	2	9	490

FIGURES



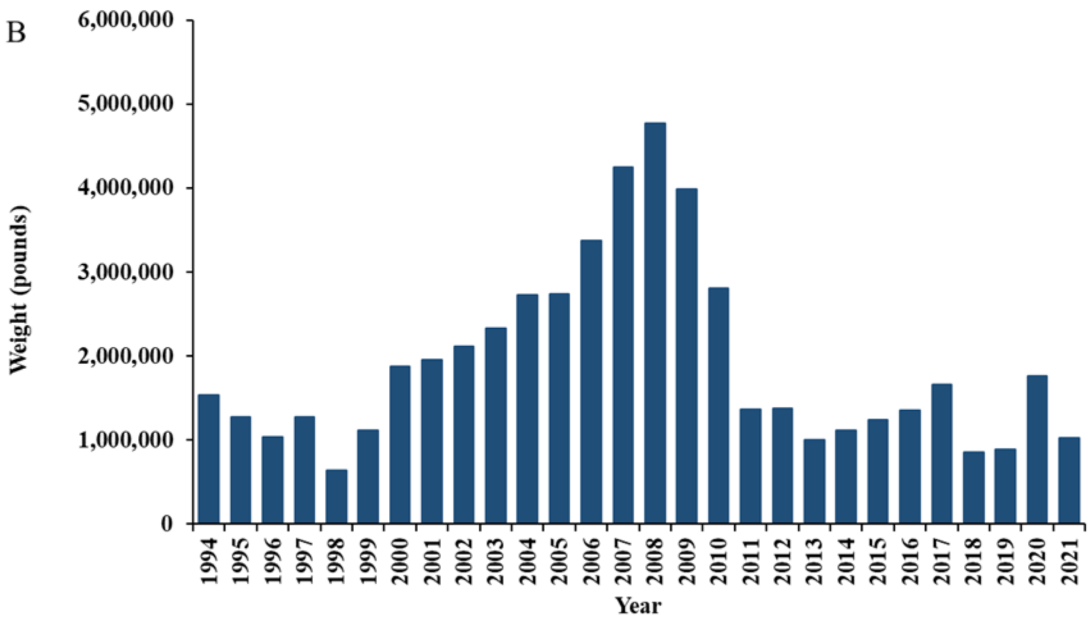


Figure 1. Annual commercial (A) and recreational (B) landings in pounds for snapper grouper species in North Carolina, 1994–2021.

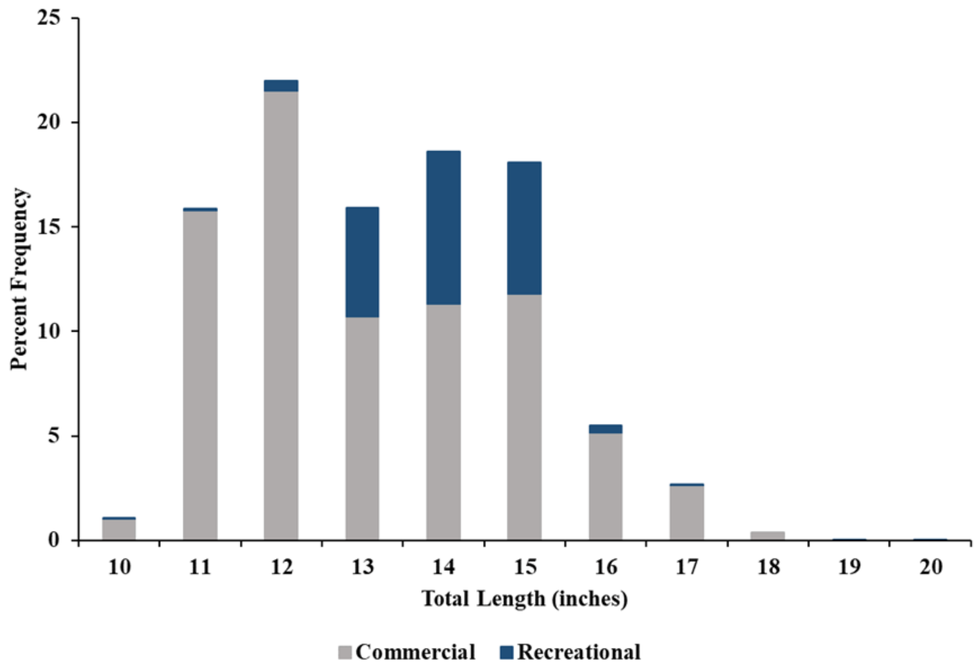


Figure 2. Commercial and recreational length frequency distribution from black sea bass south of Cape Hatteras harvested in 2021.

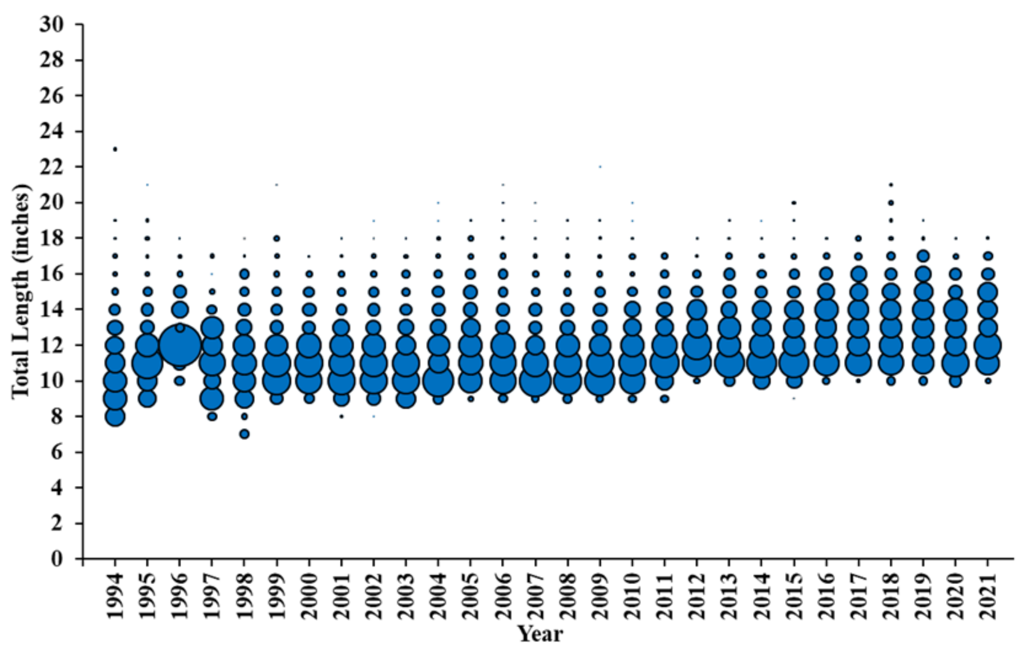


Figure 3. Commercial length frequency (total length, inches) of black sea bass south of Cape Hatteras harvested, 1994–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

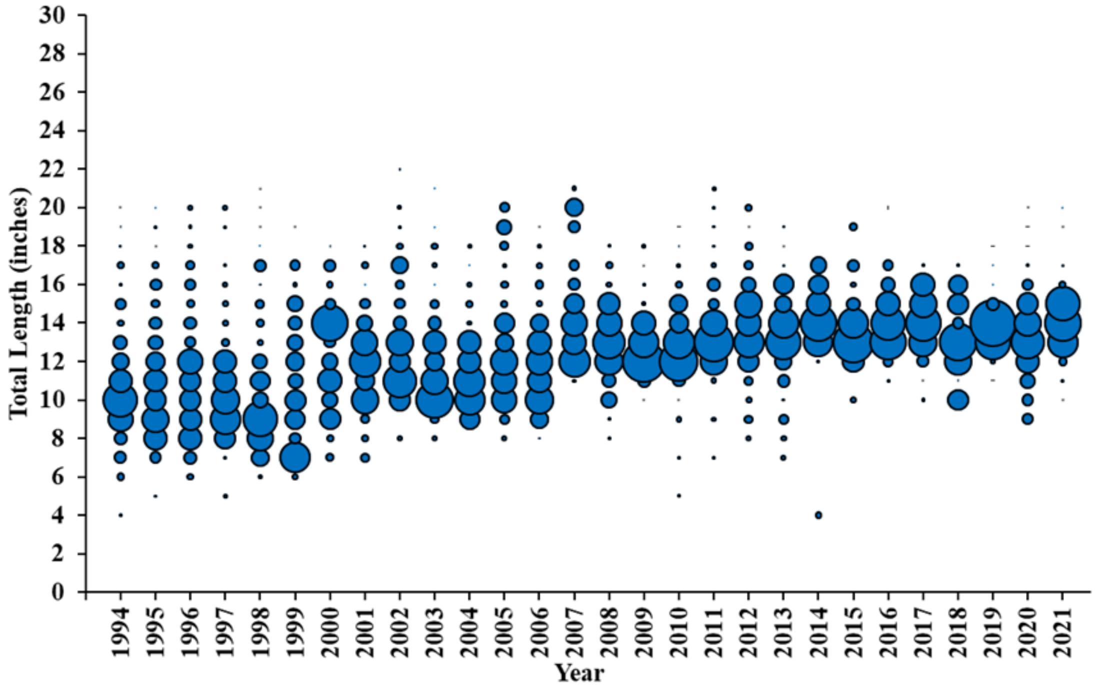


Figure 4. Recreational length frequency (total length, inches) of black sea bass south of Cape Hatteras harvested, 1994–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

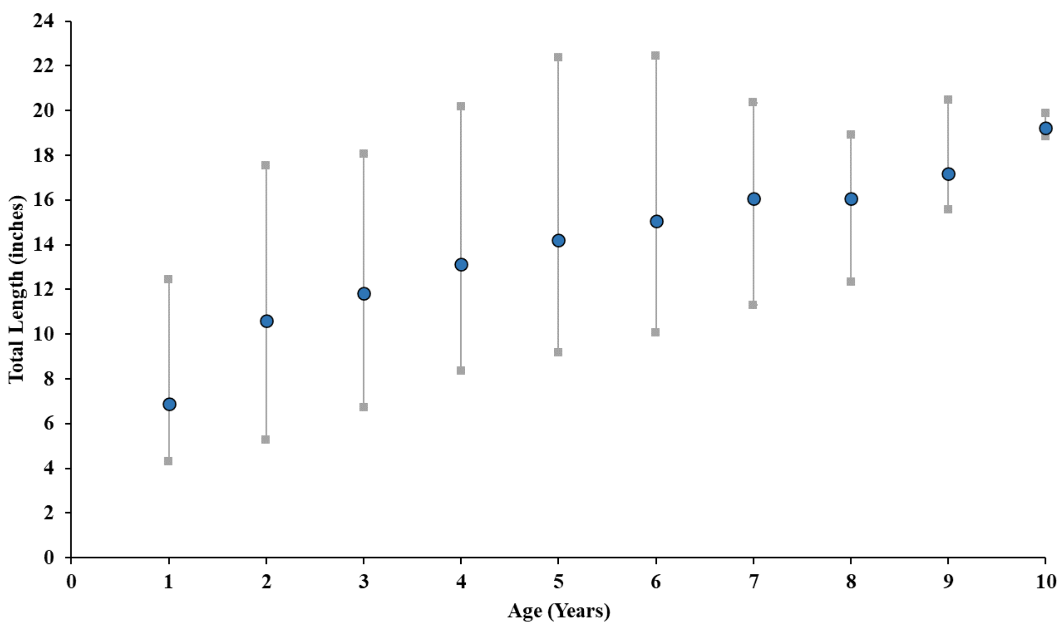


Figure 5. Black sea bass south of Cape Hatteras length at age based on all age samples collected, 2004–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
SPANISH MACKEREL
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	February 1983	
	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	August 2013

Comprehensive Review: 2022

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 (SAFMC 1982; ASMFC 2011). 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 (FL) 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 1998a).

Amendment 14 established a three-year moratorium on the issuance of for-hire (charter vessel and headboat) 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 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 2010).

Amendment 20A prohibits the sale of Spanish mackerel caught under the recreational 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 2014a).

Amendment 22 2013 included in the Generic Headboat Reporting Amendment: Requires weekly electronic reporting for headboats in the South Atlantic (SAFMC 2013a).

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 2014c) updated the ACLs and ACTs for Gulf and Atlantic migratory groups of Spanish mackerel based on the results of the 2012 stock assessment.

Amendment 22. modified headboat reporting regulations to require weekly electronic reporting of all SAFMC managed species (SAFMC 2013b).

Amendment 23 (SAFMC 2014b) 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 2017) 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 FMP 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 FL 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 FMPs, 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 2022).

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:

- 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.
- 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.

- To provide necessary information for effective management and establish a mandatory reporting system.
- To minimize gear and user group conflicts.
- 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.
- To minimize waste and bycatch in the fishery.
- To provide appropriate management to address specific migratory groups of king mackerel.
- 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:

- 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.
- Manage the Spanish mackerel stock to maintain the spawning stock biomass above the target biomass levels.
- Minimize endangered species bycatch in the Spanish mackerel fishery.
- 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.
- 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.

DESCRIPTION OF THE STOCK

Biological Profile

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 eight years old. Spanish mackerel in North Carolina grow as large as 30 inches FL, but most recreational catches are between 12- and 15-inches FL. 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 2022, the Atlantic Spanish mackerel stock was assessed and peer reviewed through the Southeast Data, Assessment and Review (SEDAR 2022). The results of the assessment (SEDAR 78) indicate Atlantic Spanish mackerel are not overfished and overfishing is not occurring. The assessment is awaiting review by the SAFMC' Science and Statistical Committee (SSC) before being used in management.

Stock Assessment

The SEDAR 78 South Atlantic Spanish Mackerel assessment took place over a series of webinars held from May 2021 to March 2022. This SEDAR was an operational assessment using data from 1986-2020. The assessment estimated that spawning stock has fluctuated near or above the minimum stock size threshold (MSST) level. The base-run estimate of terminal (2020) spawning stock was above the MSST (SSB_{2020}/MSST =1.40). The estimated fishing rate has been at or below the maximum fishing mortality threshold (MFMT), represented by F_{MSY} with the exception of the terminal year (2020). The terminal estimate, which is based on a three-year geometric mean, was below F_{MSY} in the base run ($F_{2018–2020}/ F_{MSY}$ = 0.77) and in the median of the Monte Carlo/Bootstrap Ensemble ($F_{2018–2020}/ F_{MSY}$ = 0.74), indicating that the stock is not experiencing overfishing. However, if the overfishing rate of 2020 continued in 2021, the geometric mean would indicate overfishing.

DESCRIPTION OF THE FISHERY

Current Regulations

The North Carolina Division of Marine Fisheries (NCDMF) currently complements the management measures of the Coastal Migratory Pelagic FMP through rules NCMFC Rule 15A NCAC 03M .0512 and proclamation authority (NCMFC Rule 15A NCAC 03M .0512). Current regulations include a recreational bag limit of 15 Spanish mackerel per person per day and 12-inch FL minimum size. Commercial regulations also include a 12-inch FL minimum size and a trip limit of 3,500 pounds. Federal vessel permits are required for commercial, charter and headboats 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 Fishery

In 2021, commercial landings were 1,155,289 pounds (Table 1, Figure 1) and 97% of the Spanish mackerel harvest was taken in estuarine and ocean gill nets (Figure 2). Landings for 2021 are higher than the 10-year average of 789,870 pounds, with most landings occurring between May and October. Predominant commercial fisheries for Spanish mackerel include gill nets and estuarine pound nets (Table 2). 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). On June 28, 2021, the harvest of Spanish mackerel in federal waters was closed when NOAA Fisheries estimated the Northern zone quota had been reached. On June 28, 2021, a harvest period for the commercial Spanish mackerel fishery in North Carolina Coastal Fishing Waters was opened with a 500-pound daily trip limit. The fishery remained closed in federal waters. The state water harvest period closed on November 12, 2021.

Recreational Fishery

Recreational landings of Spanish mackerel are estimated from the Marine Recreational Information Program (MRIP). For more information on MRIP 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. Recreational anglers harvested 1,894,535 pounds of Spanish mackerel in 2021 (Table 1; Figure 1B).

The NCDMF offers award citations for exceptional catches of Spanish mackerel. Spanish mackerel greater than six pounds are eligible for an award citation. In 2021, 205 citations were awarded (Figure 6).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Length-frequency information for the commercial Spanish mackerel fishery in North Carolina is collected through NCDMF's Program 431 (sciaenid pound net), Program 434 (ocean gill net), Program 461 (estuarine gill net), and Program 466 (sea turtle by-catch programs) (Table 4; Figures 3 and 5). 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 (Table 3).

Fishery-Independent Monitoring

Length-frequency information for Spanish mackerel is collected in the division's statewide Independent Gill Net Survey (Program 915) and the Pamlico Sound Trawl Survey (Program 195) (Table 6). Ageing structures, otoliths, are collected from both fishery-independent sampling programs and sent to the Southeast Fisheries Science Center in Panama City, Florida for processing and ageing (Table 5).

RESEARCH NEEDS

From Omnibus Amendment (ASMFC 2011):

- Increase collection of fishery-dependent length, sex, age, and Catch Per Unit Effort (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).

MANAGEMENT STRATEGY

In North Carolina, Spanish mackerel are included in the North Carolina FMP for Interjurisdictional Fisheries (NCDMF 2022), which defers, to the SAFMC's Coastal Migratory Pelagics FMP (SAFMC 2015) and the ASMFC's Spanish Mackerel FMP (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 recreational 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 NC-SC state line) and Southern Zone (south of NC-SC 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 FL 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 2015-2018 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 FL 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 did not implement the Addendum in 2019. Current management strategies for Spanish mackerel in South Atlantic waters are summarized in Table 7.

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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 Spanish mackerel from North Carolina, 1991– 2021.

Year	Recreational			Commercial	
	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight Landed (lb)
1994	641,980	292,919	724,589	531,371	1,255,960
1995	397,190	239,972	492,096	402,392	894,488
1996	533,333	184,518	709,589	401,830	1,111,419
1997	956,589	304,629	1,444,907	766,958	2,211,865
1998	374,804	145,746	488,951	372,415	861,366
1999	891,001	253,317	1,035,943	459,100	1,495,043
2000	1,102,777	451,910	1,175,351	659,426	1,834,777
2001	942,500	338,918	1,155,788	653,673	1,809,461
2002	787,125	309,546	987,238	698,448	1,685,686
2003	540,399	266,887	641,024	456,784	1,097,808
2004	534,720	317,189	819,978	456,242	1,276,220
2005	561,073	303,641	526,054	446,001	972,055
2006	439,736	165,098	624,488	470,662	1,095,150
2007	604,518	340,027	799,263	487,879	1,287,142
2008	1,013,980	806,280	1,234,030	415,405	1,649,435
2009	1,480,931	752,806	2,155,692	961,811	3,117,503
2010	927,116	701,634	1,116,099	911,866	2,027,965
2011	854,554	479,586	1,100,110	871,217	1,971,327
2012	995,852	591,792	1,327,350	916,439	2,243,789
2013	994,599	685,692	1,242,029	620,752	1,862,781
2014	1,028,925	814,064	1,193,442	673,974	1,867,416
2015	835,011	514,714	981,867	561,714	1,543,581
2016	918,352	546,950	907,400	601,623	1,509,023
2017	995,706	688,062	1,094,778	816,089	1,910,867
2018	1,012,889	1,019,418	1,156,702	796,890	1,953,592
2019	1,478,890	1,340,366	1,694,247	722,398	2,416,645
2020	1,286,131	1,267,210	1,843,314	1,033,526	2,876,840
2021	1,312,929	1,294,525	1,894,535	1,155,289	3,049,824
Mean	872,986	550,622	1,091,673	654,363	1,746,037

Table 2. North Carolina commercial harvest of Spanish mackerel with landings in pounds by gear type, 1994–2021.

Year	Gear				Total
	Ocean Gill Net	Estuarine Gill Net	Pound Net	Other	
1994	327,155	138,452	29,708	36,057	531,371
1995	233,296	104,827	49,077	15,192	402,392
1996	215,536	124,013	45,221	17,060	401,830
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	221,799	25,772	3,875	673,974
2015	289,489	229,114	40,032	3,080	561,714
2016	328,635	242,291	27,806	2,891	601,623
2017	507,905	287,434	17,314	3,436	816,089
2018	486,707	280,689	19,931	9,563	796,890
2019	354,891	322,101	39,118	6,288	722,398
2020	601,095	369,436	53,384	9,611	1,033,526
2021	711,685	404,168	31,767	7,669	1,155,289

Table 3. Spanish mackerel length (fork length, inches) data from Marine Recreational Information Program samples, 1981–2021.

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1981	21.2	8.9	27.0	62
1982	18.0	8.0	31.9	69
1983	20.3	16.9	20.1	4
1984	14.7	13.0	23.8	28
1985	19.7	9.8	27.4	45
1986	15.4	8.1	27.2	110
1987	15.5	9.1	34.1	950
1988	5.0	7.9	32.9	1,118
1989	15.3	7.9	33.5	1,799
1990	15.9	8.3	35.5	2,160
1991	15.2	6.3	37.0	2,135
1992	15.4	7.5	33.1	1,354
1993	16.1	9.0	28.5	1,056
1994	15.2	6.4	29.4	2,255
1995	15.1	8.2	31.9	799
1996	16.0	9.8	70.2	1,107
1997	16.2	8.9	33.3	1,846
1998	15.5	9.2	31.1	895
1999	15.3	8.5	28.9	1,286
2000	15.7	9.0	27.2	1,242
2001	16.1	11.4	28.7	858
2002	16.3	9.5	28.0	827
2003	15.9	10.8	28.0	476
2004	16.7	11.1	27.5	298
2005	14.6	11.9	29.2	289
2006	16.0	11.1	39.4	236
2007	15.4	10.6	28.6	240
2008	15.2	8.9	26.2	596
2009	15.8	11.4	26.9	788
2010	15.2	10.7	26.5	763
2011	15.0	11.1	28.1	543
2012	15.1	10.6	28.0	776
2013	15.1	10.1	27.1	454
2014	14.8	9.0	29.9	754
2015	14.8	9.2	27.4	644
2016	14.3	11.0	26.3	1,030
2017	14.8	10.3	26.4	1,023
2018	15.0	9.9	27.2	1,691
2019	15.0	9.3	28.2	1,486
2020	15.6	9.0	68.0	1,914
2021	15.8	9.6	32.3	1,313

Table 4. Spanish mackerel length (fork length, inches) data from commercial fish house samples, 1997–2021.

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
2019	16.5	9.6	28.4	4,427
2020	16.1	8.6	27.9	4,947
2021	16.6	9.9	28.8	5,077

Table 5. Mean, minimum and maximum fork lengths (inches) and total number sampled of Spanish mackerel collected by NCDMF from both dependent (commercial and recreational) and independent (survey) sources for ageing by the NOAA Southeast Fisheries Science Center, 1997–2021.

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
2019	14.3	5.0	28.0	640
2020	16.4	4.8	27.3	337
2021	15.0	5.8	25.7	778

Table 6. Mean, minimum and maximum fork lengths (inches) and total number sampled of Spanish mackerel from fishery independent sampling programs, 1997–2021.

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
2019	12.7	1.9	22.6	517
2020	6.2	2.1	13.4	336
2021	14.1	5.0	22.8	360

FIGURES

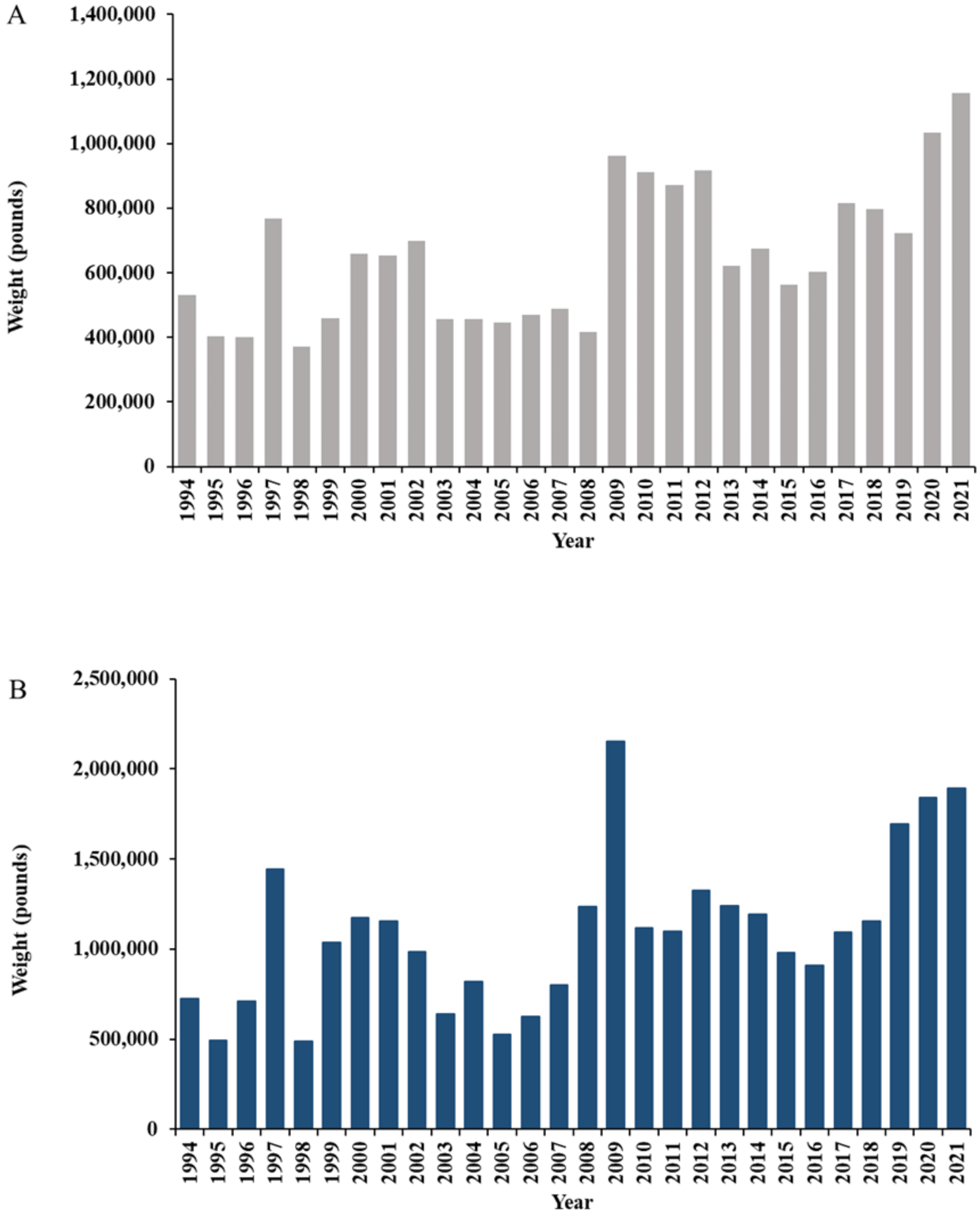

Figure 1. Annual commercial (A) and recreational (B) landings in pounds for Spanish mackerel in North Carolina, 1994–2021.

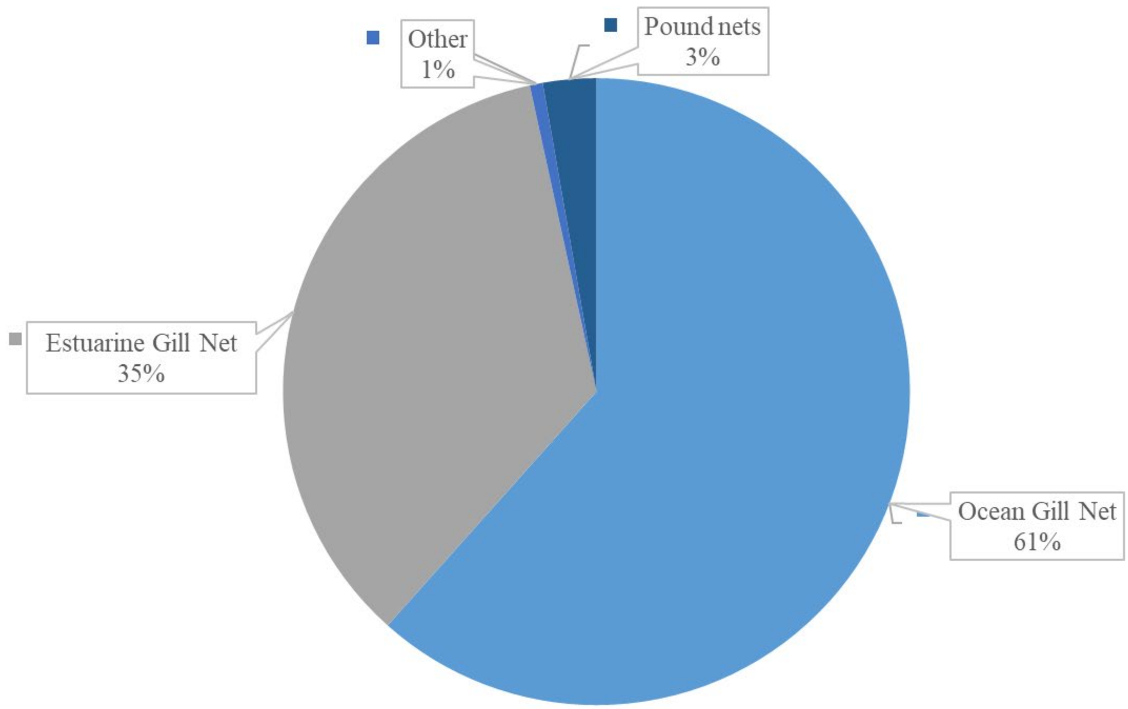

Figure 2. Commercial harvest of Spanish mackerel by gear, 2021.

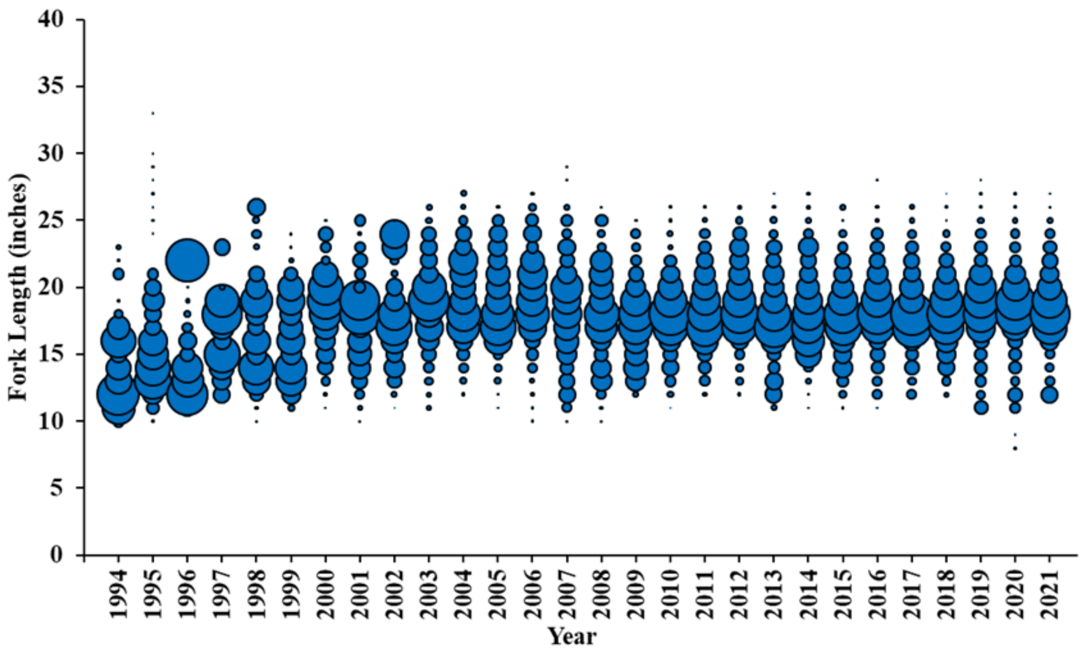

Figure 3. Commercial length frequency (fork length, inches) for Spanish mackerel harvested, 1995–2021. Bubbles represent fish harvested at length and the size of the bubble represents the proportion of fish at that length in that year.

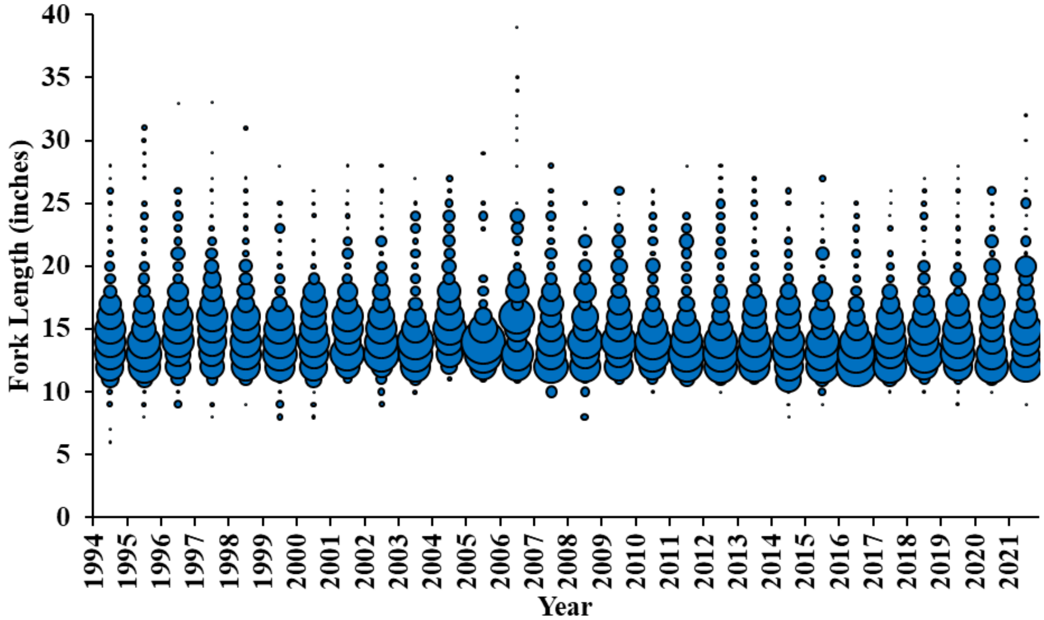

Figure 4. Recreational length frequency (fork length, inches) for Spanish mackerel harvested, 1994–2021. Bubbles represent fish harvested at length and the size of the bubble represents the proportion of fish at that length in that year.

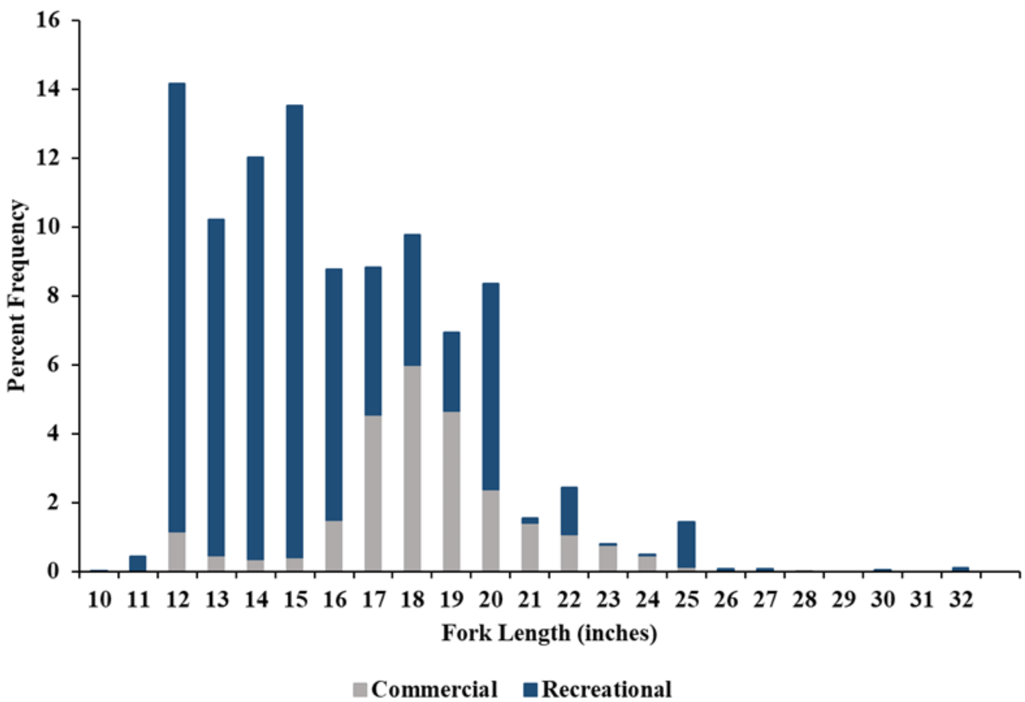

Figure 5. Commercial and recreational length frequency distribution from Spanish mackerel harvested in 2021.

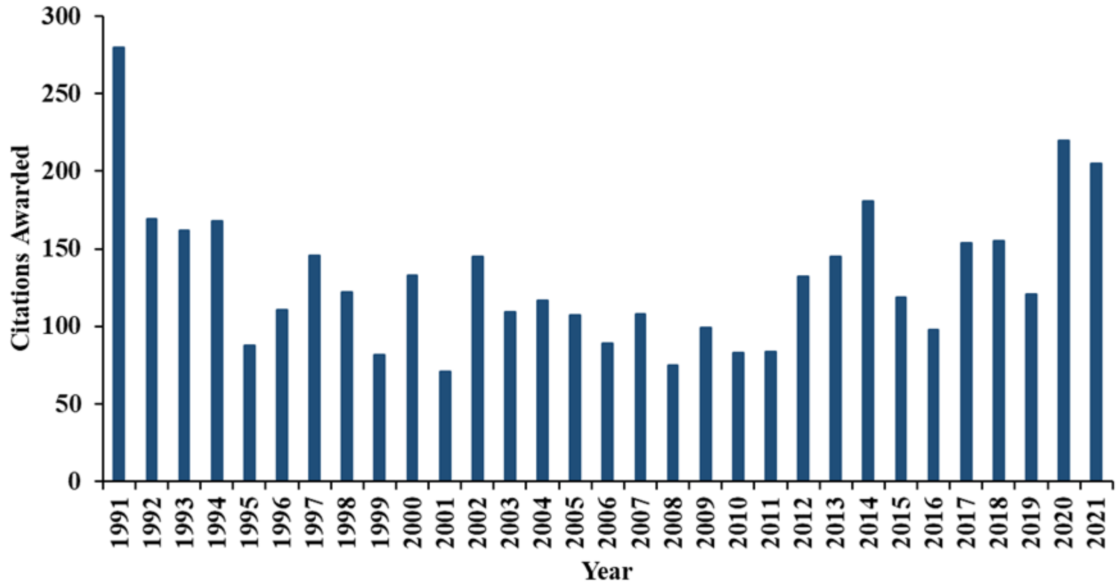

Figure 6. North Carolina Saltwater Fishing Tournament citations awarded for Spanish mackerel from 1991–2021. Citations are awarded for Spanish mackerel greater six pounds.

FISHERY MANAGEMENT PLAN UPDATE
SPINY DOGFISH
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	MAFMC/NEFMC FMP	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
	Framework 4	2020
	Framework 5	2020
	ASMFC FMP	November 2002
	Addendum I	November 2005
	Addendum II	October 2008
	Addendum III	April 2011
	Addendum IV	August 2012
	Addendum V	October 2014
	Addendum VI	October 2019

Comprehensive Review: 2022

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 fishery management plan (FMP) was created for the stock in 2000 (MAFMC and NEFMC 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). The MAFMC/NEMFC spiny dogfish FMP, associated amendment documents, and framework information can be found at https://www.mafmc.org/dogfish.

In state waters, the ASMFC 2002 Interstate FMP for spiny dogfish establishes the annual quota and possession limits (ASMFC 2002). The Spiny Dogfish Coast Wide 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 six 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 5%, state-specified possession limits, and includes a three-year reevaluation of the measures. North Carolina is allocated 14.036% of the 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. Addendum VI allows quota to be transferred between all regions and states to enable full utilization of the coast-wide commercial quota and avoid quota overages. The ASMFC spiny dogfish FMP and associated addendum documents can be found at http://www.asmfc.org/species/spiny-dogfish.

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 2022).

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.

Goal 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 following objectives were adopted:

- Reduce fishing mortality to ensure that overfishing does not occur.

- Promote compatible management regulations between state and council jurisdictions and the US and Canada.
- Promote uniform and effective enforcement of regulations.
- Minimize regulations while achieving the management objectives stated above.
- Manage the spiny dogfish fishery to minimize the influences of the regulations on the prosecution of other fisheries, to the extent practicable.
- 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:

- Reduce fishing mortality and rebuild the female portion of the spawning stock biomass (SSB) to prevent recruitment failure and support a more sustainable fishery.
- Coordinate management activities between state, federal, and Canadian agencies to ensure complementary regulations throughout the species range.
- Minimize the regulatory discards and bycatch of spiny dogfish within state waters.
- Allocate the available resource in biologically sustainable manner that is equitable to all the fishers.
- 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.

DESCRIPTION OF THE STOCK

Biological Profile

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). Spiny dogfish 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 length of approximately 4 feet. Males are mature at approximately 23.6 inches (6 years old), while females mature at between 29.5 and 31.5 inches (12 years old; Nammack et al. 1985). The maximum recorded age is 35 years for males and 40 years for females (Campana et al. 2006). Spiny dogfish give 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). Completion of the next stock assessment is scheduled for late 2022.

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, results from the assessment indicated a decreasing trend in female spawning stock biomass from 2013 to 2018, the terminal year of the assessment. To address this trend, the federal quota for 2019 was set at 20.5 million pounds, a 46% reduction from the 2018 quota (38.2 million pounds). The quota was set at 23.2 million pounds in 2020 and 29.9 million pounds in 2021.

DESCRIPTION OF THE FISHERY

Current Regulations

The fishery is typically opened via proclamation from November through April, as the quota allows; this time period corresponds to the time when spiny dogfish are available in North Carolina waters [see most recent North Carolina Division of Marine Fisheries (NCDMF) proclamation]. 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. There are no recreational harvest restrictions for spiny dogfish.

Commercial Fishery

In North Carolina, spiny dogfish commercial landings peaked in 1996 and declined sharply through 2001. Landings remained low through 2008 and then steadily increased from 2009 through 2014. Landings have declined since 2014 (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. In 2021, 98% of spiny dogfish were caught in ocean gill nets.

Recreational Fishery

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 minimal 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 2022. Prior to 1999, sampling was minimal and sex was not recorded. Therefore, length data presented in this report includes the years 1999 through 2021. Samples were collected 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 sample collected, total length (TL) and fork length (FL), aggregate weight (nearest kg), and sex were recorded. From 1999 through 2021, sampled spiny dogfish TL has averaged 33 inches and ranged from 19 to 43 inches (Table 3). The total number of spiny dogfish measured in 2021 was 76. Female spiny dogfish are typically encountered more often during sampling events due to their relatively higher abundance in nearshore areas where fishing occurs (Table 4). Like many elasmobranch species, spiny dogfish exhibit sexual dimorphism; males are generally smaller than females.

Fishery-Independent Monitoring

The NCDMF initiated a fishery-independent gill net survey of Pamlico Sound in 2001 (P915). The objective of this project is to provide annual, independent, relative-abundance indices for key estuarine species in the 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 half-inch increments). A total of 936 spiny dogfish were measured in the Pamlico Sound Independent Gill Net Survey from 2001 to 2021. Total length ranged from 20 to 40 inches and averaged 32 inches during the survey period.

RESEARCH NEEDS

Research needs from the ASMFC's 2021 FMP review are provided below:

Fishery-Dependent Priorities

- Determine area, season, and gear specific discard mortality estimates coast-wide in the recreational, commercial, and non-directed (bycatch) fisheries.
- Characterize and quantify bycatch of spiny dogfish in other fisheries.
- Increase the biological sampling of dogfish in the commercial fishery and on research trawl surveys.
- Further analyses of the commercial fishery are also warranted, especially with respect to the effects of gear types, mesh sizes, and market acceptability on the mean size of landed spiny dogfish.

Fishery-Independent Priorities

- Conduct experimental work on NEFSC trawl survey gear performance, with focus on video work to study the fish herding properties of the gear for species like dogfish and other demersal groundfish.
- Investigate the distribution of spiny dogfish beyond the depth range of current NEFSC trawl surveys, possibly using experimental research or supplemental surveys.
- Continue to analyze the effects of environmental conditions on survey catch rates.

Modeling / Quantitative Priorities

- Continue work on the change-in-ratio estimators for mortality rates and suggest several options for analyses.
- Examine observer data to calculate a weighted average discard mortality rate based on an assumption that the rate increased with catch size.

Life History, Biological, and Habitat Priorities

- 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 DFO, other interested agencies, academia, and other international investigators with an interest in dogfish ageing.
- Identify how spiny dogfish abundance and movement affect other organisms.

Management, Law Enforcement, and Socioeconomic Priorities

- Monitor the changes to the foreign export markets for spiny dogfish and evaluate the potential to recover lost markets or expand existing ones.
- Update on a regular basis the characterization of fishing communities involved in the spiny dogfish fishery, including the processing and harvesting sectors, based upon Hall-Arber et al. (2001) and McCay and Cieri (2000).
- Characterize the value and demand for spiny dogfish in the biomedical industry on a state-by-state basis.
- Characterize the spiny dogfish processing sector.

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 formed using fisheries data collected from the previous fishing season. These quota recommendations are then communicated to the Spiny Dogfish Management Board and MAFMC for approval. Current management targets and thresholds are below:

- Fmsy = 0.2439
- SSBtarget = 351.2 million pounds (159,288 metric tons); level of biomass that would maximize recruitment to the population (100% SSBmax).
- SSBthreshold = 175.6 million pounds (79,644 metric tons); 50% of SSBtarget

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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), 1994–2021.

	Recreational			Commercial	
Year	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight Landed (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	2,472,840
2017	683	44,038	5,616	393,085	398,701
2018	7,514	157,394	43,732	1,168,247	1,211,979
2019	6,106	261,322	43,551	1,124,291	1,167,842
2020	1,785	31,195	13,638	1,501,331	1,514,969
2021	21,587	400,905	117,447	131,501	248,948
Average	5,016	183,605	23,332	**2,809,193	**2,835,325

*Confidential data

* Mean does not include confidential data

Table 2. Spiny dogfish length (total length, inches) data from NOAA Marine Recreational Information Program recreational samples, 1994–2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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
2019	35	32	38	3
2020	32	27	38	11
2021	29	24	35	10

Table 3. Spiny dogfish length (total length, inches) data from commercial fish house samples, 1999–2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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
2019	34	24	39	580
2020	31	23	41	454
2021	34	28	38	76

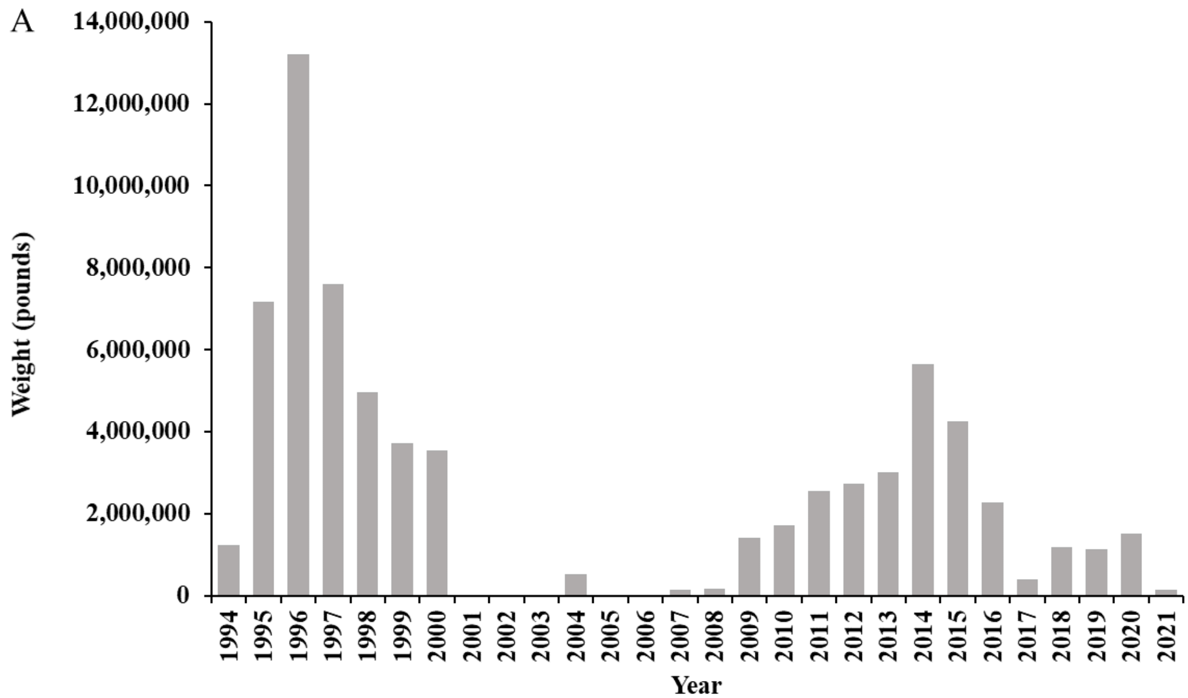
Table 4. Female spiny dogfish length (total length, inches) data from commercial fish house samples, 1999–2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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
2019	34	25	39	523
2020	32	23	41	362
2021	31	31	31	1

Table 5. Male spiny dogfish length (total length, inches) data from commercial fish house samples, 1999–2021.

Year	Mean Length (in)	Minimum Length (in)	Maximum 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
2019	30	24	35	57
2020	29	25	37	88
2021	34	28	38	75

FIGURES



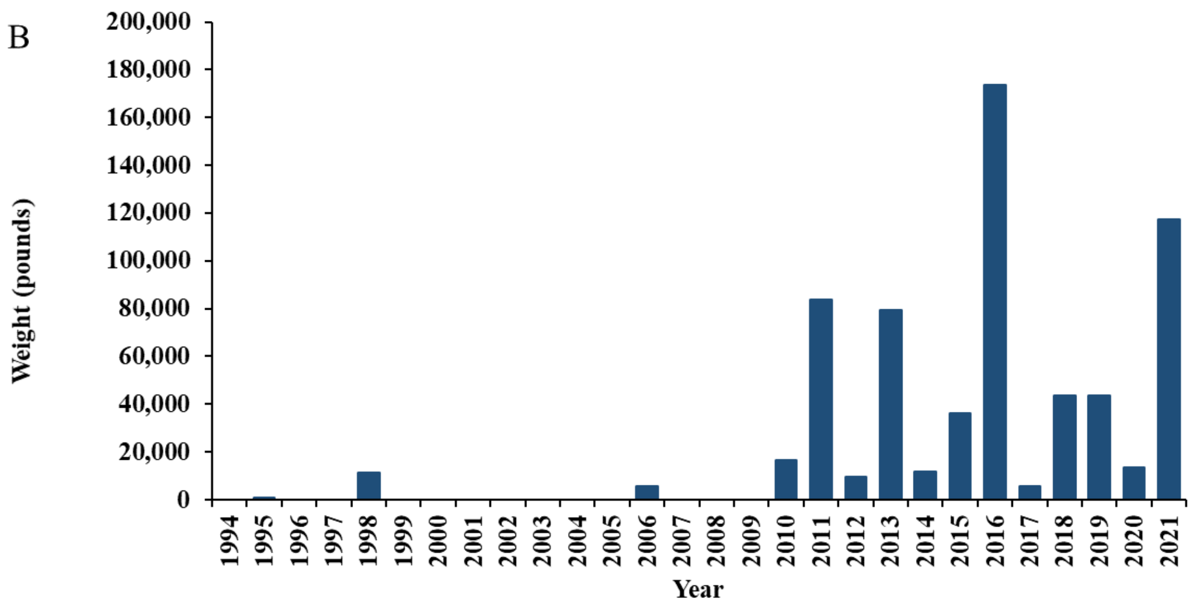


Figure 1. Annual commercial (A) and recreational (B) landings in pounds for spiny dogfish in North Carolina, 1994–2021.

FISHERY MANAGEMENT PLAN UPDATE
ATLANTIC STRIPED BASS
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	October 1981	
	Amendment 1	1984
	Amendment 2	1984
	Amendment 3	October 1985
	Amendment 4	October 1989
	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	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
	Addendum VI	October 2019
		Updated May 2021
	Amendment 7	May 2022

Comprehensive Review: 2018

Increased fishing pressure in the 1970s, coupled with degradation and loss of habitat, led to stock collapse and stimulated the development of a cooperative interstate fisheries management plan (FMP). While a notable first step, the first FMP (1981) and Amendments 1 and 2 to the plan (1984) only provided recommendations on how to manage the resource. States could take voluntary actions under these management plans but there was no statutory requirement that ensured unified management actions by all the involved states. The passage of the Atlantic Striped Bass Conservation Act in 1984 (Striped Bass Act) changed this by requiring the states, through the Commission, to develop and implement management plans that included mandatory conservation measures. Amendment 3 (1985) was the first plan under the Striped Bass Act with such measures, including regulations to protect the 1982-year class, the first modestly sized cohort for nearly a decade. Some states elected for an even more conservative approach and imposed a total moratorium to protect the 1982-year class. The Amendment contained a mechanism to relax fishery regulations based on a juvenile abundance index. The mechanism was triggered with the recruitment of the 1989-year class and led to the implementation of Amendment 4 (1989), which aimed to rebuild the resource rather than maximize yield. In 1995, with adoption of Amendment 5, the Commission declared Atlantic coastal striped bass stocks fully recovered.

Amendment 6 (2003) introduced a new set of biological reference points based on female spawning stock biomass (SSB), and a suite of management triggers based on the reference points. It also restored the commercial quota for the ocean fishery to 100% of average landings during the 1972-1979 historical period, and recreational fisheries were constrained by a 2-fish bag limit and a minimum size limit of 28 inches, except for the Chesapeake Bay fisheries, Albemarle-Roanoke (A-R) fisheries, and fisheries with approved conservation equivalency proposals. From 2007 to 2014, a series of four Addenda (I-IV) to Amendment 6 were implemented. These addenda addressed a range of issues, including implementation of a bycatch monitoring program, modifying the definition of recruitment failure, implementation of a mandatory commercial harvest tagging program, and establishing one set of F reference points for the coastal migratory population in all management areas. Addendum IV (2014) also formally defered management of the A-R stock to the State of North Carolina, under the auspices of the Commission, since the A-R stock was deemed to contribute minimally to the coastal migratory population.

In 2019, a new benchmark assessment which used updated recreational catch estimates, changed our understanding of stock status. The benchmark assessment found the stock to be overfished and experiencing overfishing. As a result, Addendum VI to Amendment 6 was initiated to end overfishing, and bring F to the target level in 2020. Specifically, the Addendum reduced all state commercial quotas by 18%, and implemented a 1-fish bag limit and a 28” to less than 35” recreational slot limit for ocean fisheries and a 1-fish bag limit and an 18” minimum size limit for Chesapeake Bay recreational fisheries. These measures were implemented in 2020 and designed to achieve at least an 18% reduction in total removals at the coastwide level. The Addendum maintained flexibility for states to pursue alternative regulations through conservation equivalency and the Board approved CE programs for multiple states. Since catch and release practices contribute significantly to overall fishing mortality, the Addendum mandated the use of circle hooks when fishing with bait to reduce release mortality in recreational striped bass fisheries.

As it considered its actions under Addendum VI, the Management Board also discussed the development of a new Amendment to the FMP, one that reflected our understanding of the resource and the fisheries that depend on it. This led to the development and approval of Amendment 7 in 2022.

Amendment 7 establishes an updated recruitment management trigger, which determines when the Board is required to make management adjustments based on striped bass young-of-the-year data. The updated recruitment trigger is more sensitive to low recruitment than the previous trigger, and it requires a specific management response to low year class strength. The response requires reevaluation of the fishing mortality management triggers to account for low recruitment. If one of those triggers trips after reevaluation, the Board is required to take action to reduce fishing mortality. Amendment 7 also updates the spawning stock biomass triggers by establishing a deadline for implementing a rebuilding plan. The Board must implement a rebuilding plan within two years of when a spawning stock biomass trigger is tripped. For conservation equivalency (CE), which provides states the flexibility to tailor management measures, Amendment 7 does not allow CE to be used for most recreational striped bass fisheries if the stock is in an overfished state.

Amendment 7 also provides constraints around the use of Marine Recreational Information Program data for CE proposals and defines the overall percent reduction/liberalization a proposal must achieve, including required uncertainty buffers. These restrictions are intended to minimize the risks due to uncertainty when CE is used for non-quota managed striped bass fisheries. Since recreational release mortality is a large component of annual fishing mortality, Amendment 7 establishes a new gear restriction which prohibits gaffing striped bass when fishing recreationally. This new restriction, along with the existing circle hook requirement when fishing recreationally with bait, are intended to increase the chance of survival after a striped bass is released alive. Additionally, Amendment 7 requires striped bass caught on any unapproved method of take (e.g., caught on a J-hook with bait) must be returned to the water immediately without unnecessary injury. This provision, which is related to incidental catch, was previously a recommendation in Addendum VI to Amendment 6.

For stock rebuilding, Amendment 7 addresses the upcoming 2022 stock assessment and how it will inform efforts to meet the 2029 stock rebuilding deadline. Given concerns about recent low recruitment and the possibility of continued low recruitment, Amendment 7 requires the 2022 stock assessment's rebuilding projections to use a low recruitment assumption to conservatively account for that future possibility. Amendment 7 also establishes a mechanism for the Board to respond more quickly to the 2022 assessment results if action is needed to achieve stock rebuilding by 2029.

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 striped bass in the North Carolina FMP for Interjurisdictional Fisheries (IJ FMP). The goal of the IJ FMP is to adopt FMPs, 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 all coastal migratory striped bass stocks on the East Coast of the United States, excluding the Exclusive Economic Zone (3-200 nautical miles offshore), which is managed separately by NMFS. The coastal migratory striped bass stocks occur in the coastal and estuarine areas of all states and jurisdictions from Maine through the Albemarle-Roanoke striped bass stock in North Carolina. Inclusion of these states in the management unit is also congressionally mandated in the Atlantic Striped Bass Conservation Act (PL 98-613). In North Carolina the striped bass stocks in the Tar-Pamlico, Neuse, and Cape Fear rivers are considered estuarine and non-migratory, and are not managed through the ASMFC FMP, rather they are managed under the N.C. Estuarine Striped Bass FMP.

Goal and Objectives

The Goal of Amendment 7 to the Interstate Fishery Management Plan for Atlantic Striped Bass is to perpetuate, through cooperative interstate fishery management, migratory stocks of striped bass (*Morone saxatilis*); to allow commercial and recreational fisheries consistent with the long-term maintenance of a broad age structure, a self-sustaining spawning stock; and to provide for the restoration and maintenance of their essential habitat.

In support of this goal, the following objectives are specified:

- 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.
- Manage fishing mortality to maintain an age structure that provides adequate spawning potential to sustain long-term abundance of striped bass populations.
- Provide a management plan that strives, to the extent practical, to maintain coastwide consistency of implemented measures, while allowing the States defined flexibility to implement alternative strategies that accomplish the objectives of the FMP.
- Foster quality and economically viable recreational, for-hire, and commercial fisheries.
- Maximize cost effectiveness of current information gathering and prioritize state obligations in order to minimize costs of monitoring and management.
- Adopt a long-term management regime that minimizes or eliminates the need to make annual changes or modifications to management measures.

- 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.

DESCRIPTION OF THE STOCK

Biological Profile

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 some taxonomists suggest the striped bass found in the Gulf of Mexico warrant description as a subspecies (GSMFC 2006). 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 also 31 years old.

Stock Status

In May 2019, the Board accepted the 2018 Benchmark Stock Assessment and Peer Review Report for management use. The assessment indicated the resource is overfished and experiencing overfishing relative to the updated reference points.

Stock Assessment

The accepted model is a forward projecting statistical catch-at-age model, which uses catch-at-age data and fishery-dependent data and fishery-independent survey indices to estimate annual population size, fishing mortality, and recruitment. Female SSB in the terminal year (2017) was estimated at 151 million pounds, which is below the SSB threshold of 202 million pounds. F in

2017 was estimated at 0.31, which is above the F threshold of 0.24. The assessment also indicated a period of strong recruitment (numbers of age-1 fish entering the population) from 1994-2004, following by a period of low recruitment from 2005-2011 which likely contributed to the decline in SSB in recent years. Recruitment was high in 2012, 2015, and 2016. In 2017, estimated at 108.8 million age-1 fish in 2017 which is below the time series average of 140.9 million fish (Figure 1).

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 Marine Recreational Information Program (MRIP) estimates of recreational catch 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).

A stock assessment is not available for this species. (If there is a plan for establishing a stock assessment feel free to briefly explain and reference the FMP for more details.)

DESCRIPTION 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 3–200 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 294,495-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. It is also illegal to harvest striped bass less than 28 inches TL or greater than or equal to 35 inches TL. It is also unlawful to fish for or possess striped bass from the Atlantic Ocean for recreational purposes using hook and line gear with natural bait unless using a non-stainless steel, non-offset (inline) circle hook, regardless of tackle or lure configuration. Natural bait is defined as any living or dead organism (animal or plant) or parts thereof. Non-offset circle hook is defined as a hook with the point pointed perpendicularly back towards the shank and the point and barb are in the same plane as the shank. Striped bass may be taken seven days a week and the season is open year-round.

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 in prior years. 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 Fishery

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 Fishery

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 coastwide 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 coastwide 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).

RESEARCH NEEDS

The following research recommendations were developed by the 2018 Benchmark Stock Assessment Subcommittee and the 66th SARC (NEFSC 2019).

- Continue collection of paired scale and otolith samples, particularly from larger striped bass, to facilitate development of otolith-based age-length keys and scale-otolith conversion matrices.
- Develop studies to provide information on gear specific (including recreational fishery) discard morality rates and to determine the magnitude of bycatch mortality.
- Conduct study to directly estimate commercial discards in the Chesapeake Bay.
- Collect sex ratio information on the catch and improve methods for determining population sex ratio for use in estimates of female SSB and biological reference points.
- Develop an index of relative abundance from the Hudson River Spawning Stock Biomass survey to better characterize the Delaware Bay/Hudson River stock.
- Improve the design of existing spawning stock surveys for Chesapeake Bay and Delaware Bay.
- Develop better estimates of tag reporting rates; for example, through a coastwide tagging study.
- Investigate changes in tag quality and potential impacts on reporting rate.
- Explore methods for combining tag results from programs releasing fish from different areas on different dates.
- Develop field or modeling studies to aid in estimation of natural mortality and other factors affecting the tag return rate.
- Compare M and F estimates from acoustic tagging programs to conventional tagging programs.
- Continue in-depth analysis of migrations, stock compositions, sex ratio, etc. using mark-recapture data.
- Continue evaluation of striped bass dietary needs and relation to health condition.
- Continue analysis to determine linkages between the Mycobacteriosis outbreak in Chesapeake Bay and sex ratio of Chesapeake spawning stock, Chesapeake juvenile production, and recruitment success into coastal fisheries.
- See Section 4.4 of Amendment 7 asmfc.org/species/atlantic-striped-bass for habitat conservation and restoration recommendations, which include reviewing striped bass habitat use and data (e.g., water quality criteria) to inform habitat conservation and restoration.

MANAGEMENT STRATEGY

The Amendment establishes new requirements for the following components of the FMP: management triggers, conservation equivalency, measures to address recreational release mortality, and the stock rebuilding plan. The last striped bass stock assessment found the stock was overfished and that overfishing was occurring. This finding required the Board to end overfishing within one year and rebuild the stock by 2029. Amendment 7 strengthens the Commission's ability to reach the rebuilding goal by implementing a more conservative recruitment trigger, providing more formal guidance around uncertainty in the management process, and implementing measures designed to reduce recreational release mortality. This

Amendment builds upon the Addendum VI action to address overfishing and initiate rebuilding in response to the assessment findings.

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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 striped bass from the Atlantic Ocean, North Carolina, 1982–2021. Recreational data presented from MRIP are for waves 1 (Jan–Feb) and 6 (Nov–Dec).

Year	Recreational			Commercial	
	Number Landed	Number Released	Weight Landed (lb)	Number Landed	Weight Landed (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
2019	0	0	0	0	0
2020	0	0	0	0	0
2021	0	0	0	0	0
Mean	36,538	36,099	718,896	7,509	147,888

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 coastwide (states from Maine to North Carolina) commercial quota in 1991.

	Gear				
Fishing Year	Beach Seine	Gill Net	Trawl	Total Landings	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	4,045	2,181	6,226	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
2018/2019	0	0	0	0	360,360
2019/2020	0	0	0	0	295,495
2020/2021	0	0	0	0	295,495

*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, 1981/1982–2020/2021.

Year	Mean Length	Minimum Length	Maximum 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
2018/2019				0
2019/2020				0
2020/2021				0

Table 4. Striped bass total length (inches) data from Marine Recreational Information Program recreational fishery samples, Atlantic Ocean, North Carolina, 1991–2021.

Year	Mean Length	Minimum Length	Maximum 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
2019				0
2020				0
2021				0

Table 5. Striped bass total length (inches) and tagging data from the Cooperative Winter Tagging Program, trawl and hook-and-line gear, 1988–2021.

	Number Tagged		Mean Length		Minimum Length		Maximum 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	
2019	44	**	40		31		45	
2020	202	**	41		37		56	
2021	1,020	**	38		26		48	

* 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 1982–2021.

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				0
2014				0
2015				0
2016				0
2017				0
2018				0
2019				0
2020				0
2021				0

FIGURES

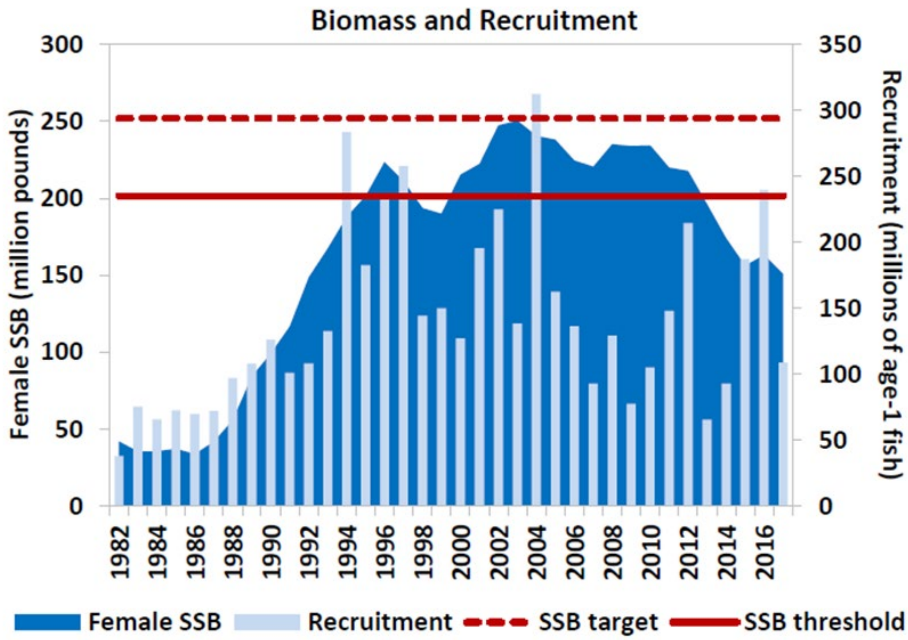


Figure 1. Atlantic striped bass female spawning stock biomass and recruitment (abundance of age-1). Source: ASMFC Atlantic Striped Bass Stock Assessment 2018.

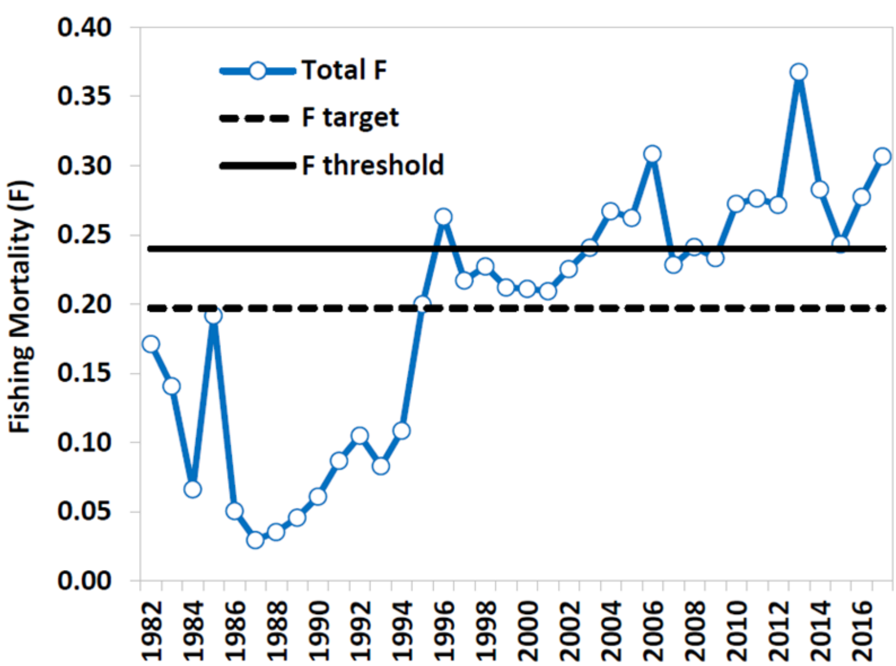
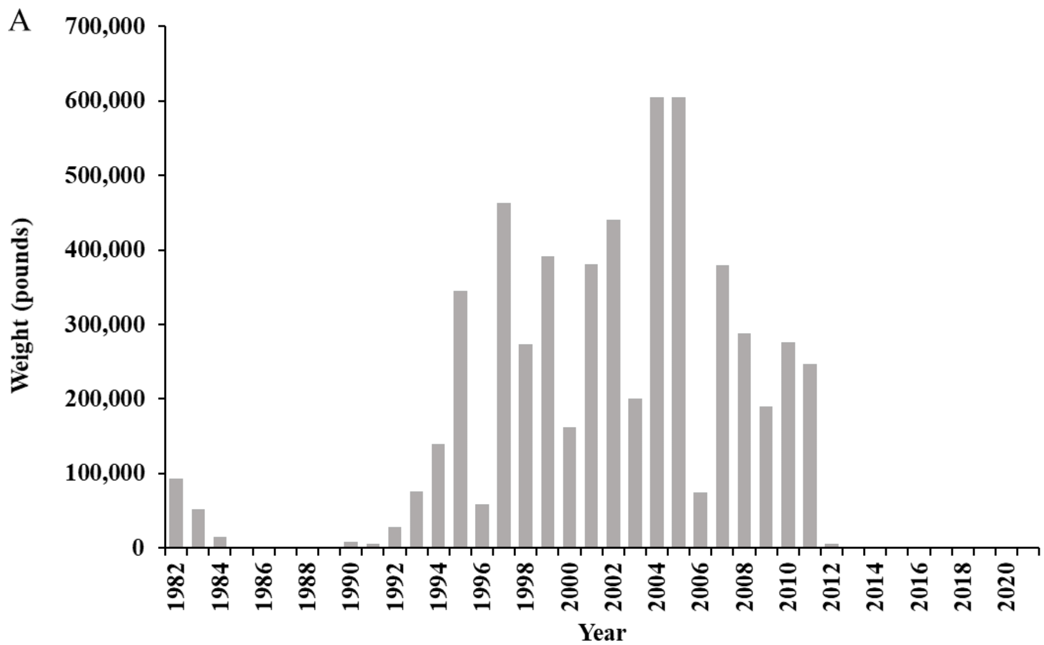


Figure 2. Atlantic striped bass estimates of fishing mortality and the fishing mortality target and threshold reference points. Source: ASMFC Atlantic Striped Bass Stock Assessment 2018.



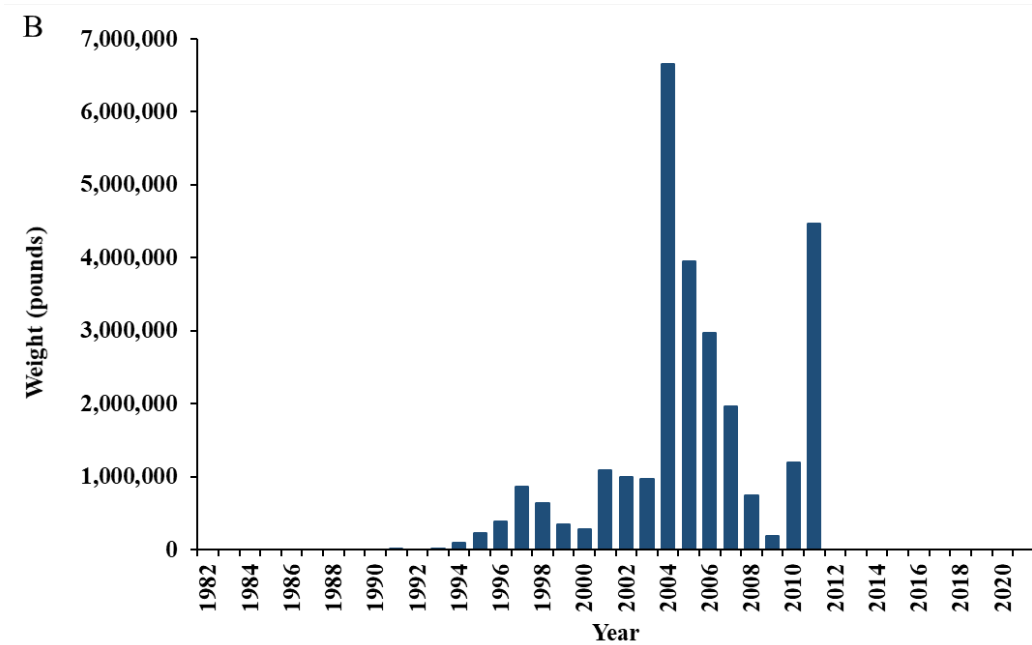


Figure 3. (A) Atlantic striped bass commercial landing (pounds) reported through the North Carolina Trip Ticket Program and (B) recreational landings (Type A + B1; pounds) estimated from the Marine Recreational Information Program survey for North Carolina, 1982–2021.

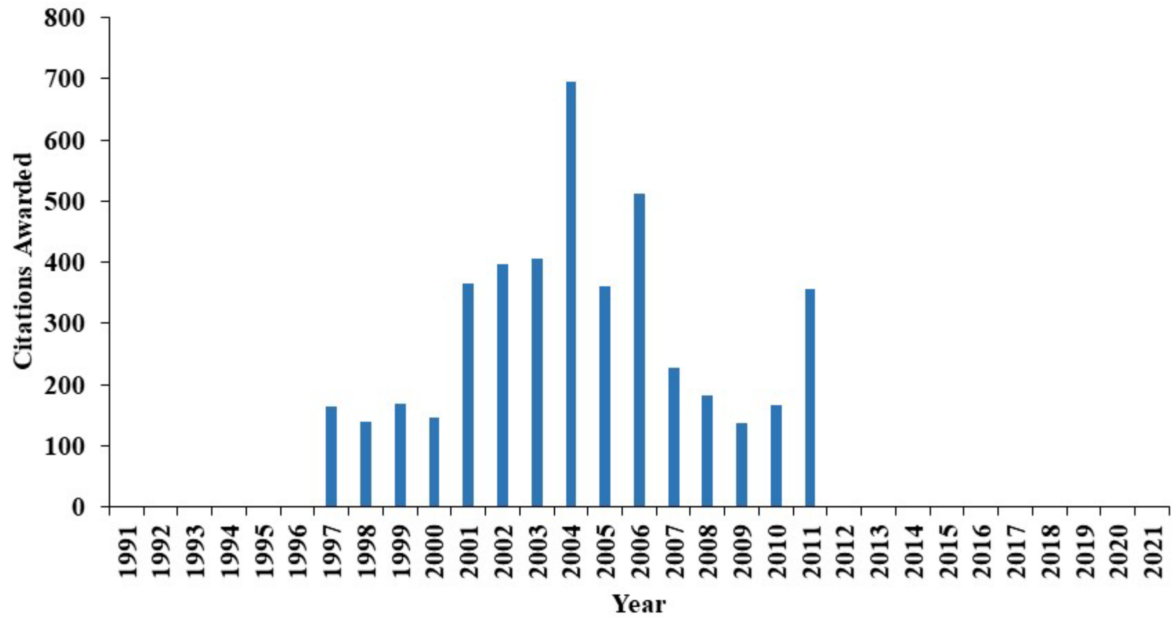


Figure 4. North Carolina Saltwater Fishing Tournament citations awarded for striped bass from the Atlantic Ocean, 1991–2021. Citations are awarded for striped bass greater than 35 pounds or 45 inches total length. Striped bass were removed from the citation program May 1, 2021.

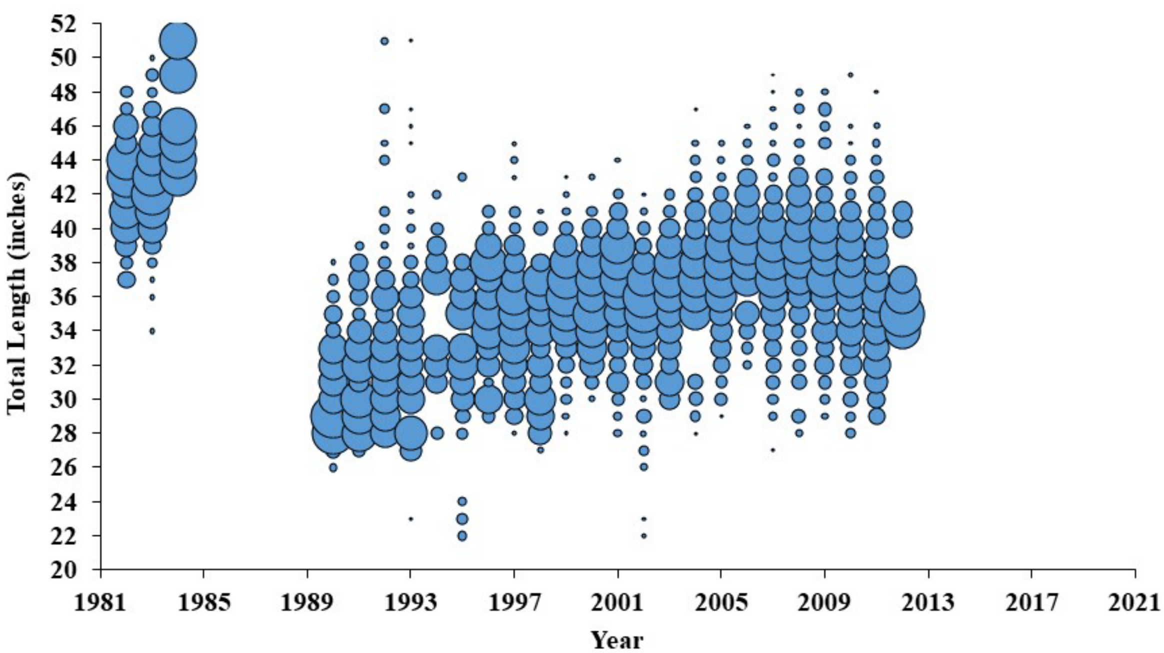


Figure 5. Commercial length frequency (total length, inches) of striped bass harvested from the Atlantic Ocean, 1982–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

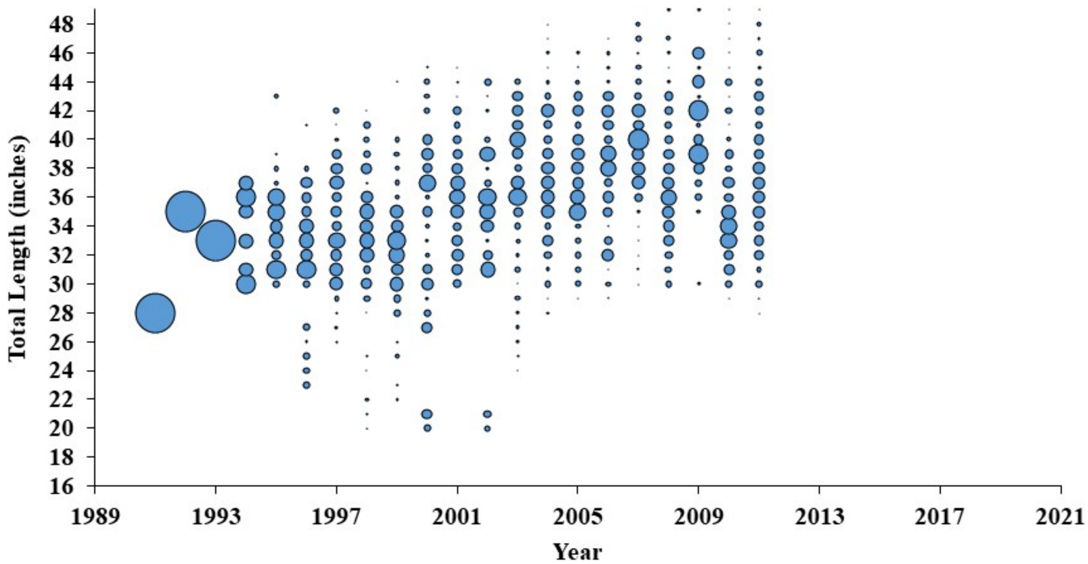


Figure 6. Recreational length frequency (total length, inches) of striped bass harvested from the Atlantic Ocean, 1988–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

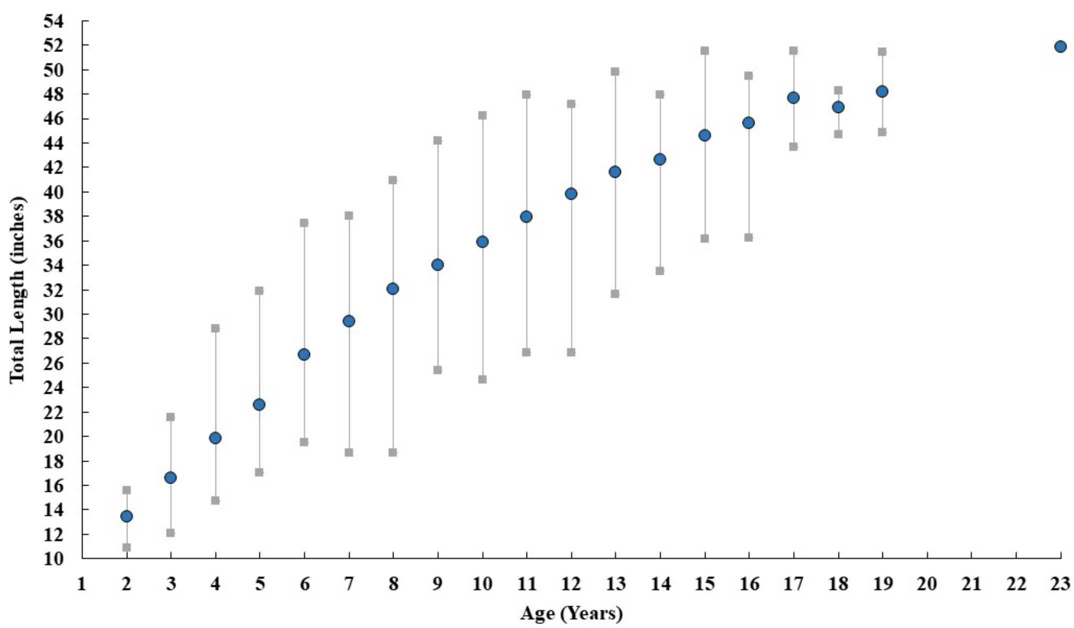


Figure 7. Striped bass length at age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources from the Atlantic Ocean, 1982–2020. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
WAHOO
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	June 2004	
	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 12	June 2021
	Amendment 10	May 2022
Comprehensive 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. The Council adopted a precautionary and risk-averse approach to management for the wahoo fishery to maintain the status quo. The original FMP established no minimum size limit for wahoo in the Atlantic EEZ; established a commercial trip limit of 500 pounds; identified allowable gears in the fishery; and prohibited the use of longline gear to harvest wahoo 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), modified the allocations for both commercial and recreational sectors, and established Annual Catch Targets (ACT) for the recreational sector. 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 wahoo 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 (MRIP). 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 12 was approved by the Council at its September 2020 meeting and became effective June 6, 2021 (SAFMC 2020). Amendment 12 adds bullet mackerel and frigate mackerel to the Dolphin Wahoo Fishery Management Plan and designates them as ecosystem component species. Amendment 10 was approved by the Council at its September 2021 meeting and became effective May 2, 2022 (SAFMC 2020). Amendment 10 includes actions that accommodate updated recreational data from the MRIP by revising the annual catch limits and sector allocations for dolphin and wahoo. The amendment also contains actions that implement other management changes in the fishery including revising accountability measures, accommodating possession of dolphin and wahoo on vessels with certain unauthorized gears onboard, removing the operator card requirement, and reducing the bag limit/recreational vessel limit for dolphin.

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 wahoo (*Acanthocybium solandri*) 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 wahoo and ensure that no new fisheries develop (SAFMC 2003). To achieve these goals, the following management objectives were identified:

- 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.
- 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.
- 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.

- Optimize the social and economic benefits of the dolphin and wahoo fishery. Given the significant importance of dolphin and wahoo to the recreational sector throughout the range of these species and management unit, manage the resources to achieve optimum yield on a continuing basis.
- 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.
- Direct research to evaluate the role of dolphin and wahoo as predator and prey in the pelagic ecosystem.
- Direct research to enhance collection of biological, habitat, social, and economic data on dolphin and wahoo stocks and fisheries.

DESCRIPTION OF THE STOCK

Biological Profile

Wahoo are an epipelagic marine species and can be found worldwide in tropical and subtropical waters and extend seasonally into temperate waters. Wahoo are typically solitary but may form small loose aggregations (Collette and Nausen 1983). They gather around floating debris and flotsam, including sargassum, spending most of their time in water less than 200m depth, and prefer water temperatures ranging from 17.5 to 27.5 degrees Celsius (63.5 – 81.5 degrees Fahrenheit; Theisen and Baldwin 2012). The species is presumed to be short lived (with a possible lifespan of up to or more than 5-6 years; Oxenford et al. 2003); there is much uncertainty in aging wahoo, and there has been no successful validation of presumed annuli or daily growth checks in otoliths to date. In addition, wahoo grows rapidly, with fish captured off North Carolina reaching a mean length of 44 inches by approximately age-1 (Hogarth 1976). The state record for wahoo was caught off Ocracoke in 1994 and weighed 150 pounds; however, fish landed in North Carolina weigh on average approximately 27 pounds. Wahoo become sexually mature during their first year, at around 34 inches for males and 40 inches for females (Hogarth 1976). 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 open-ocean currents from June to August, with a peak in June and July (Hogarth 1976).

Stock Status

The stock status of wahoo in the western Atlantic is unknown.

Stock Assessment

A stock assessment is not available for this species.

DESCRIPTION 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 .0517). It is unlawful to possess for recreational purposes more than two wahoo per person per day taken by hook and line. For commercial fishing, there is a 500-pound trip limit (landed head and tail intact). It is unlawful for a commercial fishing operation to take or possess or sell a recreational bag limit of wahoo without a Federal Commercial Dolphin/Wahoo Vessel Permit. Commercial vessels federally permitted in another fishery are allowed to land up to 200 pounds of dolphin and wahoo combined.

Commercial Fishery

Commercial landings of wahoo are reported through the mandatory NCDMF Trip Ticket program. Landings since 1986 have fluctuated with a low of 6,014 pounds in 1986 and a high of 40,731 pounds in 1995 (Table 1; Figure 1). In the past 10 years, landings have averaged approximately 21,596 pounds; commercial landings in 2021 (7,343 pounds) were much lower than the average.

Recreational Fishery

Recreational landings of wahoo are estimated from the MRIP. Recreational 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 see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Landings of wahoo, on average, have decreased in the last 10 years (2012-2021 average of 644,339 pounds compared to the 2002-2011 average of 1,058,188 pounds). After peaking in 2004 (2,220,765 pounds), wahoo landings have fluctuated, declining to low of 251,421 pounds in 2021 (Table 1; Figure 2). Landings remained stable in 2020 at 462,937 pounds and declined substantially in 2021 at 251,421 pounds.

The NCDMF offers award citations for recreational fishermen who land wahoo greater than 40 pounds. After a period of high, stable number of citations from 2012-2019, total number of citations awarded through the North Carolina Saltwater Fishing Tournament decreased in 2020 to 527 citations, and further decreased in 2021 to 310 citations; the lowest number awarded since 1991 (247 citations; Table 2; Figure 2).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Fishery dependent length-frequency information for the commercial wahoo fishery in North Carolina is collected by fish house samplers, specifically through NCDMF programs 438 (Offshore Live Bottom Fishery) and 439 (Coastal Pelagic). The number of wahoo samples obtained by fish house samplers is generally low, ranging from 1 to 101 samples each year from

1986 to 2021; this is due to it being an incidental catch in other fisheries. In 2021, four wahoo lengths were obtained, a decrease from the previous year (5 samples in 2020) and below the average number of samples (11 samples; Table 3; Figure 3). The average size of wahoo sampled from the commercial fishery increased in 2021 (48.3 inches fork length) from the previous year (46.9 inches fork length) and was below the time series average (49.4 inches fork length; Table 3; Figure 4). The maximum size of wahoo sampled from the commercial fishery decreased in 2021 (52.6 inches fork length) from the previous year (65.7 inches fork length) and was below the time series average (59.9 inches fork length; Table 3; Figure 4).

Length and weight information for the recreational fishery are collected through the MRIP dockside sampling. The average size of wahoo sampled from the recreational fishery was slightly smaller in 2021 (46.0 inches fork length) compared to the previous year (46.9inches fork length), and overall has remained relatively constant throughout the time series (Table 3; Figure 5). The minimum size of wahoo sampled from the recreational fishery remained the same in 2021 (26.0 inches fork length) from the previous year. The maximum size of wahoo sampled from the recreational fishery increased in 2021 (71.9 inches fork length) from the previous year (70.5 inches fork length in 2020).

Due to so few commercial samples, there was no modal length for the commercial fishery in 2021; however, in 2019, the commercial modal length was 44 inches fork length. The modal length for the wahoo recreational fishery in 2021 was 47 inches fork length (Figure 5). On average, the recreational fishery harvests larger maximum sizes of wahoo than the commercial fishery (Table 3; Figure 5); the average maximum length of wahoo sampled from the recreational fishery is 67.3, compared to an average of 59.9 inches fork length by the commercial fishery. However, on average, the commercial fishery harvests similar size fish (49.4 inches fork length) to the recreational fishery (47.9 inches fork length; Table 3; Figure 5).

Fishery-Independent Monitoring

Currently, NCDMF does not have any fishery-independent sampling programs that target or catch wahoo in great numbers.

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 wahoo in order of priority from highest to lowest:

- What is the areal and seasonal abundance of pelagic Sargassum off the southeast U.S.?
- Develop methodologies to remotely assess Sargassum using aerial or satellite technologies (e.g., Synthetic Aperture Radar)
- What is the relative importance of pelagic Sargassum weedlines and oceanic fronts for early life stages of wahoo?

- Are there differences in wahoo abundance, growth rate, and mortality?
- 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?
- Is pelagic Sargassum mariculture feasible?
- Determine the species composition and age structure of species associated with pelagic Sargassum when it occurs deeper in the water column.
- Additional research on the dependencies of pelagic Sargassum productivity on the marine species using it as habitat.
- Quantify the contribution of nutrients to deepwater benthic habitat by pelagic Sargassum.
- 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.
- 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.
- 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.
- Direct specific research to further address the association between pelagic Sargassum habitat and post-hatchling sea turtles

Biological research reeds for wahoo in order of priority from highest to lowest:

- Additional data are needed to develop and/or improve estimates of growth, fecundity, etc.
- 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.
- Trophic data should be considered in support of an ecosystem management approach.
- Essential fish habitats for dolphin and wahoo need to be identified.
- An overall design should be developed for future tagging work. In addition, existing tagging databases should be examined.
- Establish a list serve for dolphin and wahoo which would facilitate research and the exchange of information.

MANAGEMENT STRATEGY

In North Carolina, wahoo 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 wahoo in 2004 and it is currently managed under Amendment 5 (SAFMC 2013), Amendment 7 (SAFMC 2015a), Amendment 12 (SAFMC 2020), Amendment 10 (SAFMC 2021).

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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 wahoo from North Carolina, 1986–2021. The (-) denotes years where there were no observations of released wahoo.

Year	Recreational			Commercial	
	Number Landed	Number Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
1986	11,085		21,298	6,014	480,416
1987	6,400	42	172,708	15,827	188,535
1988	2,043	-	14,342	19,783	34,125
1989	6,674	-	194,287	9,921	204,208
1990	5,290	-	114,060	16,653	130,713
1991	5,068	17	121,382	18,620	140,002
1992	6,326	1,061	1,726,842	14,383	1,741,225
1993	7,673	-	208,325	24,121	232,446
1994	12,182	1,286	308,986	20,319	329,305
1995	21,726	14	476,289	40,731	517,020
1996	15,259	1,300	397,335	26,675	424,010
1997	19,587	152	464,335	20,628	484,963
1998	11,195	51	253,128	22,600	275,728
1999	17,341	-	387,342	28,963	416,305
2000	18,183	1,126	412,824	19,905	432,729
2001	17,889	-	473,926	20,503	494,429
2002	32,783	398	1,056,010	19,952	1,075,962
2003	21,274	-	662,567	17,222	679,789
2004	61,153	-	2,220,765	22,006	2,242,771
2005	41,364	-	1,249,160	14,980	1,264,140
2006	21,834	594	490,904	16,426	507,330
2007	47,890	-	1,495,127	24,306	1,519,433
2008	21,777	-	527,736	11,643	539,379
2009	42,129	48	1,696,717	16,397	1,713,114
2010	19,703	2,532	571,575	12,626	584,201
2011	21,501	40	611,319	15,870	627,189
2012	37,423	12	994,195	23,521	1,017,716
2013	11,951	337	319,866	23,380	343,246
2014	29,362	22	804,473	22,783	827,256
2015	36,920	608	983,232	18,380	1,001,612
2016	39,565	5	1,056,969	25,393	1,082,362
2017	30,305	-	842,604	28,963	871,567
2018	10,690	182	280,644	22,619	303,263
2019	17,098	23	454,391	31,494	485,885
2020	19,055	87	462,937	12,079	475,016
2021	9,760		244,078	7,343	251,421
Mean	21,363	452	656,620	20,162	676,783

Table 2. Total number of awarded citations for wahoo (>40 pounds landed) annually from the North Carolina Saltwater Fishing Tournament, 1991–2021.

Year	Citations
1991	247
1992	349
1993	390
1994	422
1995	400
1996	378
1997	391
1998	474
1999	493
2000	706
2001	501
2002	537
2003	448
2004	827
2005	680
2006	614
2007	913
2008	327
2009	377
2010	419
2011	358
2012	673
2013	737
2014	718
2015	697
2016	694
2017	978
2018	719
2019	786
2020	527
2021	310

Table 3. Mean, minimum, and maximum lengths (fork length, inches) of wahoo collected from the commercial and recreational fisheries, 1986–2021.

Year	Commercial				Recreational			
	Mean Length	Minimum Length	Maximum Length	Total Number Measured	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1986	51.2	47.6	55.9	3	53.2	31.0	64.0	28
1987	36.2	36.2	36.2	1	46.6	24.0	72.4	72
1988	53.2	39.8	65.4	15	47.9	28.9	72.8	96
1989	53.3	41.9	72.0	20	46.8	28.3	59.8	91
1990	54.6	41.7	68.3	7	44.5	16.9	59.6	143
1991	47.9	41.3	53.5	5	45.6	21.1	64.2	105
1992	55.0	42.9	70.3	11	47.3	29.5	66.0	139
1993	45.3	38.4	57.1	15	46.9	21.9	71.0	154
1994	53.5	40.9	63.4	4	47.0	4.3	66.5	320
1995	51.7	39.4	60.4	6	45.4	3.9	72.1	391
1996	56.5	46.5	63.0	4	48.0	25.6	67.5	253
1997	-	-	-	0	45.6	23.2	70.6	302
1998	-	-	-	0	45.5	28.2	61.0	327
1999	51.9	32.3	65.0	11	44.7	31.7	68.5	275
2000	49.8	40.9	57.1	5	44.9	33.1	83.5	247
2001	45.5	41.7	50.0	3	46.1	36.0	77.1	249
2002	41.3	41.3	41.3	1	48.0	33.0	68.0	260
2003	52.9	44.5	61.8	4	48.2	37.3	68.0	58
2004	41.7	31.9	50.0	4	52.3	35.6	66.1	151
2005	55.1	48.8	62.6	8	48.1	34.4	67.2	75
2006	61.4	61.0	61.8	2	45.0	28.2	67.3	87
2007	26.7	24.6	29.4	4	50.4	24.3	62.0	110
2008	44.8	40.9	52.2	3	46.1	30.3	68.0	113
2009	45.4	39.5	52.0	10	53.6	34.0	68.2	145
2010	50.4	38.1	87.3	6	49.0	28.0	67.6	184
2011	47.9	41.1	63.4	16	49.0	31.0	68.1	227
2012	49.3	35.4	70.0	101	48.2	32.0	70.6	393
2013	45.5	41.3	49.6	2	48.4	39.8	65.6	97
2014	46.2	39.7	54.3	30	48.2	26.0	59.0	133
2015	53.2	50.3	56.5	8	47.9	31.7	78.0	135
2016	49.8	39.5	68.3	18	48.1	30.9	62.6	211
2017	54.4	50.0	60.0	4	48.8	36.3	68.0	163
2018	53.0	35.9	69.5	14	47.7	28.1	68.5	126
2019	55.5	41.7	71.1	50	47.1	32.1	78.4	104
2020	46.9	35.0	65.7	5	46.9	26.0	70.5	93
2021	48.3	43.6	52.6	4	46.0	26.0	71.9	39

FIGURES

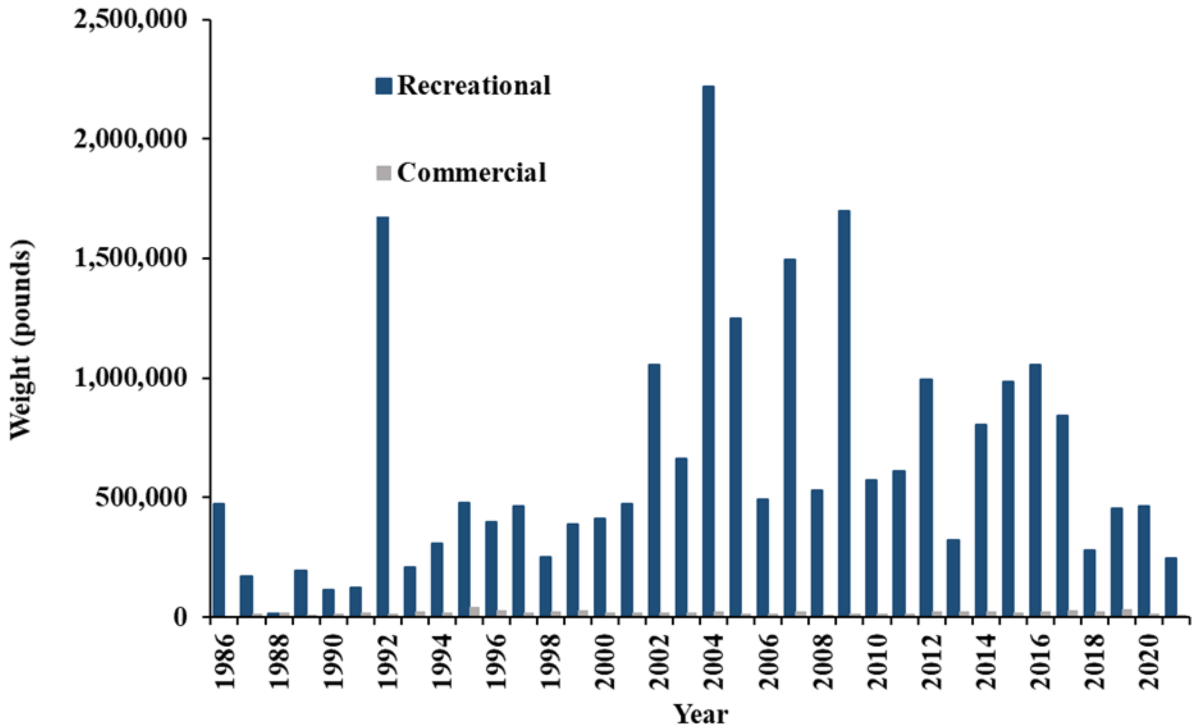


Figure 1. Annual commercial and recreational landings in pounds of wahoo in North Carolina, 1986–2021.

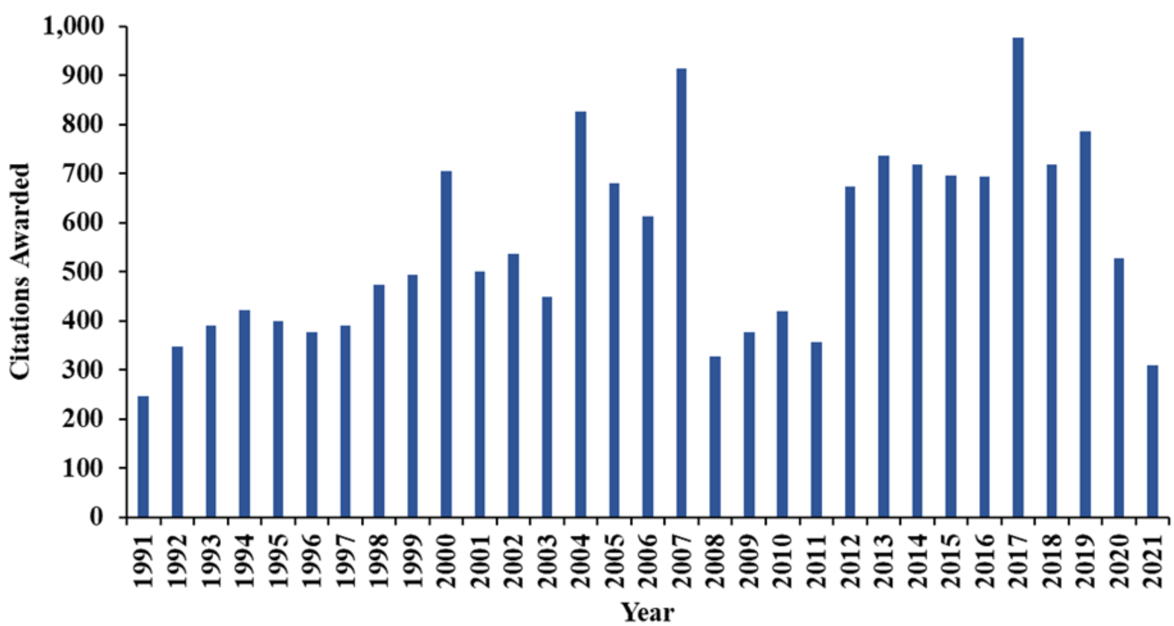


Figure 2. Total number of awarded citations for wahoo (>40 pounds landed) annual from the North Carolina Saltwater Fishing Tournament, 1991–2021.

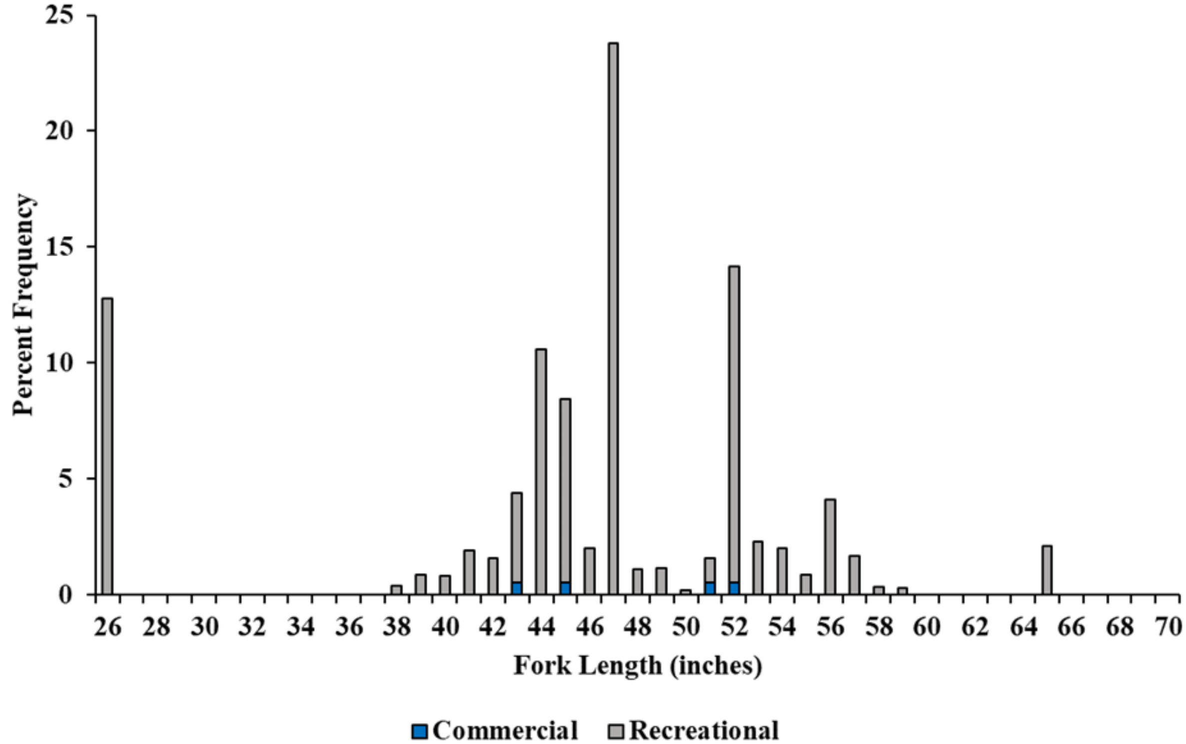


Figure 3. Commercial and recreational length frequency distribution for wahoo harvested in 2021.

Figure 4. Commercial length frequency (fork length, inches) of wahoo harvested, 1994–2021. 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.

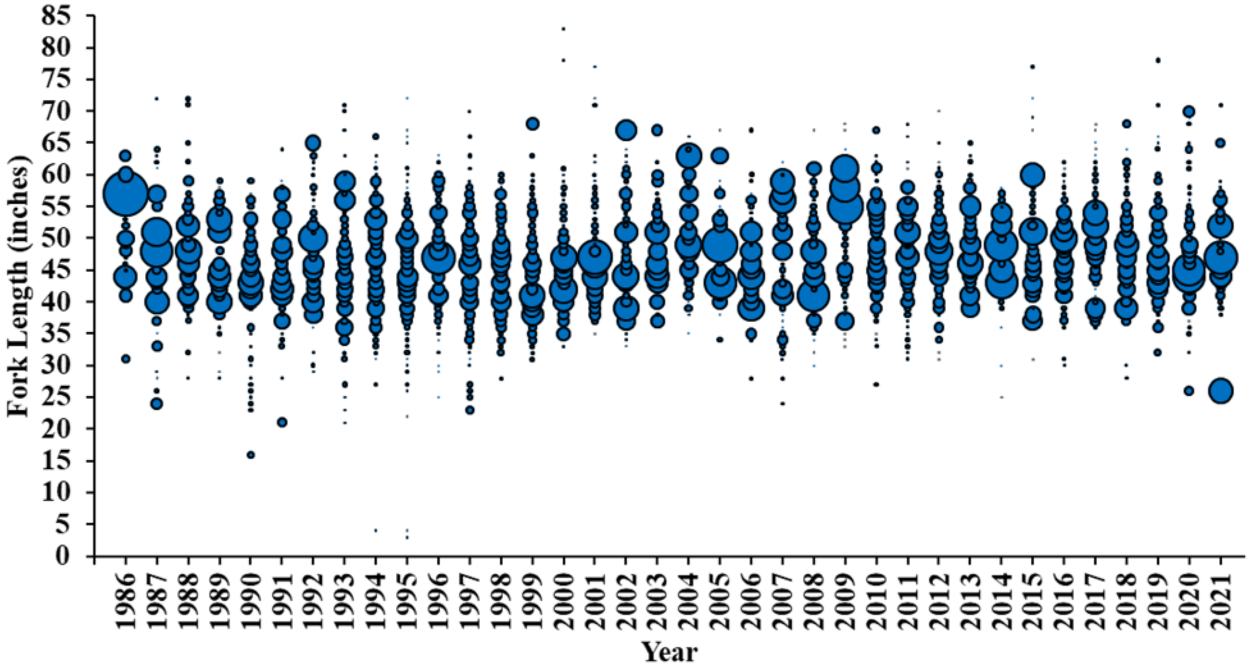


Figure 5. Recreational length frequency (fork length, inches) of wahoo harvested, 1986–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length in that year.

Estuarine Striped Bass Fishery Management Plan Amendment 2 Decision Document

August 2022

N.C. Division of Marine Fisheries

3441 Arendell Street

Morehead City, North Carolina 28557

This Decision Document is a companion document to Amendment 2 to the Estuarine Striped Bass Fishery Management Plan. It provides a brief overview and context for the issues. The document also provides references to the full Amendment document where more detailed information and exact management option language is located. The Estuarine Striped Bass Fishery Management Plan Amendment 2 document is the plan under consideration and is the focus of all MFC action.

Summary

During the August MFC business meeting the MFC will review departmental comments and vote on final adoption of draft Amendment 2 of the Estuarine Striped Bass Fishery Management Plan (Amendment 2) . If approved, the DMF, Marine Fisheries Commission (MFC) and Wildlife Resource Commission (WRC) will begin implementing the approved management.

The current stock assessment indicates the Albemarle-Roanoke Striped Bass Stock Assessment is overfished and overfishing is occurring. To address overfishing, the DMF implemented adaptive management approved under Amendment 1 of the Estuarine Striped Bass FMP. This significantly reduced the total allowable harvest for all fisheries to end overfishing. The management being considered in Amendment 2 will continue with this reduced total allowable harvest for all fisheries and the rebuilding process.

A stock status determination is not available for the Central Southern Management Area stocks of striped bass, however, based on evaluation of available data sustainable management are presented as part of Amendment 2.

Amendment Timing

November 2020	Division holds public scoping period
February 2021	MFC approves goal and objectives of FMP
October 2020 - September 2021	Division drafts FMP
September - October 2021	Division holds workshops to further develop draft FMP with Plan Advisory Committee
October 2021 - January 2022	Division updates draft plan
February 2022	MFC votes to send draft FMP for public and AC review
March 2022	MFC Advisory Committees meet to review draft FMP and receive public comment
May 2022	MFC selects preferred management options
June - July 2022	DEQ Secretary and Legislative review of draft FMP
August 2022	**MFC votes on final adoption of FMP**
TBD	DMF, WRC and MFC implement management strategies

FMP Goal and Objectives

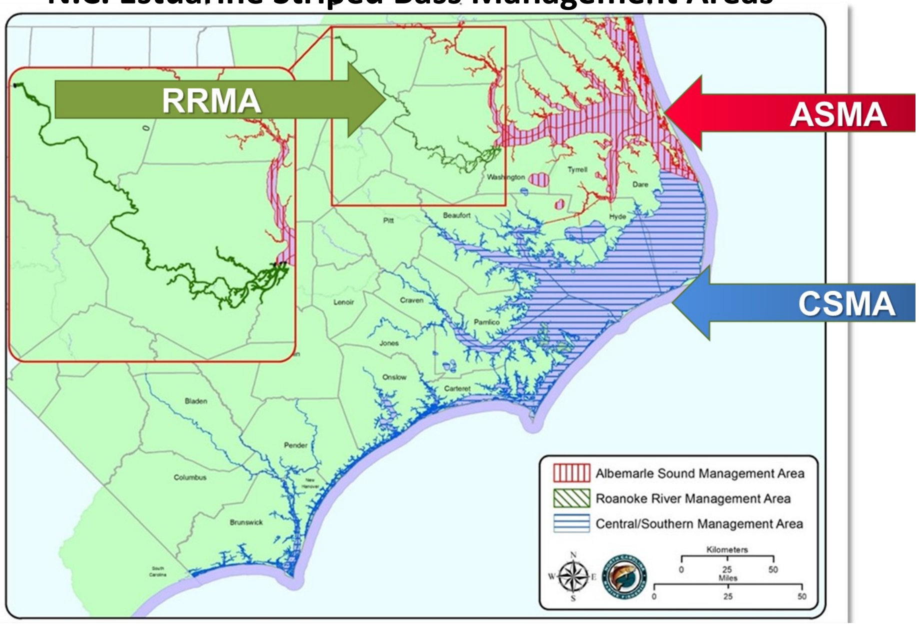
The goal of Amendment 2 is to manage the estuarine striped bass fisheries to achieve self-sustaining populations that provide sustainable harvest based on science-based decision-making processes. If biological and/or environmental factors prevent a self-sustaining population, then alternate management strategies will be implemented that provide protection for and access to the resource. The following objectives will be used to achieve this goal.

- Implement management strategies within North Carolina and encourage interjurisdictional management strategies that maintain and/or restore spawning stock with adequate age structure and abundance to maintain recruitment potential and to prevent overfishing.
- Restore, enhance, and protect critical habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan, to maintain or increase growth, survival, and reproduction of the striped bass stocks.
- Use biological, social, economic, fishery, habitat, and environmental data to effectively monitor and manage the fisheries and their ecosystem impacts.
- Promote stewardship of the resource through public outreach and interjurisdictional cooperation regarding the status and management of the North Carolina striped bass stocks, including practices that minimize bycatch and discard mortality.

Background

There are two estuarine striped bass management units and four stocks in North Carolina. The Northern management unit includes the Albemarle Sound Management Area (ASMA) and Roanoke River Management Area (RRMA). The striped bass stock in these two harvest management areas is referred to as the Albemarle– Roanoke (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 MFC. Within the RRMA, commercial regulations are the responsibility of the MFC while recreational regulations are the responsibility of the WRC. The A-R stock is also included in the management unit of Amendment 7 to the Atlantic States Marine Fisheries Commission (ASMFC) Interstate FMP for Atlantic Striped Bass. The Southern management unit is the Central Southern Management Area (CSMA) and includes the Tar-Pamlico, Neuse, and the Cape Fear rivers stocks.

N.C. Estuarine Striped Bass Management Areas



The most recent A-R striped bass stock assessment was completed and approved for management use in 2020. The assessment indicated the resource is overfished and is experiencing overfishing. The North Carolina Fisheries Re-form Act and Amendment 7 to the ASMFC Interstate FMP for Atlantic Striped Bass require management measures to be implemented to end overfishing in 1-year and end the overfished status in 10-years. Adaptive management described in Amendment 1 was triggered by the assessment and the November 2020 Revision to Amendment 1 to the North Carolina Estuarine Striped Bass FMP reduced the striped bass total allowable landings (TAL) from 275,000 pounds to 51,216 pounds in the ASMA and RRMA. This reduction in TAL is expected to end overfishing in one year. This adaptive management action maintains compliance with Amendment 1 to the North Carolina Estua-rine Striped Bass FMP and ASMFC Addendum IV to Amendment 6 to the Interstate FMP for Atlantic Striped Bass. The new TAL was effective January 1, 2021. The commercial and recreational fisheries are set at a 50/50 allocation. Recreational allocation is split evenly between the ASMA and RRMA.

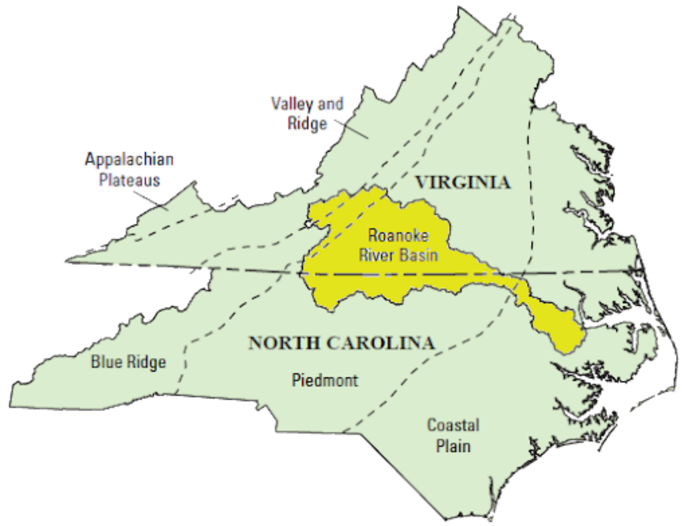
The CSMA Estuarine Striped Bass Stocks report completed in 2020, is a collection of (1) all data that have been collected, (2) all management effort, and (3) all major analyses that have been completed for CSMA stocks to serve as an aid in development of Amendment 2. While this report does not yield a stock status, it does indicate that sustainability of Tar-Pamlico and Neuse rivers stocks is unlikely at any level of fishing mortality. It also indicates that natural recruitment is the primary limiting factor. The report concludes that without stocking, abundance will decline. In the Cape Fear River, abundance declined even with no possession measures in place. No-possession measures were implemented in the Cape Fear River in 2008 and the Tar-Pamlico and Neuse rivers in 2019. The overall goal of the no-possession measures is to increase the age structure and abundance of fish in these systems to move towards sustainable stocks.

River Flow

Striped bass are broadcast spawners, producing eggs that must remain suspended in the water column to develop and hatch. Proper river flow is a critical environmental factor influencing year class strength. In the RRMA, extended periods of high water flow from May to June negatively impact eggs and fry. Recruitment failures since 2001 are thought to be due to spring flooding.

There are three dams on the Roanoke River above Weldon. The Federal Energy Regulatory Commission does limit activities, such as hydropeaking, to limit dam impacts. However, rainfall in the river basin impacts the ability to regulate river flow while limiting flooding. The Roanoke River is impacted by rain north of Winston-Salem, NC and into southern Virginia.

A cooperative agreement with the US Army Corp. of Engineers strives to maintain Roanoke River flow rates within specified ranges to allow for striped bass spawning success. Flow rates that strive to benefit striped bass spawning are negotiated. Spawning success is measured by the annual juvenile abundance index (JAI). In 2005, the flow was ideal for spawning and the JAI was high. In 2013, the flow rate was too high for half of the spawning period. The resulting JAI was low. Poor recruitment is a major factor causing population declines. Inter-agency work continues to address these environmental concerns.



Roanoke River Basin USGS Report 2012-5101

Stocking

In the late 19th century, the Weldon Hatchery began growing striped bass to release into the wild. Since then striped bass have been stocked in the Albemarle Sound, Tar-Pamlico, Neuse, and Cape Fear rivers. An interagency cooperative agreement (See Appendix 1A, p. 51) between the US Fish and Wildlife Service, DMF, and WRC was established in 1986 to oversee the North Carolina Coastal Striped Bass Stocking Program. An annual workplan establishes stocking goals by river system.

Historically, Roanoke River broodstock were used when stocking the rivers of North Carolina. This has resulted in genetically similar fish stocks across the state. Broodstock are now retrieved from the different river systems; however, the fish are genetically from the same stock.

Stocking is necessary to maintain the Tar-Pamlico, Neuse, and Cape Fear stocks. Data collection efforts continue to evaluate if self-sustaining stocks are achievable in these systems. If not, alternative management may be considered, such as hatchery supported fisheries. More on the history of stocking and an assessment of the state stocking program is provided in Appendix 1 of the FMP document (p. 31) . This information informs the three sustainable harvest issue papers.

MFC Preferred Management Measures

In May 2022, the North Carolina MFC reviewed the input from the WRC, MFC Advisory Committees, and the public for draft Amendment 2 and selected its preferred management options listed below. The MFC selected the options recommended by the DMF which are listed below. In addition, the MFC passed a motion continuing the current prohibition of gill nets above the ferry lines in the Tar-Pamlico and Neuse Rivers. The DMF is to study the effects of the gill net closure and reevaluate the decision based on the study outcome during the next full amendment review. Amendment 2 was jointly developed by the Division of Marine Fisheries (DMF) staff and Wildlife Resources Commission (WRC) staff, with recommendations provided by the WRC and DMF.

Measures to Achieve Sustainable Harvest for the Albemarle Sound-Roanoke River Stock *(Appendix 2)*

- Continue to use stock assessments and projections to determine the Total Allowable Landings (TAL) that achieve sustainable harvest
- Continue managing the ASMA commercial fishery as a bycatch fishery
- Modify accountability measures: if landings in any fishery exceeds their allocation, all landings in excess will be deducted from that fisheries TAL the next calendar year or until the overage is paid back
- In the ASMA, implement a harvest slot of a minimum size of 18-inches TL to not greater than 25 inches TL in the commercial and recreational sectors
- In the RRMA, maintain current harvest slot limit of a minimum size of 18-inches TL to not greater than 22-inches TL with no harvest allowed on fish greater than 22 inches.
- Allow commercial harvest of striped bass with gill nets in joint and coastal waters of the ASMA and continue recreational harvest and catch-and-release fishing in the ASMA and RRMA. Implement a requirement to use non-offset barbless circle hooks when fishing with live or natural bait in the inland waters of the Roanoke River upstream of the Hwy 258 bridge from May 1 through June 30. The requirement from April 1 through June 30, only a single barbless hook or lure with single barbless hook (or hook with barb bent down) may be used in the inland waters of the Roanoke River upstream of U.S. Highway 258 Bridge will remain in effect.
- Adopt adaptive management framework that will allow for future adjustments of the TAL based on results of updated stock assessments and provide the Director the flexibility to modify daily possession limits, harvest seasons, and gear requirements to manage harvest to the TAL and reduce discards.

Measures to Achieve Sustainable Harvest for the Tar-Pamlico and Neuse Rivers Stocks *(Appendix 3)*

- Continue the no-possession measure.
- Continue gill net closure above the ferry lines and the 3-foot tie-downs below the ferry lines.
- In 2025, review data through 2024 to determine if populations are self-sustaining and if sustainable harvest can be determined.

Measures to Achieve Sustainable Harvest for the Cape Fear River Stock *(Appendix 4)*

- Continue Cape Fear River harvest moratorium.
- Adaptive management based on young of year surveys and parentage-based tagging analysis to evaluate if the levels of natural reproduction in the system further warrant a harvest moratorium and allow the Director the flexibility to allow harvest after consultation with the Finfish Advisory Committee

Measures for the Use of Hook and Line as a Commercial Gear *(Appendix 5)*

- Continue to manage the use of hook and line gear in the commercial fishery as an adaptive management option across the fishery. Commercial harvest of stiped bass from hook and line gear is not authorized at this time.

DRAFT
North Carolina Estuarine Striped Bass Fishery Management Plan Amendment 2

By

North Carolina Division of Marine Fisheries

and

North Carolina Wildlife Resources Commission

August 2022

North Carolina Department of Environmental Quality
North Carolina Division of Marine Fisheries
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DRAFT – SUBJECT TO CHANGE

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Disclaimer: Data in this Fishery Management Plan may have changed since publication based on updates to source documents.

ACKNOWLEDGEMENTS

Amendment 2 to the North Carolina (NC) Estuarine Striped Bass Fishery Management Plan (FMP) was developed jointly by the NC Department of Environmental Quality (DEQ), NC Division of Marine Fisheries (DMF) and the NC Wildlife Resources Commission (WRC) under the auspices of the NC Marine Fisheries Commission (MFC) with the advice of the Estuarine Striped Bass FMP Advisory Committee (AC). Deserving special recognition are the members of the Estuarine Striped Bass FMP AC and the DMF Plan Development Team who contributed their time and knowledge to this effort.

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EXECUTIVE SUMMARY

The North Carolina (NC) Estuarine Striped Bass Fishery Management Plan (FMP) is jointly developed by the NC Division of Marine Fisheries (DMF) and NC Wildlife Resources Commission (WRC). Striped bass fisheries that occur in the sounds and coastal rivers of NC are managed under this FMP, while striped bass fisheries that occur in the Atlantic Ocean are managed through the Atlantic States Marine Fisheries Commission (ASMFC) Interstate FMP for Atlantic Striped Bass. There are four estuarine striped bass stocks managed under two management units in NC. The northern management unit includes the Albemarle Sound (ASMA) and Roanoke River Management Areas (RRMA) while the remainder of the states estuarine waters comprise the CentralSouthern Management Area (CSMA).

The 2020 stock assessment of the Albemarle Sound-Roanoke River striped bass indicated the stock is overfished and undergoing overfishing. The ASMFC requires an end to overfishing within one year, which was addressed through the November 2020 Revision to Amendment 1. This meets the NC standard requiring management action end overfishing in two years. NC law also requires management action to recover from the overfished status within 10 years. Stock status is not available for the other NC stocks due to continuous stocking efforts. However, modeling indicates that these stocks are depressed to an extent sustainability is unlikely under any fishing mortality.

The goal of Amendment 2 is to manage the estuarine striped bass fisheries to achieve self-sustaining populations that provide sustainable harvest based on science-based decision-making processes. If biological and/or environmental factors prevent a self-sustaining population, then alternate management strategies will be implemented that provide protection for and access to the resource. The objectives to achieve this goal include: implement management strategies within NC and encourage interjurisdictional management strategies that maintain and/or restore spawning stock with adequate age structure and abundance to maintain recruitment potential and to prevent overfishing; restore, enhance, and protect critical habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan (CHPP), to maintain or increase growth, survival, and reproduction of the striped bass stocks; use biological, social, economic, fishery, habitat, and environmental data to effectively monitor and manage the fisheries and their ecosystem impacts; promote stewardship of the resource through public outreach and interjurisdictional cooperation regarding the status and management of the NC striped bass stocks, including practices that minimize bycatch and discard mortality.

To meet statutory requirements to achieve self-sustaining striped bass stocks, sustainable harvest is addressed in the FMP. An additional issue addresses the use of hook and line as a commercial gear. Specific recommendations for each issue are as follows:

Sustainable harvest: Albemarle Sound-Roanoke River Stock *(Appendix 2)*:

- Use stock assessments and projections to determine the Total Allowable Landings (TAL) that achieve sustainable harvest.
- If fishing mortality (F) exceeds the F_{Target}, reduce the TAL to achieve the F_{Target} in one year through a Revision.
- Continue managing the ASMA commercial fishery as a bycatch fishery.

- Accountability measures to address total allowable landing (TAL) overages: if landings in any fishery exceeds their TAL, all landings in excess will be deducted from that fisheries TAL the next calendar year or until the overage is paid back.
- In the ASMA, implement a harvest slot of a minimum size of 18-inches TL to not greater than 25-inches TL in the commercial and recreational sectors.
- In the RRMA, maintain current harvest slot limit of a minimum size of 18-inches TL to not greater than 22-inches TL with no harvest allowed on fish greater than 22-inches.
- Allow commercial harvest of striped bass with gill nets in joint and coastal waters of the ASMA and continue recreational harvest and catch-and-release fishing in the ASMA and RRMA. Implement a requirement to use non-offset barbless circle hooks when fishing with live or natural bait in the inland waters of the Roanoke River upstream of the Hwy 258 bridge from May 1 through June 30.
- Adopt adaptive management framework that will allow for future adjustments of the TAL based on results of updated stock assessments and provide the Director the flexibility to modify daily possession limits, harvest seasons, and gear requirements to manage harvest to the TAL and reduce striped bass discards.

Sustainable harvest: Tar-Pamlico, and Neuse rivers stocks *(Appendix 3):*

- Continue the no-possession measure in Supplement A to Amendment 1.
- Maintain gill net closure above the ferry lines and maintain the 3-foot tie-downs below the ferry lines.
- In 2025, review data through 2024 to determine if populations are self-sustaining and if sustainable harvest can be determined.

Sustainable harvest: Cape Fear River stock *(Appendix 4):*

- Maintain Cape Fear River harvest moratorium.
- Adaptive management based on young-of-year surveys and parentage-based tagging analysis to evaluate if the levels of natural reproduction in the system further warrant a harvest moratorium and provide the Director the flexibility to allow harvest after consultation with the Finfish Advisory Committee.

Hook and line as a commercial gear *(Appendix 5):*

- Continue to manage the use of hook and line gear in the commercial fishery as an adaptive management option across the fishery. Commercial harvest of stiped bass from hook and line gear is not authorized at this time.

INTRODUCTION

This is Amendment 2 to the NC Estuarine Striped Bass FMP. By law, each FMP must be reviewed at least once every five years in accordance with N.C.G.S. section 113-182.1. The NC DMF reviews each FMP annually and a comprehensive review is undertaken about every five years. The last comprehensive review of the plan (Amendment 1) was approved by the NC Marine Fisheries Commission (MFC) in 2013. FMPs are the ultimate product that brings all information and management considerations into one document. The DMF prepares FMPs for adoption by the MFC for all commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources. The goal of these plans is to ensure long-term viability of these fisheries.

In NC striped bass (*Morone saxatilis*) stocks are managed among four areas: (1) Albemarle Sound Management Area (ASMA), (2) Roanoke River Management Area (RRMA), (3) Central/Southern Management Area (CSMA), and (4) Atlantic Ocean. The MFC adopts rules and policies and with DMF implements management measures for the estuarine striped bass fishery in Coastal Fishing Waters in accordance with N.C.G.S. section 113-182.1. The Estuarine Striped Bass FMP is jointly developed with the NC WRC. The migratory Atlantic Ocean stock is managed by the ASMFC. The ASMA and RRMA are also subject to compliance requirements of the ASMFC Interstate FMP for Atlantic Striped Bass.

FISHERY MANAGEMENT PLAN HISTORY

Original FMP Adoption:	November 1993
	May 2004
Amendments:	Amendment 1 – May 2013
Revisions:	November 2014 Revision to Amendment 1
	November 2020 Revision to Amendment 1
Supplements:	Supplement A – February 2019
Information Updates:	None
Schedule Changes:	August 2016
Comprehensive Review:	At least five years after Amendment 2 adoption

Past versions of the Estuarine Striped Bass FMP, Revisions, Amendment, and Supplement (NCDMF 2004, 2013, 2014, 2019, and 2020) are available on the DMF website.

MANAGEMENT UNIT

There are two geographic striped bass management units in NC (Figure 1). The northern management unit is comprised of two harvest management areas: the RRMA and the ASMA. These two management areas form the geographical area of the Albemarle-Roanoke (A-R) stock of striped bass. Commercial regulations in the RRMA are the responsibility of the MFC, while recreational regulations are the responsibility of the WRC. Recreational and commercial striped bass regulations within the ASMA are the responsibility of the MFC. The RRMA and ASMA are also subject to the ASMFC Interstate FMP for Atlantic Striped Bass. To ensure compliance with the ASMFC Interstate FMP, the A-R stock is additionally managed under the NC FMP for Interjurisdictional Fisheries.

The southern geographic management unit is the CSMA that is comprised of the Tar-Pamlico, Neuse, and Cape Fear rivers and the Pamlico Sound. Management of striped bass within the CSMA is the sole responsibility of NC through the MFC and the WRC.

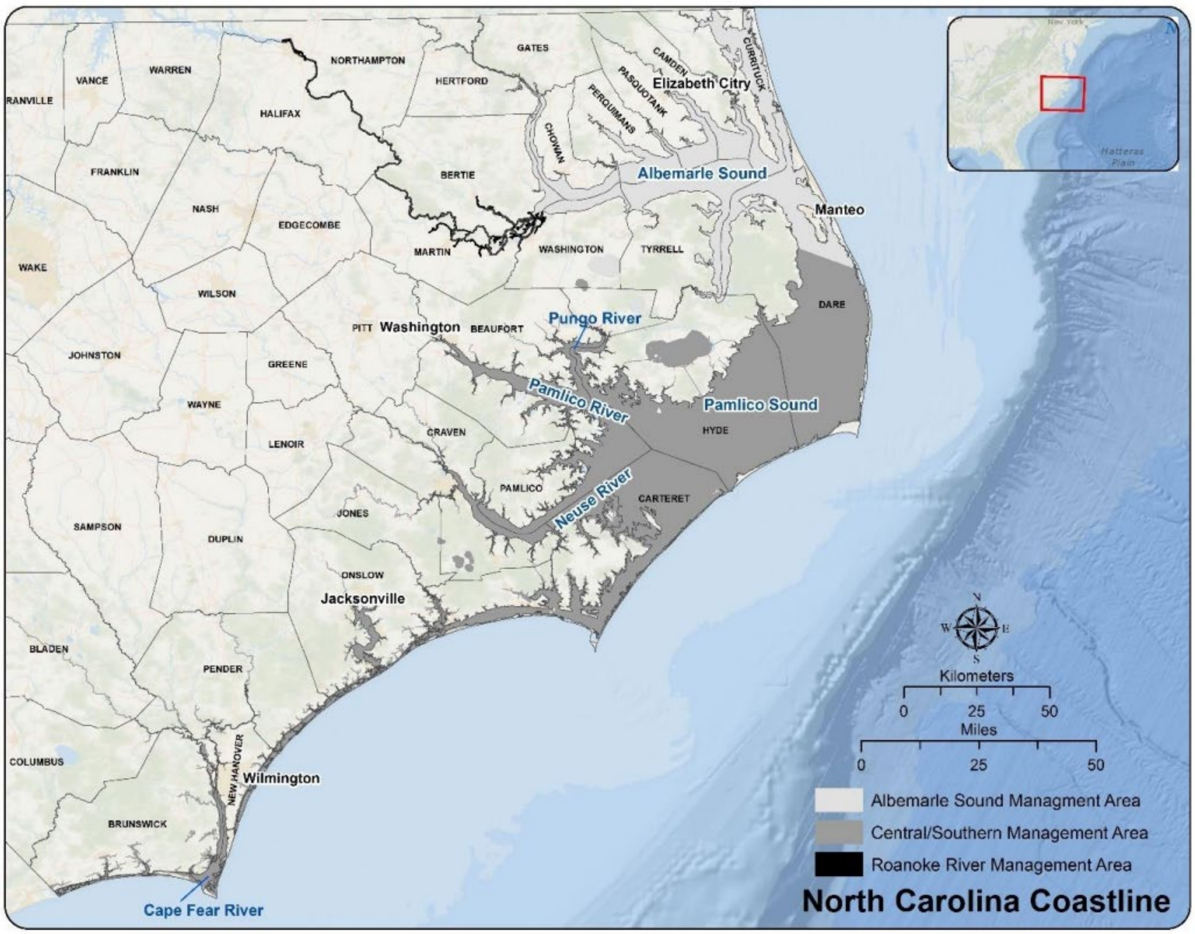


Figure 1. Boundary lines defining the Albemarle Sound Management Area, Central/Southern Management Area, and the Roanoke River Management Area.

GOAL AND OBJECTIVES

The goal of Amendment 2 is to manage the estuarine striped bass fisheries to achieve self-sustaining populations that provide sustainable harvest based on science-based decision-making processes. If biological and/or environmental factors prevent a self-sustaining population, then alternate management strategies will be implemented that provide protection for and access to the resource. The following objectives will be used to achieve this goal.

- Implement management strategies within North Carolina and encourage interjurisdictional management strategies that maintain and/or restore spawning stock with adequate age structure and abundance to maintain recruitment potential and to prevent overfishing.
- Restore, enhance, and protect critical habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan, to maintain or increase growth, survival, and reproduction of the striped bass stocks.
- Use biological, social, economic, fishery, habitat, and environmental data to effectively monitor and manage the fisheries and their ecosystem impacts.
- Promote stewardship of the resource through public outreach and interjurisdictional cooperation regarding the status and management of the North Carolina striped bass stocks, including practices that minimize bycatch and discard mortality.

DESCRIPTION OF THE STOCK

BIOLOGICAL PROFILE

Striped bass is an estuarine dependent species found from the lower St. Lawrence River in Canada to the west coast of Florida, through the northern Gulf of Mexico to Texas. In NC, the species is also known as striper, rockfish, or rock. Stocks from Maine to the A-R in NC are migratory, spending most of their adult life in the estuaries and ocean before moving into fresh water to spawn in the spring. The large, A-R stock striped bass leave the Roanoke River system after spawning and migrate north, to ocean waters from New Jersey to Massachusetts. In the fall, these fish migrate south to ocean waters off Virginia and NC, before entering the Albemarle Sound and Roanoke River again in the spring (Callihan et al. 2015). Southern stocks, including the stocks of the CSMA, are riverine, spending their entire life in the estuary and river systems (Setzler et al. 1980; Rulifson et al. 1982; Callihan 2012).

Striped bass migrate far distances to spawning grounds located in freshwater portions of coastal rivers. Spawning grounds for the A-R stock are concentrated at the fall line, where the coastal plain meets the piedmont, 137 miles up the Roanoke River near Weldon, NC. Spawning grounds in the CSMA rivers are not as clearly defined. On the Tar-Pamlico River, striped bass spawning is suspected to occur from the Rocky Mount Mills Dam,125 miles upstream of Washington, NC, to Tarboro, NC (Smith and Rulifson 2015). Neuse River spawning grounds are centered between Smithfield and Clayton, NC, but range from Kinston river mile (rm) 130 to Raleigh (rm 236). On the Cape Fear River, historic striped bass spawning grounds are located at the fall line near Smiley's Falls (rm 165) in Lillington, NC, but access to this spawning habitat is restricted by a series of three lock and dam systems. In the Northeast Cape Fear River, adult striped bass have been captured and acoustically tagged during the spawning season between White Stocking, NC (rm 73) and Chinquapin, NC (rm 104), with potential spawning occurring as far upstream as Hallsville, NC (rm 114; Rock et al. 2018).

Striped bass are relatively long-lived and can reach 50–60 pounds. Females grow larger than males, with a reported maximum total length of 60 inches. The oldest observed striped bass in the A-R stock was 31 years old, while within the CSMA the maximum age was 17 years. The largest recorded striped bass, which weighed 125 pounds, was caught in the early 1900s in the Albemarle Sound. Females in the A-R stock are 97% mature at age-4 (Boyd 2011), while females in the Tar-Pamlico and Neuse rivers are 98% mature by age-3 (Knight 2015). In the Tar-Pamlico and Neuse rivers, fecundity (number of eggs a female produces) ranges from 223,110 eggs for an age-3 female to 3,273,206 eggs for an age-10 female (Knight 2015).

Streamflow and water temperature are important environmental conditions that influence the success of annual striped bass reproduction and recruitment (number of juveniles produced). Striped bass require flowing, freshwater that allows eggs to remain suspended until they hatch and fry to be transported to nursery areas. Female striped bass produce large quantities of eggs that are broadcast into riverine spawning areas and fertilized by mature males. Fertilized eggs drift with downstream currents and hatch in 1.5–3 days depending on water temperature (Mansueti 1958). Spawning in NC can occur from late March until early June. Peak spawning activity for the A-R stock occurs when water temperature reaches 62–67 degrees Fahrenheit on the spawning grounds.

Striped bass form large schools, feeding on available fishes and invertebrates. Oily fish such as Atlantic menhaden (*Brevoortia tyrannus*), herrings (*Clupea* spp.), and shads (*Alosa* spp.) are common prey, but spot (*Leiostomus xanthurus*), mullet (*Mugil* spp.), Atlantic croaker (*Micropogonias undulatus*), American eel (*Anguilla rostrata*), and blue crabs (*Callinectes sapidus*) are also consumed.

STOCK UNIT

There are four striped bass stocks in NC: Albemarle-Roanoke (A-R), Tar-Pamlico, Neuse, and Cape Fear stocks.

ASSESSMENT METHODOLOGY

The A-R stock was assessed using Stock Synthesis through a forward-projecting statistical catch-at-age model which was applied to data characterizing landings/harvest, discards, fishery-independent indices, and biological data collected during 1991–2017 (Lee et. al 2020).

Traditional stock assessment techniques could not be applied to CSMA stocks because of high hatchery contribution and lack of natural recruitment in these systems. A demographic matrix model was developed to evaluate stocking and management measures for striped bass in all three CSMA river systems. In addition, a tagging model was developed to estimate striped bass abundance in the Cape Fear River.

STOCK STATUS

A-R Stock

The 2020 A-R striped bass stock assessment indicates the stock is overfished and overfishing is occurring (Lee et. al 2020). The estimate of fishing mortality (F) in the terminal year of the assessment (2017) was 0.27, greater than the $F_{35\%\text{SPR Threshold}}$ of 0.18 (Figure 2). The estimate of spawning stock biomass (SSB) was 78,576 pounds, less than the $SSB_{35\%SPR\ Threshold}$ of 267,390 pounds (Figure 3). The stock had a period of strong recruitment from 1993 to 2000, then a period of low recruitment from 2001 to 2017. The complete stock assessment can be reviewed on the division Fishery Management Plans website.

The 2020 stock assessment is used to establish sustainable harvest in the A-R stock fisheries. This is done by calculating the Total Allowable Landings (TAL) that can be removed annually from the stock. The TAL is currently allocated with a 50/50 split to the recreational and commercial fisheries. The ASMA commercial fishery receives 50% of the TAL with the RRMA recreational and the ASMA recreational fisheries each receiving a 25% allocation of the TAL.

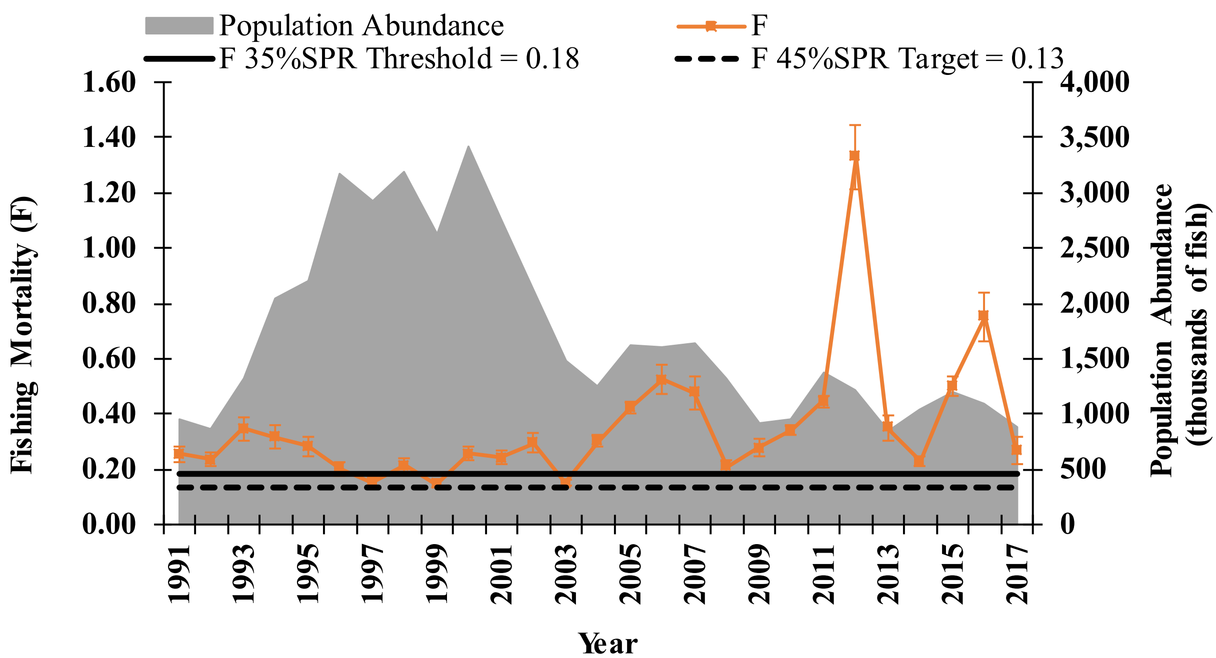


Figure 2. Estimates of fishing mortality (F) and population abundance for the Albemarle-Roanoke striped bass stock, 1991–2017. Error bars represent ± two standard errors. Source: Lee et al. 2020.

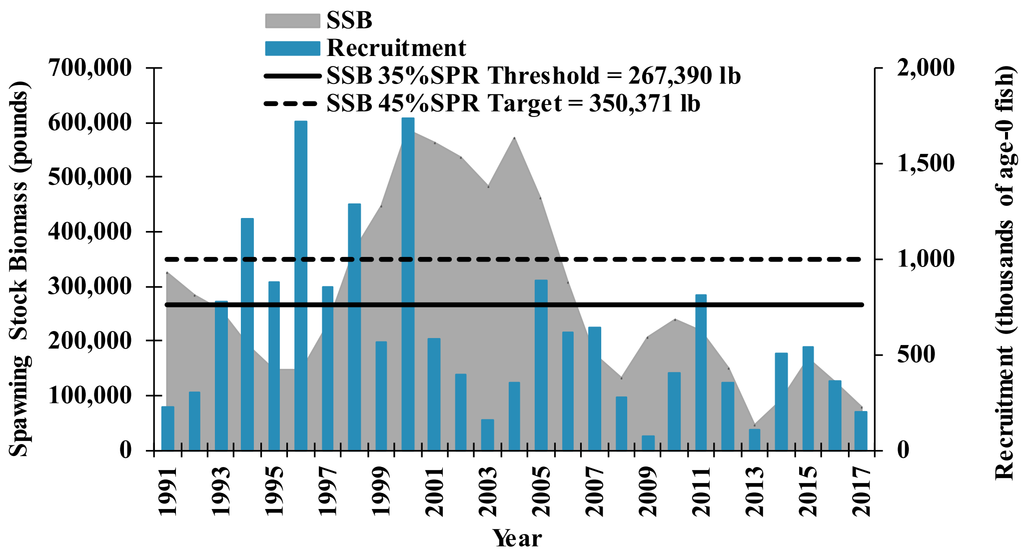


Figure 3. Estimates of spawning stock biomass (SSB) and recruitment of age-0 fish coming into the population each year for the Albemarle-Roanoke striped bass stock, 1991–2017. Source: Lee et al. 2020

CSMA Stocks

The demographic matrix model indicates the striped bass populations in the CSMA are depressed to an extent that sustainability is unlikely at any level of fishing mortality. The model suggests insufficient natural recruitment is the primary factor limiting population abundance of Tar-Pamlico and Neuse stocks and suggests the populations would decline without stocking (Mathes et al. 2020). Tagging model results indicate a consistent decline in abundance estimates for striped bass in the Cape Fear River (2012–2018). Even with a no-possession provision for the Cape Fear River since 2008, 2018 abundance was less than 20% of the 2012 abundance. The CSMA stocks are supported by continuous stocking efforts as evidenced by stocked fish comprising nearly 100% of the striped bass on the spawning grounds (O'Donnell and Farrae 2017). For more information on stocking see Appendix 1: Striped Bass Stocking in Coastal North Carolina. The complete stock assessment report can be reviewed on the division Fishery Management Plans website.

DESCRIPTION OF THE FISHERIES

Additional in-depth analyses and discussion of NC's commercial and recreational striped bass fisheries can be found in earlier versions of the Estuarine Striped Bass FMP, Revisions, Amendment 1, and Supplement A (NCDMF 2004, 2013, 2014, 2019, and 2020); all FMP documents are available on the DMF Fishery Management Plans website and commercial and recreational landings can be found in the License and Statistics Annual Report (NCDMF 2020) produced by the DMF which can be found on the DMF Fisheries Statistics page, including a report entitled North Carolina Striped Bass (*Morone saxatilis*) Commercial Fishery (Gambill and Bianchi 2019).

COMMERCIAL FISHERIES

ASMA

Under Amendment 1, the ASMA commercial striped bass fishery is a bycatch fishery, striped bass harvest occurs while targeting other finfish species. Striped bass cannot be greater than 50% by weight of all other finfish species landed per trip. Daily landing limits of 5–25 striped bass further deter fishers from targeting striped bass and aim to ensure striped bass quota is available when multispecies gill net fisheries are operating. Most striped bass harvest occurs with the American shad (*Alosa sapidissima*) anchored gill net fishery in the spring, followed by the southern flounder (*Paralichthys lethostigma*) anchored gill net fishery in the fall. Since 2015, as a commercial fishery for invasive blue catfish (*Ictalurus furcatus*) has developed, more striped bass landings have occurred in this strike net fishery. Strike nets are fished by locating a school of fish, encircling the school with a gill net, then immediately retrieving the net. Harvest from pound nets is the second leading harvest gear with an average of 20% of the total harvest since 2010.

Commercial landings in the ASMA have been limited by an annual TAL since 1991. Due to gill net mesh size regulations and minimum striped bass size limits since 1993, most harvest consists of fish 4–6 years of age. During 1990–1997 the commercial TAL was set at 98,000 pounds because the A-R stock was at historically low levels of abundance and required rebuilding. The stock was declared recovered in 1997 and the commercial 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.

Beginning in 2004, commercial landings no longer reached the annual TAL, even with increases in the number of harvest days and daily possession limits. From 2005 to 2009, landings steadily declined averaging 150,000 pounds annually (Figure 4).

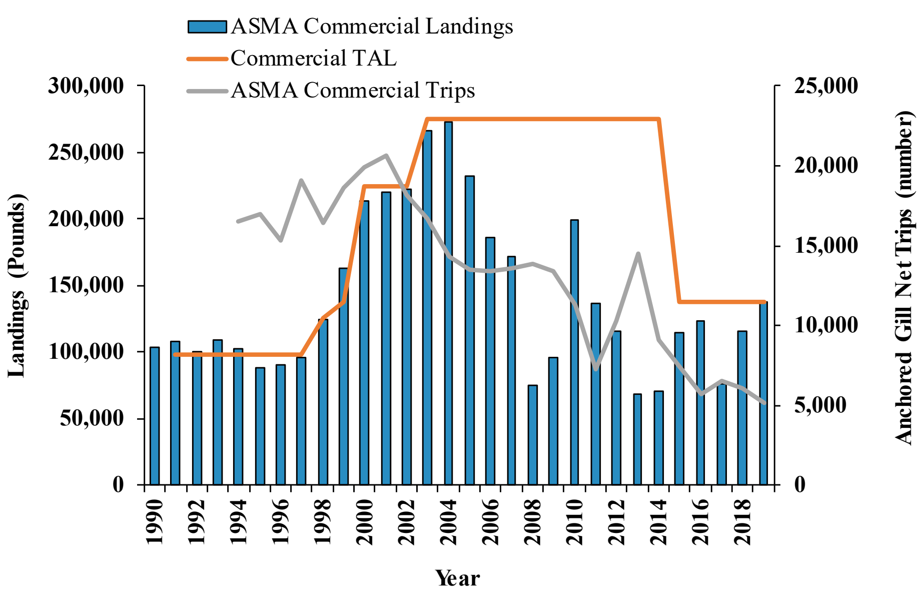


Figure 4. Commercial striped bass landings and the number of all anchored gill net trips in the Albemarle Sound Management Area (ASMA), 1991–2019.

The decline in landings in years 2005–2009 was due to poor year classes produced during 2001–2004. An increase in landings in 2010 was due to the strong 2005-year class. Since 2013, landings have declined in part because of a shortened American shad season. In 2021, the commercial TAL was reduced to 25,608 pounds to meet requirements of adaptive management measures in Amendment 1 to the Striped Bass FMP to end overfishing in one year of stock assessment results indicated the stock was undergoing overfishing (NCDMF 2020).

CSMA

Supplement A (NCDMF 2019) closed the CSMA commercial striped bass fishery to protect important year classes of striped bass. From 1994 to 2018 commercial landings in the CSMA were limited by a 25,000 lb annual TAL. From 1994 to 2018 striped bass commercial landings in the CSMA averaged 26,132 lb (Figure 5). Most commercial landings are from the Tar-Pamlico, Pungo, Neuse, and Bay rivers (Figure 6). From 2004 to 2018, there was only a spring harvest season, opening March 1 and closing when the annual TAL was reached.

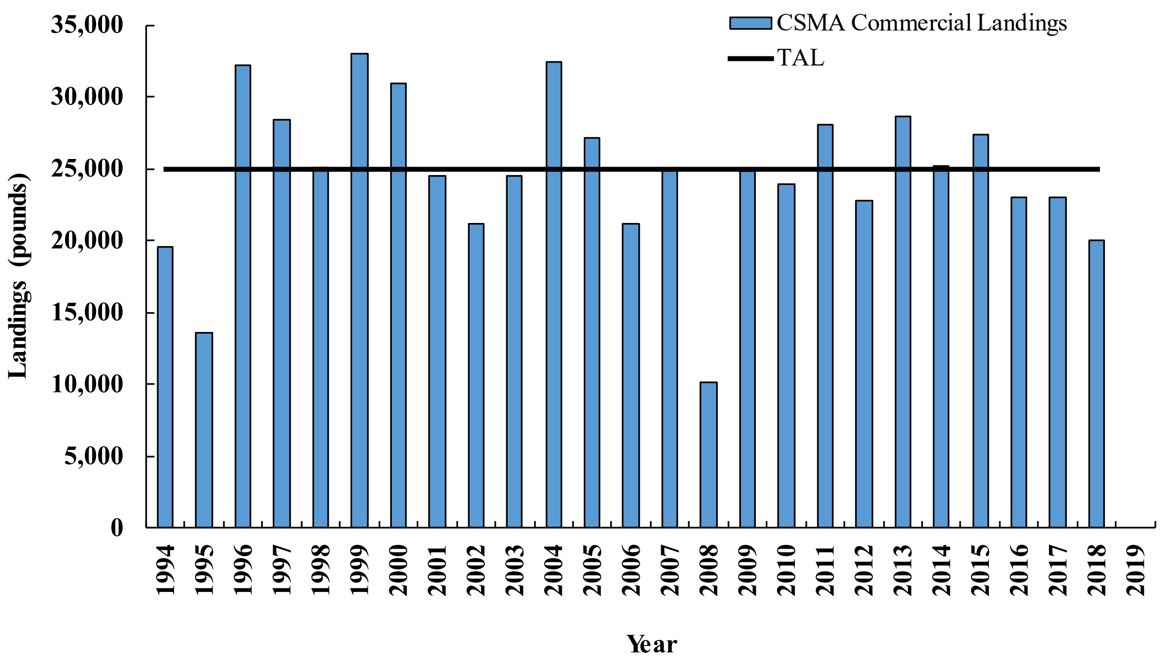


Figure 5. Annual commercial CSMA striped bass harvest and TAL in pounds, 1994–2019. Since 2019 the commercial season has been closed.

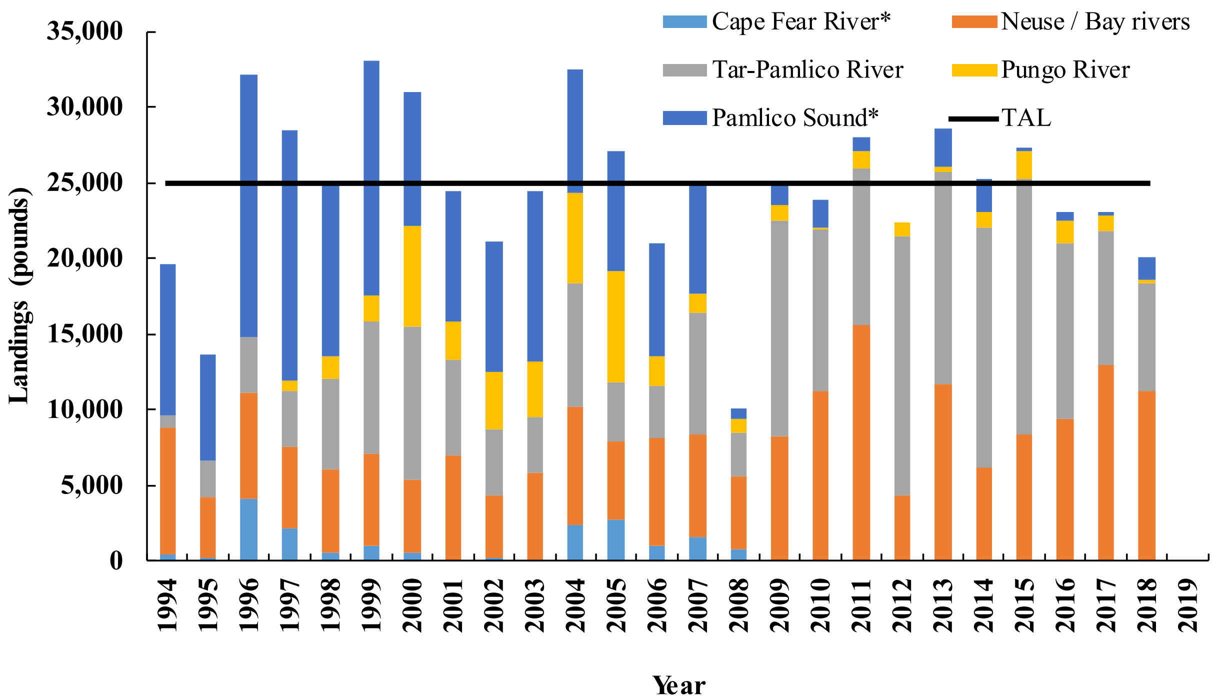


Figure 6. Commercial striped bass harvest by system, and the TAL in the CSMA, 2004–2019. There has been a harvest moratorium in the Cape Fear River since 2008, and a closed season in the CSMA since 2019. *Landings data for the Cape Fear River in 2001 and the Pamlico Sound in 2012 are confidential.

RECREATIONAL FISHERIES

ASMA

In the initial 1993 FMP, effective January 1, 1994, the MFC and WRC approved management to split the TAL evenly between the commercial and recreational sectors when the stock recovered (NCDMF 1993). In 1997 the stock was declared recovered and in 1998 the MFC allocated the TAL 50/50 between the commercial and recreational sectors through incremental steps. The ASMA receives 25% of the recreational allocation. The ASMA recreational TAL increased from 29,400 pounds in 1997 to 137,500 pounds in 2003. Adaptive management to address the overfished status in 2021 reduced the ASMA recreational TAL to 12,804 pounds (NCDMF 2020). Recreational landings peaked in 2001 at 118,506 pounds (Figure 7). Recreational landings in the ASMA primarily consist of fish age 3–5.

Beginning in fall 2005, harvest was allowed seven days a week in the ASMA. Additionally, in fall 2006 possession limits were increased from two to three fish. Despite the increases in bag limits and days recreational fishery was open, harvest continued to decline. Several poor year classes produced since 2001 may have contributed to the decline in stock abundance and recreational harvest since 2006. The recreational limit was decreased to two fish per person per day in January 2016. Recreational harvest from 1991 to 2019 averaged 42,466 pounds in the ASMA. 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 24,051 fish (Table 1).

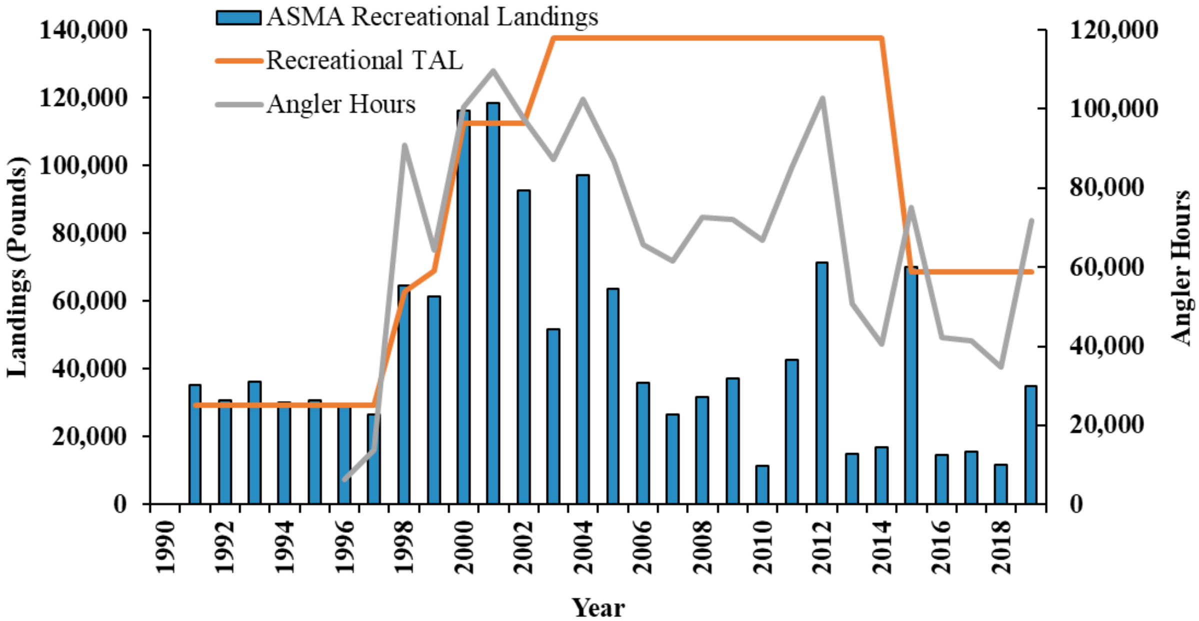


Figure 7. Recreational striped bass landings and the hours of striped bass fishing effort in the Albemarle Sound Management Area (ASMA) 1991–2019.

RRMA

Harvest from 1982 through 2019 averaged 54,103 pounds in the RRMA (Table 2; Figure 8). Discards outnumber landings annually, especially in the RRMA where concentrations of fish on the spawning grounds can be dense. Annual releases from 2005 through 2019 in the RRMA averaged 80,821 fish.

From 2003 to 2016, landings averaged 64,389 pounds, with a few noticeably low years (Figure 8). Adaptive management measures implemented in 2021 reduced the RRMA recreational TAL to 12,804 pounds (NCDMF 2020). Recreational landings in the RRMA are dominated by age-3 to age-5 fish, primarily due to a no possession rule of fish between 22 and 27-inches total length (TL) and general angling techniques. Few fish over age 9 are observed in the creel survey because most anglers do not use the large artificial lures or natural bait needed to effectively target striped bass over 28-inches TL.

Table 1. Estimates of striped bass angling effort, harvest, and numbers caught and released from the Albemarle Sound Management Area, 1991–2019. Cells with a dash indicate estimates were not generated in that year. Estimates of discards are not available for the post-harvest period.

Year	Striped Bass Trips	Angler Hours	Number of fish harvested	Total pounds harvested	Striped Bass Discard (#over-creel)	Striped Bass Discard (#under-sized)	Striped Bass Discard (#legal-sized)	Total number of fish released
1991			14,395	35,344				23,540
1992			10,542	30,758				19,981
1993			11,404	36,049				13,241
1994			8,591	30,217				
1995			7,343	30,564				
1996		6,349	7,433	29,186				
1997		13,656	6,901	26,724				30,771
1998		90,820	19,566	64,761				91,888
1999		64,442	16,967	61,447				40,321
2000		100,425	38,085	116,414				78,941
2001		109,687	40,127	118,645				61,418
2002		97,480	27,896	92,649				51,555
2003		87,292	15,124	51,794				25,281
2004		102,505	28,004	97,097	9,877	28,859	2,305	41,041
2005	13,735	86,943	17,954	63,477	11,333	7,032	2,855	21,220
2006	10,707	65,757	10,711	35,985	2,490	6,339	626	9,455
2007	9,629	61,679	7,143	26,633	1,148	12,259	192	13,599
2008	11,793	72,673	10,048	31,628	391	36,324	260	36,975
2009	11,326	72,021	12,069	37,313	20	38,683	1,860	40,563
2010	9,660	66,893	3,504	11,470	569	15,398	233	16,200
2011	13,114	85,325	13,341	42,536	317	20,114	1,141	21,572
2012	14,490	102,787	22,345	71,456	1,024	19,977	3,970	24,971
2013	7,053	50,643	4,299	14,897	31	16,034	316	16,381
2014	7,264	40,478	5,529	16,867	18	22,558	510	23,086
2015	11,132	75,009	23,240	70,008	1,573	45,559	2,402	49,534
2016	7,023	42,276	4,794	14,486	252	8,822	1,278	10,352
2017	7,658	41,371	4,215	15,480	56	24,004	600	24,660
2018	9,057	34,764	3,465	11,762	281	21,337	3,970	25,588
2019	19,864	61,645	8,502	34,968	2,301	34,452	1,625	38,378

Table 2. Estimates of striped bass angling effort, harvest, and numbers caught and released from the Roanoke River Management Area, 1988–2019. Blank cells indicate data was not collected in that year. **For 1989–2009 number of trips was calculated by dividing the angler hours by 4.75 (assumes each trip was 4.75 hours long). Since 2010, number of trips were estimated based on creel survey data sampling probabilities.

	Open Season (Harvest estimates)					Post-Harvest Period (Catch and Release Only)		
Year	Number Harvested	Weight (lb)	Effort (angler-hours)	Trips**	Number released	Number released	Effort (angler-hours)	Trips**
1988		74,639						
1989	8,753	32,107	46,566	9,803				
1990	15,694	42,204	56,169	11,825				
1991	26,934	72,529	74,596	15,704				
1992	13,372	36,016	49,277	10,374				
1993	14,325	45,145	52,932	11,144				
1994	8,284	28,089	44,693	9,409				
1995	7,471	28,883	56,456	11,885		52,698	20,639	4,345
1996	8,367	28,178	46,164	9,719		148,222	32,743	6,893
1997	9,364	29,997	23,139	4,871		271,328	47,001	9,895
1998	23,109	73,541	72,410	15,244		102,299	26,367	5,551
1999	22,479	72,967	72,717	15,309		113,394	30,633	6,449
2000	38,206	120,091	95,622	20,131				
2001	35,231	112,805	100,119	21,078				
2002	36,422	112,698	122,584	25,807				
2003	11,157	39,170	77,863	16,392				
2004	26,506	90,191	145,782	30,691				
2005	34,122	107,530	130,755	27,527		68,147	24,146	5,083
2006	25,355	84,521	120,621	25,394		24,719	15,235	3,207
2007	19,305	62,492	141,874	29,868		11,622	9,254	1,948
2008	10,541	32,725	110,608	23,286		47,992	17,764	3,740
2009	23,248	69,581	120,675	25,405				
2010	22,445	72,037	125,495	24,347	77,882	46,028	31,281	5,111
2011	22,102	71,561	122,876	27,311	80,828	26,865	15,110	2,707
2012	28,847	88,539	110,982	27,151	40,772	22,246	8,935	1,881
2013	7,718	25,197	100,391	19,539	49,148	25,074	12,423	2,246
2014	11,058	33,717	80,256	15,960	93,471	72,068	17,542	2,972
2015	20,031	58,962	111,419	22,827	78,401	29,839	12,229	2,207
2016	21,260	65,218	129,132	25,036	34,753	17,891	11,291	2,087
2017	9,899	32,569	101,565	19,688	68,693	9,754	7,446	1,317
2018	8,741	26,797	95,447	18,280	121,969	65,245	14,499	2,462
2019	16,582	53,379	99,259	20,633	117,550	69,642	26,867	5,283

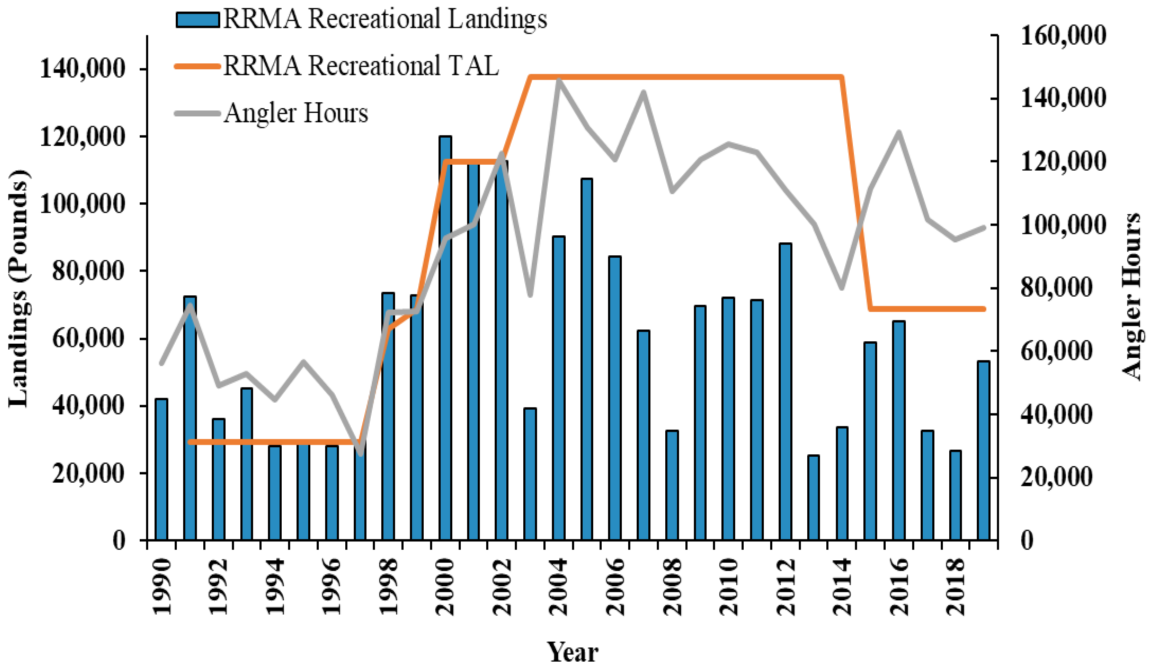


Figure 8. Recreational striped bass landings and the hours of striped bass fishing effort in the Roanoke River Management Area (RRMA) 1991–2019.

CSMA

The DMF began collecting recreational striped bass data in the major rivers of the CSMA in 2004. In 2013, due to low recreational striped bass catch in the Cape Fear River, creel survey methodology was adjusted to target American and hickory shad (*Alosa mediocris)* effort. The Supplement A recreational no possession measure approved in February 2019 limited recreational harvest in 2019. Recreational landings fluctuated between 2004 and 2019 (Table 3; Figure 9).

From 2004 to 2007 most recreational harvest occurred in the Neuse River, but since 2008 harvest has generally been split between the Tar-Pamlico and Neuse rivers (Figure 10). In 2016 and 2017, the number of trips and hours spent targeting striped bass in the CSMA increased substantially compared to other years (Table 3). Within the CSMA there is a significant catch-and-release fishery, averaging 47,309 releases from 2010 to 2019 (Table 3). Undersized discards peaked in 2017 but declined through 2019.

Table 3. Recreational striped bass effort, harvest and discards from the CSMA, 2004–2019. The 2019 season was January 1–March 19, 2019.

Year	Fishing Trips	Effort Hours	Number Harvested	Pounds Harvested	Total Discards
2004	12,782	63,791	6,141	22,958	13,557
2005	16,414	69,370	3,832	14,965	16,854
2006	10,611	42,066	2,481	7,352	14,895
2007	10,971	46,655	3,597	10,794	23,527
2008	6,621	28,413	843	2,990	17,966
2009	5,642	26,611	895	3,061	6,965
2010	6,559	25,354	1,757	5,537	7,990
2011	12,606	51,540	2,728	9,474	24,188
2012	18,338	71,964	3,922	15,240	43,313
2013	20,394	86,918	5,467	19,537	32,816
2014	15,682	70,316	3,301	13,368	30,209
2015	18,159	79,398	3,934	14,269	31,353
2016	23,675	110,453	6,697	25,260	75,461
2017	26,125	119,680	7,334	26,973	131,129
2018	16,393	69,917	3371	10,884	49,122
2019	8,820	40,580	959	3,562	37,039
Average	14,362	62,689	3,579	12,889	34,774

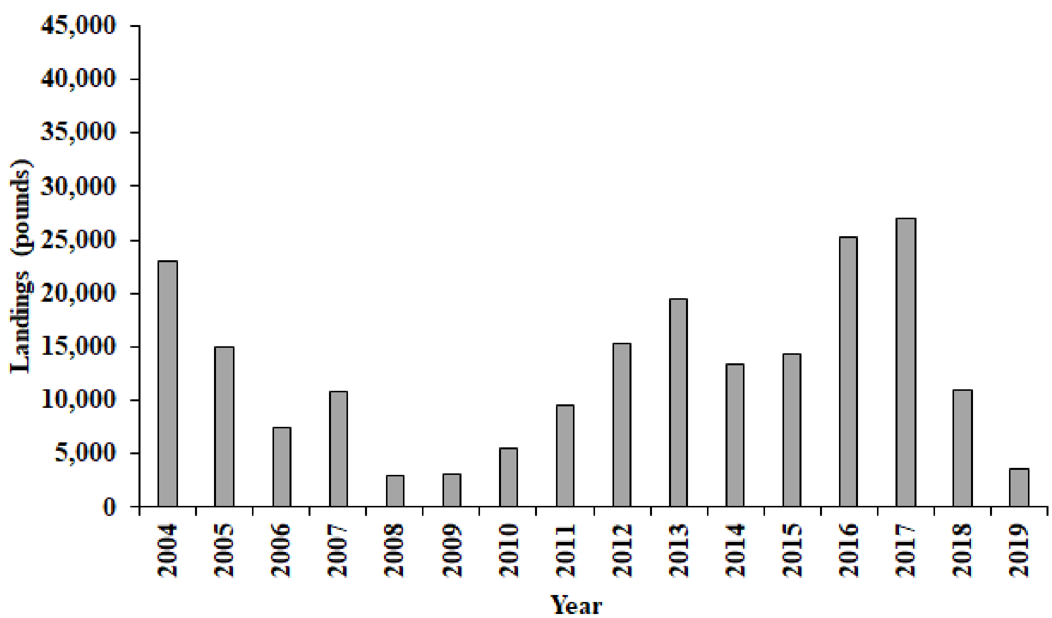


Figure 9. Annual recreational CSMA striped bass landings in pounds, 2004–2019. The 2019 season was January 1–March 19, 2019.

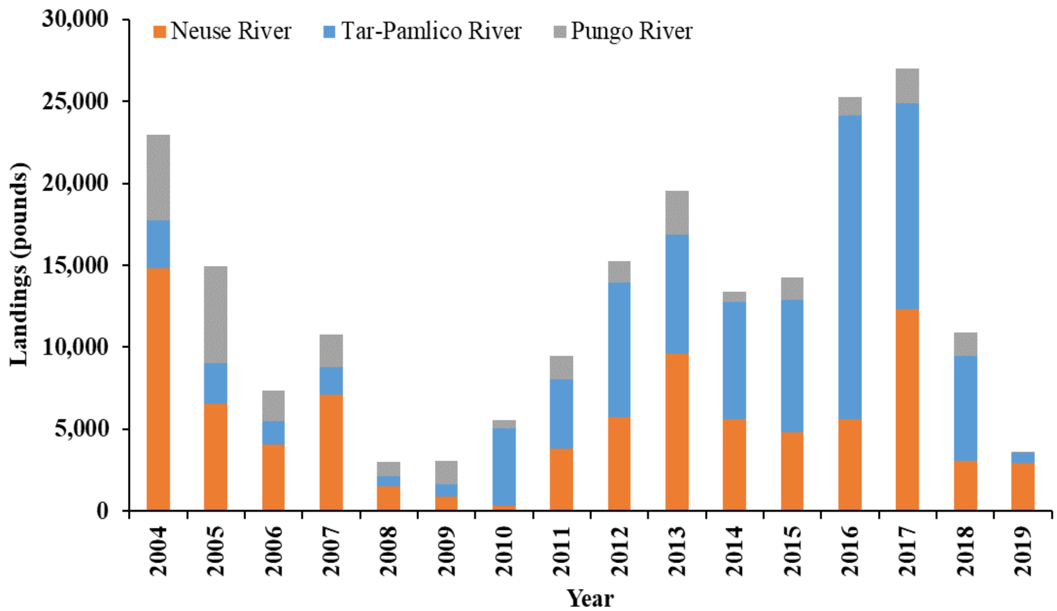


Figure 10. Recreational striped bass harvest in the Tar-Pamlico, Pungo, and Neuse rivers, 2004–2019. The 2019 season was January 1–March 19, 2019.

SUMMARY OF ECONOMIC IMPACTS OF STRIPED BASS FISHING

Modeling software, IMPLAN, is used to estimate the economic impacts of an industry to the state at-large, accounting for revenues and participation. For a detailed explanation of the methodology used to estimate the economic impacts please refer to DMF's License and Statistics Section Annual Report on the Fisheries Statistics page. For further information on overall trends, economics, and characteristics of the commercial fishery see the report entitled North Carolina Striped Bass (*Morone saxatilis*) Commercial Fishery (Gambill and Bianchi 2019).

Commercial

Commercial landings and effort data collected through the DMF trip ticket program are used to estimate the economic impact of the commercial fishing industry. For commercial fishing output, total impacts are derived by incorporating modifiers from NOAA's Fisheries Economics of the United States report (National Marine Fisheries Service 2018), which account for proportional expenditures and spillover impacts from related industries. By assuming striped bass fisheries contribute to the expenditure categories at a proportion equal to their contribution to total commercial ex-vessel values, we can generate an estimate of the total economic impact of striped bass harvest in the CSMA and ASMA. This same indirect impact methodology is applied to the aggregate landings of other species harvested during a striped bass trip. Economic impacts of the striped bass fishery and alternative species cannot be combined. As these landings occurred during the same trips with the same participants, much of the economic impact of striped bass harvest is also reflected in the economic impact of harvest of other species. These two impact categories have been separated to demonstrate how commercial striped bass fishing in the CSMA and ASMA impacts the state economy outside of direct landings, and how that effect could change if commercial striped bass effort were eliminated or reduced.

ASMA

Commercial effort and output in the ASMA are greater than in the CSMA. The number of striped bass commercial fishery participants in the ASMA is roughly two to three times higher than in the CSMA. More effort, and historically higher TAL in the ASMA compared to the CSMA leads to increased harvest of striped bass. Average annual landings of striped bass are roughly 100,000 pounds in the ASMA, with average ex-vessel values of $300,000 (Figure 11). Both values are approximately five times greater than annual values in the CSMA.

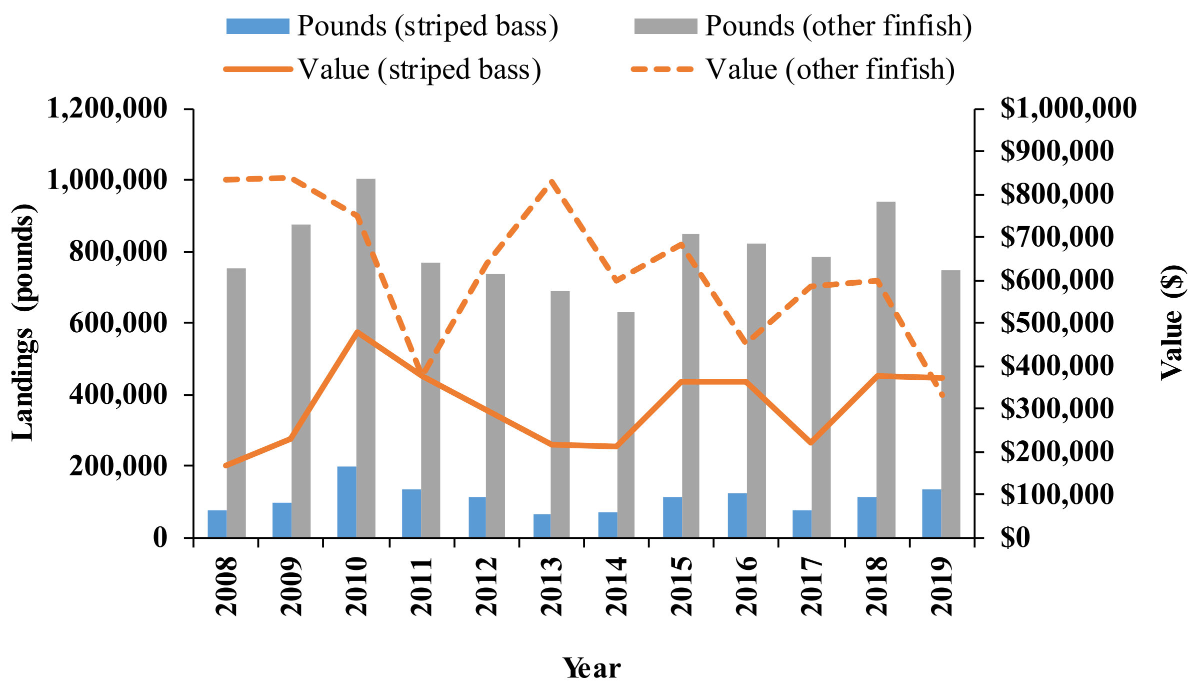


Figure 11. Annual commercial striped bass effort and ex-vessel value data for the ASMA, 2008–2019.

From 2008 to 2019 striped bass landings in the ASMA averaged 110,691 pounds (Table 4). During the same period harvest of all other species during trips which had striped bass as bycatch in the ASMA averaged 799,570 pounds (Table 5). Dockside value of other species landed in nets that also caught striped bass varies annually although the highest value species are often a mixture of catfishes, American shad, white perch (*M. Americana*), striped mullet (*M. cephalus*), spotted seatrout (*Cynoscion nebulosus*), and southern flounder.

As the total value of striped bass and other products harvested annually in the ASMA is significantly greater, so are the economic impacts to the state (Tables 4 and 5). Annual sales impacts of striped bass harvest average over $1 million annually, with the impacts from the harvest of other species valued between $1 million and nearly $4 million. In general, these estimates demonstrate that the ASMA striped bass commercial fishery produces a greater overall economic impact to the state than in the CSMA.

Table 4. Annual commercial striped bass effort data and estimates of annual economic impact to the state of North Carolina from striped bass harvest for the ASMA, 2008–2019.

Year	Pounds Landed	Ex-Vessel Value	Total Participants	Total Trips	Job Impacts	Income Impacts	Value-added Impacts	Sales Impacts
2008	74,921	$167,750	278	2,857	287	$311,255	$583,523	$756,264
2009	95,794	$231,914	279	3,495	291	$430,176	$813,040	$1,033,704
2010	199,829	$479,648	327	6,116	353	$847,691	$1,586,334	$2,043,151
2011	136,266	$378,577	276	4,212	296	$671,721	$1,256,856	$1,618,695
2012	115,605	$298,162	264	3,612	280	$524,276	$978,808	$1,258,901
2013	68,338	$218,662	268	2,864	280	$372,105	$692,894	$893,139
2014	70,989	$214,143	236	2,834	248	$359,952	$668,554	$864,931
2015	114,488	$365,505	237	4,043	257	$633,013	$1,183,400	$1,515,359
2016	123,111	$362,759	197	4,245	215	$633,119	$1,177,209	$1,477,691
2017	75,991	$222,854	178	2,717	189	$374,107	$696,497	$887,232
2018	116,144	$377,668	193	3,621	215	$683,207	$1,239,287	$1,614,420
2019	136,820	$370,278	192	3,309	212	$636,930	$1,167,901	$1,507,707
Average	110,691	$307,327	244	3,660	260	$539,796	$1,003,692	$1,289,266

Table 5. Annual effort data and estimates of annual economic impact to the state of North Carolina from harvest of all other species caught during trips when striped bass landings occurred in the ASMA, 2008–2019.

Year	Pounds Landed	Ex-Vessel Value	Total Participants	Total Trips	Job Impacts	Income Impacts	Value-added Impacts	Sales Impacts
2008	752,788	$833,879	271	2,826	317	$1,547,237	$2,900,673	$3,759,363
2009	875,110	$838,842	276	3,423	321	$1,555,961	$2,940,795	$3,738,946
2010	1,004,196	$751,024	314	5,896	354	$1,327,298	$2,483,852	$3,199,126
2011	769,786	$376,144	262	4,012	282	$667,404	$1,248,778	$1,608,292
2012	734,894	$639,535	260	3,536	294	$1,124,534	$2,099,472	$2,700,252
2013	690,471	$828,539	265	2,840	310	$1,409,953	$2,625,466	$3,384,216
2014	628,430	$598,214	236	2,818	268	$1,005,535	$1,867,623	$2,416,208
2015	847,805	$682,205	236	3,958	273	$1,181,502	$2,208,785	$2,828,378
2016	823,328	$453,967	194	4,217	217	$792,302	$1,473,192	$1,849,224
2017	784,689	$587,458	177	2,712	207	$986,166	$1,836,006	$2,338,796
2018	937,616	$599,714	193	3,590	228	$1,084,890	$1,967,910	$2,563,599
2019	745,726	$333,321	192	3,295	210	$573,358	$1,051,334	$1,357,223
Average	799,570	$626,904	240	3,594	273	$1,104,678	$2,058,657	$2,645,302

Beyond the high-level relationship between commercial striped bass effort and statewide economic impacts, there is also a range of smaller-scale factors in this fishery that could affect its overall contribution to the state economy. A notable example is the difference in management between the CSMA and ASMA. Historically, the CSMA was allocated a smaller striped bass TAL and operated over a shorter season than the ASMA. Additionally, The ASMA striped bass fishery is regulated under a bycatch requirement, in which striped bass cannot be harvested unless it is with other finfish species.

While the exact economic costs and benefits of these differences in regulations cannot be quantified, it is likely the overall economic impact differs greatly between management areas.

CSMA

Prior to the 2019 closure, striped bass commercial effort in the CSMA was low. Roughly 100 participants engaged in less than 1,000 striped bass trips annually (Table 6), with the total harvest never exceeding 30,000 pounds or $85,000 (Table 6; Figure 12). Because of the TAL, striped bass harvest was consistent year-over-year except for 2008, which produced notably low striped bass landings. Landings of other species from the striped bass fishery are more variable than striped bass landings. Although landings of other species from striped bass trips generally produced a larger total amount of product, these species generally sold for lower overall prices. As a result, despite higher landings, annual ex-vessel values of other species are comparable to striped bass.

Table 6. Annual commercial striped bass effort data and estimates of annual economic impact to the state of North Carolina from striped bass harvest for the CSMA, 2008–2019. Commercial and recreational harvest of striped bass was closed in the CSMA in March of 2019, with no observed effort for all of 2019.

Year	Pounds Landed	Ex-Vessel Value	Total Participants	Total Trips	Job Impacts	Income Impacts	Value-added Impacts	Sales Impacts
2008	10,115	$20,906	110	706	111	$38,790	$72,722	$94,249
2009	24,847	$56,616	103	915	106	$105,016	$198,482	$252,352
2010	23,888	$55,678	103	680	106	$98,401	$184,143	$237,170
2011	28,054	$72,452	80	661	84	$128,553	$240,536	$309,785
2012	22,725	$51,958	69	571	72	$91,360	$170,567	$219,376
2013	28,597	$84,824	97	784	102	$144,348	$268,790	$346,469
2014	25,245	$69,098	125	826	129	$116,147	$215,725	$279,091
2015	27,336	$84,703	104	809	109	$146,697	$274,246	$351,175
2016	23,041	$69,271	94	685	98	$120,898	$224,795	$201,506
2017	23,018	$66,033	100	808	103	$110,850	$206,376	$237,914
2018	19,903	$61,477	90	776	94	$111,213	$201,732	$233,959
2019								
Average	23,343	$63,001	98	747	101	$110,207	$205,283	$251,186

When effort data are extended to generate state-wide economic impacts, the same patterns hold. The striped bass fishery produces roughly a quarter of one million dollars in sales impacts annually (Table 6). As the annual ex-vessel values and number of participants are comparable with other species harvested during striped bass trips, the economic impact of striped bass and other species is similar, but the economic impact of alternative species varies more year to year (Table 7).

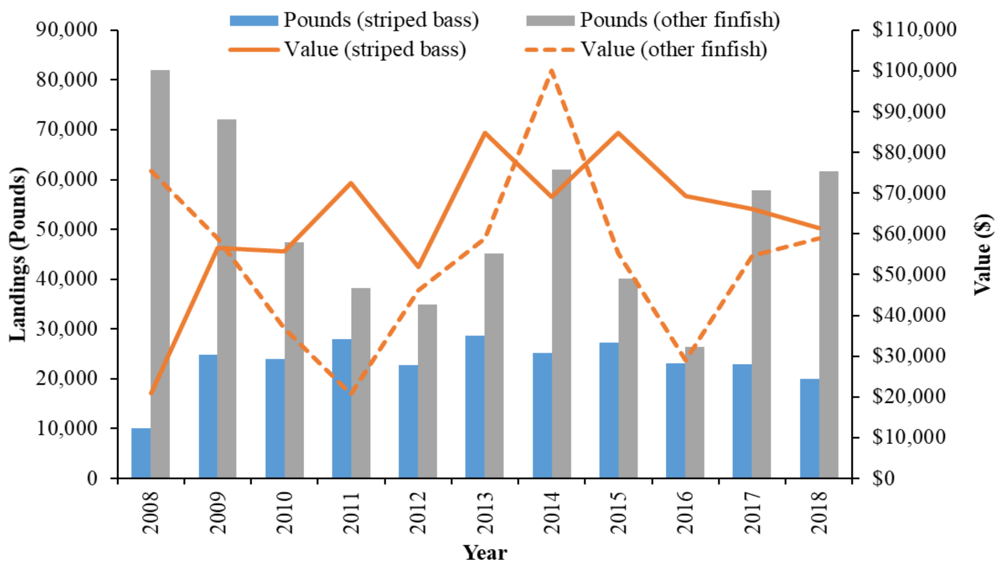


Figure 12. Annual Striped Bass effort and ex-vessel value data for the CSMA, 2008–2019.

Table 7. Annual effort data and estimates of annual economic impact to the state of North Carolina from harvest of all other species caught during trips when striped bass landings occurred in the CSMA, 2008–2019. Commercial and recreational harvest of striped bass was closed in the CSMA in March of 2019, with no observed effort for all of 2019.

Year	Pounds Landed	Ex- Vessel Value	Total Participants	Total Trips	Job Impacts	Income Impacts	Value-added Impacts	Sales Impacts
2008	81,922	$75,381	109	664	113	$139,867	$262,214	$339,839
2009	72,125	$58,882	90	824	93	$109,221	$206,429	$262,455
2010	47,382	$36,904	97	521	99	$65,220	$122,051	$157,198
2011	38,189	$20,637	71	472	72	$36,617	$68,514	$88,239
2012	34,855	$46,172	60	429	62	$81,186	$151,573	$194,947
2013	45,107	$58,914	91	668	94	$100,255	$186,685	$240,637
2014	62,013	$100,115	114	504	119	$168,283	$312,559	$404,368
2015	40,056	$55,244	89	574	92	$95,677	$178,866	$229,039
2016	26,374	$28,877	85	548	86	$50,398	$93,710	$117,629
2017	57,812	$54,695	105	712	108	$91,817	$170,941	$197,062
2018	61,723	$58,959	97	688	100	$106,658	$193,469	$224,373
2019								
Average	51,596	$54,071	92	600	94	$95,018	$177,001	$223,253

Recreational

Creel surveys provide data on recreational angler effort and expenditures to measure state-wide economic impacts of the fishery. The creel surveys collect information on target species, angler hours, and expenditures across six categories: lodging, food, ice, bait and tackle, vehicle fuel, and boat fuel. Combined, these data allow for an assessment of direct trip expenditures, as well as spillover impacts using IMPLAN statistical software.

ASMA

Annual ASMA effort estimates are combined with per-trip expenditure estimates from the CSMA creel survey, as these values are not tracked in the ASMA. Trip expenditure estimates are only provided using DMF survey data, combined with ASMA effort data. The ASMA maintains the same definition of a striped bass trip as the CSMA, in which striped bass is the angler's primary target, secondary target, or was caught.

In terms of trips and angling hours, the ASMA has the lowest striped bass angling effort among the three management areas (Table 8). Generally, the ASMA produces the lowest overall economic impact to the state of these management areas. As with the RRMA, this analysis extrapolates impact values from CSMA expenditure estimates and does not present impact estimates that are fully reflective of the ASMA system.

Table 8. Annual recreational striped bass effort estimates and state-level economic impacts of recreational striped bass angling in the Albemarle Sound Management Area. For this analysis, a striped bass trip is as a primary or secondary directed trip for striped bass, or a trip where striped bass was caught.

Year	Estimated Total ASMA Striped Bass Trips	Estimated Total ASMA Striped Bass Angling Hours	Estimated Sales Impacts	Estimated Income Impacts	Estimated Value-Added Impacts	Estimated Job Impacts	Total Expenditures Using DMF Inshore Vessel Trip Costs
2008	11,793	72,673	$378,011	$135,019	$204,838	3.44	$1,834,428
2009	11,326	72,021	$421,153	$152,375	$299,096	3.91	$1,755,517
2010	9,660	66,893	$1,466,355	$551,802	$802,439	11.82	$1,521,849
2011	13,114	85,325	$1,067,875	$377,870	$601,856	9.15	$2,131,210
2012	14,490	102,787	$836,596	$291,843	$477,153	6.99	$2,403,561
2013	7,053	50,643	$494,936	$172,553	$283,706	4.1	$1,187,069
2014	7,264	40,478	$830,858	$288,344	$476,395	6.81	$1,242,414
2015	11,132	75,009	$937,967	$326,264	$535,776	7.72	$1,906,246
2016	7,023	42,276	$312,791	$109,274	$176,394	2.63	$1,217,791
2017	7,658	41,371	$1,098,641	$382,203	$632,422	9	$1,356,190
2018	9,057	34,764	$510,289	$177,879	$289,450	4.22	$1,643,121
2019	19,864	61,645	$1,528,169	$532,055	$873,914	12.63	$3,475,633
Average	10,786	62,157	$823,637	$291,457	$471,120	6.87	$1,806,252

While angler effort, participation, and overall expenditures drive the economic impact of recreational estuarine striped bass angling in the state, the valuation can also be affected by smaller-scale factors specific to the fishery. Several social, regulatory, or environmental factors could affect the total economic impact of any fishery, though these are often difficult to quantify due to lack of data and clear causality. A notable component that may impact expenditures, and therefore economic impacts to the state, across management areas is variability in slot limits.

Each management area operates under different recreational harvest limits, including season length and size restrictions. For example, the ASMA is open for harvest from October to April with an 18-inch minimum TL size limit and the RRMA allows harvest from March to April and includes an 18-inch minimum TL size limit and a 22–27-inch TL no harvest protective slot. Varying restrictions could affect angler expenditures and total economic impact across management areas. Longer harvest seasons with less restrictive size limits could increase angler effort and expenditures in the ASMA compared to the RRMA, and likely lead to greater economic impacts to the recreational fishing industry.

RRMA

The RRMA creel survey does not collect reliable angler expenditure data annually, although Dockendorf et al. 2015 does provide an estimate of angler expenditures for the 2015 fishing year. Therefore, this analysis incorporates CSMA angler expenditure data instead, using the assumption that angler expenditures would be comparable across water bodies annually. Given that on-site expenditure values are not available, the only annual total expenditure estimates are those using RRMA effort data and DMF recreational angler expenditure survey data. In addition, the RRMA creel survey does not specifically include secondary targeting as part of its directed trip definition, but all striped bass trips, whether anglers target striped bass by itself or in combination with other species, are included in the estimates.

The state-wide economic impacts of the RRMA recreational fishery are higher than the ASMA and the CSMA because of higher overall effort and less year-to-year variability (Table 9). However, while it is assumed that CSMA expenditure values are a valid proxy for the RRMA, annual variability of the CSMA values impact the RRMA estimates. Therefore, while these are valid estimates of overall impact, they may not be perfectly reflective as they rely on indirect expenditure data.

CSMA

Recreational striped bass effort in the CSMA has generally increased over time, with corresponding increases in state-wide economic impacts. However, striped bass effort in 2019 dropped to its lowest levels in 10 years, with corresponding decreases in economic impact to the state (Table 10). The large increase in value of the fishery in 2017 is most directly attributed to higher lodging estimates from that year's creel survey, which can significantly impact model outputs.

Table 9. Annual recreational striped bass effort estimates and state-level economic impacts of recreational striped bass angling in the Roanoke River Management Area. For this analysis, a striped bass trip is as a directed trip for striped bass or a trip where striped bass was caught.

Year	Estimated Total RRMA Striped Bass Trips	Estimated Total RRMA Striped Bass Angling Hours	Estimated Sales Impacts	Estimated Income Impacts	Estimated Value-Added Impacts	Estimated Job Impacts	Total Expenditures Using DMF Inshore Vessel Trip Costs
2008	23,286	110,608	$746,409	$266,604	$404,467	6.79	$3,622,190
2009	25,405	120,675	$944,680	$341,790	$513,880	8.77	$3,937,746
2010	24,347	125,495	$3,695,792	$1,390,759	$2,022,463	29.79	$3,835,657
2011	27,311	122,876	$2,223,940	$786,945	$1,253,414	19.16	$4,438,423
2012	27,151	119,917	$1,567,592	$546,849	$894,076	13.1	$4,503,733
2013	19,539	112,814	$1,371,146	$478,033	$785,967	11.35	$3,288,550
2014	18,932	97,798	$2,165,449	$751,506	$1,241,620	17.74	$3,238,077
2015	25,034	123,648	$2,109,331	$733,712	$1,204,871	17.36	$4,286,828
2016	27,123	140,423	$1,208,006	$422,018	$681,239	10.14	$4,703,140
2017	21,004	109,011	$3,013,303	$1,048,289	$1,740,066	24.67	$3,719,693
2018	20,742	109,947	$1,168,648	$407,372	$662,889	9.67	$3,763,013
2019	20,633	99,259	$1,674,227	$582,907	$957,440	13.84	$3,811,110
Average	23,376	116,039	$1,824,044	$646,399	$1,030,199	15.20	$3,929,013

Table 10. Annual recreational striped bass effort estimates and state-level economic impacts of recreational striped bass angling in the Central-Southern Management Area. For this analysis, a striped bass trip is defined as any trip in which striped bass was an angler's primary target species, secondary target, or was caught.

Year	Estimated Total CSMA Striped Bass Trips	Estimated Total CMSA Striped Bass Angling Hours	Estimated Sales Impacts	Estimated Income Impacts	Estimated Value-Added Impacts	Estimated Job Impacts
2008	6,620	28,415	$212,196	$75,793	$114,986	1.93
2009	5,640	26,607	$209,725	$75,879	$114,085	1.95
2010	6,889	25,355	$995,635	$374,666	$544,846	8.03
2011	12,608	51,540	$1,026,671	$363,289	$578,633	8.8
2012	18,338	71,964	$1,058,786	$369,354	$603,879	8.85
2013	20,394	86,918	$1,431,103	$498,937	$820,335	11.85
2014	15,682	70,316	$1,793,659	$622,479	$1,028,444	14.69
2015	18,159	79,398	$1,530,041	$532,211	$873,974	12.59
2016	23,675	110,453	$1,054,420	$368,363	$594,627	8.85
2017	26,125	119,680	$3,748,044	$1,303,895	$2,164,350	30.69
2018	16,394	69,917	$923,651	$321,970	$523,920	7.64
2019	8,820	40,580	$715,654	$249,466	$409,261	5.92
Average	14,945	65,095	$1,224,965	$429,692	$697,612	10.15

ECOSYSTEM PROTECTION AND IMPACTS

As an anadromous species, one that migrates from the ocean or estuary upriver to spawn, habitat requirements for striped bass are specific to life stage. Striped bass are commonly found in habitats identified by the NC Coastal Habitat Protection Plan (CHPP) as priority habitats. These include the water column, wetlands, submerged aquatic vegetation (SAV), soft bottom, hard bottom, and shell bottom (NCDEQ 2016). These habitats provide appropriate conditions necessary for different life stages of striped bass.

COASTAL HABITAT PROTECTION PLAN

The Fisheries Reform Act statutes require that a CHPP be drafted by the DEQ and reviewed every five years (G.S. 143B 279.8). The CHPP is intended as a resource and guide compiled by DEQ staff to assist the department, MFC, NC Environmental Management Commission (EMC), and NC Coastal Resources Commission (CRC) for the protection and enhancement of fishery habitats of NC. The CHPP ensures consistent actions between commissions as well as their supporting DEQ divisions. The three commissions adopt rules to implement the CHPP in accordance with Chapter 150B of the General Statutes. Habitat recommendations related to fishery management can be addressed directly by the MFC. Habitat recommendations not under MFC authority (e.g., water quality management, shoreline development) can be addressed by the EMC and the CRC through the CHPP process.

The CHPP Source Document summarizes the economic and ecological value of coastal habitats to NC, their status, and the potential threats to their sustainability (NCDEQ 2016). The Coastal Habitat Protection Plans and Source Document can be viewed and downloaded from: http://portal.ncdenr.org/web/mf/habitat/chpp/07-2020-chpp.

The CHPP completed the five-year review, producing the 2021 Amendment. The Amendment includes two priority issues, "Submerged Aquatic Vegetation (SAV) Protection and Restoration, with Focus on Water Quality Improvements" and "Wetland Protection and Restoration with a Focus on Nature-based Methods", which may have implications for striped bass in NC. The presence of SAV is often used as a bio-indicator of water quality, as it is sensitive to specific conditions. One goal addressed in the CHPP is to modify water quality criteria to improve light penetration to the seafloor, one of the most important factors affecting SAV growth. Water quality improvements that benefit SAV will also benefit the species that use SAV habitat, like striped bass. As noted below, wetlands provide striped bass with a variety of habitat functions. The wetlands issue paper provides significant justification regarding nature-based methods of restoration and shoreline protection. Therefore, improvements to wetlands through the recommendations of the wetlands paper can have direct benefits to striped bass by increasing available habitat that can be used by striped bass.

THREATS AND ALTERATIONS

Striped bass use nearly all the environmentally and economically valuable habitat types that are listed in the 2016 CHPP during one or more life stages. Each habitat type provides environmental conditions critical to the enhancement and sustainability of striped bass populations in NC. Water quality impacts the habitats required by striped bass at various life stages (i.e., wetlands, submerged aquatic vegetation, shell bottom, and soft bottom). The primary human threats to these habitats include coastal development, industrial/wastewater discharges, and runoff. These threats often alter water chemistry, causing shifts in salinity, temperature, dissolved oxygen (DO), suspended solids, nutrients, pH, velocity, depth, flow, and clarity.

Wetlands, submerged aquatic vegetation, shell bottom, and soft bottom are of particular importance for striped bass as they function as nursery habitat, refuge, foraging grounds, and movement corridors. As anadromous fish, striped bass migrate from one system to another. Therefore, barriers to migration have the potential to significantly affect striped bass populations. Dams across rivers can cause segmentation in waterways and prevent striped bass from accessing historical spawning grounds. Additionally, coastal development that alters or removes migration corridors can further restrict the quantity and quality of habitat. The placement of large structures, such as breakwaters, groins, and jetties, can cause alterations in water flow patterns. For larval striped bass, this can result in altered migration patterns and force larval fish into areas where they are susceptible to predation.

Potential environmental influences on the striped bass stock include both dissolved oxygen and blue-green algae blooms. Hurricanes, increases in rainwater runoff, and blue-green algae blooms can lead to decreases in DO that can increase stress on fish and lead to fish kills (fish kills can be reported to the hotline at 1-800-858-0368 or online). For additional information on blue-green algae please see: the DEQ Algal Blooms Page, Albemarle-Pamlico National Estuarine Partnership Blue-green Algae Fact Sheet, and the North Carolina CHPP.

Another area of potential influence on the striped bass stock is the prevalence of the non-native blue catfish and flathead catfish (*Pylodictis olivaris*). Both species have been present in the Tar-Pamlico, Neuse, and Cape Fear river basins for decades, and while flathead catfish are not currently found in the Albemarle Sound basin, the population of blue catfish in the Roanoke River and Albemarle Sound and tributaries has increased dramatically in recent years (Darsee et al. 2019; NCDMF 2019). Striped bass made up only a small fraction of the overall diet of blue catfish in the James River of Chesapeake Bay (Schmitt et al. 2016), but non-native catfishes including flathead catfish and blue catfish were suggested to play a large role in structuring native fish communities and to delay recovery of anadromous fish populations in the Cape Fear River (Belkoski et al. 2021). Predation by non-native catfishes could potentially impact recruitment of striped bass directly or could influence food resources for striped bass through competition (e.g., Pine et al. 2005). The WRC published the 2019 Catfish Management Plan which details goals, strategies, and recommendations for developing and implementing management strategies for invasive catfish. Additional information about blue catfish in NC can be found in the APNEP Aquatic Nuisance Species Management Plan.

Manmade barriers also act as impediments to spawning for striped bass stocks in NC. On the Roanoke River spawning migrations have been impeded since the construction of the initial dam at Roanoke Rapids around 1900 (NMFS and USFWS 2016). In the CSMA, dams on the Tar-Pamlico, Neuse, and Cape Fear rivers obstruct migration and alter the flow regime. The Cape Fear River may provide the best opportunity for remediation of migration impediments. The U.S. Army Corps of Engineers (USACE) owns three locks and dams on the Cape Fear River that are currently not operational. These locks and dams have severely reduced access to historic spawning areas near the fall line. Various unsuccessful forms of passage have been attempted to restore spawning stocks, but recent alterations to fish passage may allow higher passage efficiency over the first lock and dam. Further details regarding fish passage on the Cape Fear River can be found in the Cape Fear River Sustainable Harvest Issue Paper Appendix 4.

FLOW

Striped bass are broadcast spawners, producing eggs that must remain in the water column to develop and hatch (Bain and Bain 1982). Appropriate river flow is critical before and after the spawning period (Hassler et al. 1981) and is the most important factor influencing year class strength. Striped bass require relatively high streamflow to encourage upstream migration prior to the peak of spawning, whereas low to moderate flows are necessary for spawning success and downstream transport of early life stages. Extremely low flows will result in eggs settling on the river bottom where they can be covered in sediment and die (Albrecht 1964), and extended periods of high water from May to June negatively impact reproduction by stranding eggs and larvae in the floodplain where dissolved oxygen is low. Recruitment failures in the ASMA since 2001 are thought to be due to extended spring flooding events.

ASMA/RRMA

Streamflow in the lower Roanoke River is regulated by John H. Kerr Dam, which is operated by the USACE for flood control, hydropower, and recreational uses. Two additional hydropower dams owned and operated by Dominion Energy, Gaston Dam and Roanoke Rapids Dam, are located downstream of Kerr Dam and further regulate streamflow in the Roanoke River. Operation of Kerr Dam is guided by a Water Control Plan (USACE 2016), which is the result of years of environmental studies and collaboration with numerous resource agencies and stakeholders. Gaston and Roanoke Rapids dams are operated by Dominion under conditions of a license received from the Federal Energy Regulatory Commission in 2005 (FERC 2005). Both the USACE Water Control Plan and Dominion’s FERC license stipulate flow regimes and restrictions intended to facilitate successful striped bass spawning in the Roanoke River. Staff from the WRC and DMF as well as other resource agencies including DEQ and U.S. Fish and Wildlife Service (USFWS) advise the USACE and Dominion Energy on a weekly basis during the striped bass spawning season to inform streamflow decisions within the constraints of the Water Control Plan and FERC license.

Appropriate flow regimes for successful striped bass reproduction in the Roanoke River have been a concern since Kerr Dam was constructed in 1953. Adequate minimum flows were first addressed in 1957 when the USACE agreed to a 2-feet increase in the guide curve to provide sufficient flows during the striped bass spawning season. The increased storage and changes to the guide curve during the spring spawning season are maintained in the current version of the Water Control Plan. The USACE along with federal and state resource agencies developed and tested a recommended flow regime during the striped bass spawning season beginning in 1989 to identify beneficial flows for successful reproduction. After testing the flow regime for four years, the USACE implemented the negotiated flow regime (Table 11), which specifies high flows in April and low to moderate flows in May and June, on a permanent basis in 1995, and they incorporated the same spawning flow targets in the 2016 revision of their Water Control Plan. Additionally, Dominion is prohibited from conducting hydropeaking operations (large daily variations in streamflow) during the striped bass spawning in April through June 15. This FERC license requirement dictates that Dominion consistently adheres to the USACE weekly flow declaration from Kerr Reservoir. Prior to each spawning season, USACE, WRC, and USFWS staff discuss an overall plan of operation based on Water Management forecasts of available storage and inflows during the upcoming spawning season, and the USACE attempts to meet the weekly target flow regime depending on water availability or the need for flood control.

Table 11. U.S. Army Corps of Engineers guidelines for providing Roanoke River striped bass spawning flows from John H. Kerr Dam.

Dates	Lower Target Flow (cfs)	Median Target Flow (cfs)	Upper Target Flow (cfs)
April 1–15	6,600	8,500	13,700
April 16–30	5,800	7,800	11,000
May 1–15	4,700	6,500	9,500
May 16–31	4,400	5,900	9,500
June 1–15	4,000	5,300	9,500

The negotiated spawning flow regime strives to maintain Roanoke River flow rates within the range of 6,000–8,000 ft^3/s, which was identified as optimum levels for striped bass spawning by Hassler (1981) and Rulifson and Manooch (1990). However, recent analysis indicates that streamflow conditions within the optimum ranges did not always produce strong year classes; rather, the analysis of year-class strength and flows since 1955 showed that poor year classes were produced when flows were above 20,000 ft^3/s during May but did not find a relationship between target-level streamflow and successful recruitment (NCDMF 2021). Flood control is the primary objective of John H. Kerr Dam (USACE 2016), and the reservoir is designed to temporarily store flood waters until they can be released later at the maximum rate possible without causing significant damaging flows downstream. When heavy rainfall causes high inflows into the reservoir, the USACE enters into flood control operations and flows will typically exceed the negotiated flow regime. The Water Control Plan allows for flood releases up to 35,000 ft^3/s when lake levels are between 300 and 320 ft (NGVD29), but flows are generally based on weekly average inflows into the reservoir. At higher lake elevations, flood releases can exceed 35,000 ft^3/s to prevent damage to the dam itself, but, to date, flows from Kerr Dam have never exceeded 35,000 ft^3/s. Between 2016 and 2020, monthly reservoir inflows during the spawning timeframe were above average and some months recorded some of the highest inflows on record (Figure 13). These high-inflow years caused the need for high streamflow and flood control operations during the striped bass spawning season (Tony Young, USACE, personal communication), which has, in turn, resulted in reduced recruitment for the Albemarle-Roanoke striped bass stock.

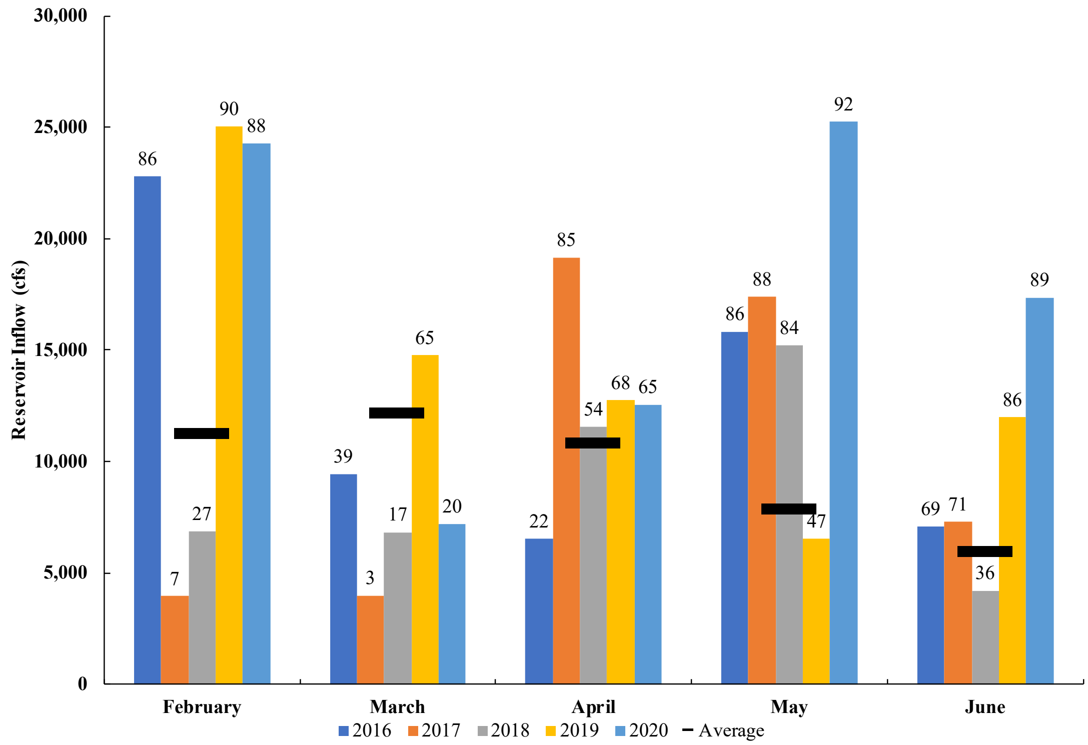


Figure 13. Monthly inflow data for John H. Kerr Reservoir on the Roanoke River during February–June of 2016–2020. Data were provided by USACE staff. Numbers of the columns provide the rank for 92 years of data. A rank of 1 is driest and rank of 92 is wettest.

CSMA

The rivers in the CSMA are less regulated than the Roanoke River, and specific, optimal flow requirements are unknown. The Tar-Pamlico River is impounded by Rocky Mount Mills Dam (rm 124) and Tar River Reservoir Dam (rm 130). Rocky Mount Mills Dam is a small, historic hydropower facility that is not currently regulated by FERC, and Tar River Reservoir is a drinking water reservoir. Both dams are run-of-river operations, and neither has enough storage capacity to provide beneficial spawning flows for striped bass. Rocky Mount Mills Dam is an impediment to anadromous fish migrations, but it is unlikely that striped bass would benefit from passage beyond the dam as the typical spawning habitat is downstream. However, regulated flows, such as hydropeaking, could reduce striped bass spawning success. Because the mill dam lacks FERC oversite, continued communication between resource agencies and the dam operators is critical to maintain striped bass spawning habitat on the upper Tar-Pamlico River. The Neuse River has benefitted from several dam removals over the last few decades, including Quaker Neck Dam (rm 140) in 1998 and Milburnie Dam (rm 218) in 2017. Falls of the Neuse Dam at rm 236 is now the first impediment to striped bass migration. Falls Dam is operated by the USACE for flood control and drinking water supply. There are no formal spawning flow agreements for Falls Dam, but the USACE consults with resource agency staff weekly regarding water releases on the Neuse River and tries to provide increased streamflow when water is available. The Cape Fear River is heavily impacted by three USACE locks and dams at rm 60, 93, and 116. Additionally, Buckhorn Dam is a run-of-river low-head dam at rm 196, and B. Everett Jordan Dam, operated by USACE, is operated for flood control and a drinking water reservoir located on the Haw River upstream of the beginning of the Cape Fear River. There are no formal striped bass spawning streamflow agreements for B. Everett Jordan Dam; however, beginning in 2020, the USACE modified reservoir release patterns into the Cape Fear River during the peak migratory season in an attempt to submerge all three locks and dams and enhance upstream passage of striped bass and other anadromous fishes to historic spawning grounds.

Egg densities and buoyancy in different systems have been shown to be suited for the predominant flow rate of that river (Bergey et al. 2003). Chesapeake Bay striped bass eggs are lighter and maintain their position in the water column of calm waters, whereas Roanoke River striped bass eggs are heavier and maintain their water column position in a high energy system (Bergey et al. 2003). A recent study indicated that, egg size and buoyancy from the Tar-Pamlico and Neuse rivers appear to be adapted to their specific river systems based on salinity alone (Kowalchyk 2020; Reading et al. 2020). Striped bass from the Tar-Pamlico and Neuse rivers have smaller and heavier eggs compared to other rivers in NC and may require higher flow rates to remain suspended in the water column (Kowalchyk 2020, Reading et al. 2020). Because low streamflow and shallow water may lead to eggs contacting the bottom (Bain and Bain 1982), striped bass spawning success in CSMA rivers may be limited to years when rainfall produces enough streamflow to keep eggs suspended, provided spawning stock biomass is adequate.

RESEARCH NEEDS

The research recommendations listed below are offered by the division to improve future management strategies of the estuarine striped bass fishery. They are considered high priority as they will help to better understand the stiped bass fishery and meet the goal and objectives of the FMP. A comprehensive list of research recommendations is provided in the annual FMP Review and Research Priorities documents available on the Fishery Management Plans website.

- Identify environmental factors (e.g., flow, salinity, predation, dissolved oxygen, algal blooms) affecting survival of striped bass eggs, larvae, and juveniles and investigate methods for incorporating environmental variables into stock assessment models.
- Refine discard mortality estimates for recreational and commercial fisheries by conducting delayed mortality studies to estimate discard losses for recreational and commercial gear during all seasons factoring in relationships between salinity, dissolved oxygen, and water temperature.
- Determine mixing rates between A-R and CSMA striped bass stocks to better inform stock assessments and management.
- Expand, modify, or develop fishery independent sampling programs to fully encompass all striped bass life stages (egg, larval, juvenile, and adult).
- Enhance recreational and commercial data collection to better characterize the magnitude and demographics (e.g., length, weight, age) of discards

STRIPED BASS AMENDMENT 2 MANAGEMENT STRATEGY

The NCMFC selected management options:

APPENDIX 2: ACHIEVING SUSTAINABLE HARVEST FOR THE ALBEMARLE SOUND-ROANOKE RIVER STRIPED BASS STOCK

1. Manage for Sustainable Harvest through harvest restrictions
   A. Continue to use stock assessments and stock assessment projections to determine the TAL that achieves a sustainable harvest for the A-R stock
2. Management of striped bass harvest in the commercial fishery as a bycatch fishery
   A. Status quo: continue managing the ASMA striped bass fishery as a bycatch fishery
3. Accountability Measures to address TAL overages
   D. If the landings in any one of the management areas' three fisheries (RRMA recreational, ASMA recreational, and ASMA commercial) exceeds their allocated TAL in a calendar year, any landings in excess of their allocated TAL will be deducted from that fisheries' allocated TAL the next calendar year.
4. Size limits to expand the age structure of the stock
   C. In the ASMA, implement a harvest slot of a minimum size of 18-inches TL to not greater than 25 inches TL in the commercial and recreational sectors
   E. In the RRMA, maintain current harvest slot limit of a minimum size of 18-inches TL to not greater than 22-inches TL with no harvest allowed on fish greater than 22 inches.
5. Gear modifications and area closures to reduce striped bass discard mortality
   A. Status quo-continue to allow commercial harvest of striped bass with gill nets in joint and coastal waters of the ASMA and continue recreational harvest and catch-and-release fishing in the ASMA and RRMA, including striped bass spawning grounds in the Roanoke River. The requirement that from April 1 through June 30, only a single barbless hook or lure with single barbless hook (or hook with barb bent down) may be used in the inland waters of the Roanoke River upstream of U.S. Highway 258 Bridge will remain in effect.
   E. Implement a requirement to use non-offset barbless circle hooks when fishing with live or natural bait in the inland waters of the Roanoke River (upstream of Hwy 258 bridge) from May 1 through June 30
6. Adaptive Management

   Adaptive management for the A-R stock and fisheries in the ASMA and RRMA encompasses the following measures:

   - Use peer reviewed stock assessments and updates to recalculate the BRPs and/or TAL. Stock assessments will be updated at least once between benchmarks. Increases or decreases in the TAL will be implemented through a Revision to the Amendment. A harvest moratorium could be necessary if stock assessment results calculate a TAL that is too low to effectively manage, and/or the stock continues to experience spawning failures.
   - Use estimates of F from stock assessments to compare to the F BRP and if F exceeds the F_{Target} reduce the TAL to achieve the F_{Target} in one year through a Revision to the Amendment.

- Ability to change daily possession limits in the commercial and recreational fisheries to keep landings below the TAL.
- Ability to open and close recreational harvest seasons and commercial harvest seasons and areas to keep landings below the TAL and reduce interactions with endangered species.
- Ability to require commercial and recreational gear modifications including, but not limited to, the use of barbless or circle hooks, area closures, yardage limits, gill net mesh size restrictions and setting requirements to reduce striped bass discards.

APPENDIX 3: ACHIEVING SUSTAINABLE HARVEST FOR THE TAR-PAMLICO AND NEUSE RIVERS STRIPED BASS STOCKS

1. Striped Bass Harvest
   A. Continue the no-possession measure in Supplement A to Amendment 1
2. Gear Restrictions/Limits
   A. Maintain gill net closure above the ferry lines and maintain the 3-foot tie-downs below the ferry lines
3. Adaptive Management

   - In 2025, review data through 2024 to determine if populations are self-sustaining and if sustainable harvest can be determined

In addition, the MFC included in its motion "*that the DMF study the effects of the gill net closure and reevaluate it at the next full amendment review. This research will be conducted, preferably within two years, and this closure be addressed based on that study*".

APPENDIX 4: ACHIEVING SUSTAINABLE HARVEST FOR THE CAPE FEAR RIVER STRIPED BASS STOCK

1. Striped Bass Harvest
   A. Status Quo: maintain Cape Fear River harvest moratorium
2. Adaptive Management

   - Continue YOY surveys and PBT analysis after the adoption of the FMP
   - If YOY surveys and/or PBT analysis suggest levels of natural reproduction have increased or decreased compared to what was observed up to the time of FMP adoption, then management measures may be re-evaluated using this new information and adjusted by proclamation using the authority granted to DMF and WRC directors. Rule changes or suspensions would be required to allow harvest.
   - Management measures which may be adjusted include means and methods, harvest area, as well as season, size and creel limit (as allowed for in rule).
   - Use of the DMF director's proclamation authority for adaptive management is contingent on evaluation of adaptive management measures by the Striped Bass Plan Development Team and consultation with the Finfish Advisory Committee.

APPENDIX 5: THE USE OF HOOK AND LINE AS A COMMERCIAL GEAR IN THE ESTUARINE STRIPED BASS FISHERY

1. Hook and Line as a Commercial Gear

   A. Do not allow hook and line as a commercial gear in the estuarine striped bass fishery at this time.

2. Adaptive Management

- If hook and line is allowed for the commercial harvest of striped bass and NC TTP and Quota Monitoring data indicate the TAL will either be quickly exceeded or unable to be met during the potential striped bass season, then management measures may be re-evaluated and adjusted by the proclamation authority granted to the Fisheries Director (as is currently occurring under the existing management strategy).
- If hook and line is allowed for the commercial harvest of striped bass and Marine Patrol enforcement activity or License and Statistics data suggest significant amounts of unreported commercial striped bass catch is occurring, then additional tagging or reporting requirements may be developed and implemented.
- Management measures that may be adjusted include means and methods, harvest area, as well as season, size and limit.
- Implementation of adaptive management measures to enact additional increased tagging or reporting requirements is contingent on evaluation of these measures by the Striped Bass Plan Development Team and consultation with the Marine Fisheries Commission.

APPENDICES

APPENDIX 1: STRIPED BASS STOCKING IN COASTAL NORTH CAROLINA

STOCKING HISTORY

Striped Bass culture originated in North Carolina in the late 19th century with the establishment of the Weldon Hatchery adjacent to the spawning grounds of the Roanoke River (Baird 1880; Worth 1884). The Weldon Hatchery was operated from 1884–1991 by federal and state fisheries agencies, including the North Carolina Wildlife Resources Commission (WRC; Harrell et al. 1990). The Edenton National Fish Hatchery (ENFH), operated by the USFWS, was also heavily involved in striped bass production, and operated the Weldon Hatchery as a sub-station before it was transferred to WRC. Striped Bass eggs and fry (larvae) produced at the Weldon Hatchery from Roanoke River broodfish were widely distributed throughout the U.S. Although annual egg and fry production totals from the early years of the Weldon Hatchery are available for most years (1906–1947; Woodroffe 2011), little is known about fry stocking numbers and locations until WRC records began in 1943. Since that time, over 96 million fry have been released in North Carolina coastal systems (Table 1.1). A detailed overview of historical striped bass stocking in North Carolina and the southeastern U.S. can be found in Woodroffe (2011).

By the 1970s collapse of the Atlantic striped bass stock, hatchery techniques had been refined to achieve grow-out to phase-I (25–50 mm; 1–2 in) and phase-II (125–200 mm; 5–8 in) sizes, providing additional opportunities for stocking. The North Carolina Division of Marine Fisheries (NCDMF) and the USFWS began a pilot project in 1979 to evaluate the restoration potential of stocking phase-II fish. In 1986, the two agencies, along with the WRC, developed a cooperative program to restore self-sustaining stocks of anadromous fishes in coastal North Carolina waters through a combination of fishery management techniques including stocking, regulations, and assessment (Appendix 1.A). The cooperative agreement included plans for USFWS production of Phase-I and Phase-II fish. All sizes of striped bass (fry; phase-I; phase-II; sub-adults; adult broodfish) have been stocked into North Carolina coastal river systems since the agreement. The three agencies produce an annual workplan that details stocking strategies of multiple species including striped bass.

Albemarle Sound

The earliest record of stocking phase-II fish in the Albemarle Sound area occurred in 1978; however, the DMF tagging program and cooperative stockings began in January 1981 (Table 1.2). From 1981–1996, over 700,000 phase-II fish were stocked in the Albemarle Sound system with nearly 54,000 fish tagged. All phase-II fish stocked in Albemarle Sound from 1991–1996 were tagged to avoid natural stock confusion. In addition, over 800,000 phase-I fish were stocked in the Albemarle Sound system from 1979–1981 and 1985. An additional 160,410 phase-I fish were stocked in the Roanoke River from 1976–1979, and 106,392 phase-I fish were stocked in 1992. Stocking in the Albemarle Sound system was discontinued in 1996 due to recovery of the stock. Poor recruitment and the overfished status of the Albemarle-Roanoke stock, however, led the WRC and DMF to develop a stocking contingency plan for the Albemarle Sound in 2021. The contingency plan outlines the decision-making process for stocking surplus phase-I fish from

Roanoke River broodstock if high flow conditions are expected to limit natural recruitment. The Albemarle-Roanoke striped bass contingency plan will be part of the annual cooperative workplan agreement, and its use will be determined each year by agreement of the agencies.

Tar-Pamlico River

Phase-II stocking began in the Tar-Pamlico River in 1977 when 4,380 fish were stocked. Phase-II fish were periodically stocked from 1982–2005, and annual stockings of phase-II fish occurred from 2007–2020 (Table 1.2). The change to annual stocking of phase-II fish was a recommendation in the NC Estuarine Striped Bass FMP (NCDMF 2004). Nearly 2.4 million phase-II fish have been stocked in the Tar-Pamlico River basin since 1977, and more than 2.8 million phase-I fish since 1979. Phase-I fish stocked in 1979 and 1983 were likely surplus, but in 1994 the WRC and ENFH began stocking phase-I fish in the Tar-Pamlico River basin with an annual stocking goal of 100,000 phase-I fish. Annual stocking of phase-I fish was discontinued in 2009 by recommendation in Amendment 1 of the NC Estuarine Striped Bass FMP (NCDMF and NCWRC 2013). Surplus phase-I fish, however, were stocked in 2013, 2014, and 2016. A portion of all phase-II fish were tagged yearly to determine migration and contribution of stocked fish to recreational and commercial fisheries. From 1998–2011, all stocked fish were marked with oxytetracycline (OTC), which leaves a chemical mark on fish otoliths (ear bone) that can be seen under fluorescent light. Parentage-based tagging (PBT) analysis using microsatellite markers was used for genetically identifying fish stocked from 2010–2020.

Neuse River

Recent stocking history of striped bass in the Neuse River basin is similar to the Tar-Pamlico River basin. A small number of phase-II fish were stocked in the Neuse River in 1975. Phase-II fish were periodically stocked from 1981–2007, and annual stockings occurred from 2009–2020 (Table 1.2). More than 2.1 million phase-II fish have been stocked in the Neuse River basin. Additionally, more than 2.4 million phase-I fish have been stocked in the Neuse River basin, with an annual goal of 100,000 fish from 1993–2009. Stocking requests for phase-I fish ended with Amendment 1, but surplus fish were stocked in the Neuse River in several years following 2009. A portion of all phase-II fish were tagged each year to determine migration patterns and contribution of stocked fish to recreational and commercial fisheries. All stocked fish were marked with OTC from 1998–2011, and all striped bass stocked since 2010 are genetically traceable with PBT analysis.

Cape Fear River

The Cape Fear River was first stocked with 4,000 phase-II fish in 1968, and periodic stockings of phase-I and phase-II fish occurred from 1979–2000 (Table 1.2). Infrequent stockings in the Cape Fear River were due to low numbers of tag returns and complications posed by the presence of hybrid striped bass from Jordan Reservoir. Hybrid striped bass stocking was discontinued in Jordan Reservoir in 2002 in favor of striped bass (Table 1.3). Phase-II fish stocking was reinitiated in the Cape Fear River, with stocking in 2004, 2006, and annually since 2008. Phase-I fish were stocked annually from 2001–2009, and surplus phase-I fish were also stocked in 2012 and 2014. A portion of the phase-II fish were tagged. All stocked fish were marked with OTC between 1998–2011, and all striped bass stocked since 2010 are genetically traceable with PBT analysis.

Northeast Cape Fear River

The WRC stocked approximately 26,000 phase-II fish in the Northeast Cape Fear River in 1999 and 2000 (Table 1.2). The WRC also stocked phase-I fish annually during 2001–2009. A final stocking of phase-I fish in the Northeast Cape Fear River occurred in 2012. Approximately 818,000 phase-I fish were stocked in the Northeast Cape Fear River (Table 1.2). All stocked fish, except for those stocked in 2012, were marked with OTC, and the 2012 year-class is genetically traceable with PBT analysis.

Broodstock source

Striped bass originating from the Roanoke River have provided most fish used for stocking in North Carolina waters, but many broodstock sources have been used throughout the state. Early fry stockings from the Weldon Hatchery were entirely from Roanoke River broodfish. Phase-II fish stocked in the Albemarle Sound region were supplied by the ENFH and the USFWS McKinney Lake National Fish Hatchery in NC, with supplemental fish produced in South Carolina, Georgia, Alabama, and Texas, all of which used various broodstock sources. During most years, phase-I fish stocked by WRC originated from Roanoke River broodstock. Broodstock from Roanoke River; Monks Corner, SC; and Weldon/Monks Corner crosses were artificially spawned at the hatcheries to provide fish for grow-out to phase-II. When WSFH began striped bass production in 1994, nearly all striped bass broodstock used for all coastal river stockings were collected from the Roanoke River and Dan River (Roanoke River basin) each year (Jeff Evans, WRC hatchery manager, personal communication). In 2010, however, local broodstock were used for producing phase-II fish for stocking in the Cape Fear River, and local broodstock have been used for stocking the Tar-Pamlico and Neuse rivers since 2012.

Broodstock collection

Striped bass broodstock are collected during annual electrofishing surveys conducted by WRC on the spawning grounds of the Roanoke, Tar-Pamlico, Neuse, and Cape Fear rivers. WRC biologists coordinate broodstock collections with hatcheries staff. Gravid (egg laden) females and three to four males per female are collected and transported to hatcheries. The number of females collected annually varies based on stocking goals and hatchery needs. Broodstock for Tar-Pamlico and Neuse rivers phase-II production are typically delivered to ENFH, whereas broodstock for phase-I production for the Cape Fear and the Roanoke rivers and inland reservoirs are delivered to WSFH. Prior to 2014, WSFH transferred fry to ENFH for grow-out to phase-II.

Table 1.1. Striped bass fry stocked into coastal systems of North Carolina, 1943–2019. Data are from WRC hatchery cards (1943–1971), ENFH records (1982–1990), and the WRC warmwater stocking database, which includes ENFH records (1994–2019).

Roanoke River		Chowan River		Albemarle Sound		Tar-Pamlico River		Neuse River		White Oak River		Northeast Cape Fear River		Cape Fear River	
Year	Fry Stocked	Year	Fry Stocked	Year	Fry Stocked	Year	Fry Stocked	Year	Fry Stocked	Year	Fry Stocked	Year	Fry Stocked	Year	Fry Stocked
1944	3,938,000	1949	171,500	1951	474,200	1943	493,000	1949	100,000	1955	330,000	1965	150,000	1968	1,830,000
1949	1,000,000	1951	359,500	1952	1,025,000	1947	250,000	1951	139,000	1957	270,000	1966	200,000	1982	399,928
1950	1,500,000	1952	750,000	1953	800,000	1948	266,000	1952	175,000	1960	33,000	1967	300,000	2002	900,000
1958	400,000	1953	400,000	1954	1,000,000	1949	475,000	1953	397,000	1964	80,000	1968	425,000	2004	900,000
1959	862,000	1954	2,030,000	1955	820,000	1950	160,000	1954	1,045,000	1983	61,772	1969	320,000		
1960	4,964,000	1955	860,000	1956	150,000	1954	690,000	1955	330,000	1984	45,000	1970	187,000		
1962	1,335,000	1956	300,000	1957	820,000	1955	1,126,000	1956	305,000			1971	100,000		
1963	3,811,000	1959	105,000	1959	200,000	1956	200,000	1957	550,000			2000	999,999		
1964	1,536,000	1961	175,000	1961	525,000	1957	420,000	1959	185,000			2002	500,000		
1965	1,052,000^{+}	1962	225,000	1962	677,000	1959	260,000	1960	25,000			2003	115,000		
1966	1,005,000^{+}	1964	69,000	1964	274,000	1961	460,000	1961	260,000						
1967	1,567,500	1965	219,000	1965	375,000	1962	3,250,000	1962	360,000						
1968	6,334,000	1966	350,000^{+}	1966	925,000	1964	393,000	1964	90,000						
1969*	2,718,000^{+}	1967	297,000	1967	592,000	1965	150,000	1965	150,000						
1970	1,375,000	1968	985,100	1968	2,063,250	1966	200,000^{+}	1966	200,000						
1971	175,000	1969	309,800	1969	619,650	1967	510,000	1967	400,000						
1990	240,000	1970	63,000	1970	156,000	1968	975,000	1968	766,000						
		1971	250,000	1971	150,000	1969	1,943,000	1969	2,049,200						
						1970	6,528,000	1970	66,600						
						1971	1,164,000	1971	66,666						
						1994	1,500,000	1983	176,547						
						2018	608,384	1984	182,000						
						2019	813,000	2015	799,700						
								2016	1,173,000						
								2018	670,464						
								2019	1,755,000						
Totals	33,812,500		7,918,900		11,646,100		22,834,384		12,416,177		819,772		3,296,999		4,029,928

*55 million eggs were also released; $^{+}$includes records with unknown size and date of release that are assumed to be fry based on year of release and data source.

Table 1.2. Stocking records of phase-I and phase-II fish released in coastal systems of North Carolina, 1967–2020. Note, some phase-II fish were stocked in January of the calendar year following the production year-class causing some discrepancies with tables in previous fishery management plans.

	Albemarle Sound		**Roanoke River**		**Tar-Pamlico River**		**Neuse River**		**Northeast Cape Fear River**		**Cape Fear River**	
Year-Class	**Phase-I**	**Phase-II**	**Phase-I**	**Phase-II**	**Phase-I**	**Phase-II**	**Phase-I**	**Phase-II**	**Phase-I**	**Phase-II**	**Phase-I**	**Phase-II**
1967												4,000
1974					*Unknown							
1975								2,124				
1976			18,074									
1977			25,000			4,380						
1978		2,358	30,336									
1979	100,013	-	87,000		104,000		93,480				3,000	14,874
1980	441,689	87,181									12,410	
1981	215,706	-						47,648				
1982		106,675				76,674						
1983		67,433			28,000	-						13,401
1984		236,242				26,000						56,437
1985	45,011	45,200						39,769				
1986		118,345										
1987		15,435				17,993						
1988		5,000										
1989		3,289										77,242
1990		9,466				1,195		61,877			169,792	
1991		2,994				30,801						
1992		2,465	106,392			-						
1993		2,180				118,600	48,000					
1994		2,481			127,635	183,254	103,057	79,933			100,733	
1995		2,498			100,000	140,972	99,176				100,000	
1996		2,490			39,450		100,000	100,760				
1997					28,022	24,031						
1998					230,786		107,730	83,195				30,479
1999					100,000	17,954	100,000			10,327		
2000					188,839		121,993	108,000		15,635		8,915

Table 1.2 (continued).

Year-Class	Albemarle Sound Phase-I	Albemarle Sound Phase-II	Roanoke River Phase-I	Roanoke River Phase-II	Tar-Pamlico River Phase-I	Tar-Pamlico River Phase-II	Neuse River Phase-I	Neuse River Phase-II	Northeast Cape Fear River Phase-I	Northeast Cape Fear River Phase-II	Cape Fear River Phase-I	Cape Fear River Phase-II
2001					171,000	37,000	103,000		94,083		90,149	
2002					39,110			147,654	50,000		50,000	
2003					100,000	159,996	100,000		151,873		104,775	
2004					100,000		100,000	168,011	50,000		50,000	172,055
2005					114,000	267,376	114,000		54,500		54,500	
2006					134,100		146,340	99,595	84,125		80,450	102,283
2007					160,995	69,871	172,882	69,953	79,690		80,376	
2008					331,202	91,962	314,298		190,460		395,226	92,580
2009					99,730	61,054	100,228	104,061	51,750		166,812	112,674
2010						114,012		107,142				210,105
2011						107,767		102,089				130,665
2012						45,667	50,180	91,985	12,384		45,000	127,070
2013					257,404	123,416	181,327	113,784				195,882
2014					138,889	92,727	79,864	78,866			211,726	141,752
2015						52,922		109,107				116,011
2016					234,718	121,190	80,910	134,559				70,734
2017						101,987		14,203				154,024
2018						120,668	96,900	86,556				101,254
2019						97,920		85,694				105,405
2020						90,614		96,933				73,038
Totals	802,419	711,732	266,802	0	2,827,880	2,398,003	2,413,365	2,133,498	818,865	25,962	1,714,949	2,110,880

*DMF report indicates Phase-I fish were stocked in the Tar-Pamlico in 1974, but records have not been located.

Table 1.3. Striped bass and hybrid striped bass stocked by the NC Wildlife Resources Commission in B. Everett Jordan Reservoir located in the Cape Fear River basin, 1988–2020.

	Striped bass	Hybrid striped bass			
Year-Class	**Phase-I**	**Fry**	**Phase-I**	**Phase-II**	**Total**
1988			42,517		42,517
1989			30,000	96	30,096
1990			12,114		12,114
1991			96,887		96,887
1993			214,710	21,447	236,157
1994		600,000			600,000
1995	21,780		50,600		50,600
1996	15,867		29,000		29,000
1997	35,000		35,000		35,000
1998	37,766		13,692		13,692
1999	51,567		37,330		37,330
2000	42,150		42,118		42,118
2001	35,000		35,000		35,000
2002	70,000				
2003	70,000				
2004	70,000				
2005	70,000				
2006	70,000				
2007	70,000				
2008	70,000				
2009	70,000				
2010	70,000				
2011	70,000				
2012	100,000				
2013	100,000				
2014	100,000				
2015	78,000				
2016	78,000				
2017	100,000				
2018	128,164				
2019	120,000				
2020	120,000				
Totals	1,863,294	600,000	638,968	21,543	1,260,511

Fry production

North Carolina hatcheries use established striped bass culture techniques adapted from Harrell et al. (1990). At the hatchery, male and female striped bass are injected with human chorionic gonadotropin (hCG) hormone to induce spawning. One female to three or four males are placed in a circular spawning tank and allowed to spawn. Eggs are collected by gravity and flow in a secondary circular tank equipped with an extra fine mesh egg retention screen equipped with a bubble curtain to prevent eggs from contacting the screen. Water-hardened eggs are transferred to McDonald style hatching jars at a density of 75,000 to 125,000 eggs per jar and supplied with flow-through well water to keep eggs in suspension. Incubation typically takes 48 hours, and as eggs hatch, fry are collected in aquaria. At 2 days post-hatch, fry are transferred to circular tanks and inventoried. During the period of 4–7 days post-hatch, fry are fed brine shrimp Artemia nauplii through an automated feeding system for first feeding. Fry are then transferred to earthen production ponds for phase-I fingerling production.

Fingerling production

Fry are stocked into fertilized production ponds where they feed on naturally produced zooplankton. Supplemental feeding begins 15 days after stocking. Harvest of phase-I fingerling ponds is scheduled after a 35–45-day pond culture period. Phase-I fingerlings are then cultured inside in raceways for 30–45 days. They are then graded to similar size, and advanced fingerlings are pond-stocked at a rate of 15,000–20,000 fingerlings/acre for a final pond grow-out period. Advanced fingerlings are fed sinking pellet food, and phase-II production ponds are typically treated to control algae and aquatic vegetation and to offer protection from birds. Harvest of phase-II fingerling ponds is scheduled after a 120–130-day pond culture period. Harvested fingerlings range from 5–8 fingerlings/lb. Stocking of phase-II fingerlings typically occurs from October–December yearly.

EARLY STOCKING EVALUATIONS

The DMF striped bass tagging program provided an opportunity to evaluate the contribution of stocked fish to commercial and recreational fisheries. Prior to 1980, however, striped bass stockings in coastal North Carolina systems were not formally evaluated. Winslow (2010) analyzed tag-return data for phase-II fish stocked from 1981–2008 and found stocked phase-II fish contributed to the commercial and recreational fisheries as well as the spawning stock in the Tar-Pamlico and Neuse rivers.

Studies evaluating OTC marks were conducted by WRC to estimate the contribution of stocked phase-I and phase-II fish to the spawning stocks in the Tar-Pamlico and Neuse rivers in the early 2000s. Otoliths from adult striped bass from 2000–2004 in the Neuse River and from 2002–2004 in the Tar-Pamlico River were analyzed for the presence of an OTC mark (Barwick et al. 2008). Results suggested striped bass stocked in the Tar-Pamlico and Neuse rivers contributed little to the spawning stocks in these systems. In the Tar-Pamlico River in 2004 and Neuse River from 2000–2002, no stocked juveniles were recaptured as spawning adults. Fewer than three stocked fish were recaptured as adults in other years. However, results from this study may have been impacted by low mark retention.

With low abundance of stocked striped bass documented on the spawning grounds, WRC research efforts shifted to evaluating the contribution of stocked phase-I fish to seine and electrofishing samples conducted in the Neuse River. During the summers of 2006 and 2007, beach seining and electrofishing was conducted at estuarine and inland sampling locations (Barwick and Homan 2008). No juvenile striped bass were collected in 2006 and only five were collected in 2007. Three were collected close to the stocking location near New Bern, N.C. and two without OTC marks were collected upstream, all were hatchery fish. Results from this project suggested limited benefit of phase-I stocking as a management option to supplement striped bass populations in the Neuse River. In addition, the overall low number of juveniles indicated poor reproductive success, poor survival, or a combination of these two factors (Barwick and Homan 2008).

In response to a research need identified in Amendment 1 to determine factors impacting survivability of stocked fish in each system (NCDMF and NCWRC 2013), Bradley et al. (2018) acoustically tagged 100 hatchery-reared phase-II juveniles stocked in the Neuse River to estimate mortality and monitor movement and seasonal distribution. Annual discrete total mortality of phase-II stocked striped bass juveniles was 66.3% and was not related to seasonal variation in dissolved oxygen, temperature, or salinity. High observed mortality could be related to inadequate feeding or lack of predator avoidance. Future research should address whether changes in hatchery protocols could improve survival of stocked fish.

PARENTAGE-BASED TAGGING STOCKING EVALUATION

In 2010, WRC began using PBT to evaluate contributions of stocked striped bass to the populations in the Tar-Pamlico, Neuse, and Cape Fear rivers. PBT method uses genetic microsatellite markers to match stocked fish with broodfish used in hatchery production (Denson et al. 2012). Evaluating stocking with PBT is non-lethal as it requires a small fin clip. Fish are permanently marked with PBT without the issues of poor mark retention seen with OTC and without having to physically tag every fish with external tags. However, PBT cannot distinguish the origin of non-hatchery striped bass. Fish determined to not be of hatchery origin could be the result of wild reproduction in any system. Additionally, striped bass stocked prior to 2010 are not identifiable using this technique.

The WRC and DMF began collecting striped bass fin clip samples for PBT analysis in 2011. Fin clips are processed and analyzed by the South Carolina Department of Natural Resources Hollings Marine Laboratory. Samples in the early years focused on small fish, but as more PBT year-classes became available, fin clip samples were analyzed from all size-classes of striped bass. PBT analysis of samples collected on the spawning grounds and internal coastal fishing waters of the Tar-Pamlico, Neuse, and Cape Fear rivers revealed stocked striped bass can make up greater than 90% of the fish sampled some years (O'Donnell and Farrae 2017); however, results from 2017 and 2018 indicated a noticeable decrease in contribution of hatchery-stocked fish in the Tar-Pamlico and Neuse rivers (Farrae and Darden 2018).

Tar-Pamlico River

In 2012, WRC began collecting fin clips in the Tar-Pamlico River during annual spawning area surveys for PBT evaluation. DMF began collecting additional samples from adult striped bass in lower portions of the Tar-Pamlico River in 2016. Annual hatchery contribution from 2012–2019 ranged between 38%–94% (Table 1.4) and were similar between WRC and DMF samples (Table 1.5). Non-PBT fish overlapped with size-classes of 2010 and 2011 stocked cohorts (Figure 1.1 and 1.2). These results indicate stocked fish heavily contribute to the Tar-Pamlico striped bass population, but there is some evidence of natural recruitment, particularly in 2014 and 2015 (Figure 1.2). It is possible these recruits were migrants from the Albemarle-Roanoke stock or some other source as a DMF telemetry study indicated non-PBT fish tagged in the Tar-Pamlico River migrated to the Albemarle Sound, suggesting mixing in the systems (NCDMF unpublished data). Continued sampling to document young-of-the-year production will be required to verify natural recruitment in the Tar-Pamlico River.

Table 1.4. Parentage-based tagging results for Tar-Pamlico, Neuse, and Cape Fear River at-large striped bass samples collected by WRC and DMF, 2011–2019. Data presented here do not include results for hybrids, broodfish, duplicates, and errors.

		Hatchery Cohort											
River Basin	**Sample Year**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Unknown**	**Total**	**Hatchery Percentage**
Tar-Pamlico	2012	19	12								14	45	69%
	2013	99	41								23	163	86%
	2014	55	112	5							29	201	86%
	2015	22	79	56	34						12	203	94%
	2016	28	102	101	98	6					51	386	87%
	2017	7	35	17	86	24	1	1			78	249	69%
	2018	4	11	6	38	43	3	21	9		225	360	38%
	2019		7	1	7	9	4	57	11	4	85	185	54%
Neuse	2011	36									0	36	100%
	2012	24	8								1	33	97%
	2013	123	5	2	1						69	200	66%
	2014	96	77	20	99						55	347	84%
	2015	31	53	34	11						55	184	70%
	2016	20	25	42	83	22	1				42	235	82%
	2017	16	30	35	70	65	5	1			78	300	74%
	2018	14	19	26	35	67	76	39			117	393	70%
	2019	3	10	5	19	21	42	158	6	9	57	330	83%
Cape Fear	2011	55									0	55	100%
	2012	72	35								3	110	97%
	2013	109	27	14							92	242	62%
	2014	39	42	75	67						65	288	77%
	2015	45	31	32	41	10					66	225	71%
	2016	18	24	59	84	25					28	238	88%
	2017	17	9	37	46	51	18	1			17	196	91%
	2018	12	8	26	50	38	34	13	10		24	215	89%
	2019	6	2	10	10	7	7	25	85	115	31	298	90%

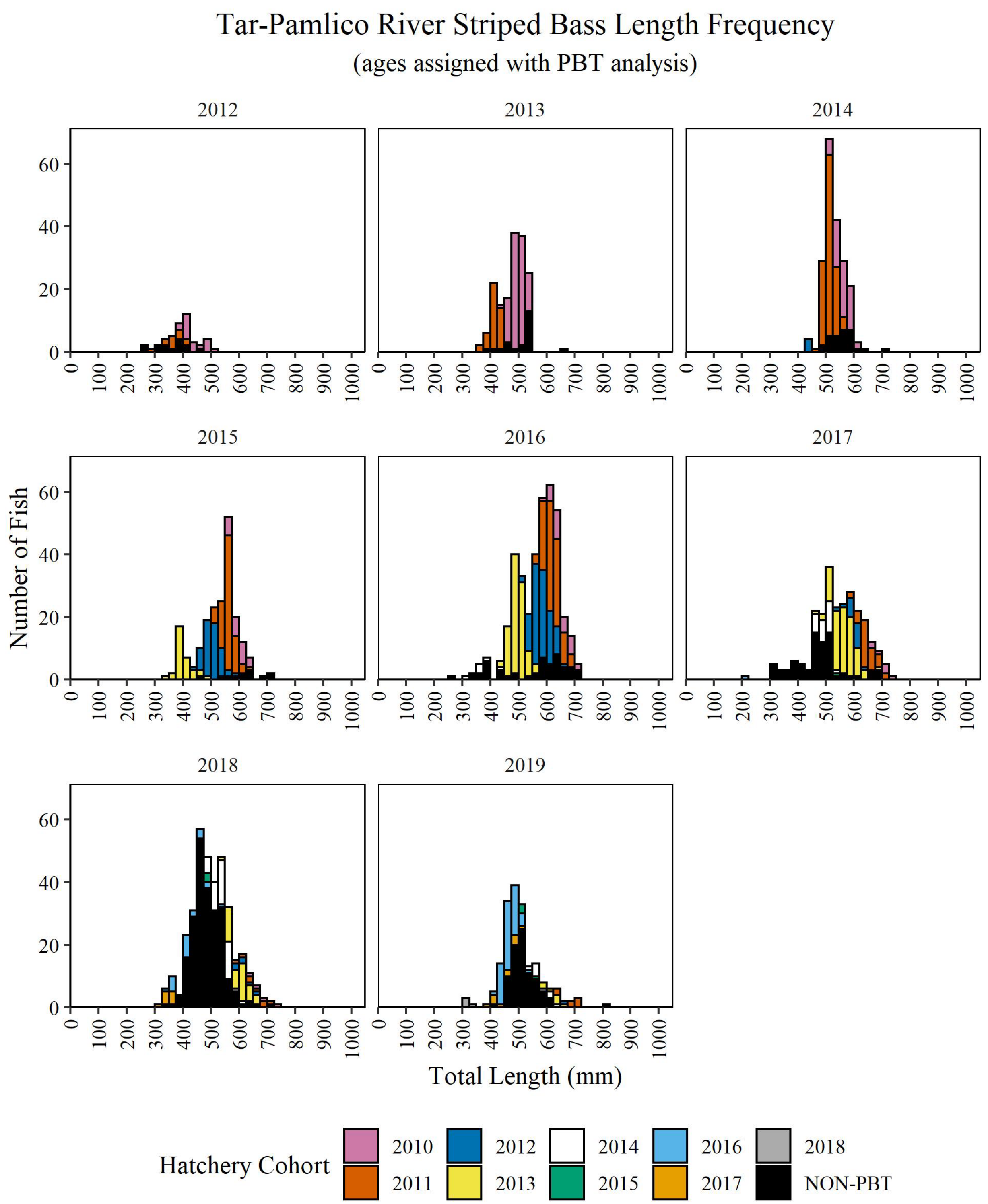


Figure 1.1. Length-frequency histograms for at-large striped bass collected in the Tar-Pamlico River by WRC and DMF, 2012–2019. Hatchery cohorts identified by parentage-based tagging analysis (PBT) are plotted within each 25-mm length group. Fish identified as non-PBT were not assigned to a hatchery cohort because they did not match to a broodstock pair.

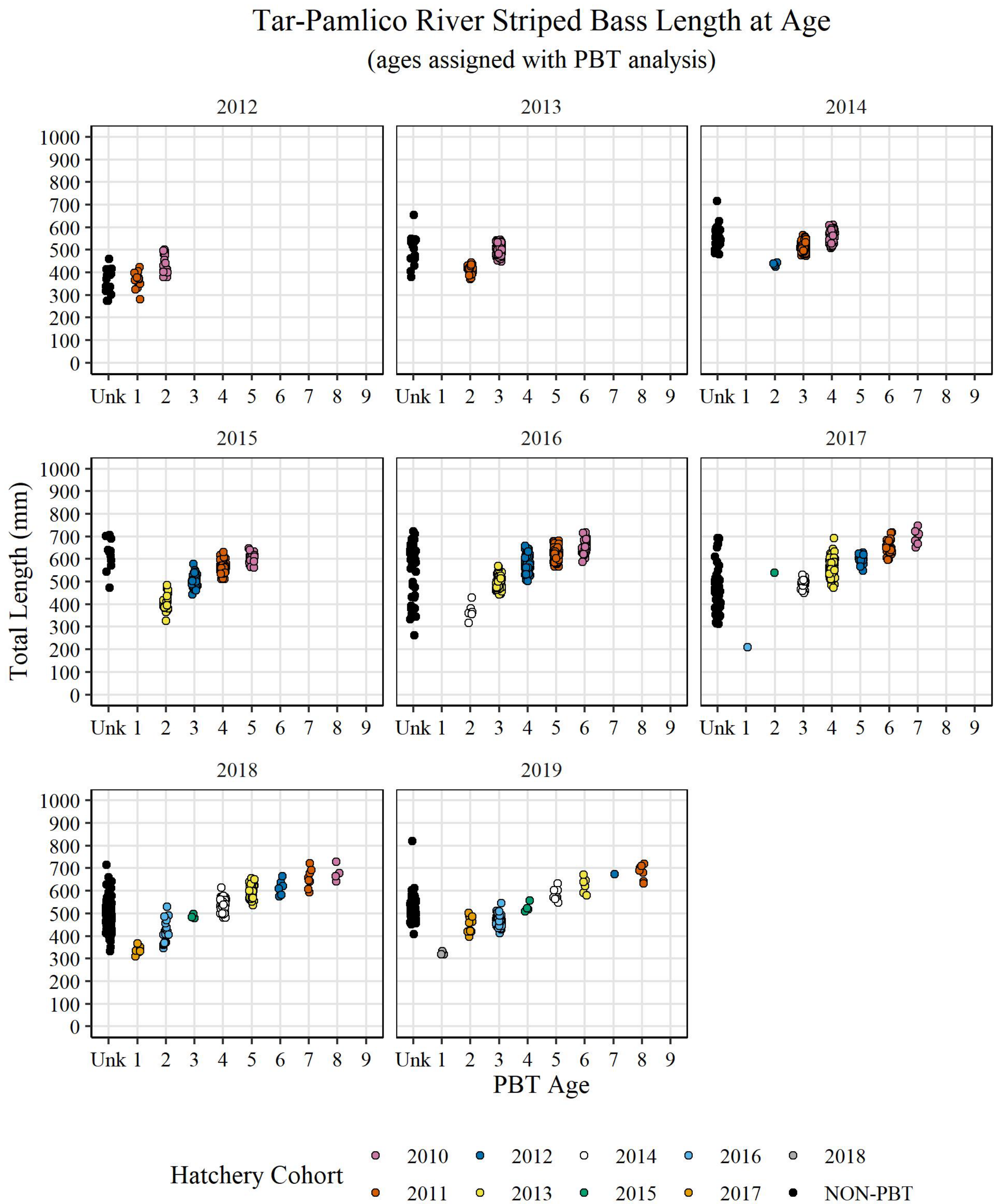


Figure 1.2. Length at age for at-large Tar-Pamlico River striped bass collected by WRC and DMF, 2012–2019. Ages were identified using parentage-based tagging (PBT) analysis. Those fish with an unknown age (Unk) each year were not identified as hatchery cohorts by PBT analysis and could not be assigned an age. Points are jittered about each age column to clarify overlapping data points. Outliers were removed before plotting.

Table 1.5. Parentage-based tagging hatchery contribution for at-large samples (excluding hybrids, broodfish, duplicates, and errors) collected by WRC during the Tar-Pamlico River spawning area survey and by DMF in downstream portions of the Tar-Pamlico River basin.

	WRC Samples			DMF Samples		
Year	**Non-PBT**	**Total**	**Hatchery Percentage**	**Non-PBT**	**Total**	**Hatchery Percentage**
2016	25	196	87%	26	190	86%
2017	31	100	69%	47	149	68%
2018	93	154	40%	132	206	36%
2019	26	78	67%	59	107	45%

Neuse River

WRC began collecting fin clips from the Neuse River spawning area survey in 2011. DMF began collecting additional samples in lower portions of the Neuse River basin in 2016. Annual hatchery contribution from 2011–2019 ranged between 66%–100% (Table 1.4; Figures 1.3–1.4). Non-PBT contribution estimated in early years of this study may have fish from age classes before 2010. Results from 2019 are more likely to accurately reflect actual hatchery contribution for the Neuse River striped bass population and indicate non-PBT recruitment in 2014 and 2015 is contributing to the Neuse River striped bass population. The non-hatchery fish from the 2014 and 2015 year-classes could be wild-spawned fish from the Neuse River or another system. Telemetry studies conducted by DMF documented that striped bass tagged in the lower Neuse River migrated to the Albemarle Sound (NCDMF unpublished data), suggesting mixing in these populations. Additionally, hatchery contribution was much higher for WRC samples collected on the Neuse River spawning grounds compared to DMF samples collected in the lower Neuse River in 2017–2019 (Table 1.6). The lower hatchery contribution for the downstream samples could indicate striped bass from the Albemarle-Roanoke population mix with the Neuse River population. Nevertheless, results indicate some non-PBT fish from the 2015 year-class are participating in the upstream spawning migration.

Table1.6. Parentage-based tagging hatchery contribution for at-large samples (excluding hybrids, broodfish, duplicates, and errors) collected by WRC during the Neuse River spawning area survey and by DMF in downstream portions of the Neuse River basin.

	WRC Samples			DMF Samples		
Year	**Non-PBT**	**Total**	**Hatchery Percentage**	**Non-PBT**	**Total**	**Hatchery Percentage**
2016	34	85	60%	8	150	95%
2017	26	182	86%	52	118	56%
2018	77	307	75%	40	86	53%
2019	23	228	90%	34	102	67%

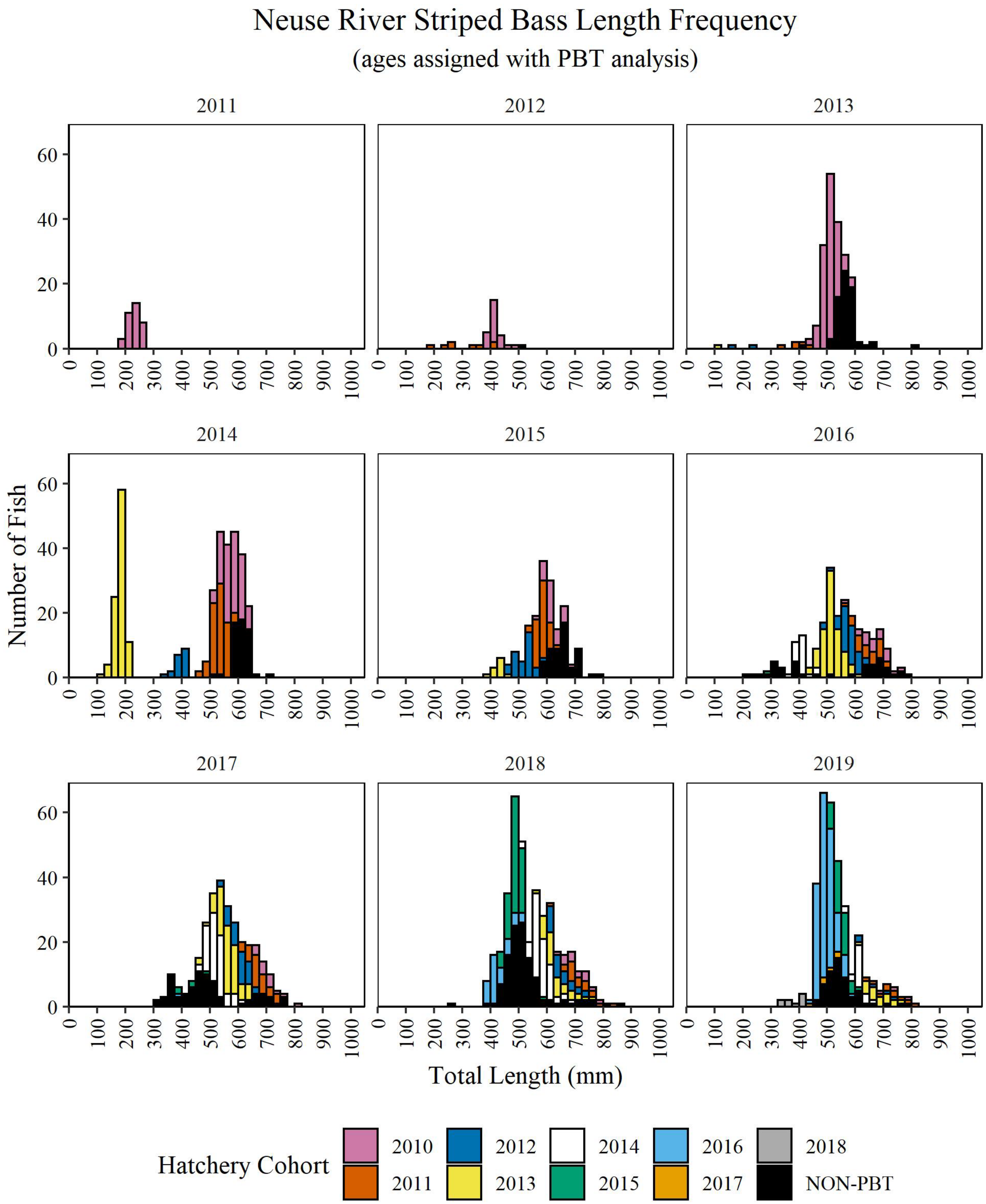


Figure 1.3. Length-frequency histograms for at-large striped bass collected in the Neuse River basin by WRC and DMF, 2011–2019. Hatchery cohorts identified by parentage-based tagging analysis (PBT) are plotted within each 25-mm length group. Fish identified as non-PBT were not assigned to a hatchery cohort because they did not match to a broodstock pair.

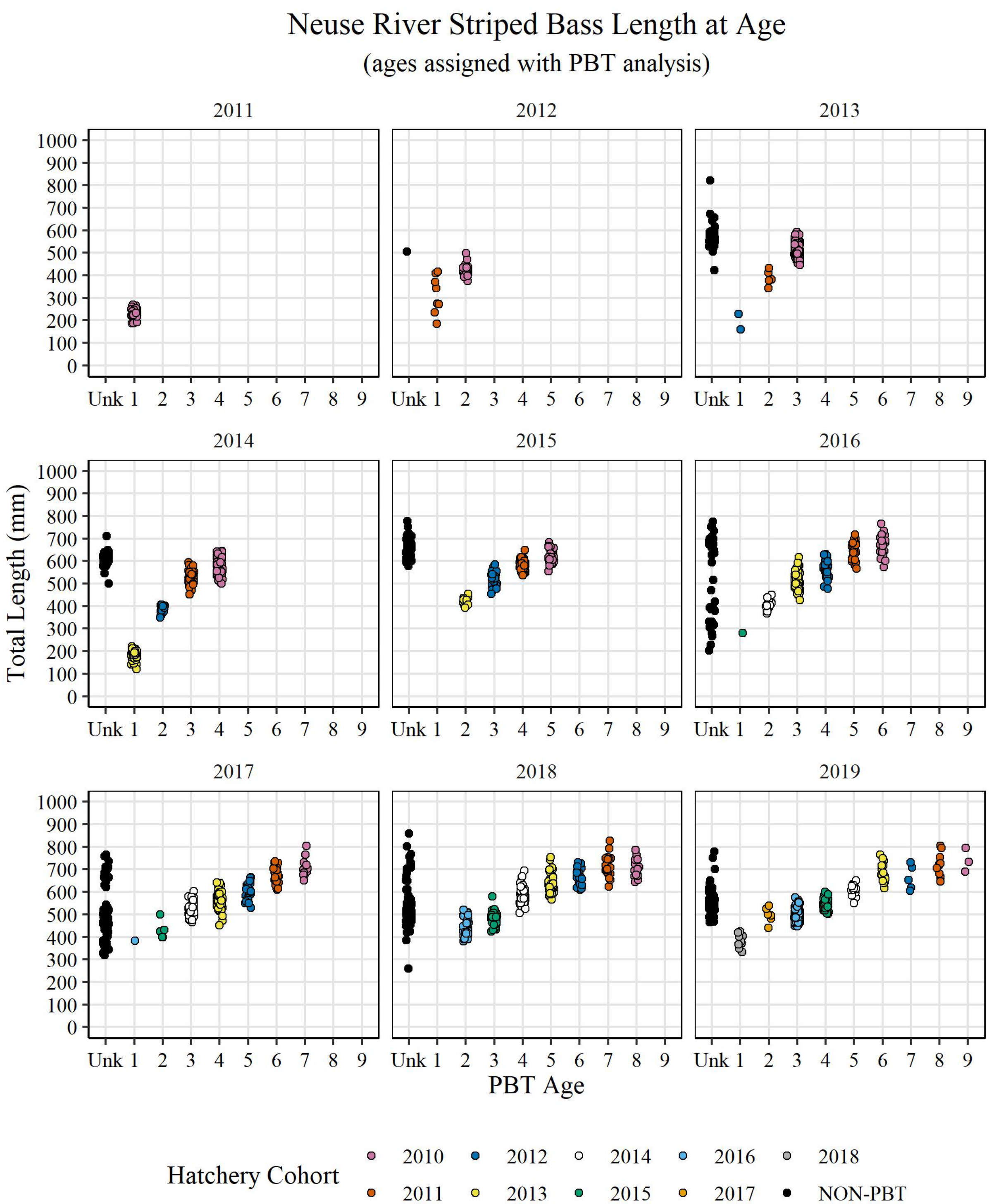


Figure 1.4. Length at age for at-large Neuse River striped bass collected by WRC and DMF, 2011–2019. Ages were identified using parentage-based tagging (PBT) analysis. Those fish with an unknown age (Unk) each year were not identified as hatchery cohorts by PBT analysis and could not be assigned an age. Points are jittered about each age column to clarify overlapping data points. Outliers were removed before plotting.

Cape Fear River

In 2011, WRC began annual PBT analysis of striped bass captured in the Cape Fear spawning survey. DMF provided samples from the lower Cape Fear River in 2011 and 2012. Starting in 2017, DMF began collecting additional samples from adult fish in the lower portion of the Cape Fear River during winter months. Additionally, DMF tested fin clips from five young-of-the-year striped bass collected in the Northeast Cape Fear River during 2018. Results of PBT analysis from both agencies combined show hatchery-origin fish comprise between 62%–100% of the fish tested annually with increasing percentage of hatchery-origin fish each year since 2013 (Table 1.4). Despite the high hatchery contribution in 2019, there was evidence of wild recruitment in the 2018 year-class (Figures 1.5 and 1.6). Juveniles collected in the Northeast Cape Fear River in 2018 were not of hatchery origin suggesting limited natural reproduction

Escapement of striped bass stocked in Jordan Reservoir is the source of most striped bass found in the Cape Fear River upstream of the locks and dams. PBT analysis revealed an increasing proportion of fish stocked in upriver reservoirs in later year-classes, increasing as sites move upriver (Figure 1.7). The Jordan Reservoir striped bass fishery is entirely hatchery supported to provide recreational fishing opportunities in the reservoir. Due to low survival and low angler participation, WRC fisheries biologists stopped striped bass stocking in Jordan Reservoir in 2021 (C. Oakley, WRC, personal communication). Future striped bass stock enhancement decisions in the Cape Fear River need to account for the loss in contribution from striped bass escapement from Jordan Reservoir. Additionally, stocking decisions regarding hybrid striped bass in Jordan Reservoir should consider escapement potential and effects on the Cape Fear River.

MANAGEMENT CONSIDERATIONS

Historically, many hatchery programs have operated as harvest augmentation or production hatcheries with the primary goal of producing as many fish as possible for put-grow-take fisheries (Trushenski et al. 2015, 2018). Conversely, supplementation hatchery programs compensate for poor recruitment caused by limitations related to habitat quantity or quality, environmental quality, or intense harvest pressure (Trushenski et al. 2015). Many anadromous fish stocking programs have experienced a shift since 2000 (Trushenski et al. 2018), using a hatchery model with increased emphasis on producing fish genetically equivalent to wild fish with a long-term goal of producing a self-sustaining, naturally spawning population. The Amendment 1 objective of the striped bass stocking program in North Carolina coastal rivers (NCDMF and NCWRC 2013) employs an integrated hatchery program model "to increase spawning stock abundance while promoting self-sustaining population levels appropriate for various habitats and ecosystems."

Hatchery rearing, stocking, and stocking evaluation methods vary depending upon stocking program goals. Lorenzen et al. (2010) identified that lack of clear fishery management objectives, lack of stock assessments, ignoring the need for a structured decision-making process, lack of stakeholder involvement, and failure to integrate flexible and adaptive management into the stocking plan are weaknesses of hatchery programs. When implementing a stocking program, Lorenzen et al. (2010) recommended managers should set goals used to evaluate the potential for stocking, establish appropriate rearing protocols to ensure the genetic and physiological integrity of stocked fish, and define and implement management plans with metrics that can be used to evaluate program success/failure. The cooperative agreement between the USFWS, DMF, and

WRC established the current striped bass stocking program in coastal North Carolina. This agreement should be revisited annually to provide adaptive management and reaffirm program goals and objectives, integrate evaluation results, and update future needs for stocking in each specific system. The contingency plan created for outlining the decision-making process for stocking surplus phase-I fish in the Albemarle Sound provides a template for stocking decisions in other North Carolina coastal river systems, though the process for each system will be unique based on local challenges.

Striped bass stocking practices have likely altered natural population genetics in North Carolina's coastal rivers. Patrick and Stellwag (2001) identified six distinct lineages among striped bass from the Roanoke, Tar-Pamlico, and Neuse rivers; the Tar-Pamlico and Roanoke rivers populations were similar but were significantly different from the Neuse River population. The researchers concluded that stocking practices could potentially affect the natural genetic distribution in these populations and suggested that broodstock should be taken from each specific population, especially when stocking the Neuse River. LeBlanc et al. (2020) showed that Cape Fear River striped bass were genetically similar to the Roanoke River population; and although North Carolina rivers, including the Tar-Pamlico and Neuse rivers, may have once supported genetically distinct populations, evidence suggests there is currently little genetic differentiation between populations (Reading 2020). While maintaining native population genetics is often a goal of restoration stocking programs (Lorenzen et al. 2010), introducing different genetic strains may be beneficial especially if native population genetics have been altered. Potential benefits, consequences, feasibility, and utility of alternative broodstock sources from systems outside coastal North Carolina systems should be thoroughly evaluated before introducing new genetic strains of striped bass.

The effectiveness of the striped bass stocking program in coastal North Carolina river systems has changed throughout the evaluation period of 1980–2019. Initial evaluations indicated limited contribution of stocked fish to commercial and recreational fisheries and little contribution to fish collected during spawning grounds surveys. Results of new evaluation methods indicated striped bass stocks in the Tar-Pamlico, Neuse, and Cape Fear rivers are maintained by phase-II stocking. Natural recruitment is low in these systems, and striped bass stocking has yet to produce self-sustaining populations. Stocking remains a necessary tool for persistence of striped bass populations in the Tar-Pamlico, Neuse, and Cape Fear river systems (Mathes et al. 2020). Stocking strategies should complement management measures that promote natural reproduction and recruitment to sustain the populations.

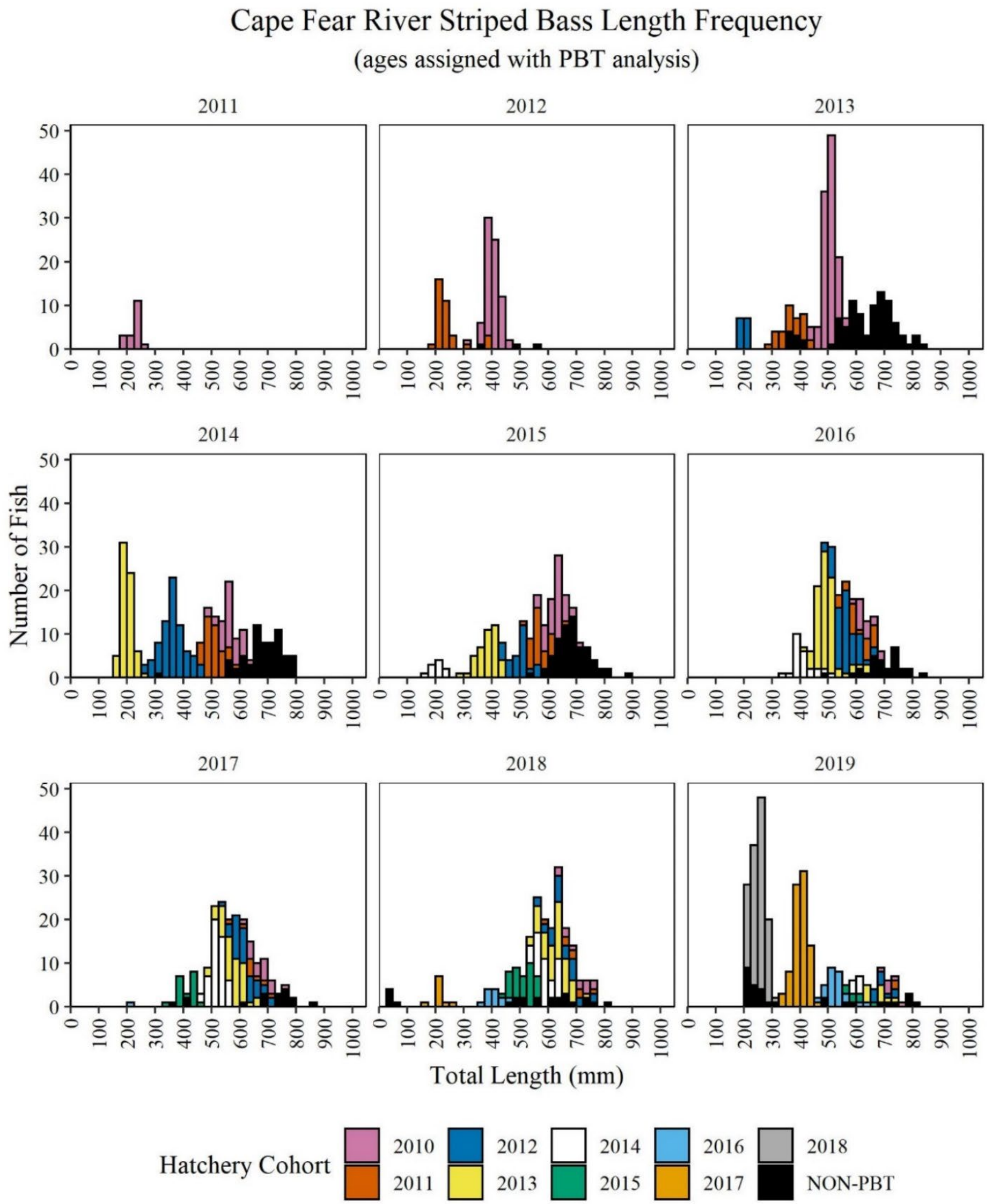


Figure 1.5. Length-frequency histograms for at-large striped bass collected in the Cape Fear River basin by WRC and DMF, 2011–2019. Hatchery cohorts identified by parentage-based tagging analysis (PBT) are plotted within each 25-mm length group. Fish identified as non-PBT were not assigned to a hatchery cohort because they did not match to a broodstock pair.

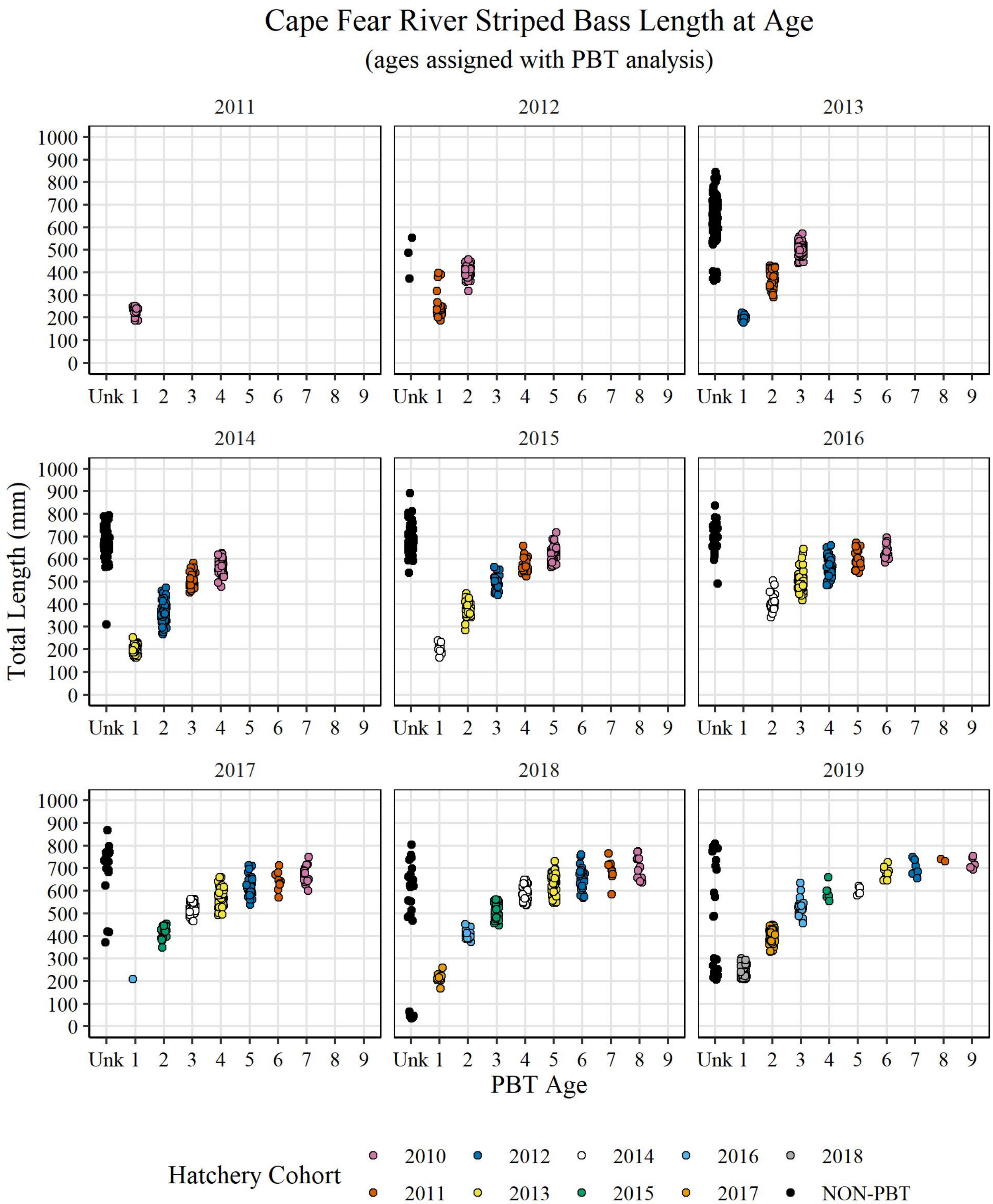


Figure 1.6. Length at age for at-large Cape Fear River striped bass collected by WRC and DMF, 2011–2019. Ages were identified using parentage-based tagging (PBT) analysis. Those fish with an unknown age (Unk) each year were not identified as hatchery cohorts by PBT analysis and could not be assigned an age. Points are jittered about each age column to clarify overlapping data points. Outliers were removed before plotting.

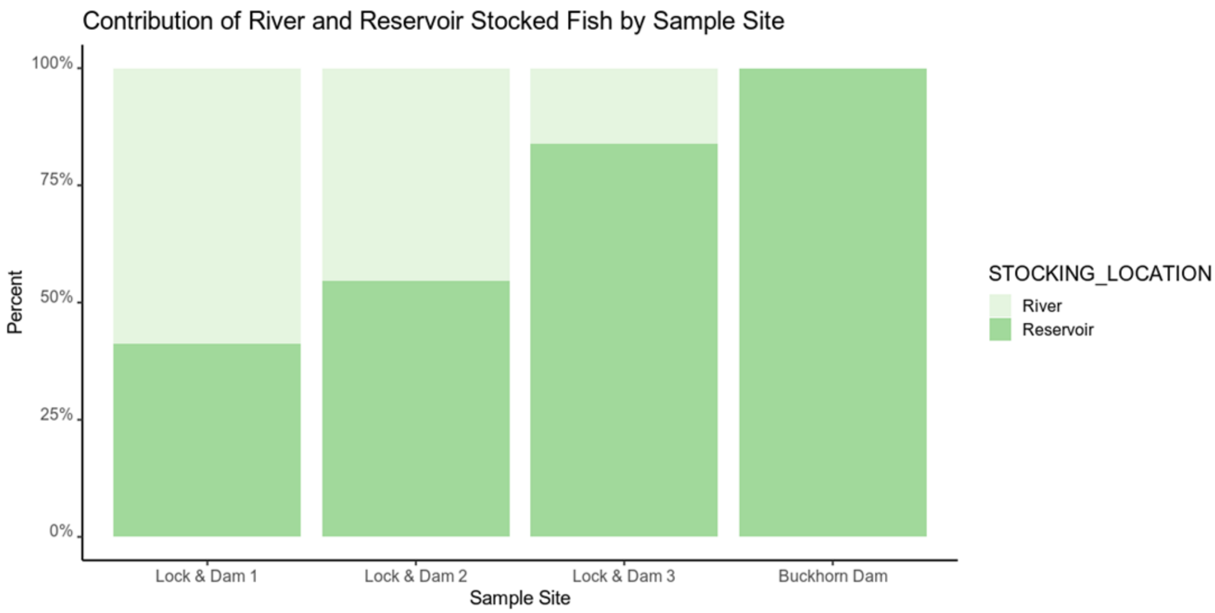


Figure 1.7. Relative contribution of hatchery-origin striped bass by stocking location to each WRC electrofishing sample site in the Cape Fear River, 2015–2019.

ADDITIONAL RESEARCH NEEDS

Parentage-based tagging analysis allows for precise investigation of multiple stocking treatments when using genetically distinct broodstock families. Various stocking treatments, including fry, phase-I, phase-II and different stocking locations, have been attempted in the Tar-Pamlico, Neuse, and Cape Fear rivers. Results from multiple treatments should be analyzed in the future to provide more precise guidance of future stocking decisions.

APPENDIX 1.A. COOPERATIVE AGREEMENT BETWEEN USFWS, DMF AND WRC THAT ESTABLISHED THE CURRENT VERSION OF THE NORTH CAROLINA COASTAL STRIPED BASS STOCKING PROGRAM, 1986.

AGREEMENT NO. 14-16-0004-87-904

COOPERATIVE AGREEMENT

for Anadromous Species Restoration in Historically Significant

Coastal River Basins

Between

U.S. Fish and Wildlife Service

and

Department of Natural Resources and Community Development

and

North Carolina Wildlife Resources Commission

I. Purpose

THIS AGREEMENT is made and entered into by and between the Fish and Wildlife Service, United States Department of the Interior—hereinafter referred to as the "Service," and the Department of Natural Resources and Community Development and the North Carolina Wildlife Resources Commission—hereinafter referred to as the "State," to establish by mutual agreement the restoration of self-sustaining stocks of anadromous species in North Carolina coastal river basins. For the purposes of this agreement, anadromous species shall include striped bass, American shad, hickory shad, blueback herring, and alewife. Principal emphasis shall be on the restoration of self-sustaining stocks of striped bass. The State's authority to engage in this agreement is set forth in Gen. Stat. of NC §§ 113-181 (a) and NC §§ 113-224. The Government of the United States has expressed a national interest in maintaining our fishery resources and has authorized the Service through the Fish and Wildlife Coordination Act (16 U.S.C. 661-666c, as amended) and other related legislation to provide assistance and cooperate with other Federal agencies and the States in the maintenance and development of fishery resources, and has further expressed a particular interest in restoration of anadromous species such as striped bass on the east coast as demonstrated by the Chafee amendment to the Anadromous Fish Conservation Act (16 U.S.C. 757g, as amended) and the Atlantic Striped Bass Conservation Act (P.L. 98-613). The Service, through its Fishery Resources Program's Statement of Responsibilities and Role document, seeks to foster strong and mutually supportive linkages with the States and other Federal agencies to restore and protect depleted nationally significant interjurisdictional fishery resources, with particular emphasis on Atlantic and Gulf anadromous striped bass as well as other anadromous and migratory intercoastal/estuarine fishes.

This agreement also complements an intrast te agreement between the North Carolina Wildlife Resources C mmission and the Department of Natural Resources and Community Development concerning regulations and management of striped bass in Albemarle Sound and the Roanoke River.

II. Mutual Agreement

North Carolina waters are recognized as historically providing major contributions to the coastal stocks of anadromous fishes on the east coast.

River herring (blueback herring and alewife) stocks have declined drastically since the early 1970s, and recovery has been very slow, probably due to poor water quality in the Albemarle Sound spawning areas. Stocks of American shad are much below the levels of the 1960s and earlier throughout the south Atlantic coastal area. Striped bass stocks in North Carolina coastal waters have declined since the mid-1970s and are currently at extremely low levels. The Albemarle Sound stock, which has historically supported important recreational and commercial fisheries, is exceptionally depressed and has shown no ability to rebound.

The State and the Service entered into a pilot program in October 1979 to evaluate the potential for hatchery Phase II striped bass production and stocking to determine (1) effects on the commercial and recreational fisheries, and (2) contributions of stocked fish to spawning runs. Tagging returns, to date, have conclusively shown that these stocked fish have contributed to spawning runs and have recruited into the recreational and commercial fisheries.

The State has the responsibility to manage the fishery resources within its boundaries, including the mixed species fisheries which harvest anadromous fishes along with other species in coastal waters. The State has expressed a desire to continue to stock hatchery-reared striped bass fingerlings as a management tool in the restoration of this species, and the Service has the hatchery capability with which to assist the State in the production of striped bass.

It is the joint desire of the State and the Service to enter into a cooperative program to restore self-sustaining stocks of anadromous fishes in coastal North Carolina waters through a combination of fishery management techniques including stocking, regulations, and assessment.

Therefore, it is mutually agreed that:

1. The Service will produce Phase I and Phase II striped bass fingerlings based on restoration objectives established by the Service and the State for specific rivers in North Carolina.

2. The Service will provide facilities for holding and tagging striped bass, a hatchery truck to transport the fish to the release site(s), appropriate supervision in handling the fish to minimize mortality, and advisory personnel for the tagging project and related technical assistance efforts.

3. The State will provide personnel, tags and equipment for tagging the fish prior to release from hatcheries, tag rewards, and publicity on the cooperative program.

4. The State will evaluate survival and contribution of the hatchery fish to the population and spawning stocks and provide a report annually to the Service.

5. News releases on the cooperative restoration program initiated by the Service will receive prior approval from the State, and news releases initiated by the State will receive prior approval from the Service.

6. As an initial action, the cooperators will jointly develop a Striped Bass Restoration Plan for coastal North Carolina waters including goals, objectives, and milestones reflecting both the restoration as well as the maintenance of stocks. Restoration plans for other anadromous species such as American shad will be developed at a later date.

7. The Service will establish a Project Coordinator in North Carolina to provide liaison with the State for restoration purposes.

8. The principal signatory parties shall meet annually to review project progress and plan future activities.

9. A technical committee with representation from each signatory of this agreement shall meet quarterly and oversee the development of restoration plans and their implementation. Chairmanship of the technical committee will be rotated among the three cooperating agencies. Term of the chairman will be one year.

This agreement shall be contingent upon the availability of funds for the expenditures contemplated herein. The liability of the parties to this agreement, to each other, and to third persons shall be governed by applicable laws and regulations, now and hereafter in force.

The Equal Opportunity clause prescribed in 1-12.803-2 of the Federal Procurement Regulations is hereby incorporated into this agreement by reference and made a part thereof. No members of or delegate to Congress or Resident Commissioner shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom.

This agreement will become effective upon the date subscribed by the last signatory and shall continue in force from year to year until cancelled by any signatory party on 30 days' written notice to the other parties. The agreement and its addenda may be amended by mutual consent of all parties.

Date: 11/19/86 By: ______________________
for S. Thomas Rhodes, Secretary
North Carolina Department of Natural Resources and Community Development

Date 12/1/86 By: Charles R. Fullwood
Charles R. Fullwood, Jr.
Executive Director
North Carolina Wildlife Resources Commission

Date 12/12/86 By: ______________________
James W. Pulliam, Jr.
Regional Director
U.S. Fish and Wildlife Service
Region 4, Atlanta, GA

TOTAL P.07

APPENDIX 2: ACHIEVING SUSTAINABLE HARVEST FOR THE ALBEMARLE SOUND-ROANOKE RIVER STRIPED BASS STOCK

ISSUE

Implement long term management measures to achieve sustainable harvest, end overfishing, and rebuild the Albemarle Sound-Roanoke River (A-R) striped bass spawning stock biomass.

ORIGINATION

North Carolina Division of Marine Fisheries (DMF) and North Carolina Wildlife Resources Commission (WRC).

BACKGROUND

Albemarle Sound-Roanoke River Striped Bass Stock Status

The 2020 A-R striped bass stock assessment was approved for management use by peer reviewers and the DMF for at least five years. Results indicate in the terminal year (2017) the A-R striped bass stock is overfished and overfishing is occurring, relative to the biological reference points (BRPs). Overfishing BRPs are based on a fishing mortality (F) rate of F_{Target} = 0.13 and $F_{\text{Threshold}}$ = 0.18 and overfished BRPs are based on a level of spawning stock biomass (SSB) of $\text{SSB}_{\text{Target}}$ = 350,371 pounds and $\text{SSB}_{\text{Threshold}}$ = 267,390 pounds (Lee et al. 2020). In the terminal year of the assessment F=0.27, above the $F_{\text{Threshold}}$, meaning overfishing is occurring. Female SSB was 78,576 pounds, below the $\text{SSB}_{\text{Threshold}}$, indicating the stock is overfished. For more details, see the Amendment 2 Stock Status section and Lee et al. (2020).

The Fisheries Reform Act of 1997 requires management measures be enacted to end overfishing within two years and end the overfished status within 10 years with at least a 50% probability of achieving sustainable harvest (NCGS 113-182.1), with exceptions related to biology, environmental conditions, or lack of sufficient data. Amendment 1 to the North Carolina Estuarine Striped Bass FMP and Amendment 6 to the ASMFC Interstate FMP for Atlantic Striped Bass stipulate "Should the target F be exceeded then restrictive measures will be imposed to reduce F to the target level" (NCDMF 2013; ASMFC 2003). Therefore, adaptive management measures were implemented in January 2021 to reduce the total allowable landings (TAL) to 51,216 pounds, a level projected to lower F to the F_{Target}, in one year, and represents a 47.6% reduction in F (NCDMF 2020).

Striped Bass Management Areas and their Fisheries

The striped bass commercial and recreational fisheries in the ASMA and RRMA have been managed with a TAL since 1991 (Table 2.1). Combined landings from both commercial and recreational sectors in the ASMA and RRMA have ranged from 108,432 lb in 2013 to 460,853 lb in 2004. Landings followed the TAL closely until 2003 for the recreational sectors and 2005 for the commercial sector. During 2003–2014, when the TAL was increased to 550,000 lb, neither sector reached their TAL (Figure 2.1; Table 2.2). The low level of landings observed in some of these years was due to multiple poor year classes produced since 2001. For more information on the commercial and recreational fisheries see the Amendment 2 Description of the Fisheries section.

Table 2.1. Total allowable landings (TAL) in pounds for the Albemarle Sound and Roanoke River Management Areas (ASMA & RRMA) 1991–2021.

Years	Total Allowable Landings (lb)	ASMA Commercial (lb)	ASMA Recreational (lb)	RRMA Recreational (lb)
1991—1997	156,800	98,000	29,400	29,400
1998	250,800	125,400	62,700	62,700
1999	275,880	137,940	68,970	68,970
2000—2002	450,000	225,000	112,500	112,500
2003—2014	550,000	275,000	137,500	137,500
2015—2020	275,000	137,500	68,750	68,750
2021	51,216	25,608	12,804	12,804

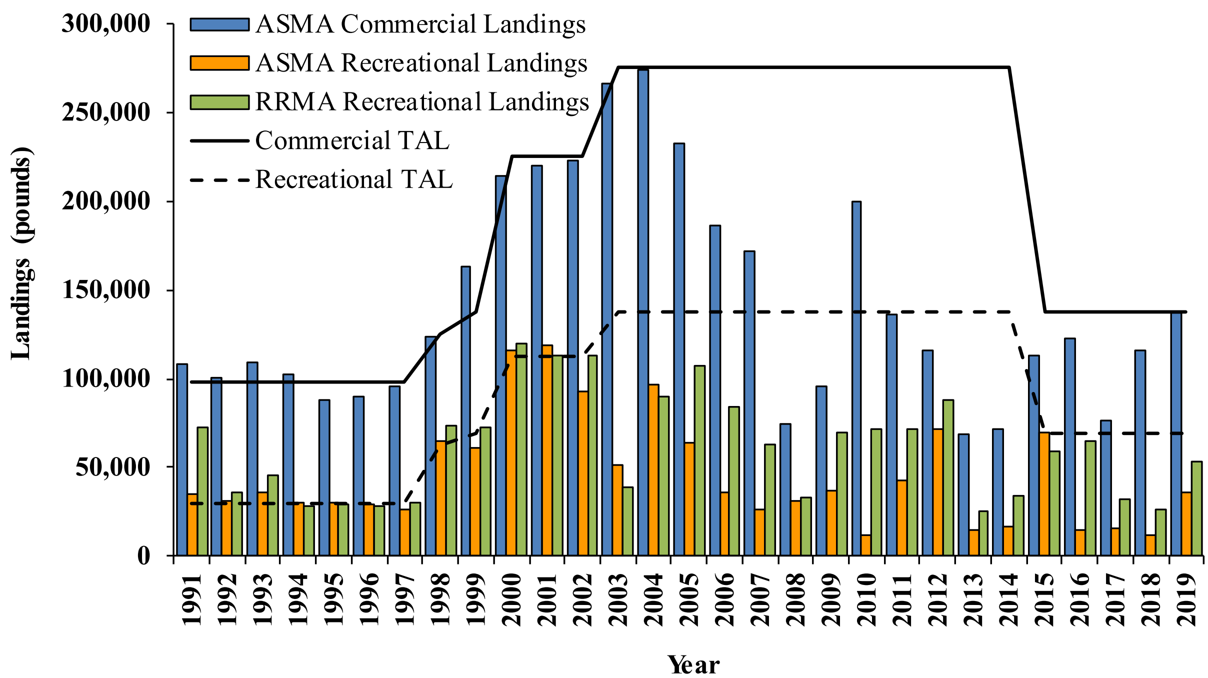


Figure 2.1. Striped bass landings from the Albemarle Sound Management Area (ASMA) commercial and recreational sectors, the Roanoke River Management Area (RRMA) recreational sector, and the annual total allowable landings (TAL) by sector, 1991–2019.

Table 2.2. Total allowable landings (TAL) and the annual harvest in pounds for striped bass from the commercial and recreational sectors in the Albemarle Sound Management Area (ASMA) and Roanoke River Management Area (RRMA). Bolded and underlined numbers indicate a TAL that was lowered due to previous year's overage, and red numbers in parentheses indicate landings that exceeded the respective TAL. (See NCDFM 1993, 2004)

	ASMA Commercial			ASMA Recreational			RRMA Recreational			Total	Total
Year	**TAL**	**Landings**	**(+)/-**	**TAL**	**Landings**	**(+)/-**	**TAL**	**Landings**	**(+)/-**	**TAL**	**Landings**
1991	98,000	108,460	(10,460)	29,400	35,344	(5,944)	29,400	72,529	(43,129)	156,800	(216,333)
1992	98,000	100,549	(2,549)	29,400	30,758	(1,358)	29,400	36,016	(6,616)	156,800	(167,323)
1993	98,000	109,475	(11,475)	29,400	36,049	(6,649)	29,400	45,145	(15,745)	156,800	(190,669)
1994	98,000	102,370	(4,370)	29,400	30,217	(817)	29,400	28,089	1,311	156,800	(160,676)
1995	***93,630***	87,836	5,794	***28,583***	30,564	(1,981)	29,400	28,883	517	***151,613***	147,283
1996	98,000	90,133	7,867	***27,419***	29,186	(1,767)	29,400	28,178	1,222	***154,819***	147,497
1997	98,000	96,122	1,878	***27,633***	26,581	1,052	29,400	29,997	(597)	***155,033***	152,700
1998	125,400	123,927	1,473	62,700	64,580	(1,880)	62,700	73,541	(10,841)	***250,800***	(262,048)
1999	137,940	162,870	(24,930)	***67,090***	61,338	5,752	68,970	72,967	(3,997)	***274,000***	(297,175)
2000	***200,070***	214,023	(13,953)	112,500	116,158	(3,658)	112,500	120,091	(7,591)	***425,070***	(450,272)
2001	***211,047***	220,233	(9,186)	***108,842***	118,506	(9,664)	112,500	112,805	(305)	***432,389***	(451,544)
2002	***215,814***	222,856	(7,042)	***102,836***	92,649	10,187	112,500	112,698	(198)	***431,150***	428,203
2003	***267,958***	266,555	1,403	137,500	51,794	85,706	137,500	39,170	98,330	***542,958***	357,519
2004	275,000	273,565	1,435	137,500	97,097	40,403	137,500	90,191	47,309	550,000	460,853
2005	275,000	232,693	42,307	137,500	63,477	74,023	137,500	107,530	29,970	550,000	403,700
2006	275,000	186,399	88,601	137,500	35,997	101,503	137,500	84,521	52,979	550,000	306,917
2007	275,000	171,683	103,317	137,500	26,663	110,837	137,500	62,492	75,008	550,000	260,838
2008	275,000	74,921	200,079	137,500	31,628	105,872	137,500	32,725	104,775	550,000	139,274
2009	275,000	96,134	178,866	137,500	37,313	100,187	137,500	69,581	67,919	550,000	203,028
2010	275,000	199,829	75,171	137,500	11,470	126,030	137,500	72,037	65,463	550,000	283,336
2011	275,000	136,266	138,734	137,500	42,536	94,964	137,500	71,561	65,939	550,000	250,363
2012	275,000	115,605	159,395	137,500	71,456	66,044	137,500	88,271	49,229	550,000	275,332
2013	275,000	68,338	206,662	137,500	14,897	122,603	137,500	25,197	112,303	550,000	108,432
2014	275,000	71,372	203,628	137,500	16,867	120,633	137,500	33,717	103,783	550,000	121,956
2015	137,500	113,475	24,025	68,750	70,008	(1,258)	68,750	58,962	9,788	275,000	242,445
2016	137,500	123,108	14,392	68,750	14,487	54,263	68,750	65,218	3,532	275,000	202,813
2017	137,500	75,990	61,510	68,750	15,480	53,270	68,750	32,569	36,181	275,000	124,039
2018	137,500	115,711	21,789	68,750	11,762	56,988	68,750	26,796	41,954	275,000	154,269
2019	137,500	137,156	344	68,750	29,005	39,745	68,750	53,379	15,371	275,000	219,540

Stock Concerns

Annual recruitment is influenced by spawning stock biomass, egg and larval transport to nursery areas, predation, food availability, and optimum water quality conditions. The occurrence of recruitment failures since 2001, especially since 2017, is thought to be a function of spring flooding events in the upper Roanoke basin during critical periods of egg and larval transport. Extended periods of flood or high flow releases during the critical spawning period (May through early June) negatively impact successful transport and delivery of eggs and fry down the Roanoke River and into the western Albemarle Sound nursery area. There is high year-to-year variability regarding flow releases and year-class strength. Consequently, all years with documented high flow rates (2017, 2018, 2020) had very low juvenile abundance index values, indicating poor spawning success (NCDMF 2020). It should also be noted the last year of data in the stock assessment was 2017, so poor recruitment from 2018–2021 impacts have not been modeled.

AUTHORITY

The MFC and the WRC implemented a Memorandum of Agreement in 1990 to address management of the A-R striped bass stock in the Albemarle Sound and Roanoke River (see Appendix I in DMF 1993). This was the first agreement between the two agencies to jointly manage the A-R striped bass stock. North Carolina's existing fisheries management system for estuarine striped bass is adaptive, with rulemaking authority vested in the MFC and the WRC within their respective jurisdictions. The MFC also may delegate to the fisheries director the authority to issue public notices, called proclamations, suspending or implementing, in whole or in part, particular MFC rules. Management of recreational and commercial striped bass regulations within the ASMA are the responsibility of the MFC. Within the RRMA commercial regulations are the responsibility of the MFC while recreational regulations are the responsibility of the WRC. The commercial harvest of striped bass in the RRMA is prohibited by 15A NCAC 03M .0202 (b). It should also be noted that under the provisions of Amendment 1 to the North Carolina Estuarine Striped Bass FMP the DMF Director maintains proclamation authority 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. The WRC Executive Director maintains proclamation authority to establish seasons.

NORTH CAROLINA GENERAL STATUTES

N.C. General Statutes

G.S. 113-132.	JURISDICTION OF FISHERIES AGENCIES
G.S. 113-134.	RULES
G.S. 113-182.	REGULATION OF FISHING AND FISHERIES
G.S. 113-182.1.	FISHERY MANAGEMENT PLANS
G.S. 113-221.1.	PROCLAMATIONS; EMERGENCY REVIEW
G.S. 113-292.	AUTHORITY OF THE WILDLIFE RESOURCES COMMISSION IN REGULATION OF INLAND FISHING AND THE INTRODUCTION OF EXOTIC SPECIES.
G.S. 143B-289.52.	MARINE FISHERIES COMMISSION—POWERS AND DUTIES
G.S. 150B-21.1.	PROCEDURE FOR ADOPTING A TEMPORARY RULE

NORTH CAROLINA RULES

N.C. Marine Fisheries Commission Rules 2020 and N.C. Wildlife Resources Commission Rules 2020 (15A NCAC)

15A NCAC 03H .0103 PROCLAMATIONS, GENERAL

15A NCAC 03M .0201	GENERAL
15A NCAC 03M .0202	SEASON, SIZE AND HARVEST LIMIT: INTERNAL COASTAL WATERS
15A NCAC 03M .0512	COMPLIANCE WITH FISHERY MANAGEMENT PLANS
15A NCAC 03Q .0107	SPECIAL REGULATIONS: JOINT WATERS
15A NCAC 03Q .0108	MANAGEMENT RESPONSIBILITY FOR ESTUARINE STRIPED BASS IN JOINT WATERS
15A NCAC 03Q .0109	IMPLEMENTATION OF ESTUARINE STRIPED BASS MANAGEMENT PLANS: RECREATIONAL FISHING
15A NCAC 03Q .0202	DESCRIPTIVE BOUNDARIES FOR COASTAL-JOINT-INLAND WATERS
15A NCAC 03R .0201	STRIPED BASS MANAGEMENT AREAS
15A NCAC 10C .0107	SPECIAL REGULATIONS: JOINT WATERS
15A NCAC 10C .0108	SPECIFIC CLASSIFICATION OF WATERS
15A NCAC 10C .0110	MANAGEMENT RESPONSIBILITY FOR ESTUARINE STRIPED BASS IN JOINT WATERS
15A NCAC 10C .0111	IMPLEMENTATION OF ESTUARINE STRIPED BASS MANAGEMENT PLANS: RECREATIONAL FISHING
15A NCAC 10C .0301	INLAND GAME FISHES DESIGNATED
15A NCAC 10C .0314	STRIPED BASS

DISCUSSION

The November 2020 Revision to Amendment 1 implemented a lower TAL calculated to end overfishing in one year. Management measures developed in Amendment 2 will be implemented to ensure long term sustainable harvest and end the overfished stock status within 10-years as required by law. If adopted in Amendment 2 adaptive management measures will allow the flexibility outlined in this issue paper.

Option 1. Manage for sustainable harvest through harvest restrictions

The General Statutes of North Carolina require that a FMP specify a time period not to exceed two years from the date of the adoption to end overfishing (G.S. 113-182.1). The statutes also require that a FMP specify a time period not to exceed 10 years from the date of adoption and at least a 50% probability to achieve a sustainable harvest. A sustainable harvest is attained when the stock is no longer overfished (G.S. 113-129). The statutes allow some exceptions to these stipulations related to biology, environmental conditions, or lack of sufficient data.

Sustainable harvest levels for the A-R striped bass stock have been determined using stock assessments and stock projections since the 1995 assessment (Gibson 1995).

Option 1.A. Continue to use stock assessments and stock assessment projections to determine the TAL that achieves a sustainable harvest for the A-R stock

A TAL is a management measure used to set harvest levels for a stock with the goal of preventing overfishing and ensuring the stock does not get in an overfished state. The 1991 TAL was set at 156,800 pounds, which was 20% of the average harvest from 1972–1979, (see Appendix I in NCDMF 1993). Under Amendment 1, the TAL for the A-R stock is determined through stock assessments and stock assessment projections. Projections are used to calculate the annual amount of harvest that maintains SSB at its target level and provides for long-term sustainable harvest. In the event the stock assessment results indicate fishing mortality is above the F_{Target}, adaptive management allows for calculation of a new TAL to reduce F back to the F_{Target} in one year, as was done with the November 2020 Revision to Amendment 1. Adaptive management allows managers to quickly address overfishing while allowing for and monitoring fishing. See adaptive management in this issue paper for more information on determining the TAL. The use of a TAL is a management option proven effective in recovery of the striped bass stock.

A key component of successfully using a TAL is the ability to accurately monitor recreational and commercial harvest in a timely manner and close fishing sectors when harvest is nearing the sector TAL. The DMF and WRC use agency-run creel surveys specifically designed to estimate recreational striped bass catch and effort in the ASMA and RRMA. Data is available 1–2 weeks after collection. It is important to note, harvest estimates calculated with one or two weeks of data have greater uncertainty than harvest estimates calculated monthly. Striped bass dealer permits are required for dealers to purchase commercially harvested striped bass and dealers must report daily the number and pounds of striped bass bought to the DMF. The ability to monitor harvest from the recreational and commercial sectors in a timely manner means the DMF and WRC have a greater likelihood of keeping annual harvest below the TAL in their respective management areas.

Flexibility in authority given to the DMF Director and the Executive Director of the WRC is used to prevent harvest from exceeding the TAL. Harvest seasons have been closed early in the RRMA by proclamation in years when the harvest estimate approached the TAL. Conversely, proclamation authority has also been used to extend the harvest season beyond April 30 by a few days. The decision to extend the season in the RRMA is based on availability of remaining landings within the TAL and environmental conditions, such as flood control operations and water temperatures. Due to much higher mortality of striped bass discards when the water temperature is warmer, both recreational and commercial harvest seasons have been closed during the summer months, typically May–September, since 1991.

Daily possession limits for the recreational and commercial sectors have been used since 1991 to limit or expand harvest opportunities and keep landings below the TAL. The DMF Director has proclamation authority to change the daily possession limits in the ASMA throughout the harvest seasons. The WRC can change daily possession limits and size limits in the RRMA through permanent or temporary rulemaking processes. In the absence of proclamation authority to change size limits or creel limits, temporary rulemaking can be used by the WRC to expedite conservation measures. Recreational sector daily possession limits have ranged from 1 to a maximum of 3 fish per person per day since 1991. Daily possession limits for the commercial sector have ranged from 3–25 fish per day per commercial operation.

Over the long-term, combined use of a TAL with other management measures has maintained landings in the A-R striped bass fisheries below or near the TAL. However, if actual recruitment is less than the estimated recruitment used in projections, stock abundance will not support harvest of the TAL and the F_{Target} may be exceeded and SSB may fall below the $SSB_{\text{Threshold}}$, as the 2020 stock assessment currently indicates. Continuing use of a TAL with the ability to monitor harvest, adjust harvest seasons, and change daily possession limits to provide the greatest likelihood of keeping harvest below the TAL allows a balance of conservation needs and stakeholder access to the resource while the stock is rebuilding.

Option 1.B. Implement a harvest moratorium

A complete harvest moratorium could potentially recover the striped bass stock more quickly than if a low level of harvest is allowed. However, any anchored, set gill net fisheries occurring in the ASMA and recreational catch-and-release for striped bass, will continue to contribute to discard mortality. Discard mortality in the anchored set gill net fishery for American shad would be substantial if that fishery was to continue to operate with a striped bass harvest moratorium in the ASMA. If poor environmental conditions persist on the spawning grounds during May and early June, recovery may not occur even with a harvest moratorium.

The A-R stock has experienced several years of poor recruitment since 2000. The juvenile abundance index (JAI) during 2017–2020 indicated few eggs and larval striped bass survived. However, the recent five years of poor recruitment (2017–2021) do not compare to chronic spawning failures the stock experienced during 1978–1992 (Figure 2.2). When a TAL was implemented in 1991, it was set at nearly three times the 2021 TAL. In 2014 and 2015, the stock produced year classes above the long-term average level of recruitment (FMP Figure 2), indicating that with favorable environmental conditions during the spawning period the stock can produce strong year classes even during periods of low SSB. Based on past trends, stock abundance can increase quickly under the right conditions. The 2020 stock assessment indicated SSB increased from 145,962 pounds in 1996 to above the SSB_{Target} (350,371 pounds) in two years (FMP Figure 2.3). However, future stock conditions, driven by continued poor recruitment and decreasing stock abundance, may warrant a harvest moratorium.

Projections evaluated overfishing with trends in SSB under the existing TAL and a complete harvest moratorium. Discards were assumed equal to the terminal year of the stock assessment and three recruitment scenarios were input to account for the uncertainty and the variability of recruitment observed in the stock; 1) the average level of recruitment for the entire time series of the assessment, 1991–2017, 2) a high level of recruitment observed in years 1991–2001, and 3) a low level of recruitment as observed in years 2004–2017. Under the harvest moratorium the stock would no longer be overfished in 2024, while under the current TAL the stock would no longer be overfished in 2026 (Figure 2.3).

Option 2. Management of striped bass harvest in the commercial fishery as a bycatch fishery

The commercial fishery for striped bass in the ASMA has been managed as a bycatch fishery since 1995. Often the term "bycatch" is associated with species captured in a fishing operation that were not intended and are discarded and is generally considered something that should be avoided. However, a bycatch fishery management strategy in multi-species fisheries means a portion of overall landings must be landed in order to land striped bass. The striped bass bycatch provision requires 50% of commercial landings by weight be other finfish species.

The bycatch provision was implemented as a management tool in the ASMA striped bass commercial fishery to prevent fishers not already participating in the American shad and southern flounder gill net fisheries from entering to specifically target striped bass. The idea being, that if additional participants entered the striped bass fishery, the TAL would be caught more quickly and the large mesh gill net fisheries continuing to operate would have higher numbers of striped bass discards. However, daily landings limits discourage fishers from targeting striped bass in the same fashion, making it less profitable to sell only striped bass each day without additional finfish catch.

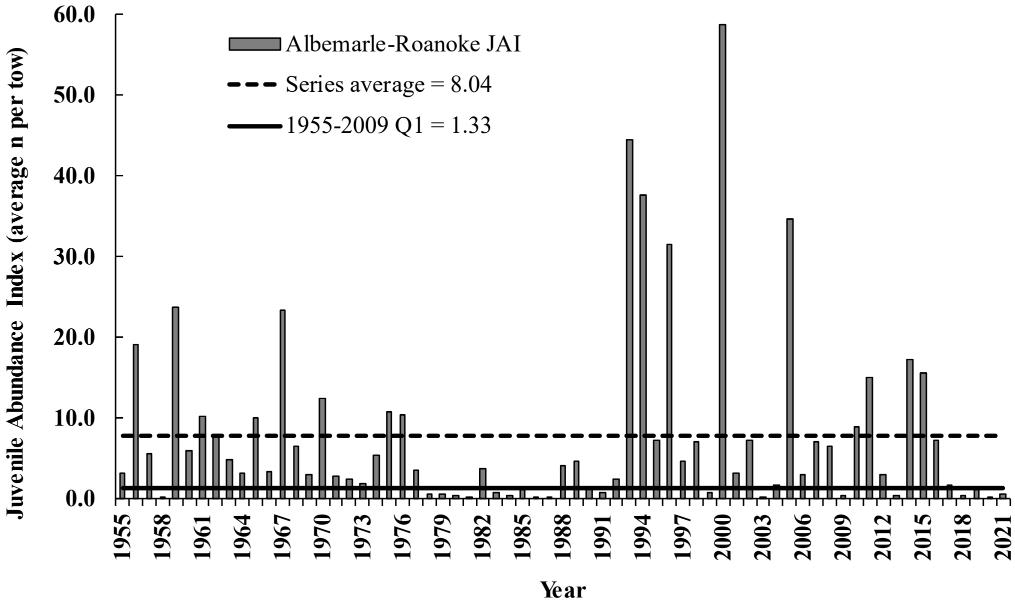
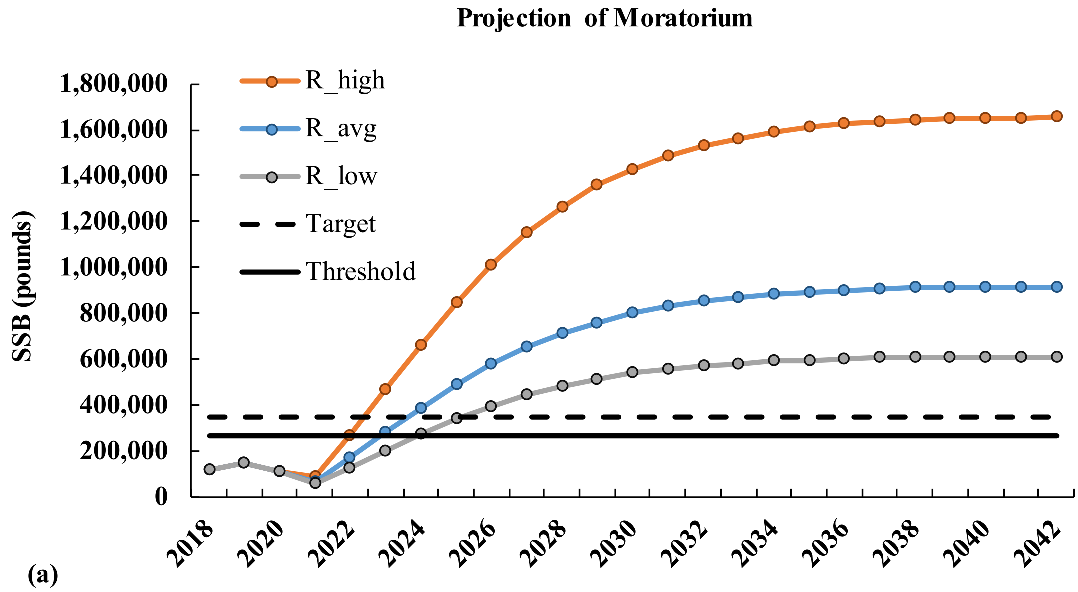


Figure 2.2. The juvenile abundance index (JAI) for Albemarle Sound-Roanoke River striped bass, North Carolina, 1955–2021. A JAI value below the first quartile (Q1 solid black line) is considered a spawning failure.

The gill net fisheries have changed considerably since the early 1990s and the bycatch provision may no longer be necessary. The number of participants that landed striped bass in the ASMA peaked at nearly 450 in 2000 but has decreased to just more than 150 in 2019. The number of fishers and trips taken each year in the American shad and flounder gill net fisheries has also declined steadily to less than 83 and 143 participants respectively in 2019 (Tables 2.3 and 2.4). The harvest season for American shad since 2015 has been March 3–March 24, whereas prior to 2015 it was open January 1–April 14. Floating gill nets are not allowed in the ASMA outside of shad season. In addition, the harvest season for southern flounder in 2021 was September 15–October 1 in the ASMA, whereas the harvest season previously was open 11–12 months each year.

Currently, gill nets configured for harvesting flounder are removed from the water when flounder harvest season is closed (NCDMF 2019).

If the bycatch provision for harvesting striped bass were removed, it is possible there would not be a significant increase in participants in the striped bass fishery because the daily landings limit and TAL would still apply. Removing the bycatch provision associated with harvesting striped bass makes it easier to allow hook and line as a commercial gear (see the Hook and Line Issue Paper for more information). If, however, the option is chosen to stop requiring 50% of other finfish species associated with striped bass harvest, and a large number of participants did enter the fishery, adaptive management could stipulate the DMF Director may reinstitute the bycatch requirements at any time through proclamation authority. There has also been concern expressed from some commercial participants that removing the bycatch provision could potentially reduce the price per pound of striped bass and/or some of the most commonly landed species associated with striped bass catch. Since 2010 the top five species landed on trip tickets along with striped bass in the ASMA include southern flounder, American shad, white perch, catfishes, striped mullet, yellow perch, and spotted seatrout.



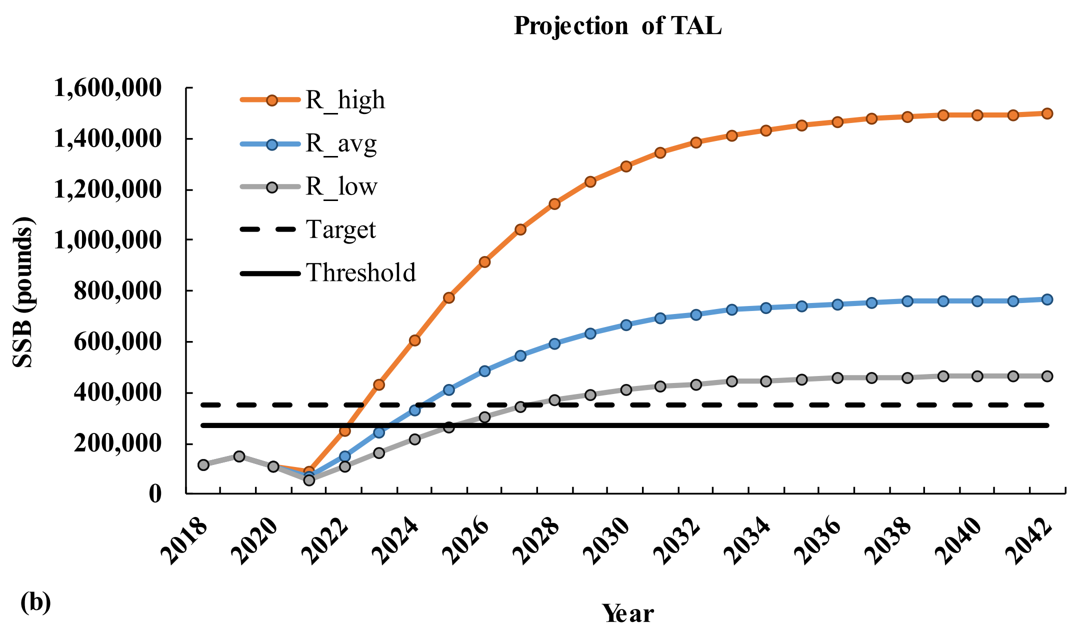


Figure 2.3. Projections of spawning stock biomass (SSB) in pounds for the Albemarle Sound-Roanoke River striped bass stock under the current total allowable landings (TAL) of 51,216 lb (a) and a harvest moratorium (b). Average recruitment (R_avg), low recruitment (R_low), and high recruitment (R_high) refer to the three recruitment scenarios used in the projections.

Table 2.3. Number of gill net trips, number of participants, total pounds of seafood landed, and dockside value from gill net trips that landed American shad in the ASMA, 2010–2019.

Year	Trips	Participants	Seafood sold (lb)	Dockside value
2010	2,520	176	539,233	$444,350
2011	1,960	138	481,801	$384,421
2012	1,922	139	391,407	$368,776
2013	1,953	132	411,081	$436,262
2014	714	92	206,733	$153,559
2015	817	98	252,993	$193,043
2016	587	73	178,947	$150,806
2017	601	73	167,906	$148,854
2018	387	55	109,855	$96,226
2019	690	83	215,279	$167,537

Table 2.4. Number of gill net trips, number of participants, total pounds of seafood landed, and dockside value from gill net trips that landed southern flounder in the ASMA, 2010–2019.

Year	Trips	Participants	Seafood sold (lb)	Dockside value
2010	5,389	323	801,426	$1,111,612
2011	1,990	204	325,799	$327,779
2012	5,661	324	821,383	$1,558,772
2013	7,417	335	1,202,078	$2,210,127
2014	5,772	297	818,565	$1,373,840
2015	3,289	234	506,042	$819,664
2016	2,306	181	368,867	$613,572
2017	3,321	193	368,709	$894,733
2018	2,681	164	294,802	$682,719
2019	2,001	143	259,438	$486,475

Option 3. Accountability Measures to Address TAL Overages

Fisheries managed with a TAL commonly include accountability measures to address situations when the TAL is exceeded. One common and simple option is to subtract the number of pounds the TAL was exceeded in one year from the following year's TAL. A more complex option is to adapt accountability measures to current stock status. For example, if *F* and SSB targets are being met, accountability measures may include management measures to reduce harvest the following year without subtracting overages from the TAL. However, if the stock is in an overfished or overfishing state accountability measures will be more conservative.

In most quota-managed fisheries, unused quota is not added to the following year's quota. The reasoning for this is twofold: 1) any amount of uncaught quota will benefit the stock in the long-term and 2) if the quota is not being caught because stock abundance is declining and can no longer support the current quota, then increasing the quota also increases the likelihood of causing the stock to become overfished and/or cause overfishing to occur. The TAL for the A-R striped bass stock in Amendment 1 is allocated with a 50/50 split to the recreational and commercial fisheries. The ASMA commercial fishery receives 50% of the TAL with the RRMA recreational and the ASMA recreational fisheries each receiving a 25% allocation of the TAL. The current accountability measures for TAL overages under Amendment 1 are:

<u>Short-term Overages:</u> point harvest estimate exceeds the total TAL by 10 percent in a single year, overage deducted from the next year and restrictive measures implemented in the responsible fishery(ies).

<u>Long-term Overages:</u> five year running average of point estimate exceeds the five-year running average of the total TAL harvest by 2 percent, the responsible fishery exceeding the harvest limit will be reduced by the amount of the overage for the next five years.

The requirement that harvest must exceed the total TAL by 10% before a reduction in the succeeding year's TAL is imposed was adopted in the 2004 FMP and re-adopted in Amendment 1 (NCDMF 2013). The rationale was that because recreational harvest estimates are generated from a statistical survey with uncertainty it was argued that as long as the lower bounds of the harvest estimate encompassed the TAL, then the harvest estimate was not statistically different from the TAL, and there was no overage to repay. The 10% buffer is roughly equivalent to a 90% confidence interval when PSE = 10%, which indicates the point estimate lies within the reported range with 90% certainty. In order to keep a buffer to account for the uncertainty in the recreational creel estimates yet recognize the need to ensure harvest levels are sustainable, an additional option for the short-term overages is to reduce the TAL buffer from 10% to 5%. In this situation with such a low buffer the PDT feels there will not be a need to address long-term overages. A third option is to evaluate overages and potential paybacks for each of the management area's fishery(ies) TAL individually rather than the evaluating at the level of the combined TAL. The final and most conservative option is to remove the buffer altogether and use the point estimate of harvest to determine if the TAL has been exceeded and subtract any overages from the succeeding year's TAL.

Option 4. Size limits to expand the age structure of the stock

Size limits are a common management measure to limit and focus harvest on a specific size and age class(es) of fish in the stock. The overall management objectives for a stock and associated fisheries and the life history of the species inform managers of what size limit should be implemented. By setting a minimum size limit based on length at maturity, managers can ensure a portion of the females in the stock have a chance to spawn at least once before harvest. For long-lived fish, a slot limit ensures fish that grow out of the slot will reproduce many times. Female A-R striped bass are 27% mature at age-3 and 97% mature by age-4. The length at maturity is 50% mature at 16.8 inches and 100% mature at 18.8 inches (Boyd 2011; Table 2.5). The current minimum size limit of 18 inches total length (TL) ensures about 75% of females have spawned at least once before subject to harvest.

Table 2.5. Percent mature at age and length (inches) of female Albemarle-Roanoke striped bass.

Percent Mature at Age		Percent Mature at Length	
Age	**Percent Mature**	**Length**	**Percent Mature**
1	0%	16.8	50%
2	1%	17.4	75%
3	27%	18.8	100%
4	97%		
5+	100%		

It is critical to the resiliency of the stock (i.e., the ability to recover SSB after times of poor recruitment), that to maintain a wide range of age classes in the population. Stocks with multiple age classes can withstand several years of poor spawning success. A-R striped bass of 23 and 31 years of age have been observed in the past 5 years based on tag return data from fish tagged on the spawning grounds. Female striped bass also produce more eggs and of higher quality as they get older (Boyd 2011). Female striped bass from the A-R stock produce between 176,873–381,998 eggs at ages 3–6. For ages 8–16, egg production ranges from 854,930 to 3,163,130 eggs (Boyd 2011; Figure 2.4).

Secor (2000) suggested striped bass populations can persist during long periods of poor recruitment due to a long reproductive life span as demonstrated by the presence of fish greater than 30 years of age. This longevity and abundance of older fish provided stock resiliency against an extended period of recruitment overfishing. Marshall et al. (2021) indicated that even when rare in a stock, large fish make very strong contributions to total egg production. They also noted harvest slots with minimum and maximum size limits are a way of maintaining large-sized fish within a population, especially if commercial fisheries use gear types which target within the slot size. The different role in replenishment that larger fish play should be better recognized and incorporated in future management approaches to (Marshall et al. 2021).

Increasing minimum size limits will increase the number of dead discards in the recreational and commercial sectors. Most fish harvested in the ASMA recreational sector are between 18–22-inches (Figure 2.5) even though anglers have no upper harvest size limit like in the RRMA. The same is true in the RRMA due to the 18–22-inch TL harvest slot limit and limiting possession to 1 fish greater than 27 inches (Figure 2.6). The fish harvested in the ASMA commercial fishery have a wider length distribution compared to the recreational harvest (Figure 2.7). If the minimum size limit is increased, a significant percentage of harvest will turn into discards, of which a proportion will die. Research from a gill net study in Delaware determined 43% of fish released alive died (ASMFC stock assessment citation). Depending on salinity at the study location and the time of year of numerous hook and line studies, delayed mortality estimates range from 6.4% to 74% (Wilde et al. 2000).

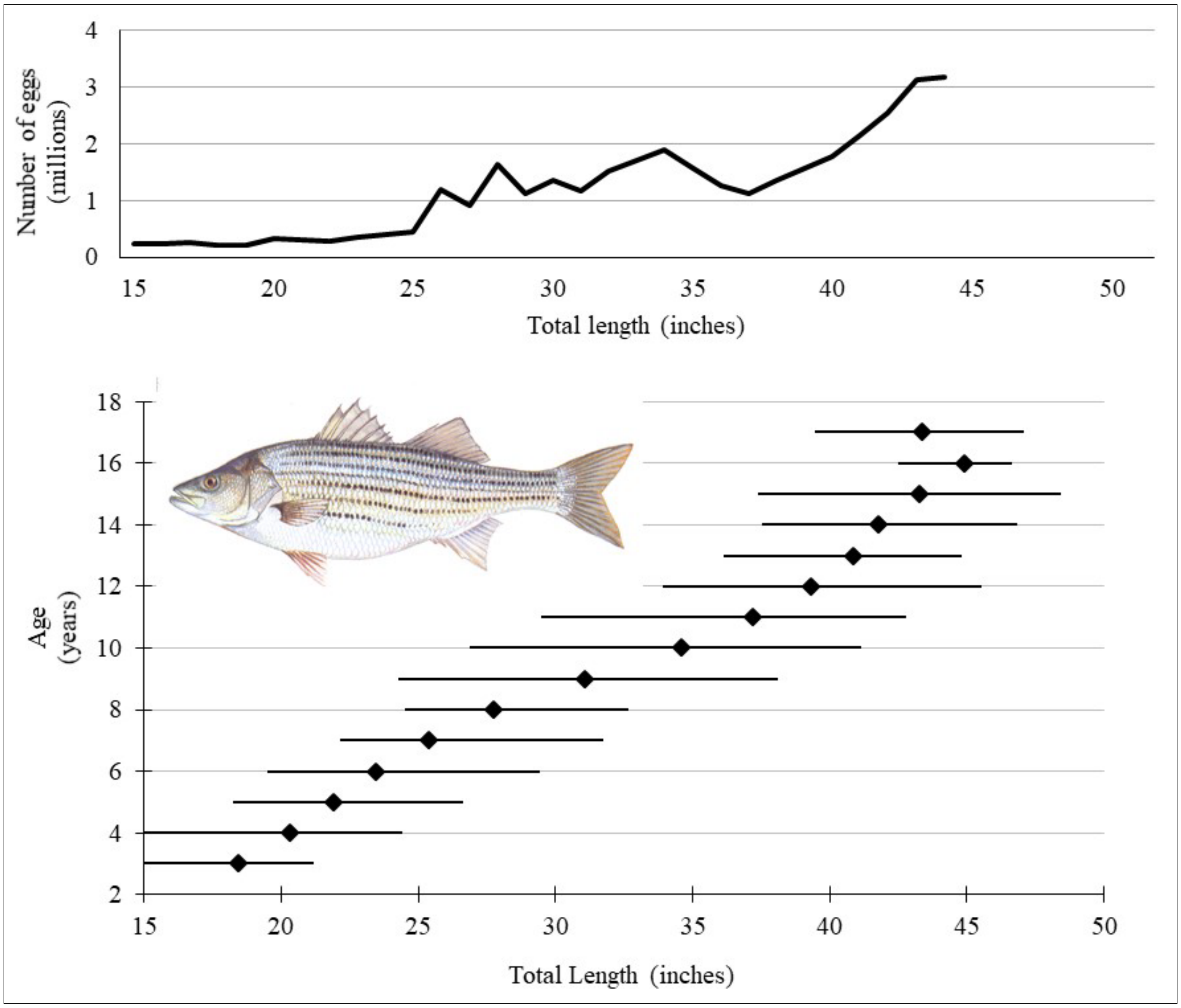


Figure 2.4. Number of eggs produced by female Albemarle-Roanoke striped bass at age and the average length of female striped bass at age. The diamond represents the average total length, and the lines represent the minimum and maximum observed length. Number of eggs at age data from Boyd 2011. Length at age based on annual spawning stock survey in the Roanoke River near Weldon (WRC data).

A harvest slot limit will increase the number of older fish in the population. However, if the slot limit is too wide, savings may be insignificant. A slot limit too narrow will result in additional dead discards if fishing practices do not match the selected slot size. Commercial sampling in the ASMA indicates 86% of the striped bass measured were below 25 inches (Figure 2.9). An 18–25-inch TL harvest slot size limit would include most of the current harvest in both the recreational and commercial sectors and not lead to significant increases in discards, while protecting fish once they grow out of the slot to increase abundance of older and larger striped bass in the A-R stock.

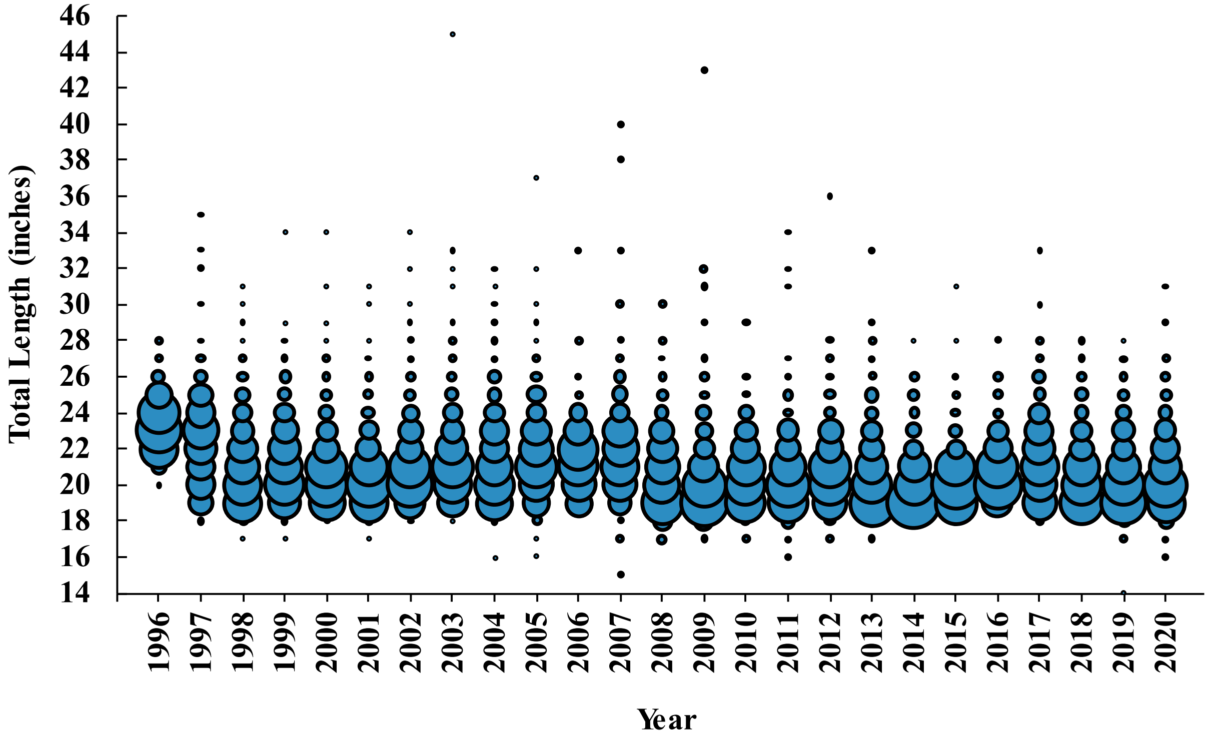


Figure 2.5. Recreational length frequency (total length, inches) of striped bass harvested in the ASMA, NC, 1996–2020. Bubble size represents the proportion of fish at length.

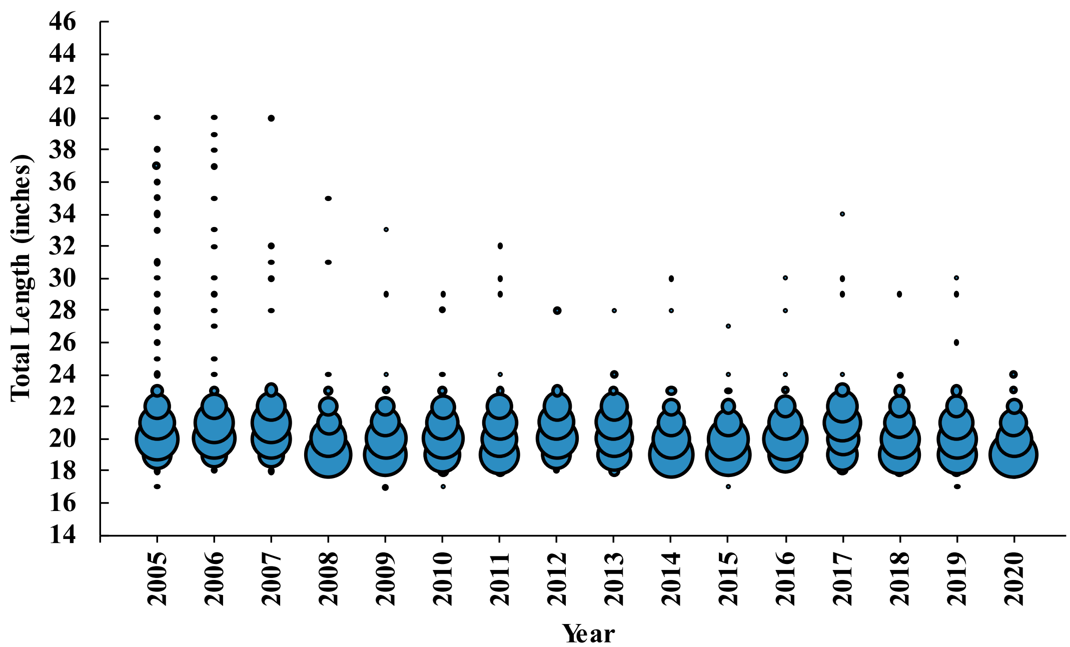


Figure 2.6. Recreational length frequency (total length, inches) of striped bass harvested in the RRMA, NC, 2005–2020. Bubble size represents the proportion of fish at length.

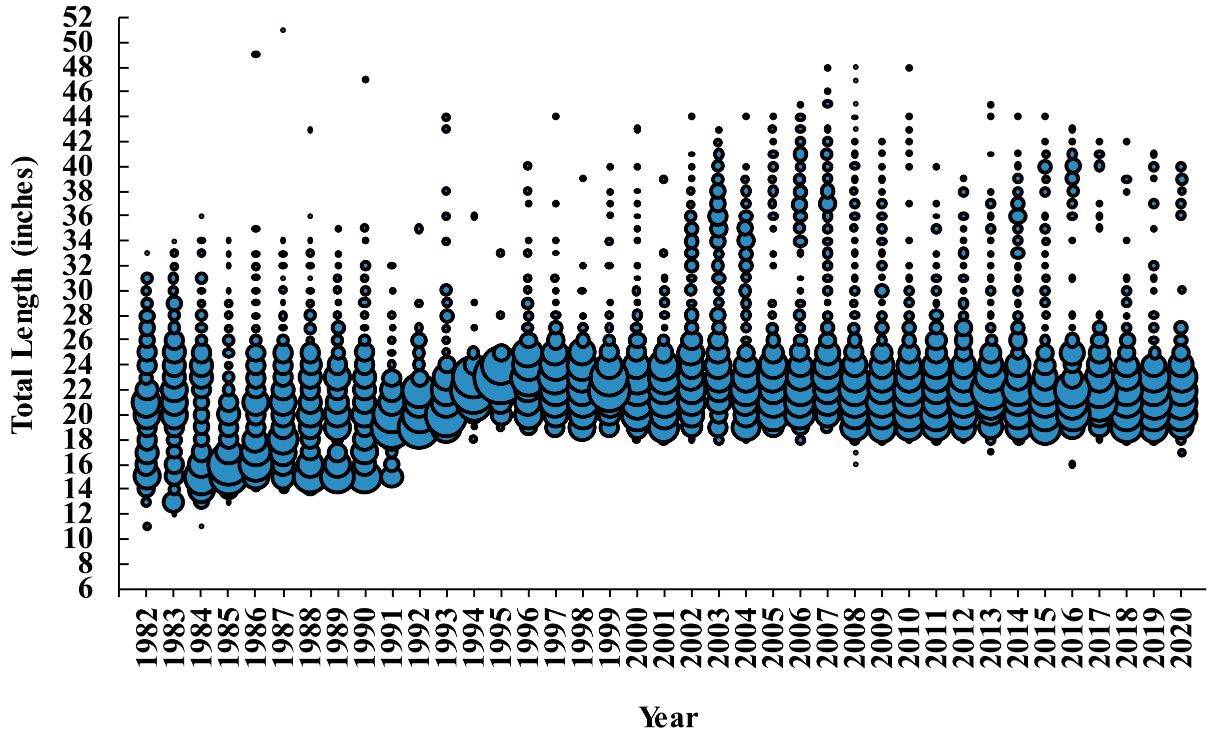


Figure 2.7. Commercial length frequency (total length, inches) of striped bass harvested in the ASMA, NC, 1982–2020. Bubble size represents the proportion of fish at length.

Option 5. Gear modifications and area closures to reduce discard mortality

Commercial Fisheries

To reduce discard mortality from gill nets, gear modifications have included: reducing maximum yardage allowed, restricting mesh sizes, attendance requirements, not allowing harvest during the summer months when water temperatures are higher and discard mortality increases significantly, and requiring tie-downs in the flounder fishery.

Area closures are another tool used to reduce discard mortality. Since 1987 the mouth of the Roanoke River from Black Walnut Point to the mouth of Mackey's Creek has been closed to the use of all gill nets during times of the year when striped bass are present in large concentrations and/or water temperatures are warmer and discard mortality will be high. Other closures have eliminated the use of small mesh gill nets in shallow waters close to shore to reduce undersized discards from large year classes.

The MFC requested analysis to reduce striped bass discard mortality through the elimination of gill net use in the ASMA. While such a measure cannot be pursued in the Estuarine Striped Bass FMP, the MFC does have the authority to eliminate harvest of striped bass with gill nets. However, if the gill net fisheries for American shad and flounder continue, and striped bass cannot be retained, striped bass discards will still occur and will increase. If the large mesh gill net fisheries in the ASMA that create unacceptable levels of striped bass discards are eliminated, serious economic impacts will occur to numerous fishers currently participating in these fisheries. The number of gill net trips, number of participants, pounds of seafood landed at dealers, and dockside value associated with the American shad and southern flounder fisheries in the ASMA are presented in Tables 2.3 and 2.4. The number of gill net trips, number of participants, pounds of seafood landed at dealers, and the dockside value associated with all of the gill net trips (large and small mesh) in the ASMA are presented in Table 2.8.

Table 2.8. Number of gill net trips, number of participants, total pounds of seafood landed, and dockside value from all gill net trips in the ASMA, 2010–2019.

Year	Trips	Participants	Seafood sold (lb)	Dockside value
2010	11,691	420	2,003,385	$1,972,341
2011	7,484	370	1,673,071	$1,280,433
2012	10,253	427	1,860,312	$2,316,010
2013	13,685	432	2,188,732	$3,199,403
2014	9,164	396	1,607,618	$1,903,979
2015	7,855	336	1,614,889	$1,578,145
2016	6,001	268	1,012,693	$1,108,990
2017	6,678	284	1,269,011	$1,521,611
2018	6,340	273	1,318,485	$1,349,733
2019	5,822	234	1,307,117	$1,148,976

At the MFC August 2021 business meeting, a motion passed relative to the Small Mesh Gill Net Rules Modification Information Paper which stated, *"to not initiate rulemaking on small mesh gill nets but refer the issue to the FMP process for each species, and any issues or rules coming out of the FMP process be addressed at that time".* The Information Paper focused mainly on options that could be implemented to address small mesh gill nets south of Gill Net Management Unit A (roughly the same area as the ASMA), as small mesh gill nets have a long history of being regulated more strictly in the Albemarle Sound area because of the concern over the striped bass stocks during the 1970s–1980s.

Some of the earliest small mesh gill net rules were implemented through proclamation authority in the Albemarle Sound region as early as 1979 (see Appendix 3, 2004 N.C. Estuarine Striped Bass FMP). The intent of issuing small mesh gill net regulations from 1979–1990 was focused on reducing striped bass harvest rather than reducing discards, as the minimum size for striped bass was still 12 inches TL for the commercial sector. Starting in 1991 when the minimum size limit increased to 18 inches TL and a TAL was implemented in the ASMA, the focus of small mesh gill net regulations shifted to reducing dead discards, as most striped bass captured in small mesh nets are under 18 inches TL.

The various gill net regulations implemented in the ASMA since 1979 have focused on closing areas during times of high striped bass concentrations, restricting mesh sizes, requiring tie-downs in deep water for both large and small mesh nets, and implementing mandatory attendance of small mesh gill nets (NCDMF 2004). The mandatory attendance serves a dual purpose to reduce dead discards and reduce effort.

The target species in the anchored, multi-species small mesh gill net fishery in the ASMA has changed significantly over the past 30 years. The biggest change was the moratorium on the harvest of river herring in 2008 (NCDMF 2007 RH FMP). Trip ticket data that included landings of river herring, white perch, striped mullet, spotted seatrout, yellow perch, and spot were used as a proxy to determine a small mesh gill net trip in the ASMA. Analysis indicates an overall, steady decline of anchored, small mesh gill net trips in the ASMA from a high of 9,490 trips in 1999 to a low of 1,589 trips in 2018 (Figure 2.8).

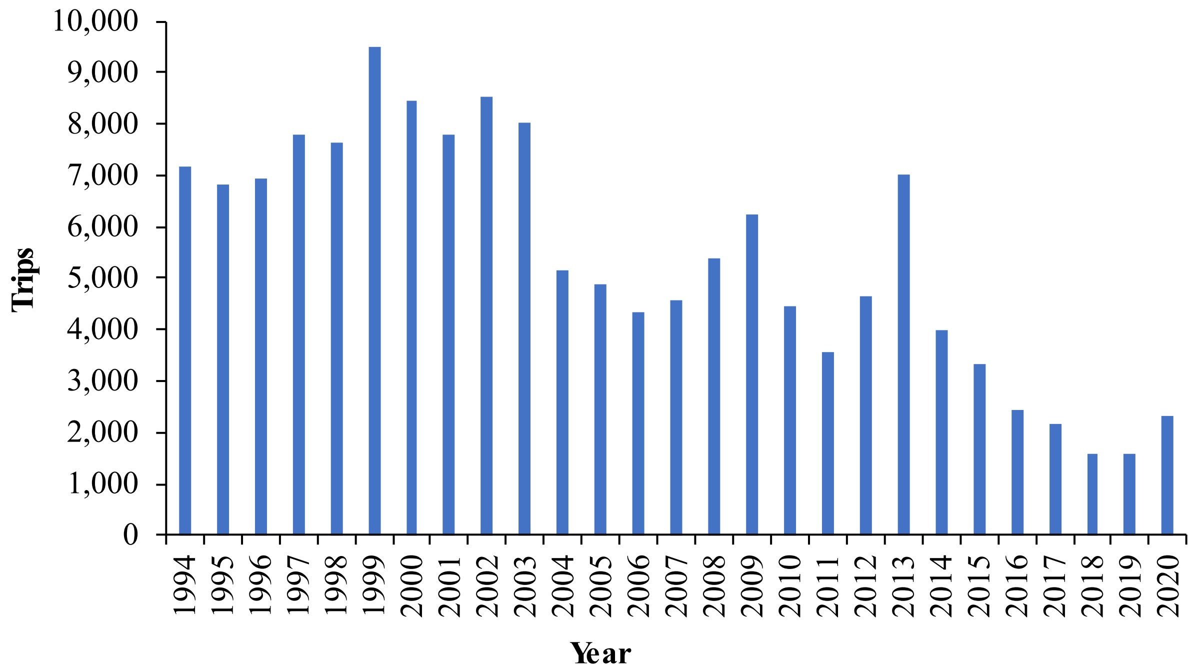


Figure 2.8. Number of anchored gill net trips in the ASMA that landed either river herring, white perch, striped mullet, spotted seatrout, yellow perch, or spot. These species were selected to determine a "small mesh" gill net trip in the ASMA.

Estimating striped bass dead discards in the small and large mesh gill net fisheries in the ASMA is part of the annual compliance with the ASMFC Interstate FMP for striped bass since 1994. The method for estimating striped bass discards has changed through the years based on available on-board observer coverage. Amendment 1 contains a detailed discussion of the methods (NCDMF 2013). Since 2012, striped bass released alive from gill nets have a 48% delayed mortality rate applied. A detailed explanation of discard modeling can be found in the A-R striped bass stock assessment (Lee et al. 2020). Dead discards in the ASMA large and small mesh gill net fisheries have averaged 1,870 fish per year with a high of 6,429 fish in 2013 and a low of 1,175 fish in 2019 (Table 2.9).

Table 2.9. Number of striped bass dead discards from large and small mesh anchored gill net fisheries in the ASMA estimated from on-board observer data and trip ticket data.

Year	Large Mesh (N)	Small Mesh (N)
2012	1,607	3,419
2013	1,846	4,583
2014	1,028	2,850
2015	1,600	3,814
2016	1,311	2,854
2017	1,695	2,260
2018	778	976
2019	465	709
2020	409	1,457

Recreational Fisheries

Since 1997, WRC has required use of single barbless hooks for all anglers during the striped bass spawning season in the inland portions of the RRMA to reduce discard mortality. Reducing discard mortality in the RRMA is particularly important due to recreational fishery discards being many times greater than harvest. Barbless hooks reduce discard mortality by reducing the time it takes an angler to remove the hook from fish and by reducing the damage to the mouth of fish (Nelson 1994).

Use of circle hooks and barbless treble hooks to reduce discard mortality of fish is gaining popularity among the recreational fishing industry. DMF staff presented information on the efficacy of using circle hooks and bent-barbed treble hooks to reduce discard mortality of captured-and-released fish to the MFC at its May 2020 business meeting (see Information on requiring the use of circle hooks and bent-barbed treble hooks in North Carolina NCDMF 2020a). Circle hooks reduce discard mortality compared to traditional J hooks because fish are much less likely to get deep hooked (Cook et al. 2021; Kerstetter and Graves 2006). Circle hooks are required in the Atlantic Ocean waters of North Carolina when fishing for striped bass or sharks and using natural bait. Amendment 1 to the North Carolina Red Drum FMP (NCDMF 2008) requires the use of circle hooks in certain times and areas of the Pamlico Sound when anglers target large red drum using natural bait to reduce deep hooking and release mortality (Aguilar 2003, Beckwith and Rand 2004).

Although less research has been done on the effects of bent or barbless treble hooks on the survival of captured-and-released fish, the same reasons are thought to reduce hook trauma when using single barbless hooks applies. However, as noted in the May 2020 circle hook information paper, the promotion of barbless treble hooks as a conservation measure has largely been replaced by the use of single inline hooks instead of treble hooks on artificial lures. Use has been encouraged for a variety of reasons including: less damage to fish, ease of unhooking, fish hooked more securely, less likely to collect grass or debris, and angler safety. Many manufacturers have started selling lures rigged with single hooks. This trend is being driven by the tackle industry, retailers, and conservation-minded anglers (NCDMF 2020a).

Area closures could also be implemented in the recreational fisheries to reduce striped bass discards. Catch-and-release fishing for striped bass during the closed harvest season is popular in several areas, including the old Manns Harbor Bridge in Manteo, the highway 32 bridge crossing the Albemarle Sound at Pea Ridge, Corey's Ditch located in the Mackay Island National Wildlife Refuge in Currituck, and in the Roanoke River. While data do not exist to determine the exact extent of economic losses, closing areas to the use of recreational hook and line when striped bass harvest is not allowed would impact numerous industries that rely in part or whole on recreational fishing. Closing an area to targeting striped bass is unenforceable.

An area closure on the spawning grounds to eliminate the harvest and catch-and-release of striped bass as they gather in large numbers and spawn also serves to reduce discard mortality. Releases after the harvest period has closed on the spawning grounds has ranged from 9,754–271,328 fish (FMP Table 5). Closing the spawning grounds to the harvest of fish is a common practice in many fisheries to protect the spawning stock, although there is no research on the impacts of catch-and-release fishing on the quality or amount of egg production for striped bass. Based on experience, the A-R striped bass stock has recovered from low stock abundance and produced strong year classes under catch-and-release fishing practices on the spawning grounds.

Option 6. Adaptive management

Adaptive management is a structured decision-making process when uncertainty exists, with the objective to reduce uncertainty through time with monitoring. Adaptive management is based on a learning process to improve management outcomes (Holling 1978). Adaptive management provides flexibility to incorporate new information and accommodate alternative and/or additional actions. As flexibility increases, so do the resources needed to acquire and analyze data, as well as to implement and enforce complexities of management. These elements create trade-offs that must be balanced for all users.

The ASMFC uses annual juvenile abundance indices as an indicator of year class strength and a trigger for management evaluations (ASMFC 2010). If the JAI is below 75% of the other JAI values for three consecutive years, the ASMFC Striped Bass Technical Committee will review the state's data and make a recommendation to the ASMFC Striped Bass Management Board about possible causes for the spawning failures and if management action is needed. The A-R striped bass juvenile abundance index met this trigger in 2020, the third year in a row the index value was below the 75% threshold (Figure 2.2).

Adaptive management for the A-R stock and fisheries in the ASMA and RRMA encompass the following measures:

- Use of peer reviewed stock assessments and updates to recalculate the BRPs and/or TAL if assessment results deem it necessary. Stock assessments will be updated at least once between benchmarks. Changes in the TAL will be implemented through a Revision to the Amendment.
- Use estimates of F from stock assessments to compare to the F BRP and if F exceeds the F_{Target} reduce the TAL to achieve the F_{Target} in one year through a Revision to the Amendment.

- Ability to change daily possession limits in the commercial and recreational fisheries to keep landings below the TAL.
- Ability to open and close recreational harvest seasons and commercial harvest seasons and areas to keep landings below the TAL and reduce interactions with endangered species.
- Ability to require commercial and recreational gear modifications including, but not limited to, the use of barbless or circle hooks, area closures, yardage limits, gill net mesh size restrictions and setting requirements to reduce striped bass discards.

MANAGEMENT OPTIONS AND IMPACTS

(+ Potential positive impact of action)
(- Potential negative impact of action)

1. Manage for Sustainable Harvest through harvest restrictions
   A. Continue to use stock assessments and stock assessment projections to determine the TAL that achieves a sustainable harvest for the A-R stock.

      + The best option to maintain harvest at a sustainable level when mechanisms exist to monitor recreational and commercial harvest in near real-time and close fisheries when the TAL is calculated to be reached.
      + Maintains a sustainable harvest if the TALs are set appropriately and updated at regular intervals.
      - Will not achieve sustainable harvest if TALs are set too high and not updated at regular intervals.
      - Does not allow for increased harvest based on year class strength if TALs are not updated often enough through stock assessments.

   B. Implement a harvest moratorium

      + Would eliminate all harvest which would likely reduce fishing mortality to the stock even more than the current TAL of 51,216 pounds
      + Would likely increase abundance and further expand the age structure
      - Mortality associated with discards in other commercial and recreational fisheries would still occur and likely increase
      - May not achieve the desired results if environmental factors have a greater influence than the level of SSB on the formation of strong year classes
      - Would have significant economic impacts across the commercial sector if fisheries and gears that interact with striped bass were also eliminated
      - Would have significant economic impacts to businesses across the recreational sector supported by recreational fishing for striped bass

2. Management of striped bass harvest in the commercial fishery as a bycatch fishery
   A. Status quo: continue managing the ASMA striped bass fishery as a bycatch fishery

      + Consistent with regulations since 1995

+ May still discourage additional participants from entering the fishery and harvesting striped bass quota that don't normally participate in the other multi-species large mesh gill net fisheries in the ASMA
- Makes it more difficult to implement hook-and-line as a commercial gear

B. Stop managing the ASMA striped bass fishery as a bycatch fishery

+ Would reduce enforcement issues for Marine Patrol
+ Would make it easier to implement hook and line as a commercial gear by not requiring bycatch provisions for one gear and not another
+ Would have no impact on the other management measures (e.g., daily possession limits) intended to maintain harvest below the TAL
+ Would offer a more resource friendly gear that has less discard mortality than gill nets and would have less interactions with endangered species compared to gill nets
+ Would be an additional gear available to the commercial sector to harvest striped bass when gill nets may not be allowed due to excessive interactions with endangered species are because of harvest reductions needed in other FMPs (e.g. southern flounder and American shad)
- Could potentially lead to increased participants in the commercial fishery which would possibly decrease the annual income received per participant in the fishery
- Could potentially lead to increased participants in the commercial fishery which could cause the TAL to be reached quicker and cause gill net fisheries for other species (e.g., American shad) to close earlier than planned

3. Accountability Measures to Address TAL Overages (Examples in Table 2.10)

A. Single Year Overages: if the landings from the management area/sectors three fisheries combined (RRMA recreational, ASMA recreational, and ASMA commercial) exceeds the total TAL by 10% in a single calendar year, then each fishery that exceeded their allocated TAL will have their allocated TAL reduced the next calendar year. The reduction required for a fishery will be equal to the percent contribution that fishery made to the combined TAL overage.

Chronic Overages: if the five-year running average of the landings from the management area/sectors three fisheries combined (RRMA recreational, ASMA recreational, and ASMA commercial) exceeds the five-year running average of the total TAL by 2%, the fishery(ies) exceeding their allocated TAL will deduct the annual average overage from their annual TAL for the next five years.

+ Allows for a buffer around the TAL to account for the uncertainty associated with estimates of recreational harvest
+ Could prevent constantly changing the TAL each year if overages are below the 10% buffer
+ Will be less confusing to anglers if regulations do not change often
- Exceeding the TAL by less than the prescribed buffer, would potentially reduce the ability to maintain a sustainable harvest

B. If the landings from the management area/sectors three fisheries combined (RRMA recreational, ASMA recreational, and ASMA commercial) exceeds the total TAL by 5% in a single calendar year, then each fishery that exceeded their allocated TAL will have their allocated TAL reduced the next calendar year. The reduction for a fishery will be equal to the percent contribution that fishery made to the combined TAL overage.

The same positives and negatives apply to this option, it is just a more conservative buffer than option 3.A.

C. If the landings in any one of the management areas' three fisheries (RRMA recreational, ASMA recreational, and ASMA commercial) exceeds their allocated TAL by 5% in a calendar year, any landings in excess of their allocated TAL will be deducted from that fisheries' allocated TAL the next calendar year.

D. If the landings in any one of the management areas' three fisheries (RRMA recreational, ASMA recreational, and ASMA commercial) exceeds their allocated TAL in a calendar year, any landings in excess of their allocated TAL will be deducted from that fisheries' allocated TAL the next calendar year.

+ Is the most conservative approach to managing a TAL and will provide the greatest chance at rebuilding the stock and maintaining a sustainable harvest
- Does not incorporate statistical uncertainty in inherent to recreational harvest estimates
- Can lead to very short seasons, or no season at all for some years, if TALs are exceeded often and/or by significant amounts when TALs are low
- Can cause confusion among users if regulations change every year

For all overage options: overages will be deducted from the management area/sectors fishery(ies) TAL, not the management area/sectors fishery(ies)TAL plus a buffer; if paybacks to a fishery exceed the next year's allocated TAL for that fishery, paybacks will be required in subsequent years to meet the full reduction amount; in situations where a fisheries allocated TAL has been reduced from a previous year's overage, if the reduced TAL is exceeded, any required paybacks the subsequent year are reduced from the fisheries' original allocated TAL, not from the reduced TAL.

Managing agencies will implement strategies, including proclamations to close harvest seasons, to prevent landings from exceeding the TAL, rather than attempting to harvest the TAL and the buffer.

Table 2.10. EXAMPLES of Accountability measures to address TAL Overage.

Option	Buffer	When Payback Is Required	Management Area/Sector	Area/Sector TAL	TAL + Buffer	Area/Sector Landings	Landings Over/Under TAL	Total Payback Required	Percent Contribution to Overage	Payback	Next Season Area/Sector TAL (lb)	Explanation
3.A.	10% over TAL	Overall landings are greater than (Overall TAL + Buffer)	RRMA recreational	12,804	14,084	27,546	14,742	12,197	88%	12,197 x 88% = 10,733 lb	2,071	Total TAL+10% exceeded so payback is necessary.
			ASMA recreational	12,804	14,084	8,258	-4,546		0%	12,197 x 0% = 0 lb	12,804	
			ASMA Commercial	25,608	28,169	27,609	2,001		12%	12,197 x 12% = 1,464 lb	24,144	
3.B.	5% over TAL	Overall landings are greater than (Overall TAL + Buffer)	RRMA recreational	12,804	13,444	17,804	5,000	0	100%	0	12,804	Despite RRMA recreational exceeding TAL, Total TAL+5% not exceeded so no paybacks are necessary.
			ASMA recreational	12,804	13,444	4,000	0		0%	0	12,804	
			ASMA Commercial	25,608	26,888	25,608	0		0%	0	25,608	
3.C.	5% over Fishery TAL	Fishery landings are greater than (Fishery TAL + Buffer)	RRMA recreational	12,804	13,444	12,000	-804	Not Applicable		0	12,804	ASMA recreational landings exceeded TAL+5% so must pay back full overage. ASMA commercial exceeded TAL by less than 5% buffer so no paybacks are necessary.
			ASMA recreational	12,804	13,444	14,000	1,196			1,196 lb	11,608	
			ASMA Commercial	25,608	26,888	26,200	392			0	25,608	
3.D.	No Buffer	Landings greater than Fishery TAL	RRMA recreational	12,804	12,804	12,954	150			150 lb	12,654	Each area/sector exceeded their TAL and must pay back all landings in excess of their TAL.
			ASMA recreational	12,804	12,804	13,494	690			690 lb	12,114	
			ASMA Commercial	25,608	25,608	25,825	217			217 lb	25,391	

4. Size limits to expand the age structure of the stock

+ Will provide resiliency to the stock during times of poor recruitment
+ Can provide anglers with the opportunity of a “trophy” fishery, even if it is catch-and-release only
- Can reduce the number of fish available for harvest depending on the size limit chosen
- Can increase the number of dead discards from fisheries depending on the size limit chosen

A. Status Quo-maintain the current minimum size limit of 18-inch TL in the ASMA, and in the RRMA maintain the current harvest size limit of a minimum of 18-inch TL to 22-inch TL maximum, with a no harvest slot of fish 22–27 inches, with only one fish in the daily creel being greater than 27 inches

+ Is consistent with management since the 1990s
+ Provides some harvest protection of females in the 22–27 inch no harvest slot while on the spawning grounds
- Does not offer as much protection of fish greater than 27 inches as a harvest slot with a maximum allowed harvest size would

B. Increase the minimum size limit in all sectors in the ASMA and RRMA

+ Could increase chances of achieving a sustainable harvest by allowing females to spawn more times before becoming available to harvest
+ Will provide consistent regulations across all sectors and management areas
- Will lead to greater and greater discards the higher the minimum size limit is raised
- Will decrease the percentage of recreational anglers that will catch and retain the daily limit of striped bass (the greater the increase in the minimum size limit the greater the decrease in the percentage of anglers that keep a daily landing limit)
- Will not allow the harvest of a “trophy” fish by anglers

C. In the ASMA, implement a harvest slot of a minimum size of 18-inches TL to not greater than 25 inches TL in the commercial and recreational sectors

+ Will provide resiliency to the stock during times of poor recruitment
+ Can provide anglers with the opportunity of a “trophy” fishery, even if it is catch-and-release only
- Will reduce the number of fish available for harvest depending on the size limit chosen
- Will increase the number of dead discards from fisheries depending on the size limit chosen
- Will increase the potential to reach TAL quicker in the RRMA if harvest is allowed on larger fish
- Any increase in the abundance of older fish in the population may not be noticeable if the slot is too large

D. In the RRMA, maintain current harvest slot limit of a minimum size of 18-inches TL to 22-inches TL with a no harvest slot of 22–40 inches TL, and the ability to harvest one fish greater than 40 inches per day to allow for harvest of a trophy fish.

E. In the RRMA, maintain current harvest slot limit of a minimum size of 18-inches TL to not greater than 22-inches TL with no harvest allowed on fish greater than 22 inches.

.5. Gear modifications and area closures to reduce striped bass discard mortality

A. Status quo-continue to allow commercial harvest of striped bass with gill nets in joint and coastal waters of the ASMA and continue recreational harvest and catch-and-release fishing in the ASMA and RRMA, including striped bass spawning grounds in the Roanoke River. The requirement that from April 1 through June 30, only a single barbless hook or lure with single barbless hook (or hook with barb bent down) may be used in the inland waters of the Roanoke River upstream of U.S. Highway 258 Bridge will remain in effect.

+ Consistent with management since 1990
+ Allows for harvest with traditional gears and in traditional locations user groups are accustomed to
+ Experience has demonstrated the stock can recover from low levels of abundance and produce strong year classes with these fishing practices in place
- Gill nets interact with endangered species and require incidental take permits to operate
- Catch rates can be extremely high when striped bass are congregated on the spawning grounds
- There has been little research on the effects of catch-and-release fishing to egg production and quality

B. Do not allow the harvest of striped bass with gill nets in the ASMA commercial fishery

+ Will reduce dead discards associated with harvesting striped bass with gill nets
- Will create a significant number of dead discards unless all other gill net fisheries in the ASMA are eliminated
- Will have a significant economic impact to commercial fishers using gill nets to harvest striped bass unless they can easily and inexpensively switch to another gear

C. Do not allow harvest or targeted catch-and-release fishing for striped bass while on the spawning grounds or other areas of high concentration.

+ Would reduce all discards associated with hook and line fishing on the spawning grounds and in other areas of high striped bass concentration
+ Would likely increase abundance and further expand the age structure
- May not achieve the desired results if environmental factors have a greater influence than the level of SSB on the formation of strong year classes

- Would have significant economic impact to all businesses in the areas supported by recreational angling for striped bass while on the spawning grounds and in other areas of high concentration
- Would eliminate access to the resource by the user groups in the area of the spawning grounds and in other areas of high concentration unless they travel to another area to harvest striped bass

D. Implement single barbless hook rule in the remainder of the RRMA during the open harvest season and catch-and-release season

+ Would reduce mortality associated with undersized releases and catch-and-release fishing
- Would have negative impacts on other recreational fisheries mainly largemouth bass fishing in the area and time of year

E. Implement a requirement to use non-offset barbless circle hooks when fishing with live or natural bait in the inland waters of the Roanoke River (upstream of Hwy 258 bridge) from May 1 through June 30

+ Would reduce mortality associated with undersized releases and catch-and-release fishing
- Would require significant angler education on the types of circle hooks that would be required
- Would have significant impact on other recreational fisheries using live bait for other species, such as crickets for bream, if there were not exemptions for certain size J hooks
- Would require significant angler education on the types of J hooks that would be exempted

6. Adaptive Management

Adaptive management for the A-R stock and fisheries in the ASMA and RRMA encompasses the following measures:

- Use peer reviewed stock assessments and updates to recalculate the BRPs and/or TAL. Stock assessments will be updated at least once between benchmarks. Increases or decreases in the TAL will be implemented through a Revision to the Amendment. A harvest moratorium could be necessary if stock assessment results calculate a TAL that is too low to effectively manage, and/or the stock continues to experience spawning failures.
- Use estimates of F from stock assessments to compare to the F BRP and if F exceeds the F_{Target} reduce the TAL to achieve the F_{Target} through a Revision to the Amendment.
- Ability to change daily possession limits in the commercial and recreational fisheries to keep landings below the TAL.
- Ability to open and close recreational harvest seasons and commercial harvest seasons and areas to keep landings below the TAL and reduce interactions with endangered species.

- Ability to require commercial and recreational gear modifications including, but not limited to, the use of barbless or circle hooks, area closures, yardage limits, gill net mesh size restrictions and setting requirements to reduce striped bass discards.

RECOMMENDATIONS

See Appendix 6 for DMF, WRC, and advisory committees recommendations and a summary of online public.

NCMFC Preferred Management Strategy

Options: 1.A., 2.A., 3.D., 4.C., 4.E., 5.A., 5.E., and 6.

APPENDIX 3: ACHIEVING SUSTAINABLE HARVEST FOR THE TAR-PAMLICO AND NEUSE RIVERS STRIPED BASS STOCKS

ISSUE

Consider existing factors that prevent a self-sustaining population in the Tar-Pamlico and Neuse rivers and implement management measures that provide protection for and access to the striped bass resource.

ORIGINATION

North Carolina Division of Marine Fisheries (DMF) and North Carolina Wildlife Resources Commission (WRC)

BACKGROUND

Natural reproduction is the primary process responsible for maintaining self-sustaining fish populations at levels that support harvest. In self-sustaining populations, the numbers of offspring produced by natural reproduction are greater than can be stocked by managers. Striped bass stocks that allow harvest and can self-replace through natural reproduction are considered sustainable. Until there are naturally reproducing populations in these rivers capable of self-replacement, the sustainable harvest objective of this plan cannot be met.

The Tar-Pamlico and Neuse rivers striped bass fisheries have been sustained by continuous stocking to maintain the populations while allowing recreational and commercial harvest (O'Donnell and Farrae 2017; see Appendix 1). Roanoke River origin striped bass have either been stocked or used as broodstock in the Tar-Pamlico and Neuse rivers for decades (Bayless and Smith 1962; Woodroffe 2011). It is likely there are no Tar-Pamlico or Neuse River native strains of striped bass remaining in the river systems; however, striped bass in the Tar-Pamlico and Neuse rivers display genetic differences from other striped bass in North Carolina, which is to be expected given the history of stocking in these systems (Cushman et al. 2018). The need for continued conservation management efforts are supported by persistent recruitment failure, multiple mortality sources, absence of older fish on the spawning grounds, non-optimal environmental conditions on the spawning grounds in the spring, impacts from hatchery reared juveniles and escaped hybrid striped bass, and the high percentage of stocked fish in the populations (Bradley et al. 2018; Rachels and Ricks 2018; Mathes et al. 2020). Reliable population estimates have never been determined for Tar-Pamlico River striped bass. In 2018, Bradley et al. (2018) provided a population estimate of 18,457 for Neuse River adult striped bass; however, the persistence of striped bass populations in these rivers to support recreational and commercial fisheries has been the result of continuous stocking efforts (Mathes et al. 2020; NCDMF 2020a).

Tar-Pamlico and Neuse Rivers Striped Bass Stocks Life History

For a comprehensive review of striped bass life history in the Tar-Pamlico and Neuse rivers see Mathes et al. (2020) and NCDMF (2013).

The age structure of striped bass in the Tar-Pamlico and Neuse rivers remains limited, with few fish over ten years old collected in DMF and WRC surveys. Sampling by WRC in 2007 showed age-4 and age-6 fish were common in both rivers (Barwick et al. 2008). Older, larger individuals were seldom encountered. Since adoption of the Estuarine Striped Bass FMP (NCDMF 2004), there has been little change in the size and age distribution in the Tar-Pamlico and Neuse rivers. However, abundance of age-6 and older striped bass began increasing in 2008, peaking in 2014 (Rachels and Ricks 2015). On the Tar River, abundance of age-6 fish has varied considerably with a peak in 2012 (Rundle 2016). WRC scale-aged fish suggest a maximum age of 17 in the Tar-Pamlico River (Homan et al. 2010), and 11 on the Neuse River (WRC - unpublished data 2017). DMF otolith and genetic age data indicate maximum ages of 12 in both rivers (NCDMF 2020a). Survey data indicates limited numbers of larger striped bass in these systems, though gear selectivity likely excludes larger striped bass. Few striped bass larger than 27 inches are commercially harvested in these systems (NCDMF 2020a); however, fishery independent sampling using gill nets with larger mesh sizes (up to 10 inch stretched mesh) indicates the presence of larger, older striped bass in deeper regions of the Tar-Pamlico River (Cuthrell 2012).

Striped bass populations in the Tar-Pamlico and Neuse rivers primarily remain within their native river system throughout their life history. Tagging data indicates limited movement of striped bass from the Neuse and Tar-Pamlico rivers into other systems or the Atlantic Ocean (Setzler et al. 1980; Rulifson et al. 1982, Winslow 2007; Callihan 2012; Callihan et al. 2014; Rock et al. 2018; NCDMF – unpublished data 2020). Multiple studies have indicated striped bass make spawning migrations in the Tar-Pamlico and Neuse rivers and fertilized eggs have been found, indicating reproduction is occurring; however, there is very limited if any striped bass recruitment to the larval and juvenile life stages (Humphries 1965; Kornegay and Humphries 1975; Jones and Collart 1997; Smith and Rulifson 2015; Rock et al. 2018). Surveys suggest egg abundance in the water column downstream from spawning is not sufficient to provide recruitment of juveniles to the population.

Over the past several decades, few larval and juvenile striped bass have been collected from CSMA systems (Marshall 1976; Hawkins 1980; Nelson and Little 1991; Burdick and Hightower 2006; Barwick et al. 2008; Smith and Rulifson 2015; and Buckley et al. 2019). In 2017, the DMF began an exploratory juvenile abundance survey in the Tar-Pamlico and Neuse rivers using trawl and seine nets. As of 2020, no juvenile striped bass have been collected in this survey (Mathes et al. 2020; Darsee et al. 2020).

Striped bass are broadcast spawners that produce non-adhesive, semi-buoyant eggs that must remain neutrally buoyant in the water column as they float downriver for the best chance of survival to larvae. Sufficient current velocity is critical to keep eggs suspended in the water column for a minimum of 48 hours after fertilization (Bain and Bain 1982) preventing contact with the bottom. Eggs differ among striped bass stocks and are ideally suited for certain river flows. Chesapeake Bay stock eggs are lighter and maintain their position in the water column of calmer tidal waters, whereas Roanoke River stock eggs are heavier and maintain their water column position in the more turbulent, high energy Roanoke River system (Bergey et al. 2003). While Chesapeake Bay stock eggs appear genetically predetermined to being lighter, Roanoke River stock eggs are thought to be more adaptable to varying environmental conditions (Kowalchyk 2020). Neuse River water velocities are variable but appear sufficient to keep heavier striped bass eggs suspended until hatching (Burdick and Hightower 2006; Buckley et al. 2019) based on the minimum required water velocity (30 centimeters per second).

In 2017, North Carolina State University initiated research to provide insight into striped bass recruitment by evaluating genetic and environmental influences on egg development. Results reveal the stock with the heaviest and smallest eggs collected in 2018 and 2019 were from Tar-Pamlico and Neuse rivers striped bass broodstock (Kowalchyk 2020). The Tar-Pamlico and Neuse rivers were also found to have significantly different levels of key proteins required to maintain egg hydration compared to other North Carolina river systems, possibly contributing to differences in buoyancy and critically timed nutrient delivery.

It is clear striped bass reproduction is influenced by complex interactions between population structure, environmental, and physiological factors. In addition, reproductive success is likely impacted because the striped bass stocks in the Tar-Pamlico and Neuse rivers are a non-native strain and the physical environment in these systems has changed through time.

<u>Striped Bass Fisheries</u>

Management measures in Amendment 1 consist of daily possession limits, open and closed harvest seasons, seasonal gill net attendance and other gill-net requirements, minimum size limits, and slot limits to work towards the goal of achieving sustainable harvest. Amendment 1 also maintained the stocking measures in the major CSMA river systems (NCDMF 2013). Supplement A to Amendment 1 (NCDMF 2019) implemented a recreational and commercial no-possession provision for striped bass in the internal coastal and joint waters of the CSMA to reduce mortality on striped bass in these systems. Additionally, commercial gill net restrictions were implemented requiring 3-foot tie-downs and 50-yard distance from shore measures in accordance with Supplement A to Amendment 1 year-round (M-5-2019). Proclamation M-6-2019 maintained the year-round tie-down and distance from shore restrictions for large mesh gill nets and prohibited the use of all gill nets upstream of the ferry lines from the Bayview Ferry to Aurora Ferry on the Tar-Pamlico River and the Minnesott Beach Ferry to Cherry Branch Ferry on the Neuse River to further reduce bycatch of striped bass.

Recreational

The DMF recreational angler survey started collecting recreational striped bass harvest, discard, effort, and economic data for the Tar-Pamlico and Neuse rivers in 2004. Recreational landings fluctuated between 2004–2018, ranging from a low in 2008 (2,990 pounds) to a high in 2017 (26,973 pounds; Figure 3.1; NCDMF 2020a). Only 959 pounds were harvested in 2019 because the season closed early when Supplement A (February 2019) was approved. From 2016–2017, recreational trips and hours spent targeting striped bass increased with a decline in 2018. On average 3,327 fish were harvested annually from the Tar-Pamlico and Neuse rivers combined. (NCDMF 2020a). Recreational releases during 2009–2018 averaged 43,255 fish per year (Mathes et al. 2020). Due to the number of undersized striped bass available in 2017, there was a large increase in discards during this year.

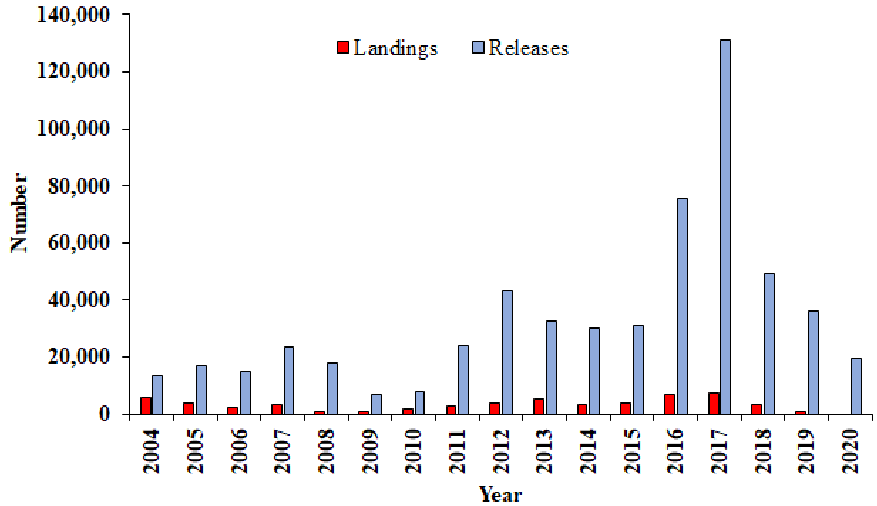


Figure 3.1. Annual recreational catch (harvested and/or released) of striped bass in the CSMA, 2004–2020. There was a limited recreational harvest season in 2019 prior to the closure, lasting from January 1 to March 19, 2019.

Commercial

Supplement A closed the commercial striped bass fishery in 2019. From 1994–2018 commercial landings in the CSMA were limited by an annual total allowable landings (TAL) of 25,000 pounds. The TAL was nearly met in all years except for 2008, when less than half of the TAL was landed (Figure 3.2). From 2004–2018, the commercial season opened March 1 and closed when the TAL was reached.

<u>Stock Concerns</u>

Lack of natural recruitment is the biggest factor affecting sustainability of striped bass stocks in the Tar-Pamlico and Neuse rivers. There has been no measurable year class in the Tar-Pamlico and Neuse rivers systems in decades, and therefore, the stocks require continuous stocking to sustain the populations. A model was developed for striped bass in the CSMA to evaluate stocking and management strategies (Mathes et al. 2020). Stock evaluation results from the model provide further evidence that natural recruitment is the primary limiting factor influencing Tar-Pamlico and Neuse rivers stocks and if stocking was stopped the populations would decline (Mathes et al. 2020). Stock evaluation results indicate that striped bass populations in the CSMA are depressed to an extent that sustainability is unlikely at any level of fishing mortality, and that no level of fishing mortality is sustainable (Mathes et al. 2020).

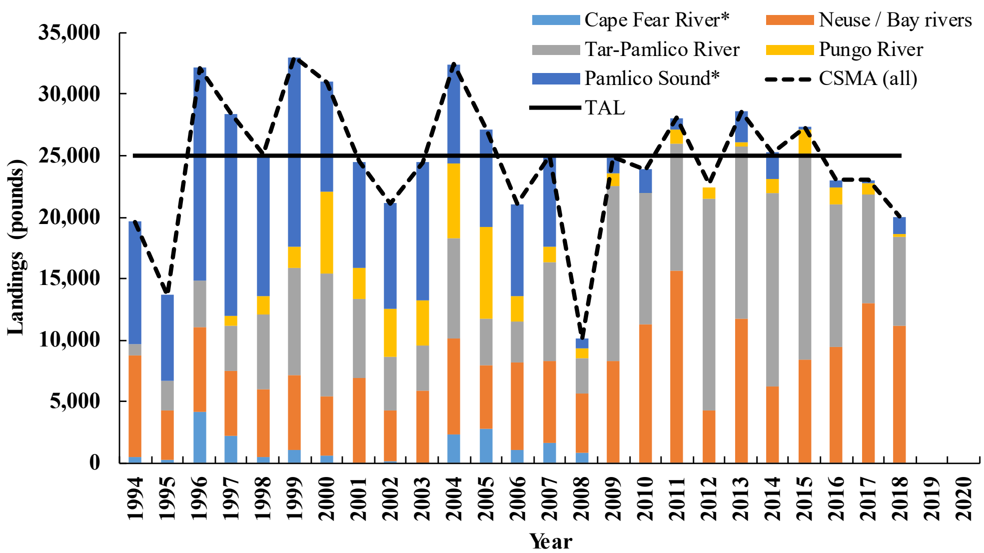


Figure 3.2. Commercial striped bass harvest by system, and the TAL in the CSMA, 1994–2020. There has been a harvest no-possession measure in the Cape Fear River since 2008 and in the CSMA since 2019. *Landings data for the Cape Fear River (2001) and for the Pamlico Sound (2012) are confidential.

Female striped bass in these systems are 100% mature at age-4 (Knight 2015), and fish up to age-8 are not uncommon, providing mature females in these populations that should be capable of producing annual natural recruitment. In the Roanoke River, consistent, measurable year classes are detected in fishery independent surveys even during poor flow years with periods of low spawning stock biomass. Additionally, in the Northeast Cape Fear River, juveniles are captured despite very low stock abundance and limited age structure (Darsee et al. 2020; Lee et al. 2020).

Reasons for low recruitment

Several factors have been suggested as potentially affecting natural recruitment in the Tar-Pamlico and Neuse rivers including spawning stock abundance, truncated age structure (Bradley et al. 2018; Rachels and Ricks 2018; Buckley et al. 2019), and egg abundance. In addition, the absence of older individuals in the populations may not be sufficient to provide natural recruitment because of lower egg production from younger, smaller fish.

Eggs produced by hatchery stocked fish produced by Tar-Pamlico and Neuse rivers broodstock are very small, heavy (dense) eggs, which are more likely to sink than float (Kowalchyk 2020). Figure 3.3 shows that eggs produced from fish residing in the Tar-Pamlico and Neuse rivers are statistically less buoyant than Roanoke River or Santee-Cooper striped bass eggs. Egg densities have been shown to be influenced by both genetic and environmental factors (Kowalchyk 2020). Spawning grounds in these river systems are shallow (between 0.2 and 1.0 meters), so the potential for heavy eggs to contact bottom sediment and die is increased. Additionally, because many of the streams and creeks in these systems have been altered by channelization, rapid flow increases can occur shortly after a rainfall event begins followed by a rapid return to base conditions after the end of the rainfall event (NCDWQ 2009; NCDWQ 2010).

Flows during the spring striped bass spawning season are an important factor affecting successful striped bass natural reproduction; however, unlike on the Roanoke River, there are no agreements with the U.S. Army Corp. of Engineers (USACE) to maintain adequate flows for striped bass spawning in the Tar-Pamlico or Neuse rivers. The USACE is consulted weekly regarding water releases in the Neuse River from Falls Lake in Raleigh, but due to the watershed and storage capabilities, it is not possible to manipulate flows in these rivers. Flows on the Tar-Pamlico River are based on pulse rainfall events. The ability to manipulate releases may become important as we get more information on flows in these systems. If flows are too low during the spawning period, heavy eggs may be more likely to contact the bottom before hatching successfully.

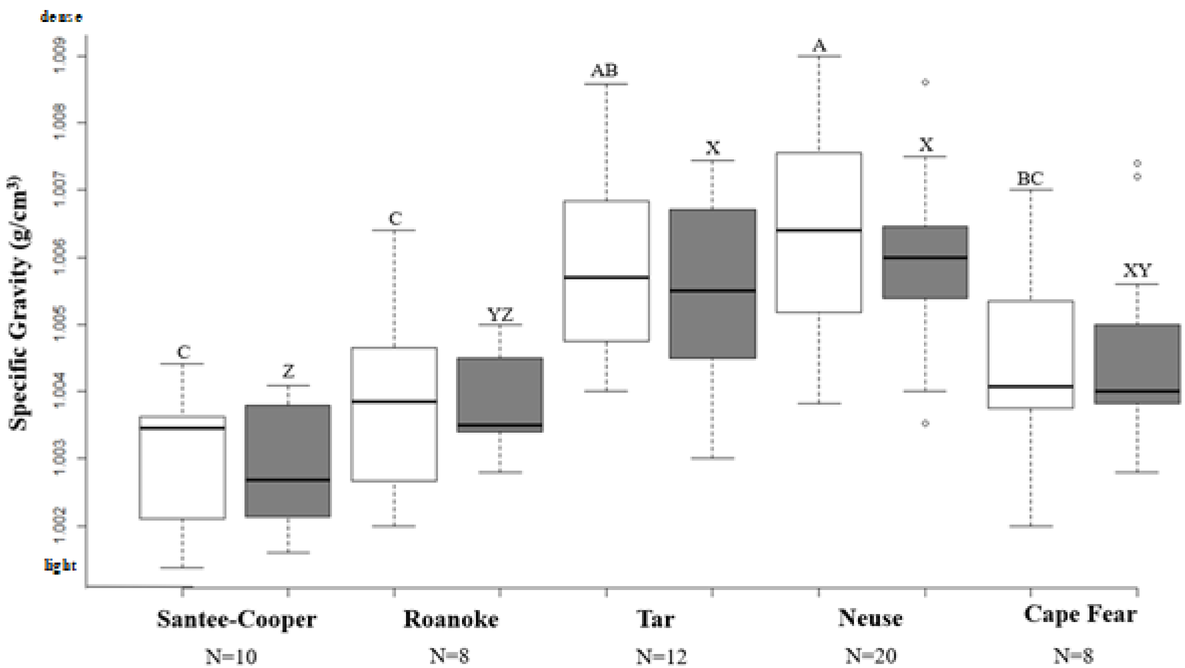


Figure 3.3. Specific gravity (buoyancy; g/cm^3) measurements from stage 1 (white boxes) and 4 (gray boxes) fertilized eggs from 2018/2019 hatchery broodstock sampling. Tukey pair wise comparisons are labeled above the boxplots with ABC indicating stage 1 significant differences and XYZ indicating stage 4 significant differences (Tukey HSD, α=0.05). N represents number of females spawned.

Stocking Considerations

Stocking of striped bass is addressed through the North Carolina Interjurisdictional Fisheries Cooperative annual work plan between DMF, WRC, USFWS (COOP; see Appendix 1). Specific objectives for stocking striped bass include attempts to increase spawning stock abundance while promoting self-sustaining population levels appropriate for various habitats (see Amendment 1, Section 11.2; NCDMF 2013). The annual number stocked was increased starting in 2010 to a goal of 100,000 hatchery reared striped bass in each of the major river systems (Tar-Pamlico, Neuse, and Cape Fear rivers).

Stocking will continue to play a key role recovering striped bass populations. As part of the COOP, consideration of future stocking measures should include evaluation of stocking striped bass with eggs adapted to environmental conditions in the rivers. In addition, because management and stocking strategy simulation results show the populations would likely benefit from stocking more striped bass, discussions related to the number of striped bass stocked annually should be considered as part of the COOP agreement. See Appendix 1 for additional stocking considerations.

AUTHORITY

North Carolina's existing fisheries management system for striped bass is adaptive, with rulemaking authority vested in the MFC and the WRC within their respective jurisdictions. The MFC also may delegate to the fisheries director the authority to issue public notices, called proclamations, suspending or implementing, in whole or in part, particular MFC rules that may be affected by variable conditions. Management of recreational and commercial striped bass regulations within the Tar-Pamlico and Neuse rivers are the responsibility of the MFC in Coastal and Joint Fishing Waters, and recreational regulations are the responsibility of the WRC in Joint and Inland Fishing Waters. It should also be noted that under the provisions of Amendment 1 to the North Carolina Estuarine Striped Bass FMP the DMF Director maintains proclamation authority 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. The WRC Executive Director maintains proclamation authority to establish seasons.

NORTH CAROLINA GENERAL STATUTES

N.C. General Statutes

G.S. 113-132.	JURISDICTION OF FISHERIES AGENCIES
G.S. 113-134.	RULES
G.S. 113-182.	REGULATION OF FISHING AND FISHERIES
G.S. 113-182.1.	FISHERY MANAGEMENT PLANS
G.S. 113-221.1.	PROCLAMATIONS; EMERGENCY REVIEW
G.S. 113-292.	AUTHORITY OF THE WILDLIFE RESOURCES COMMISSION IN REGULATION OF INLAND FISHING AND THE INTRODUCTION OF EXOTIC SPECIES.
G.S. 143B-289.52.	MARINE FISHERIES COMMISSION—POWERS AND DUTIES
G.S. 150B-21.1.	PROCEDURE FOR ADOPTING A TEMPORARY RULE

NORTH CAROLINA RULES

N.C. Marine Fisheries Commission and N.C. Wildlife Resources Commission Rules 2020 (15A NCAC)

15A NCAC 03H .0103	PROCLAMATIONS, GENERAL
15A NCAC 03M .0201	GENERAL
15A NCAC 03M .0202	SEASON, SIZE AND HARVEST LIMIT: INTERNAL COASTAL WATERS
15A NCAC 03M .0512	COMPLIANCE WITH FISHERY MANAGEMENT PLANS
15A NCAC 03Q .0107	SPECIAL REGULATIONS: JOINT WATERS
15A NCAC 03Q .0108	MANAGEMENT RESPONSIBILITY FOR ESTUARINE STRIPED BASS IN JOINT WATERS

15A NCAC 03Q .0109	IMPLEMENTATION OF ESTUARINE STRIPED BASS MANAGEMENT PLANS: RECREATIONAL FISHING
15A NCAC 03Q .0202	DESCRIPTIVE BOUNDARIES FOR COASTAL-JOINT-INLAND WATERS
15A NCAC 03R .0201	STRIPED BASS MANAGEMENT AREAS
15A NCAC 10C .0107	SPECIAL REGULATIONS: JOINT WATERS
15A NCAC 10C .0108	SPECIFIC CLASSIFICATION OF WATERS
15A NCAC 10C .0110	MANAGEMENT RESPONSIBILITY FOR ESTUARINE STRIPED BASS IN JOINT WATERS
15A NCAC 10C .0111	IMPLEMENTATION OF ESTUARINE STRIPED BASS MANAGEMENT PLANS: RECREATIONAL FISHING
15A NCAC 10C .0301	INLAND GAME FISHES DESIGNATED
15A NCAC 10C .0314	STRIPED BASS

DISCUSSION

The Tar-Pamlico and Neuse rivers populations are not self-sustaining and in the absence of stocking cannot support any level of harvest (Mathes et al. 2020). Increasing spawning stock biomass and advancing the female age-structure to older individuals may lead to improved natural recruitment (Goodyear 1984). Based on modeling, a 10-year closure was most effective at increasing adult (age 3+) and old adult (age 6+) abundance (Figure 3.4; Mathes et al. 2020). Model results indicate old adult abundance does not increase for the first five years of the simulation regardless of fishing strategy. The next best fishing strategy consisted of a 5-year closure followed by a 26-inch minimum size limit. However, the 10-year closure resulted in more than two times the number of old adult striped bass than the next best fishing strategy (Figure 3.4).

After the 10-year closure, alternative harvest strategies including minimum size limits, slot limits, and bag limits should be evaluated prior to opening of the fishery. A sufficient time period will be required to achieve an expansion of the age structure and to increase abundance of older fish to promote natural recruitment. This time period should be minimally 10-years from the adoption of Supplement A (2019). Evaluations must account for natural fluctuations in striped bass spawning success due to environmental conditions.

Continue or discontinue the no-harvest measure

Management measures implemented in Supplement A closed the fishery to commercial and recreational harvest and must be incorporated into Amendment 2 to be maintained. If Supplement A management measures are not maintained, alternative management strategies to promote sustainable harvest must be considered.

Closing the fishery to commercial and recreational harvest provides the opportunity to evaluate the population response to management without fishing mortality. If there are no other significant mortality sources (i.e., natural mortality or discard mortality) or population losses (i.e., emigration from the system), no-harvest should allow for expansion of the age structure to include fish greater than age-10.

The no-possession measure in the internal coastal and joint waters of the CSMA was implemented based on genetic evidence suggesting two successful natural spawning events occurred in the Tar-

Pamlico and Neuse rivers in 2014 and 2015 (NCDMF 2019). This potential successful recruitment was an unusual event for Tar-Pamlico and Neuse rivers stocks. Rulifson (2014) concluded 53% of fish sampled from the Neuse River in 2010 were not of hatchery origin providing anecdotal evidence that sporadic, low levels of natural recruitment may occur in these systems. Supplement A was adopted to protect striped bass from the 2014- and 2015-year classes from harvest as they mature and contribute to the spawning stock.

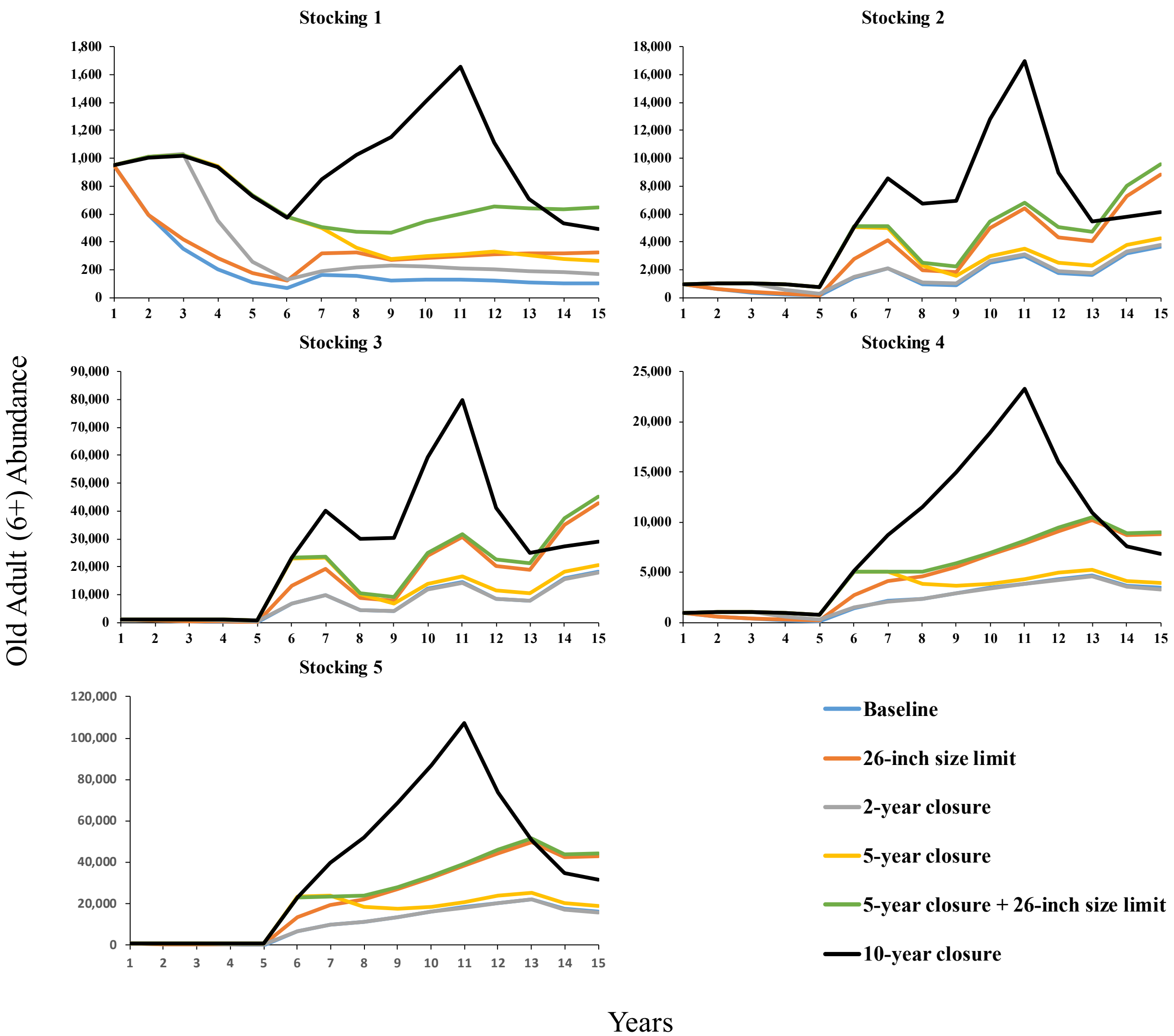


Figure 3.4. Abundance of old adults (age 6+) projected under five stocking strategies and six fishing strategies. Stocking 1 - no stocking; Stocking 2 - stocking 100,000 fish per year with 2-year stocking and 2-year no stocking alternating for 15 years (8 years of stocking in total); Stocking 3 - stocking 500,000 fish per year with 2-year stocking and 2-year no stocking alternating for 15 years (8 years of stocking in total); Stocking 4 - stocking 100,000 fish per year with 8-year continuous stocking; Stocking 5 - stocking 500,000 fish per year with 8-year continuous stocking. Lines show the median from 10,000 iterations.

Based on matrix model results, no level of fishing mortality is sustainable. Continuing the no-possession measure is important to increase the age structure and abundance of Tar-Pamlico and Neuse rivers striped bass, which should promote natural reproduction (Mathes et al. 2020). Fishing activities typically select larger fish, increasing fishing mortality disproportionally. Fishing activities impact the abundance of older fish, limiting the age structure of the population and reproductive contribution (Mathes et al. 2020). Past management measures may have maintained an artificially young age structure for a species documented to live up to age 30 (Greene et al. 2009).

An additional potential benefit of no-harvest in the CSMA is protection of A-R striped bass using juvenile and adult habitats in the Pamlico Sound and the Tar-Pamlico and Neuse rivers systems. Conventional tag return data has documented movement of smaller A-R stock striped bass into CSMA rivers (Callihan et al. 2014) and preliminary acoustic tag results from 30 adult (ages 4–5), non-hatchery origin striped bass tagged in the Tar-Pamlico and Neuse rivers indicates 63% were detected in the Albemarle Sound or on the Roanoke River spawning grounds in spring 2020 and 2021 (NCDMF unpublished data).

If the no-possession measure is discontinued in Amendment 2, alternative management strategies must be considered to manage harvest. Prior to 2019, management measures limited harvest seasons to cooler months to reduce discard mortality. Recreational fishers were subject to a two fish per person per day creel limit and commercial fishers were subject to a 10 fish per person per day limit with a maximum of two limits per commercial operation. Commercial and recreational fishers were subject to an 18-inch total length (TL) minimum size limit for striped bass, and a protective measure in joint and inland waters made it unlawful for recreational fishers to possess striped bass between 22- and 27-inches TL. In 2018, a 26-inch TL minimum size limit was established in inland waters. If harvest was allowed, changes to the size limits, or slot limits, could be considered to protect larger, older striped bass.

Among the six fishing strategies evaluated by the matrix model, a 5-year closure combined with a 26-inch TL minimum size limit was the second most effective strategy at increasing the abundance of older fish (Mathes et al. 2020). Additionally, commercial harvest was managed by an annual TAL of 25,000 pounds. With a goal of achieving self-sustaining populations in the Tar-Pamlico and Neuse rivers, lower harvest levels, alternative seasons, or area closures could be considered. Because striped bass populations in the CSMA are at an extent that sustainability is unlikely at any level of fishing mortality (Mathes et al. 2020), alternative management strategies beyond the harvest moratorium are unlikely to result in a self-sustaining stock.

Gear restrictions/limits

In 2004, DMF conducted a fishery independent study to test the effectiveness of various tie-down and gill net setting configurations in reducing striped bass bycatch. Results of these studies indicated distance from shore is a significant factor in striped bass catch rates, with up to a 60% reduction in striped bass catch when nets are set greater than 50 yards from shore (NCDMF 2013). Additionally, the use of tie-downs decreased striped bass catch by 85–99% in water depths greater than 3 feet, depending on season (NCDMF 2013). In 2008, the MFC approved requiring the use of 3-foot tie-downs in large mesh gill nets in internal coastal fishing waters and establishing a minimum setback distance from shore of 50 yards to effectively reduce striped bass discards (NCDMF 2013). After passing Supplement A, the MFC held a special meeting and passed a motion beyond what was contained in Supplement A instructing the DMF Director to issue a proclamation that prohibited the use of all gill nets upstream of the ferry lines on the Tar-Pamlico River and the Neuse River. The tie-down and distance from shore restrictions were maintained year-round for large mesh gill nets in the western Pamlico Sound and rivers below the ferry line (Figure 3.5). The gill net tie-down and distance from shore restrictions will remain in place as part of Amendment 2.

Rock et al. (2016) compared Tar-Pamlico and Neuse rivers striped bass dead discard estimates from observer data before and after the tie-down and distance from shore management measures were implemented (2004–2009 and 2011–2012). Average annual striped bass discards in the commercial gill net fishery were reduced by 75% following implementation. The persistent availability of striped bass within 50 yards of shore as indicated by fishery independent sampling and limited numbers of out of season observations from commercial gill nets indicate the setback and tie-down measures were effective in reducing gill net interactions with striped bass (Rock et al. 2016).

Relative annual variation in commercial gill net effort, commercial harvest, recreational effort, and recreational discards are significant factors contributing to the total mortality of striped bass in the Neuse River (Mathes et al. 2020). Reducing mortality, including dead discards, may increase spawning stock biomass and expand the age structure of spawning females (Rachels and Ricks 2018). Estimates of commercial striped bass total dead discards in the Tar-Pamlico River were greater than in the Neuse River (Mathes et al. 2020). From 2012 to 2018, commercial striped bass dead discards in these rivers averaged 1,606 fish per year; however, after the ferry line gill net closures were implemented, the average number of striped bass dead discards reduced to 522 fish per year (2019–2020; Table 3.1). In addition to the gill net closure above the ferry lines, there has also been an overall decline in large mesh gill net trips resulting from the adoption of Amendment 2 to the Southern Flounder FMP in 2019. Overall, relatively small estimates of dead discards are an indicator that distance from shore and tie-down requirements enacted in 2008 have been successful in reducing the number of striped bass discards in the commercial gill net fishery in the Tar-Pamlico and Neuse rivers (Rock et al. 2016). Lowering mortality on a stock that cannot sustain itself at any level of fishing mortality is likely to have benefits to the population.

Table 3.1. Recreational and commercial estimates of striped bass discards in Central Southern Management Area rivers, 2012–2020.

Year	Recreational Dead Discard Numbers	Commercial Dead Discards Numbers
2012	2,927	1,255
2013	2,263	1,797
2014	1,967	1,351
2015	2,158	1,536
2016	5,121	1,805
2017	8,657	2,429
2018	3,135	1,066
2019	2,150	371
2020	1,685	672
Total	30,063	12,282

Recreational measures to reduce discard mortality either through gear modifications or reduced angling effort could be considered as a management tool for the Tar-Pamlico and Neuse stocks due to the large number of fishing trips where anglers target striped bass in a catch and release fishery. From 2012 to 2020, recreational striped bass dead discards in the Tar-Pamlico and Neuse rivers averaged 3,340 fish per year. Over the past nine years, the number of recreational dead discards was more than double the number of commercial dead discards (Table 3.1). To reduce injury and stress-induced mortality in the upper Roanoke River, anglers are required to use a single barbless hook or lure from April 1 through June 30 while striped bass are concentrated near the spawning grounds. Similar measures, such as requiring non-offset circle hooks for natural bait and restricting the use of treble hooks, could be considered in the upper portions of the Tar-Pamlico and Neuse rivers. However, striped bass are not abundant in large numbers in the upriver sections of these systems, so the impact would likely be much smaller in magnitude when compared to the Roanoke River. Recreational gear restrictions could be required and focus by area and time of year. Gear restrictions that are targeted at one species in a multi-species fishery are difficult to enforce because one cannot prove intent (see section 11.3 of Amendment 1 to the NC Estuarine Striped Bass FMP).

Recreational angler education and outreach provide a viable option to improve survival of released fish. Practicing ethical angling techniques have been shown to improve survival (see NCDMF Ethical Angling brochure). Learning best management practices for ethical angling will give anglers confidence to release fish in a way that helps protect the resource for future generations. Increasing public awareness, through directed outreach and education will help anglers make informed decisions to minimize their impact to the striped bass population through catch and release mortality.

Anglers can minimize stress and exhaustion to fish by using appropriate tackle suited to the size of desired fish. Using barbless and non-offset circle hooks can increase the likelihood of jaw hooking a fish giving it a greater chance of survival at release. Additionally, handling can be minimized with rubberized landing nets and hook removal devices. When handling striped bass, it is very important to minimize the time out of water. If anglers must remove a fish from the water, return to the water as soon as possible. It's important to support the weight of the fish and never suspend it by the lip. Minimize handling and only touch fish with wet hands, avoiding contact with the eyes and gills. Anglers should resuscitate a sluggish fish by placing it into the water facing the current until it regains strength and can swim away on its own. High air and water temperatures create stressful environmental conditions for striped bass. Anglers should not target striped bass for catch and release on these days.

Commercial gear restrictions have been implemented that significantly reduce the impact of this gear on striped bass but also have other impacts. Year-round gill net closures above the ferry lines on the Tar-Pamlico and Neuse rivers impact commercial harvest of other species, such as hickory shad and American shad. The hickory shad commercial season in the Tar-Pamlico and Neuse rivers occurs from January 1–April 14. The American shad season occurs from February 15–April 14 and most American shad are harvested during the March striped bass gill net fishery. From 2012 –2017, an average of 16,805 pounds of American shad were harvested in the commercial fishery in January–March in the Tar-Pamlico and Neuse rivers (NCDMF 2013). After the gill net closure in March 2019, commercial landings and the number of trips were greatly reduced in both river systems (NCDMF 2020b). No American shad were harvested in 2019 and 125 pounds were harvested in 2020 in the Tar-Pamlico River. In the Neuse River, commercial harvest of American shad in 2019 was reduced to 1,539 pounds and 109 pounds in 2020.

Tie-downs and Distance from Shore

Proclamation M-6-2019 implemented year-round tie-down and distance from shore restrictions to reduce bycatch of striped bass. The restrictions remain in effect until Amendment 2 is adopted. Prior to the gill net closure, there were no tie-down or distance from shore measures during the commercial shad seasons, large mesh gill net tie-down and distance from shore restrictions were in place once the commercial striped bass season closed. On April 30 annually, or whenever the CSMA striped bass TAL was reached, the 3-foot tie-down and 50-yard distance from shore measures went into effect through December 31.

DMF commercial gill net observer data indicates few striped bass are caught in gill nets set greater than 25 yards from shore above the ferry lines in the Tar-Pamlico and Neuse rivers (Figure 3.6). Observer data indicates clear differences in the spatial distribution of American and hickory shad and striped bass at varying distance from shore. From 2012 to 2018 (Feb 15–April 14), hickory and American shad were caught in all trips observed above the ferry lines that were greater than 200 yards from shore, whereas only 26% of those observed trips caught striped bass. If the gill net closure is removed, requiring large mesh gill nets to be set a minimum distance of 200 yards from shore above the ferry lines would allow the commercial fisheries for hickory and American shad to operate without substantial increases in striped bass discards. Observer coverage would monitor interactions and adaptive management could be used to close the area if necessary.

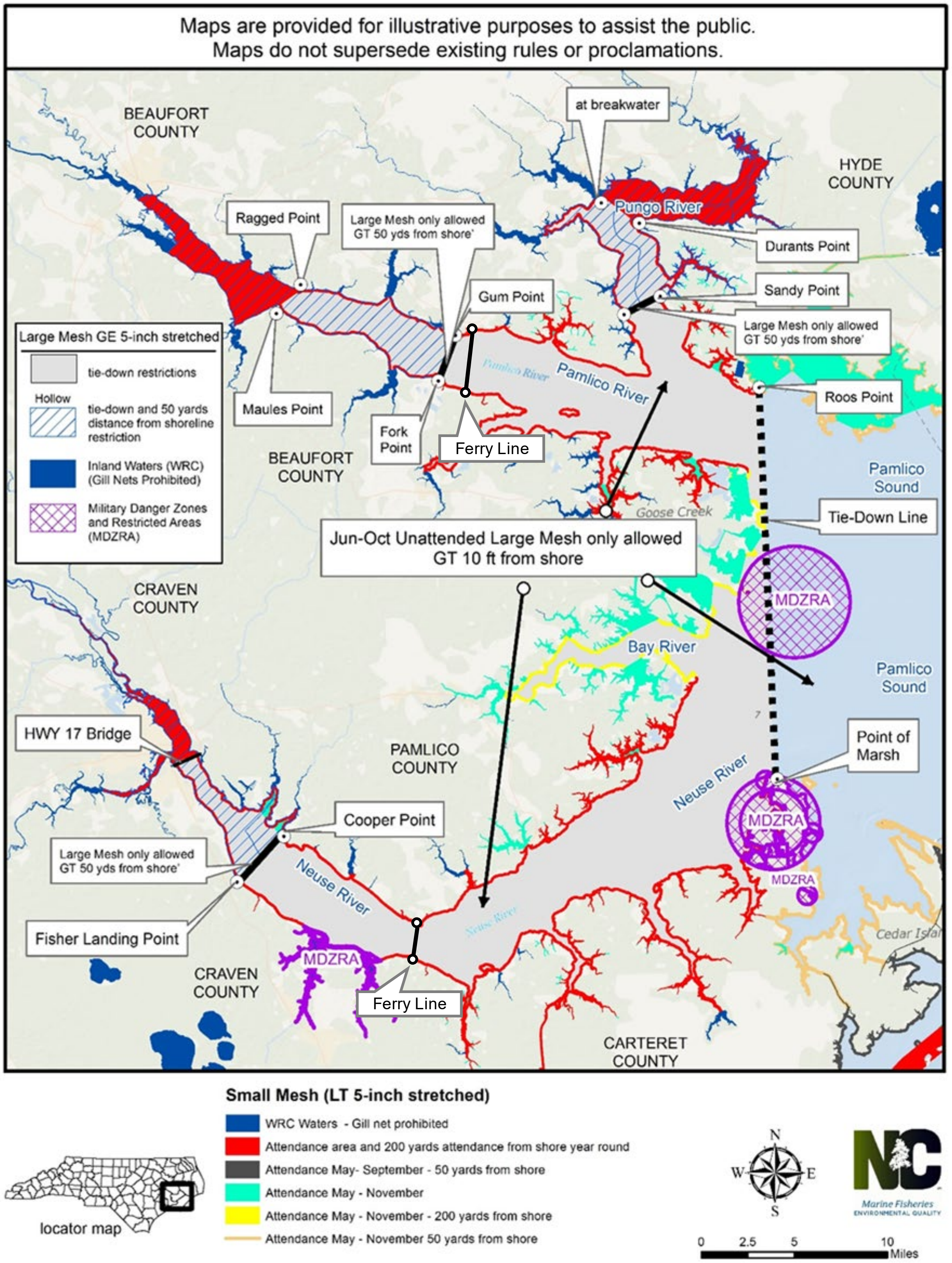


Figure 3.5. Gill net regulation map for various gill net types and seasons in the Central Southern Management Area.

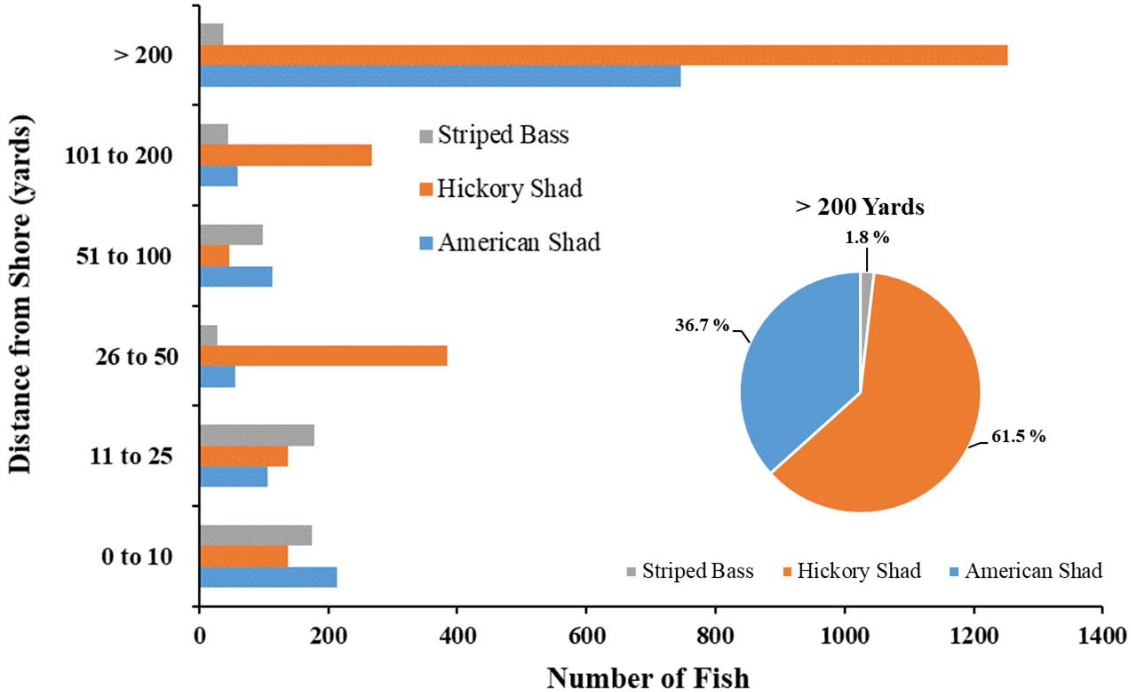


Figure 3.6. DMF observer data for striped bass, hickory shad, and American shad from gill nets set above the ferry lines on the Tar-Pamlico and Neuse rivers (2012–2020; Feb 15 – Apr 14; n=162 trips), separated by the distance from shore (yards). The insert shows the percentage of fish that were observed in gill net sets greater than 200 yards from shore (n=62 trips).

The decision in the Tar-Pamlico and Neuse rivers on opening or closing the striped bass fishery and establishing areas open or closed to gill netting is a tradeoff between providing additional protection to promote self-sustaining populations or providing opportunities to harvest limited numbers of striped bass. If the ferry line gill net closure was not carried forward, commercial gill net restrictions in place before the 2019 closure would be implemented, including the tie-down and distance from shore restrictions. Additionally, rules already in place would require year-round small mesh gill net attendance in the upper portions of the Tar-Pamlico, Pungo, Neuse, and Trent rivers and within 200 yards of shore in the lower portions of the rivers to the western Pamlico Sound. Attendance requirements for small mesh nets were put in place to reduce dead discards in the small mesh gill net fishery. If the harvest moratorium is not maintained, the rationale behind the gill net closure above the ferry lines should be reevaluated along with any additional measures that can potentially allow access to the resource while minimizing the impact on striped bass discards.

Adaptive Management

Adaptive management allows managers to adjust management measures as new information or data becomes available. Management options which are selected during FMP adoption take into account the most up to date data on the biological and environmental factors which affect the stock. After FMP adoption, data through 2024 will be reviewed in 2025 by the striped bass PDT. Trends in key population parameters like adult abundance, age structure, natural recruitment, and hatchery contribution will be evaluated to determine the impact of the 2019 no-possession provision on the stocks. Analysis will also consider environmental conditions (e.g., river flow), changes to stocking strategies, and new life history information. If the data review suggests continuing the no-possession provision is needed for additional stock recovery, no changes in harvest management measures will be recommended until the next FMP Amendment is developed. Adaptive management may be used to adjust management measures including area and time restrictions and gear restrictions if it is determined additional protections for the stocks are needed.

If analysis indicates the populations are self-sustaining and a level of sustainable harvest can be determined, recommendations for harvest strategies will be developed by the PDT. If analysis indicates biological and/or environmental factors prevent a self-sustaining population, then alternate management strategies will be developed that provide protection for and access to the resource.

MANAGEMENT OPTIONS AND IMPACTS

(+ potential positive impact of action)
(- potential negative impact of action)

1. Striped Bass Harvest
   A. Continue the no-possession measure in Supplement A to Amendment 1

      + Provides an opportunity to evaluate the population response in the absence of fishing mortality.
      + Increases abundance and expands the age structure
      + Provides protection of A-R striped bass found in the Tar-Pamlico and Neuse rivers systems
      + Provides the best chance of achieving sustainable harvest
      - Does not allow for limited harvest of the resource by commercial and recreational fishers
      - May not achieve desired results if other factors negatively influence recruitment
      - Discards in commercial and recreational fishery will still occur

   B. Discontinue the no-possession measure in Supplement A to Amendment 1 after reviewing data in 2025 if it can be shown populations are self-sustaining and a level of sustainable harvest can be determined (open harvest)

      + Allows for limited harvest of the resource by commercial and recreational fishers
      + Reduces discards
      +/- Environmental and other factors may prevent natural recruitment from occurring regardless of stock condition
      - Cannot achieve goal of sustainable harvest at any level of fishing mortality

2. Gear Restrictions/Limits

A. Maintain gill net closure above the ferry lines and maintain the 3-foot tie-downs below the ferry lines

+ Reduces dead discards from the gill net fishery
+ Could help increase abundance and expand age structure
+ Maintains reduced protected species interactions
+ Makes it easier for managers to measure any potential impacts
- Impacts commercial harvest of many species, such as, American shad
- May not increase chances of achieving sustainable harvest

3. Adaptive Management

- In 2025, review data through 2024 to determine if populations are self-sustaining and if sustainable harvest can be determined

+ Adaptive management allows for management adjustments to any of the selected management options as new data becomes available
+ Will help achieve the goal of increased abundance and expanded age structure
+ Allow for scheduled review and adjusted of management measure between scheduled FMP reviews

- Creates management uncertainty if not clearly defined

RECOMMENDATIONS

See Appendix 6 for DMF, WRC, and advisory committees recommendations and a summary of online public.

NCMFC Preferred Management Strategy

Options: 1.A., 2.A., and 3.

In addition, the MFC asked that the DMF study the effects of the gill net closure and reevaluate it at the next full amendment review. This research will be conducted, preferably within two years, and this closure be addressed based on that study.

MFC Actions

At its February 2022 business meeting, the MFC approved a motion to send the draft Estuarine Striped Bass Fishery Management Plan Amendment 2 for review by the public and advisory committees with the change of deleting Options 2.B and 2.C. from Appendix 3, leaving only Option 2.A. These options, if selected, provided access above the ferry lines to commercial gill net operations during commercial shad season. Gear, season, and area limitations were included in the options as well as observer monitoring. These options were removed from the draft plan prior to public and advisory committee review.

APPENDIX 4: ACHIEVING SUSTAINABLE HARVEST FOR THE CAPE FEAR RIVER STRIPED BASS STOCK

ISSUE

Consider existing factors that prevent a self-sustaining population in the Cape Fear River and implement management measures that provide protection for and access to the striped bass resource.

The 2020 Central Southern Management Area (CSMA) matrix and tagging models show a consistent decline in abundance estimates for striped bass in the Cape Fear River from 2012 – 2018, even with a total harvest moratorium for striped bass in place since 2008. Population abundance is maintained through stocking efforts, but genetic testing and young-of-the-year (YOY) surveys suggest limited natural striped bass reproduction occurs in the system.

ORIGINATION

North Carolina Division of Marine Fisheries (DMF) and North Carolina Wildlife Resources Commission (WRC).

BACKGROUND

Historically the Cape Fear River system supported self-sustaining populations of multiple anadromous fish species, including striped bass (Yarrow 1874; Earl 1887). Multiple factors are attributed to declines in anadromous fish stocks, including overfishing, loss of habitat, declining water quality, and blockage of upstream spawning migrations (ASMFC 2007; Limburg and Waldman 2009). Construction of three locks and dams on the mainstem of the Cape Fear River between Riegelwood and Tar Heel, NC, was completed between 1915 and 1935 (Figure 4.1). These impediments to migration severely reduced the ability of striped bass to reach historic spawning areas near Smiley's Falls at the fall line in Lillington, NC (Nichols and Louder 1970). In an effort to enhance striped bass abundance in this system, hatchery reared fish have been stocked into the Cape Fear River by management agencies since at least the 1950s (Woodroffe 2011; *Stocking Information Paper*). In 1974, DMF began a study to document and protect critical spawning habitat for anadromous fishes, resulting in the designation of Anadromous Fish Spawning Areas throughout North Carolina. Spawning areas were identified in the Cape Fear River from the mouth of Town Creek upstream to Lillington, NC (Sholar 1977). As a response to low numbers of documented spawning adults and limited evidence of juvenile recruitment, the current commercial and recreational harvest moratorium of striped bass in the Cape Fear River was implemented in 2008.

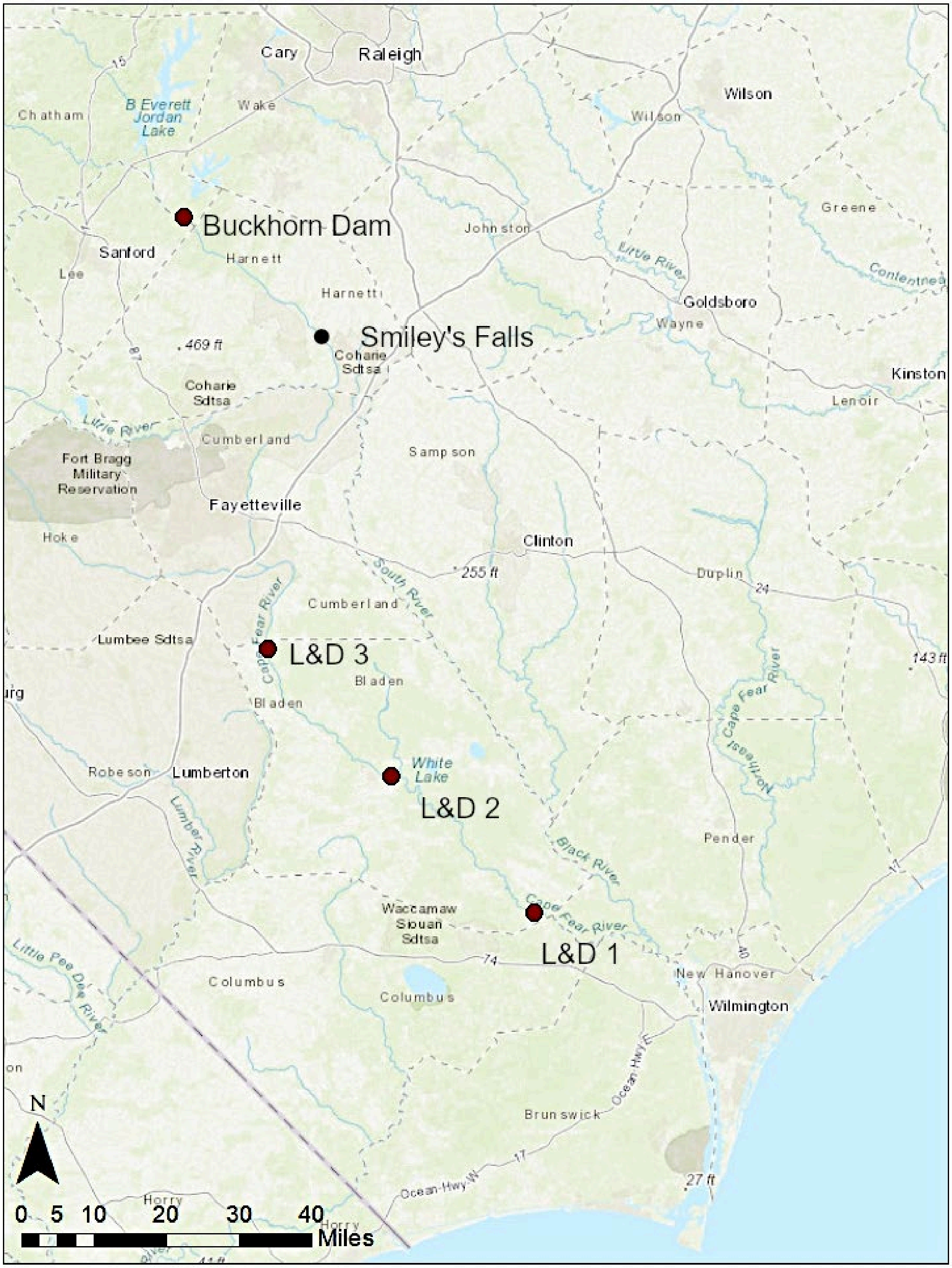


Figure 4.1. A map showing the locations of the three locks and dams on the mainstem of the Cape Fear River downstream of the historic spawning area near Smiley's Falls.

Although evidence of successful striped bass spawning in the Cape Fear River system has been documented by the collection of adult fish in spawning condition and eggs in the water column, few larvae or YOY juveniles have been observed (Hawkins 1980; Winslow et al. 1983; Smith 2009; Smith and Hightower 2012; Dial Cordy and Associates 2017; Morgeson and Fisk 2018; Rock et al. 2018). Limited natural reproduction of striped bass in the Cape Fear River Basin suggests the sustainable harvest of a self-sustaining population of wild fish is not possible at this time (Mathes et al. 2020). Evaluation of stocking efforts using parentage-based testing (PBT) analysis has shown most striped bass sampled in the Cape Fear River during spawning surveys are of hatchery origin (Boggs and Rachels 2021). Restricted access to historic spawning grounds in the mainstem Cape Fear River is likely the primary factor preventing striped bass population recovery in this system. A small amount of natural reproduction is likely occurring in the Northeast Cape Fear River, but the overall contribution to total possible production of striped bass remains unknown. Until passage of striped bass is achieved at all three locks and dams, it is unlikely sustainable harvest of wild fish will be attainable. While strategies are developed to meet passage goals, the potential for harvest of the hatchery supported population of striped bass in the Cape Fear River may be evaluated. For more information on stocking analysis see Appendix 1 Stocking in Coastal River Systems information paper.

Cape Fear River Striped Bass Stock

For a comprehensive review of striped bass life history in North Carolina, as well as the Cape Fear River, see Mathes et al. (2020) and Amendment 2 of the Estuarine Striped Bass Fishery Management Plan. Striped bass populations in the CSMA are generally considered to have an endemic riverine life history and typically do not make any oceanic migrations (Rulifson et al. 1982; Callihan 2012). Acoustic tagging studies in the Cape Fear River Basin show adult fish making seasonal migrations within the drainage and minimal emigration out of the system (Rock et al. 2018; Prescott 2019). Striped bass move upstream during the spawning season (March–May), then return to a core residency area (June–February) focused within 10 kilometers around the confluence of the Northeast and mainstem Cape Fear rivers (Rock et al. 2018; Prescott 2019). Striped bass are observed to show fidelity to either the Northeast or mainstem Cape Fear River for spawning migrations, making spring migrations up the same branch which they used the previous year before returning and mixing in the core residency area (Prescott 2019).

The WRC has conducted annual monitoring of the spawning stock of striped bass on the mainstem of the Cape Fear River since 2006. Sampling occurs weekly below each of the three locks and dams from late February through May. Adult abundance is typically much higher for the station below Lock and Dam #1 compared to the remaining stations, and peak abundance occurs in mid to late May (Figure 4.2). Very few striped bass eggs are collected above Lock and Dam #3 where the historic spawning area is located, with most eggs being collected below Lock and Dam #1 (Dial Cordy and Associates 2017). In 2017, DMF juvenile abundance trawl and seine survey stations were developed for the Cape Fear River system. Zero YOY striped bass have been collected in mainstem sampling. The last documented YOY striped bass collected in the mainstem Cape Fear River were in July 1977 (Hawkins 1980).

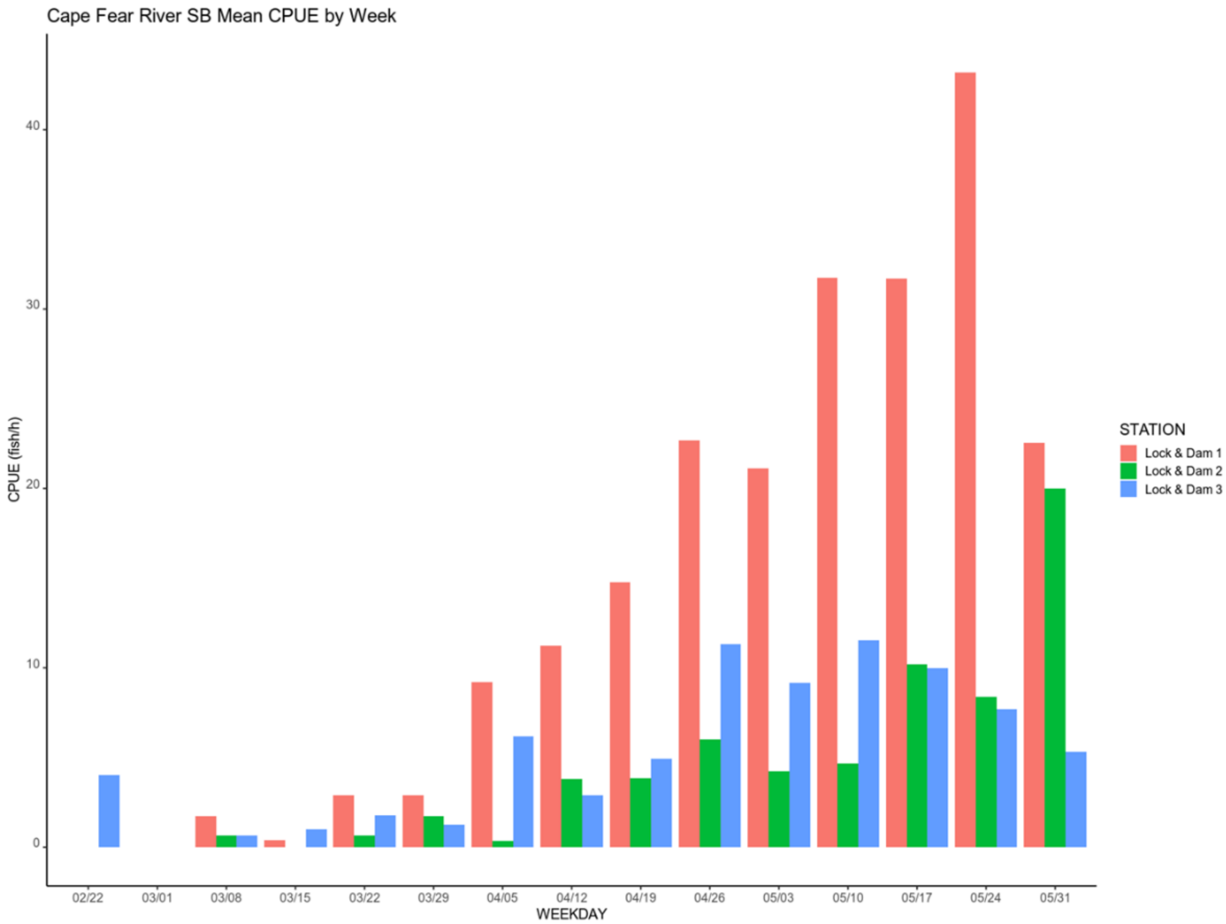


Figure 4.2. Weekly striped bass catch-per-unit-effort (CPUE) by sample site February through May 2008–2019.

In the Northeast Cape Fear River, adult striped bass have been captured and acoustically tagged during the spawning season (April – May) between White Stocking, NC, (kilometer 118) and Chinquapin, NC, (kilometer 168), with potential spawning occurring as far upstream as Hallsville, NC (kilometer 183; Rock et al. 2018). Winslow et al. (1983) documented small numbers of YOY striped bass in the lower Northeast Cape Fear River. DMF sampling collected 24 YOY striped bass in 2018, four were collected in 2019, and two were collected in 2020 at stations in the Northeast Cape Fear River (Darsee et al. 2020).

The first well documented stocking of hatchery origin striped bass into the Cape Fear system began in the 1950s (Wodroffe 2011). For a history of stocking in the Cape Fear River system see Appendix 1 Stocking in Coastal River Systems information paper. State and federal hatcheries have produced striped bass released into the system, and ongoing stocking efforts are made by a cooperative agreement between the USFWS, DMF, and WRC, which has been in place since 1986. Between 1980 and 2009, over 629,000 “phase-II” Roanoke River strain striped bass (approximately 5 – 7 inches total length), were stocked into the Cape Fear River system. Since 2010, an average of 144,000 phase-II striped bass were stocked into the system annually (Table 1.1 and 1.2). Starting in 2010, adult striped bass captured in the Cape Fear River were used as broodstock for stocking efforts into the system. No genetic difference was detected between Cape

Fear and Roanoke fish sampled between 2009–2011, and this was attributed to the previous stocking history of Roanoke hatchery origin fish into the Cape Fear system (Anderson et al. 2014). The extent of impacts from stocking striped bass originating in the Roanoke River into other striped bass populations remain relatively unknown (Rulifson and Laney 1999; Bergey et al. 2003). However, Anderson et al. (2014) suggested that, despite genetic similarity between Roanoke and Cape Fear River fish, natural reproduction of striped bass was likely occurring in the Cape Fear River.

Jordan Reservoir, a large impoundment in the Cape Fear River basin above the fall line and known historic spawning grounds for striped bass, was stocked with hybrid striped bass (*M. chrysops x M. saxatilis*) until the early 2000s. The WRC stopped stocking hybrid striped bass in Jordan Reservoir due to escapement of these fish into the lower Cape Fear River, and evidence that escaped fish would interfere with striped bass restoration efforts (e.g., interbreed with and/or outcompete for resources; Patrick and Moser 2001). Striped bass were stocked into Jordan Reservoir as a replacement for the hybrid striped bass recreational fishery from the mid-2000s until 2020. Evaluation of the stocked striped bass fishery in Jordan Reservoir suggested low survival and low angler participation, resulting in WRC discontinuing this reservoir stocking effort.

Parentage-based tagging (PBT) was implemented by the WRC as a means to determine percent hatchery contribution to the striped bass spawning populations in the CSMA systems starting in 2010. Using known genetic markers from parent brood stock, this method can determine if a fish was produced in a hatchery (Denson et al. 2012). In 2011, WRC analyzed all striped bass captured in their Cape Fear River spawning survey. In 2017, DMF began collecting additional samples in the lower portion of the Cape Fear River and in the Northeast Cape Fear River and mainstem mixing area. Additionally, a subset of the YOY captured in the Northeast Cape Fear River during 2018 and 2019 were tested, and all YOY analyzed were determined to not to be of hatchery origin and likely wild spawned. PBT results show hatchery origin fish comprise between 63% and 93% of the fish tested each year, and the percentage of fish determined to be of hatchery origin increasing annually (Table 1.4). Fish determined to be of unknown origin are not necessarily wild-spawned since parentage-based markers are only available back to the 2010 year-class of stocked fish. The 89% hatchery contribution indicated in 2018 PBT analysis is likely an accurate reflection of actual hatchery contribution to the 2018 Cape Fear River striped bass population, as striped bass aged in the system are typically less than 10 years old. Additionally, an increasing proportion of fish stocked into the upriver reservoirs are represented in the Cape Fear River system (Figure 4.3). The proportion of Jordan Reservoir stocked fish increases upriver and fish collected below Buckhorn Dam are entirely reservoir origin (Figure 4.4).

Striped Bass Fisheries

A total harvest moratorium on striped bass was enacted in 2008 as a management strategy in response to low numbers of documented spawning adults and limited evidence of juvenile recruitment in the Cape Fear River system (NCDMF 2013).

Recreational

Striped bass provide an important and popular recreational angling opportunity in the Cape Fear River. Despite a harvest moratorium, striped bass are targeted by anglers and support a catch-and-release fishery in the system. Recreational charter vessels hired by recreational fishers target Cape Fear River striped bass during the winter months; by April effort typically shifts to other fisheries.

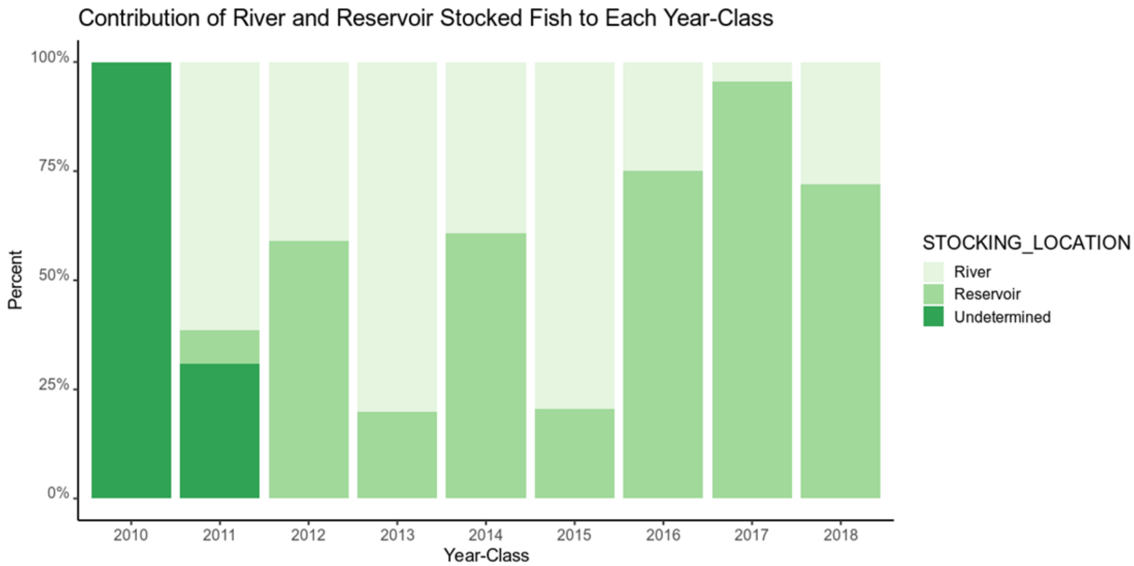


Figure 4.3. Relative contribution of hatchery-origin fish to the hatchery-origin year-class by stocking location of fish collected in WRC electrofishing surveys, 2010–2018.

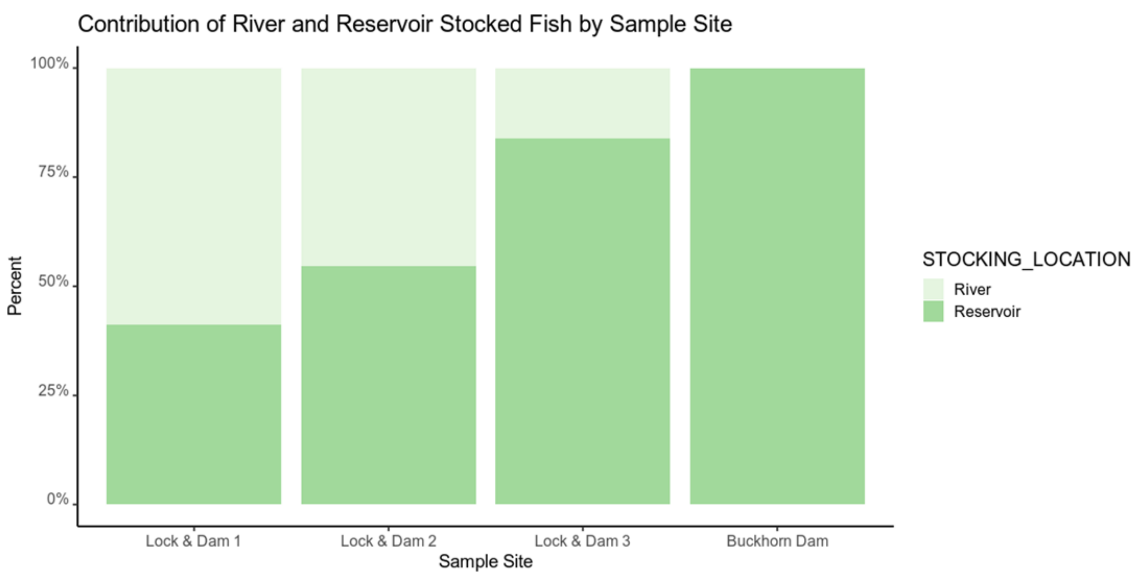


Figure 4.4. Relative contribution of hatchery-origin fish by stocking location to each WRC electrofishing sample site, 2015–2019.

Since 2013, the DMF Coastal Angling Program (CAP) has partnered with WRC on an anadromous creel survey to interview recreational anglers in the Cape Fear River for the purpose of producing effort and catch estimates for striped bass and American shad. Within the Cape Fear River, annual striped bass catch estimates are highly variable and imprecise, ranging between 14 and 1,551 fish from 2013 – 2018 (Table 4.1).

Striped bass in the Cape Fear River have been tagged using external anchor tags since 2011. These tags are highly visible and have instructions for anglers to report and return them to DMF for cash rewards. Beginning in 2015, striped bass were marked with both low ($5) and high reward tags ($100). As anglers may not report all tagged fish captured, the difference in tag returns between high (assumed to have a 100% reporting rate) and low reward tags can be used to calculate corrected low reward tag reporting rates. The percentage of tagged fish in a population which are reported by recreational anglers when taken into consideration with the tag reporting rate can be used to understand the overall recreational fishing catch. In the Cape Fear River from 2011 – 2020, 14.9% of the striped bass tagged with low reward tags were captured by recreational anglers and reported to the DMF and considering the calculated tag reporting rate this number likely represented 51.7% of the overall tagged striped bass caught by anglers during this time (Table 2.). Even though a harvest moratorium is in place, the overall proportion of high reward tagged striped bass caught and reported by recreational anglers in the Cape Fear River (28.9%) is similar to what was reported between 2020 and 2021 for high reward tags in other recreationally important species in North Carolina waters (spotted sea trout 33.3%, southern flounder 29.5%, striped bass statewide 22.4%; NCDMF 2021).

Table 4.1. Effort and catch estimates for Cape Fear River striped bass from Coastal Angling Program anadromous creel survey. PSE values are in parenthesis.

Year	Number of Striped Bass Trips	Striped Bass Trip Hours	Total Striped Bass Catch
2013	257 (48.6)	870 (63.1)	355
2014	433 (42.9)	2140 (45.9)	1,551
2105	209 (50.1)	702 (53)	199
2016	391 (46.4)	1464 (44.4)	628
2017	26 (100)	159 (100)	14
2018	24 (77.1)	61 (71.5)	140

Commercial

Between 1994 and 2008, annual commercial striped bass landings from the Cape Fear River averaged 1,206 pounds and ranged from 68 to 4,138 pounds (Table 4.2). Cape Fear River landings on average comprised less than 5% of the 25,000-pound CSMA Total Allowable Landings (TAL). Additionally, trips which contained striped bass comprised between 0.60% and 11.8% of total annual trips from the Cape Fear River which landed finfish during this time (Table 4.3). Gill nets accounted for 99.9% of the total landings of Cape Fear River striped bass, with the remainder of the landings from hook and line and crab pots (Table 4.4). Between 2011 and 2020, less than

0.01% of the reward tagged striped bass were captured and returned by commercial fishing operations.

Table 4.2. Numbers of striped bass tagged by DMF and then captured and reported by recreational anglers in the Cape Fear River by year and reward type ($5 for low reward, $100 for high reward). Low reward tag corrected reporting rate is calculated with the assumption that high reward tags are 100% reported.

	Low Reward		High Reward		
Year	# Released	% Returned	# Released	% Returned	Low Reward Corrected Reporting Rate
2011	286	4.9	*		
2012	405	6.7	*		
2013	491	9.4	*		
2014	600	13.5	*		
2015	640	18.1	49	36.7	49.3
2016	474	21.1	117	34.2	61.7
2017	349	18.3	9	33.3	55.0
2018	372	12.1	44	9.1	**
2019	259	23.2	12	0.0	**
2020	245	25.3	15	40.0	63.3
Total	4,121	14.9	246	28.9	51.7

*No high reward tags used

**Unable to be calculated

Stock Concerns

In the 2020 Central Southern Management Area (CSMA) Striped Bass Stocks report, Cape Fear River striped bass abundance estimates ranged from 1,578 (2017) to 10,983 (2012) between 2012 and 2018 (Mathes et al. 2020). Abundance estimates consistently declined over this time period, and by 2018 striped bass abundance was reduced to less than 20% of what it was in 2012 (Mathes et al. 2020).

No legal recreational or commercial harvest of striped bass has occurred in the Cape Fear River system since the harvest moratorium was established in 2008, yet adult abundance estimates have continued to decline, indicating natural reproduction in the system has been limited and non-harvest related mortality is high. Specific estimates of discard mortality are unknown in this system.

Two non-native predatory catfish species Blue Catfish (*Ictalurus furcatus*), and Flathead Catfish (*Pylodictis olivaris*) are established in the Cape Fear River system. Both of these catfish have been documented to cause reductions in the abundance and composition of native fish in the systems where they have been introduced. In the Cape Fear River, these two species have been directly observed to prey on anadromous fish, including striped bass (Ashley and Buff 1988, Belkoski et al. 2021). Population level impacts to striped bass via direct predation by introduced catfish, or through competition for the same prey resources remains unquantified in the Cape Fear system.

Table 4.3. Cape Fear River striped bass annual commercial landings in pounds from all gears, percentage that striped bass contributed to the total annual Cape Fear River finfish commercial landings, and percentage of all finfish trips with striped bass landings 1994–2008. DMF Trip Ticket Program.

Year	Landings (lbs.)	% of Total CFR Finfish Landings	% of CFR Finfish Trips With STB Landings
1994	480	0.01	2.21
1995	264	0.26	1.85
1996	4,139	3.81	11.42
1997	2,187	2.21	8.38
1998	501	0.67	6.53
1999	1,001	1.72	8.35
2000	567	0.70	5.75
2001	129	0.18	2.15
2002	173	0.22	2.51
2003	68	0.08	0.60
2004	2,364	2.96	11.80
2005	2,721	3.36	10.86
2006	1,057	1.61	4.64
2007	1,601	2.02	8.59
2008	831	1.07	6.10

Table 4.4. Percentage of total Cape Fear River commercial striped bass landings (weight) by gear, 1994–2008.

Gear	Percentage
Set sink gill net	93.09%
Set float gill net	3.58%
Drift gill net	3.15%
Runaround gill net	0.08%
Crab pot	0.06%
Hook and line	0.04%

Water quality impacts in the Cape Fear River may contribute to poor recruitment of striped bass in this system. Striped bass require dissolved oxygen (DO) levels greater than 5 mg/L (Funderburk et al. 1991), and specific flow conditions are required for the survival of egg, larvae, and juvenile life stages (Rulifson and Manooch 1990). Impacts from urban and agricultural development in the Cape Fear River Basin can negatively impact water quality parameters, and the percentage of land developed for urban and agricultural uses is generally increasing in this system. Nearly 23% of the land in the basin is used for agriculture, such as pork and poultry production (Xian and Homer 2010). Conditions such as elevated temperatures combined with nutrient loading from agricultural and stormwater runoff creates high biological oxygen demand (BOD) and low DO (below 5 mg/L) conditions in the Cape Fear River (Mallin et al. 2006). Striped bass mass mortality caused by poor water quality in the Cape Fear River associated with large storm events have also been observed. In September 2018, water quality impacts from Hurricane Florence led to fish kills in the Cape Fear River. DMF staff observed dead striped bass at multiple locations from Lock and Dam #1 to the Cape Fear River inlet at Caswell Beach and 574 dead striped bass were recovered from Battleship Park (Wilmington, NC) in the week after the storm. Numerous chemical contaminants such as endocrine disrupting compounds (EDCs), heavy metals, per- and polyfluoroalkyl chemicals (PFAS), and other organic pollutants have been found in both the fish and the water of the Cape Fear River (Mallin et al. 2011; Black and Veatch 2018; Guillette et al. 2020). Guillette et al. (2020) found concentrations of PFAS to be 40 times higher in Cape Fear River striped bass than a control group, and these elevated levels were associated with changes to the liver and immune system of the fish.

The construction of the three locks and dams on the mainstem Cape Fear River has significantly reduced the ability of striped bass to reach historic spawning habitat at the fall line. The lowermost lock and dam (river kilometer 95) was completed in 1915 and is located approximately 160 river kilometers downstream of the striped bass spawning habitat at Smiley Falls. By 1935 two more locks and dams were completed above Lock and Dam #1, further restricting possible upriver access to spawning habitat. Fish ladders were constructed at each dam, but striped bass did not successfully use them, and passage over the dam was limited to extreme high flow or locking events (Nichols and Louder 1970). From 1962–2012, the United States Army Corps of Engineers (USACE) operated a daily locking schedule developed by WRC from March through May, with the goal of passing anadromous fish over the dams; however, studies have shown that a large proportion of fish below each dam are unable to pass using the lock chamber (Moser et al. 2000; Smith and Hightower 2012). Based on acoustic telemetry results while the USACE was operating the locking schedule, Smith and Hightower (2012) estimated 77% of striped bass could pass Lock and Dam #1, and only 25% were able to pass all three locks and dams.

In 2012, a rock arch ramp was constructed at Lock and Dam #1 to allow for continuous passage of anadromous fish over the dam without the need for locking. Success criteria for the rock arch ramp was set as 80% passage efficiency for target species by project biologists. Subsequent evaluation of passage at the rock arch ramp resulted in only 25% successful passage of striped bass (Raabe et al. 2019). Despite its failure to improve passage, USACE has not conducted anadromous fish locking at Lock and Dam #1 since construction of the fishway in 2012. Additionally, the lock structures at Lock and Dam #2 and #3 were damaged by Hurricanes Matthew and Florence and have been inoperable since 2018. The rock arch ramp design at Lock and Dam #1 did not meet physical design criteria (e.g., slope, pool dimensions, weir openings) later determined to be required for successful striped bass passage by Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes (Turek and Haro 2016). Cape Fear River Watch received a Coastal Recreational Fishing License grant from DMF to modify the rock arch ramp to better meet the required passage criteria for striped bass, and construction was completed in November 2021.

The Cape Fear River Partnership is a coalition of 35 governmental, academic, and conservation organizations with a goal of restoring self-sustaining stocks of migratory fish in the Cape Fear

River. Since its formation in 2011, the Partnership has facilitated cooperation across member organizations to help achieve fish passage objectives through the construction and modification of the rock arch ramp at Lock and Dam #1 and to advance passage goals at the remaining locks and dams. Bladen County government and Cape Fear River Watch have led the efforts to engineer, design, and permit passage structures at Locks and Dams #2 and 3, securing over $3.1 M in necessary funding to date. In 2018, the USACE initiated a Disposition Study on the future of the locks and dams as they are no longer needed for their authorized purpose of maintaining commercial barge navigation between Wilmington and Fayetteville. The USACE released a draft of the Disposition Study in 2020 in which they recommend deauthorizing all three dams and transferring them to a non-federal entity. Removal of Locks and Dams #1 and #3 is unlikely, as they serve as structures to support storage and intake for the public water supplies of the Wilmington and Fayetteville areas. The NC General Assembly has enacted House Bill 2785, in which the State of North Carolina would accept the transfer of all of the locks and dams, however the structures would need to be "properly refurbished" and have fish passage structures in place for the transfer to occur. Both the NC Department of Environmental Quality and Fayetteville Public Works Commission have filed letters of intent with the USACE to take ownership of the three locks and dams if they are decommissioned. However, additional federal study and action are needed to determine the future of the dams.

In 2016 the Cape Fear River Basin was added to the Sustainable Rivers Program, a joint nationwide effort between the USACE and The Nature Conservancy (TNC) to improve the health of rivers by changing dam operations to enhance and protect ecosystems. A workshop of expert stakeholders considered biological flow needs and hydrologic conditions to make a series of environmental flow recommendations (TNC 2019). Beginning in 2020, the USACE adopted the workshop flow recommendations and modified dam release patterns during rainfall events to purposefully release flow from Jordan Reservoir during the anadromous fish migration period (March–April) to fully submerge all three locks and dams (Figure 4.5). With the dams submerged, it is believed that fish may pass without locking or the use of a fish passage structure. Preliminary evaluation of this new approach suggests that striped bass could time upstream movements with these pulsed flows and successfully migrate over the dams without a passage structure present (Bunch 2021). Additional monitoring is required to fully evaluate the efficacy of this passage strategy.

AUTHORITY

North Carolina's existing fisheries management system for striped bass is adaptive, with rulemaking authority vested in the MFC and the WRC within their respective jurisdictions. The MFC may delegate to the fisheries director the authority to issue public notices, called proclamations, suspending or implementing, in whole or in part, particular MFC rules that may be affected by variable conditions. Management of recreational and commercial striped bass regulations within the Cape Fear River are the responsibility of the MFC in Coastal and Joint Fishing Waters, and recreational regulations are the responsibility of the WRC in Joint and Inland Fishing Waters. It should also be noted that under the provisions of Amendment 1 to the North Carolina Estuarine Striped Bass FMP the DMF Director maintains proclamation authority 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. The WRC Executive Director maintains proclamation authority to establish seasons.

Figure 4.5. Photos showing Lock and Dam #2 at lower flow during the spring anadromous fish migration period (upper image), and fully submerged during the modified dam release flow pulse which is intended to allow fish to pass over the dam without a passage structure present. Photo Credit: Aaron Bunch, Clemson University (Bunch 2021)

NORTH CAROLINA GENERAL STATUTES

N.C. General Statutes

G.S. 113-132.	JURISDICTION OF FISHERIES AGENCIES
G.S. 113-134.	RULES
G.S. 113-182.	REGULATION OF FISHING AND FISHERIES
G.S. 113-182.1.	FISHERY MANAGEMENT PLANS
G.S. 113-221.1.	PROCLAMATIONS; EMERGENCY REVIEW
G.S. 113-292.	AUTHORITY OF THE WILDLIFE RESOURCES COMMISSION IN REGULATION OF INLAND FISHING AND THE INTRODUCTION OF EXOTIC SPECIES.
G.S. 143B-289.52.	MARINE FISHERIES COMMISSION—POWERS AND DUTIES
G.S. 150B-21.1.	PROCEDURE FOR ADOPTING A TEMPORARY RULE

NORTH CAROLINA RULES

N.C. Marine Fisheries Commission Rules 2020 and N.C. Wildlife Resources Commission Rules 2020 (15A NCAC)

15A NCAC 03H .0103	PROCLAMATIONS, GENERAL
15A NCAC 03M .0201	GENERAL
15A NCAC 03M .0202	SEASON, SIZE AND HARVEST LIMIT: INTERNAL COASTAL FISHING WATERS
15A NCAC 03M .0512	COMPLIANCE WITH FISHERY MANAGEMENT PLANS
15A NCAC 03Q .0107	SPECIAL REGULATIONS: JOINT FISHING WATERS
15A NCAC 03Q .0108	MANAGEMENT RESPONSIBILITY FOR ESTUARINE STRIPED BASS IN JOINT FISHING WATERS
15A NCAC 03Q .0109	IMPLEMENTATION OF ESTUARINE STRIPED BASS MANAGEMENT PLANS: RECREATIONAL FISHING
15A NCAC 03Q .0202	DESCRIPTIVE BOUNDARIES FOR COASTAL-JOINT-INLAND WATERS
15A NCAC 03R .0201	STRIPED BASS MANAGEMENT AREAS
15A NCAC 10C .0107	SPECIAL REGULATIONS: JOINT WATERS
15A NCAC 10C .0108	SPECIFIC CLASSIFICATION OF WATERS
15A NCAC 10C .0110	MANAGEMENT RESPONSIBILITY FOR ESTUARINE STRIPED BASS IN JOINT FISHING WATERS
15A NCAC 10C .0111	IMPLEMENTATION OF ESTUARINE STRIPED BASS MANAGEMENT PLANS: RECREATIONAL FISHING
15A NCAC 10C .0301	INLAND GAME FISHES DESIGNATED
15A NCAC 10C .0314	STRIPED BASS

DISCUSSION

Maintain Cape Fear River Harvest Moratorium

Despite a total harvest moratorium and annual hatchery support, the 2020 CSMA striped bass stock report shows continued decline in abundance estimates from 2012 – 2018. Passage efficiency has been demonstrated to be poor over the current configuration of the passage structure at the lowermost dam in the Cape Fear River (Raabe et al. 2019) and egg collection studies indicate most striped bass spawning activity in the mainstem occurs below Lock and Dam #1 (Dial Cordy and Associates 2017). PBT analysis suggests low successful recruitment from wild spawned fish and shows increasing proportions of reservoir stocked fish captured in the river, with fish collected below Buckhorn Dam entirely of reservoir origin. Limited upriver access to appropriate spawning habitat may be preventing stock recovery despite limiting fishing mortality via a moratorium. Modifications for the fish passage structure at Lock and Dam #1, designed to improve passage for striped bass (construction in 2021), will potentially allow striped bass to easily migrate an additional 90 river kilometers upstream before reaching Lock and Dam #2. Anecdotal evidence suggests that fish may be able to pass over Lock and Dam #2 during higher flow conditions. Through NGO and management agency partnerships, millions of dollars to construct passage at both Lock and Dams #2 and #3 have been secured and engineering and design options have been completed. However, USACE permits have not been acquired and the total funding to construct passage at both dams remains incomplete, resulting in an undetermined construction timeframe.

The Northeast Cape Fear River does not have blockages to fish passage. However, the importance of this river for striped bass reproduction has remained relatively unexamined. Acoustic telemetry has shown repeated spring spawning migrations and YOY have been captured in this tributary. Acoustic telemetry data also shows a contingent of fish which show fidelity for the Northeast Cape Fear for spawning migrations and return to the core residency area focused within 10 kilometers around the confluence of the Northeast and mainstem Cape Fear Rivers for the rest of the year (Rock et al. 2018; Prescott 2019). This suggests a small subset of striped bass in the Cape Fear River Basin are successfully spawning in the Northeast Cape Fear and are protected from harvest under the current moratorium.

High levels of PFAS have been found in Cape Fear River striped bass (Guillette et al. 2019). While the specific biological impacts to striped bass remain unknown, the consumption of fish is linked to human PFAS exposure (Haug et al. 2010). The Environmental Protection Agency has established the health advisory levels at 70 parts per trillion in drinking water, and the Great Lakes Consortium for Fish Consumption Advisories states for fish with concentrations of greater than 200 µg/kg as "DO NOT EAT". Under a harvest moratorium, striped bass are not retained for consumption. However, DMF and WRC have not placed harvest restrictions on finfish due to consumption advisories, and no specific consumption advisory has been issued for PFOS in striped bass by the Occupational and Environmental Epidemiology Branch of the North Carolina Division of Public Health.

PBT analysis results demonstrate that most of the striped bass sampled in the Cape Fear River are of hatchery origin, and most of the fish sampled above Lock and Dam #1 are hatchery reared fish which have been stocked into the upriver reservoirs. Current WRC inland fishing regulations allow for harvest in the hatchery supported striped bass fisheries of the reservoirs in the Cape Fear basin above Buckhorn Dam. However, as the reservoir stocking of striped bass has been discontinued, the downriver migration of reservoir fish into the Cape Fear River will no longer occur.

WRC management has stated if a harvest moratorium remains in place, the continued allocation of substantial WRC resources to stock striped bass on an annual basis in the Cape Fear River cannot be justified. The North Carolina Interjurisdictional Fisheries annual stocking work plan may be modified in order to best use WRC hatchery resources for stocking other systems. For annual stocking to continue in the Cape Fear River, production of striped bass may need to be shifted to the federal partner.

Allow Seasonal Harvest in All Cape Fear River Fishing Waters

Removing the harvest moratorium for striped bass in the Cape Fear River would require a change to or suspension of MFC Rules 15A NCAC 03M .0202 (a)(b), and 15A NCAC 03Q .0107 (1)(d), as well as a change to WRC Rules 15A NCAC 10C .0107 (1)(d), and 15A NCAC 10C .0314 (h). The remaining MFC rule language would allow commercial or recreational harvest in Joint and Coastal Fishing Waters (Figure 4.6) between October 1 through April 30 and would cap the potential minimum size limit at no less than 18 inches. This rule would also allow for a recreational bag limit of no more than two fish per day. More conservative season dates, size or bag limits, and area restrictions may be specified by proclamation. Any commercial landings of striped bass from the Cape Fear River could count toward a TAL applicable to the CSMA, be managed under a separate TAL, or another strategy depending on other management actions adopted.

Allowing harvest under a hatchery supported striped bass fishery management strategy in the lower river would create equity in management throughout the system. Because very few striped bass in the Cape Fear basin appear to be of wild origin and current impediments to passage limit the ability of striped bass to reach appropriate spawning habitat in the mainstem Cape Fear, fishing mortality would likely have little impact on the amount of wild spawned fish in the system. However, an increase in fishing mortality may exacerbate the decline in abundance of striped bass observed in recent years and potentially further truncate the age structure of the population. Size and possession limits could be established to protect certain age or size classes and could potentially mitigate impacts to population demographics from increased fishing mortality. As strategies to improve passage at the locks and dams are implemented, maintaining sufficient spawning stock biomass with an expanded age structure available to migrate to the spawning grounds will be necessary for striped bass recovery efforts in the Cape Fear River.

Allowing recreational harvest of the predominantly hatchery supported striped bass in the Cape Fear River may be viewed by recreational anglers as a suitable use of the hatchery produced fishery resource. However, opening the Joint and Coastal Fishing Waters to the taking of striped bass would potentially allow for the commercial harvest of this hatchery supported population. Commercial harvest of hatchery supported fish may create user conflicts or be perceived as a poor use of the resource by recreational anglers. The potential harvest by commercial fishers could be accommodated by allocating a small quota to the commercial sector and by using contributions from commercial fishing license sales to help support the hatchery program. While striped bass from the Cape Fear River did not historically contribute much to the overall statewide commercial landings, they were a consistent component of finfish landings from the system. With increased regulation in other commercial fisheries, opening striped bass for commercial harvest in the Cape Fear River may result in a larger percentage of the finfish landings from this waterbody than before the harvest moratorium.

Allowing harvest of striped bass from all waters of the Cape Fear system would increase fishing mortality on the small and relatively unstudied contingent of potentially naturally reproducing fish in the Northeast Cape Fear River, possibly leaving them vulnerable to overharvest or depletion.

Allow Seasonal Harvest in Joint and Inland Fishing Waters in the Mainstem Cape Fear River Above 140 Bridge

Harvest area boundaries can be set with the goal of allowing harvest on hatchery supported striped bass in the Cape Fear River, while protecting the relatively small and unstudied contingent of fish that may spawn in the Northeast Cape Fear. Allowing harvest of striped bass only in the Joint and Inland Fishing Waters of the Cape Fear River above the Highway 140 Bridge (Figure 4.5), would limit the harvest of the Northeast Cape Fear contingent of fish. Opening Joint Fishing Waters above the Highway 140 Bridge to striped bass harvest could allow for the commercial harvest of striped bass in this section of river. A commercial shad drift gillnet fishery operates between February 20 and April 11 each year. Due to protected species interactions, set gill net gear has been prohibited in this section of river. Striped bass may be targeted in this fishery if harvest is allowed. A hook and line commercial fishery could be developed. For more information on hook and line as a potential commercial gear, see Appendix 5 Use of Hook and Line as a Commercial Gear in the Estuarine Striped Bass Fishery.

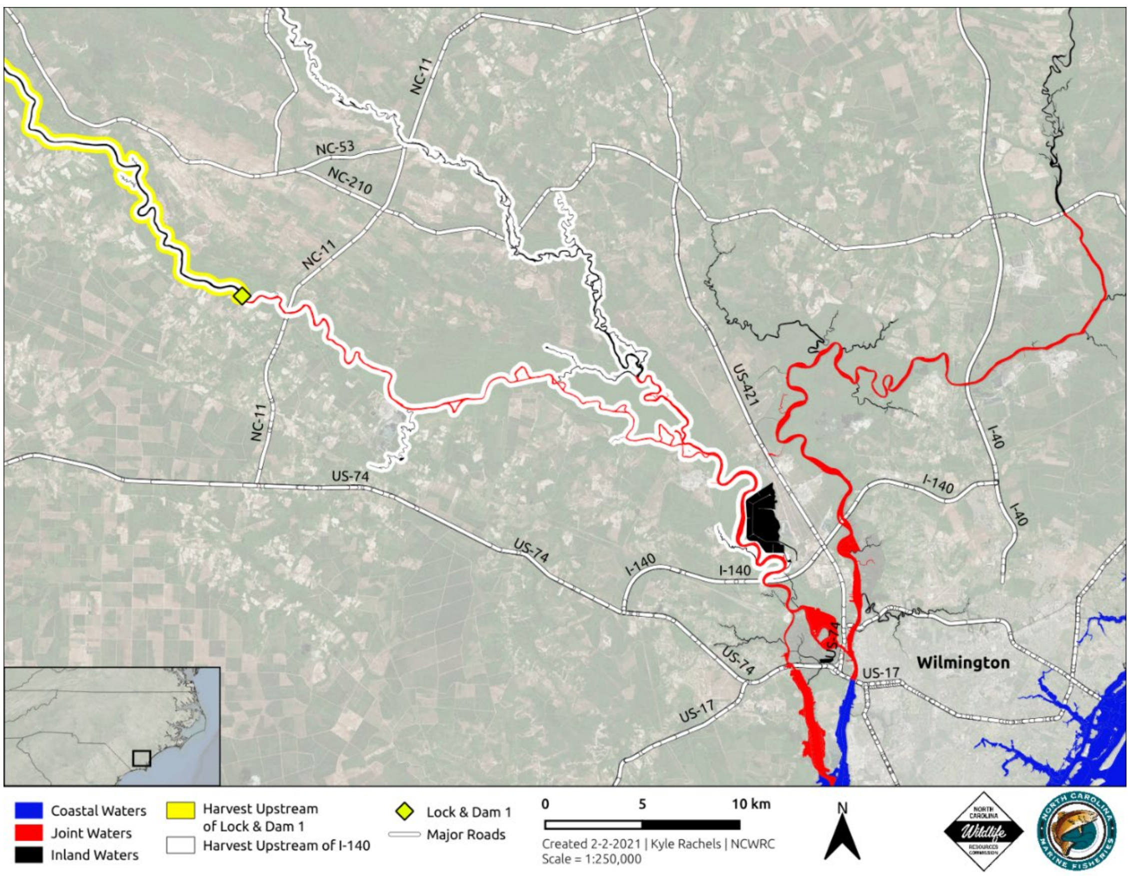


Figure 4.6. A map showing Inland, Joint, and Inland Fishing waters, as well as the harvest area boundaries for the proposed management options.

Allow Seasonal Harvest in Inland Fishing Waters only above the Joint / Inland Fishing Waters boundary on the Mainstem of the Cape Fear River

The Cape Fear River above Lock and Dam #1 is classified as Inland Fishing Waters and the commercial harvest of Inland Game Fish is prohibited in Inland Fishing Waters. Since striped bass is considered an Inland Game Fish, harvest above Lock and Dam #1 would be limited to recreational hook and line only, per inland fishing regulations. Most striped bass captured at stations above Lock and Dam #1 were determined to be hatchery origin fish which had moved down river from reservoirs. However, the discontinuation of striped bass stocking in Jordan Lake may reduce the number of fish in the Cape Fear River upstream of Lock and Dam #1. Stocking locations may be modified in the Cape Fear River to continue to supply hatchery origin fish to locations upriver of the locks and dams.

Adaptive Management

Adaptive management allows managers to change management strategies when new information or data becomes available. Management options, which are selected during the FMP process, take into account the most up to date data on the biological and environmental factors which affect the stock. After the implementation of the FMP, if additional data is available about a fishery or key factors change, adaptive management provides the flexibility to incorporate this new information to inform alternative and/or additional actions needed for sustainable fisheries management. A range of adaptive management actions, as well as criteria for their application can be established within the FMP management framework to improve both short- and long-term management outcomes.

Results from YOY juvenile abundance and distribution surveys, as well as PBT analysis can be used to evaluate natural reproduction of striped bass in the Cape Fear River system. The collection of YOY striped bass from the mainstem Cape Fear or Northeast Cape Fear rivers will be considered evidence for natural reproduction occurring in the branch where the juveniles were collected. The proportion of fish determined to be of unknown origin by PBT analysis will be used to determine the percentage of hatchery contribution to the Cape Fear River striped bass stock.

The proposed adaptive management framework for sustainable harvest of striped bass in the Cape Fear River system consists of the following:

1. Continue YOY surveys and PBT analysis after the adoption of the FMP.

a. If adopted management measures include allowing harvest of striped bass in any waters of the Cape Fear River, and YOY surveys and/or PBT analysis suggest levels of natural reproduction greater than observed up to the time of FMP adoption, then management measures may be re-evaluated and adjusted by proclamation using the authority granted to DMF and WRC directors. Rule changes or suspensions required to allow harvest.

b. If adopted management measures do not allow for harvest of striped bass in the Cape Fear River, and YOY surveys and/or PBT analysis suggest levels of natural reproduction less than observed up to the time of FMP adoption, then management measures may be re-evaluated, and harvest adjusted by proclamation using the authority granted to the DMF and WRC directors. Rule changes or suspensions required to allow harvest.

2. Management measures which may be adjusted include: means and methods, harvest area, as well as season, size and creel limit (as allowed for in rule).

3. Use of the DMF director's proclamation authority for adaptive management is contingent on evaluation of adaptive management measures by the Striped Bass Plan Development Team and consultation with the Finfish Advisory Committee.

MANAGEMENT OPTIONS

(+ potential positive impact of action)
(- potential negative impact of action)

For management of commercial striped bass regulations within Coastal and Joint Fishing Waters of the Cape Fear River, the MFC adopts rules and implements management measures. For management of recreational striped bass regulations within Coastal Fishing Waters (that are not also Joint Fishing Waters) of the Cape Fear River, the MFC adopts rules and implements management measures. For management of recreational striped bass regulations within Inland Fishing Waters of the Cape Fear River, the WRC adopts rules and implements management measures.

For management of recreational striped bass regulations within Joint Fishing Waters of the Cape Fear River, the MFC and WRC have jointly adopted rules. MFC rule 15A NCAC 03Q .0107(d) and WRC rule 15A NCAC 10C .0107(d) state it "is unlawful to possess striped bass or striped bass hybrids taken from the joint fishing waters of the Cape Fear River." If the MFC and the WRC agree to change this management measure as part of final approval of the Estuarine Striped Bass FMP Amendment 2, the corresponding rules would be amended accordingly. If the MFC and the WRC do not agree to change this management measure, the current rules would remain in place for Joint Fishing Waters.

By law, those Coastal Fishing Waters in which are found a significant number of freshwater fish, as agreed upon by the MFC and the WRC, may be classified as Joint Fishing Waters. The MFC and WRC may make joint regulations governing the responsibilities of each agency and modifying the applicability of licensing and other regulatory provisions as may be necessary for rational and compatible management of the marine and estuarine and wildlife resources in Joint Fishing Waters (G.S. 113-132). Those joint rules are found in 15A NCAC 03Q .0100 (MFC) and 10C .0100 (WRC).

1. Striped Bass Harvest
   A. Status Quo: maintain Cape Fear River harvest moratorium
   + maintains protection for Northeast Cape Fear River wild spawning contingent
   + does not increase fishing mortality to population declining in abundance
   +/- no harvest of a primarily hatchery supported stock
   +/- continues current catch and release recreational fishery

B. Allow seasonal harvest in all Cape Fear River fishing waters (proposed season and limits: open season March 1–April 30; 18-inch TL minimum length limit; 2 fish daily creel limit)
+ equity in harvest regulation across the system and user groups
+/- allow harvest of a primarily hatchery supported stock
- potential user conflicts around hatchery supported stock
- allows harvest of Northeast Cape Fear River wild spawning contingent
- may increase fishing mortality to population declining in abundance

C. Allow seasonal harvest in joint and inland fishing waters in the mainstem Cape Fear River above the 140 Bridge (proposed season and limits: open season March 1–April 30; 18-inch TL minimum length limit; 2 fish daily creel limit)
+ offers protection to Northeast Cape Fear River wild spawning contingent
+/- allow harvest of a primarily hatchery supported stock
- creates additional management boundary and regulation complexity
- inequity in harvest regulation across the system by user groups
- potential user conflicts around hatchery supported stock
- may increase fishing mortality to population declining in abundance

D. Allow harvest in inland fishing waters only above the Joint/Inland Waters boundary on the mainstem of the Cape Fear River (proposed season and limits: no closed season; 20-inch TL minimum length limit; 4 fish per day)
+ offers protection to Northeast Cape Fear River wild spawning contingent
+/- allow harvest of a primarily hatchery supported stock
- creates additional regulation complexity using existing management boundary
- inequity in harvest regulation across the system by user groups
may increase fishing mortality to population declining in abundance

2. Adaptive Management

- Continue YOY surveys and PBT analysis after the adoption of the FMP
- If YOY surveys and/or PBT analysis suggest levels of natural reproduction have increased or decreased compared to what was observed up to the time of FMP adoption, then management measures may be re-evaluated using this new information and adjusted by proclamation using the authority granted to DMF and WRC directors. Rule changes or suspensions required to allow harvest.
- Management measures which may be adjusted include means and methods, harvest area, as well as season, size and creel limit (as allowed for in rule)
- Use of the DMF director's proclamation authority for adaptive management is contingent on evaluation of adaptive management measures by the Striped Bass Plan Development Team and consultation with the Finfish Advisory Committee

+ Adaptive management allows for management adjustments to any of the selected management options as new data becomes available

- Creates management uncertainty if not clearly defined

RECOMMENDATIONS

See Appendix 6 for DMF, WRC, and advisory committees recommendations and a summary of online public.

NCMFC Preferred Management Strategy

Options: 1.A. and 2.

APPENDIX 5: THE USE OF HOOK AND LINE AS A COMMERCIAL GEAR IN THE ESTUARINE STRIPED BASS FISHERY

ISSUE

Reevaluating the use of hook and line as a gear in the estuarine striped bass commercial fishery.

ORIGINATION

North Carolina Marine Fisheries Commission (MFC) selected management strategy in Amendment 1 to the North Carolina Estuarine Striped Bass Fishery Management Plan (FMP).

BACKGROUND

In response to a petition for rulemaking received in 2010, the MFC directed the North Carolina Division of Marine Fisheries (DMF) to examine the implications of allowing and promoting a commercial hook and line fishery statewide for all finfish species. An information paper was developed and concluded the use of hook and line as a commercial gear was feasible and should be managed on a fishery-by-fishery basis in conjunction with the FMP process (NCDMF 2010).

Amendment 1 to the North Carolina Estuarine Striped Bass FMP recommended not allowing hook and line as a commercial gear for striped bass unless future restrictions on the use of gill nets necessitate alternative commercial gears (NCDMF 2013). To facilitate the adaptive management aspect of the MFC selected management strategy, the portion of rule 15A NCAC 03M .0201 which prohibited the commercial sale of striped bass taken with hook and line gear was repealed. For more information, see the issue paper titled "Estuarine Striped Bass Fishery Commercial Hook-And-Line" in Amendment 1 of the Striped Bass FMP.

Since the adoption of Amendment 1 and subsequent rule change, the Fisheries Director has used proclamation authority granted in MFC Rule 15A NCAC 03M .0202 (4) to prohibit the use of hook and line in the commercial striped bass fisheries when they occur in the Albemarle Sound Management Area (ASMA) and the Central Southern Management Area (CSMA).

The striped bass fisheries in both the ASMA and CSMA are managed through proclamations or rules designed to keep overall harvest levels below the annual Total Allowable Landings (TAL) for each management area and fishing sector (commercial or recreational). The ASMA commercial striped bass gill net fishery is regulated as a "bycatch fishery", where striped bass landings cannot exceed 50 percent by weight of all other finfish species landed by trip. Most striped bass gill net harvest in the ASMA occurs in conjunction with the American shad *(Alosa sapidissima*), southern flounder (*Paralichthys lethostigma*), or the invasive blue catfish (*Ictalurus furcatus*) gill net fisheries. Increased gill net regulations implemented to meet sustainability objectives in the American shad and southern flounder fisheries have limited the amount of time gill nets can be set and reduced the opportunity to harvest striped bass in gill net fisheries.

The 2020 Albemarle-Roanoke striped bass benchmark stock assessment indicated the stock is overfished and overfishing is occurring (Lee et. al 2020). An evaluation of CSMA stocks indicates the striped bass populations are depressed to a point where no level of fishing mortality is sustainable (Mathes et al. 2020). As a response to poor stock conditions in the CSMA a no harvest provision has been in place for striped bass in the Cape Fear River since 2008 and in the remainder of the management area since 2019.

The only management area currently open to the commercial harvest of striped bass is the ASMA. The 2020 Revision to Amendment 1 reduced the TAL in the ASMA from 275,000 pounds to 51,216 pounds, with the goal of reducing fishing mortality and ending overfishing (NCDMF 2020). As of January 1, 2021, the commercial TAL for the ASMA was set at 25,608 pounds. The commercial fishery was open for only 16 days in the spring of 2021 and exceeded the TAL by approximately 2,000 pounds (preliminary data NC Quota Monitoring Program).

For more information on the ASMA or CSMA striped bass stocks and fisheries see: Lee et al. 2020, Mathes et al. 2020, as well as Appendices 2, 3, and 4.

Since the implementation of Amendment 1, management actions resulting in additional restrictions on the use of gill nets (e.g., area closures, shorter seasons) have prompted the need to explore the steps required for the implementation of the previously selected MFC adaptive management strategy to allow hook and line as an alternative commercial gear for striped bass. With the moratorium in the CSMA and the relatively small commercial TAL in the ASMA, commercial striped bass harvesters have not had difficulty landing all of the available striped bass TAL in recent years. However, as striped bass stocks recover, harvesters may not be able to take advantage of any future TAL increases given the increasing restrictions on the use of gill nets unrelated to striped bass. This issue paper evaluates the Amendment 1 adaptive management strategy of allowing hook and line as a commercial gear in the striped bass fishery. The proposed approach enhances the ability of DMF to monitor commercial landings, with the goal of maintaining harvest levels below the TAL needed to recover the stock.

Earlier issue papers have identified conflicts and concerns related to harvest and possession limits that arise when allowing hook and line as a commercial gear (NCDMF 2010, 2013). Based on these previously identified concerns, the DMF used the following to address management considerations required to allow hook and line gear in the commercial harvest of estuarine striped bass:

- Determine licensing requirements
- Determine harvest and possession limits
- Consider simultaneous use of hook and line with other gear types
- Distinguish commercial from recreational or for hire trips
- Tagging, landing, and reporting requirements

AUTHORITY

North Carolina General Statutes

GS 113-134	RULES
GS 113-182	REGULATION OF FISHING AND FISHERIES
GS 113-182.1	FISHERY MANAGEMENT PLANS
GS 113-221.1	PROCLAMATIONS; EMERGENCY REVIEW
GS 143B-289.52	MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103	PROCLAMATIONS, GENERAL
15A NCAC 03M .0201	GENERAL, STRIPED BASS
15A NCAC 03M .0202	SEASON, SIZE AND HARVEST LIMIT: INTERNAL COASTAL WATERS
15A NCAC 03M .0512	COMPLIANCE WITH FISHERY MANAGEMENT PLANS

DISCUSSION

Determine licensing requirements

Standard Commercial Fishing License (SCFL) and Retired Standard Commercial Fishing License (RSCFL) holders are allowed to commercially harvest striped bass by any legal method when the season is open in each management area. No additional licensing requirements are necessary to use hook and line as a commercial gear. However, DMF recommends the creation and requirement of a no cost Hook and Line Striped Bass Permit for SCFL or RSCFL license holders wanting to participate in this fishery. This permit would be required for the commercial harvest of striped bass by hook and line methods and allows for the targeted collection of effort and participation data for this gear type.

Summary: Require SCFL or RSCFL with Striped Bass Hook and Line Permit.

DETERMINE HARVEST AND POSSESSION LIMITS

If striped bass TAL is available for commercial harvest in a management area, the Fisheries Director may use proclamation authority to designate hook and line as a legal commercial gear. The hook and line daily individual limit should be at least the same as the daily commercial limit for gill nets, to not disincentivize this gear as a substitute for gill nets. Additionally, the daily individual limit for the commercial harvest of striped bass by hook and line may be set higher than the gill net limit as a means to encourage the use of hook and line as an alternative gear. A vessel should be limited to two daily hook and line commercial limits when two or more permit holders are on board to align with current gill net limits, both for ease of enforcement and compliance. Having commercial limits that are higher than recreational limits may incentivize latent or dual recreational and commercial license holders to use hook and line to harvest the higher commercial limits, even if these fish were not to be sold. This concern is addressed in the following sections of this paper.

Summary: The Fisheries Director may use proclamation authority to designate hook and line as a legal commercial harvest gear in a management area and set the individual harvest limit to be at least the same for both hook and line and gill net. Commercial hook and line vessels will be restricted to the proclaimed limit of two commercial license holders when two Striped Bass Permit holders are on the vessel.

CONSIDER SIMULTANEOUS USE OF HOOK AND LINE WITH OTHER GEAR TYPES

Current restrictions limit the total weight of striped bass landed in a commercial operation to not exceed 50 percent of the combined weight of the total daily catch of all species. The purpose of managing harvest in this manner is to allow commercial gill net operations targeting other species to land striped bass, reducing discards and maintaining landings below the TAL. Any hook and line only commercial trips for striped bass (no other commercial harvest gear onboard) would not be subject to a 50 percent bycatch provision.

If an area is simultaneously open to the use of commercial hook and line and gill net, both gears could be used simultaneously. This makes it challenging for law enforcement to determine which fish were captured by what gear. Any vessel that has a gill net onboard will be subject to the catch limits and harvest restrictions for gill nets (including requiring the 50 percent bycatch provision) and will be considered a gill net trip regardless of whether the gill net was used.

Summary: If an area is open to both commercial hook and line harvest and the use of gill nets, and a vessel has a gill net onboard, the vessel is subject to the catch limits and regulations governing the use of gill nets.

DISTINGUISH COMMERCIAL FROM RECREATIONAL OR FOR-HIRE TRIPS

Some individuals hold for-hire, commercial, and/or recreational fishing licenses. The use of hook and line has typically been sufficient to delineate commercial participants from recreational and for-hire sectors. A concern of allowing hook and line gear to be used both recreationally and commercially is latent SCFL or RSCFL holders and for-hire vessel captains who also hold commercial licenses using hook and line gear to land higher commercial trip limits for recreational purposes.

The number of participants landing striped bass in the commercial fishery has steadily declined in the ASMA and CSMA since the late 1990s. The number of participants peaked at 449 in the ASMA in 1999 and declined to 155 in 2020, while the number of participants peaked at 297 in the CSMA in 1997 and fell to 95 in 2018. However, the number of commercial license holders residing in counties surrounding the ASMA and CSMA that could legally participate in the fishery is much higher. In 2020, there were 1,632 SCFL/RSCFL licenses held by individuals residing in counties adjoining the ASMA and 5,282 in counties adjoining the CSMA.

Allowing hook and line as a commercial harvest gear provides individuals who hold multiple license types the ability to retain commercial limits on what would otherwise be recreational or for-hire hook and line trips. Striped bass harvested in this manner would not be sold and not reported in the NC Trip Ticket Program (TTP), resulting in an underestimate of commercial harvest from the stock. To mitigate this scenario, commercial hook and line only trips for striped bass will be restricted to no more than two people per vessel. Appropriately licensed and permitted vessels with two people or less may harvest striped bass commercially in a manner and amount defined by proclamation, and landings concerns will be addressed by reporting requirements.

Summary: Commercial hook and line harvest for striped bass will be limited to no more than two persons per vessel.

Landing and reporting requirements

It is a requirement that all striped bass landed commercially be tagged. The purpose of this tagging requirement is to minimize the illegal harvest and sale of striped bass. North Carolina requires commercially harvested striped bass to be tagged by the dealer at the point of sale. Dealers are required to report to DMF daily the number and pounds of striped bass tagged. This daily reporting requirement allows DMF to monitor harvest in near real-time which aids in ensuring the annual TAL is not exceeded.

Fish kept for personal consumption by SCFL and RSCFL holders are not sold and accounted for as landings. Without a record of sale, this harvest would not be captured in the TTP, leading to an underestimate of total removals from the stock. An accurate estimate of total removals is important information for stock assessments to estimate population abundance and determine stock status. There is no evidence that unreported landings are occurring in any significant amount with the current harvest methods allowed in the estuarine striped bass fishery. However, without additional reporting requirements the use of hook and line as a commercial gear could increase uncertainty in stock removal estimates. To minimize the uncertainty in these removal estimates, SCFL or RSCFL holders using hook and line as a commercial gear could be required to report the disposition of all retained striped bass catch (sold or kept for personal use) through the TTP. The establishment of a reporting requirement for all retained striped bass catch by commercial license holders is an option that can pursued by DMF and MFC, however enacting this requirement would need legislative action and a change to the North Carolina General Statutes.

Summary: Maintain established tagging and reporting requirements for all landed striped bass and explore options for additional reporting requirements for all commercial license holders on the disposition of all retained striped bass catch (sold or kept for personal use) through the TTP.

The ASMA is the only management area currently open to the commercial harvest of striped bass, and this stock has been determined to be overfished. To recover this stock, harvest must remain at or below the established TAL. This relatively low TAL was reached and exceeded in 16 days in 2021, with only the amount of effort and participation occurring under the current regulatory structure. By allowing the use of hook and line as gear, there is the potential for additional effort to occur in the commercial fishery. Given the current low TAL, any increase in effort may make it more difficult to constrain commercial landings within the current TAL and impact the sustainable management of this fishery. However, immediately allowing hook and line as a means of commercial harvest concurrent with the use of gill nets, even under the current low TAL, could be a proactive approach providing additional means to harvest striped bass. This additional gear may become necessary as striped bass stocks recover and the TAL increases, assuming current gill net restrictions remain in place.

Implementation of the use of hook and line gear in the commercial fishery could be delayed again until potential future restrictions or prohibitions on the use of gill nets prevent commercial striped bass harvest with this gear, or the stocks have recovered to a point where any increase in effort will not potentially impact the ability to sustainably manage harvest in the fishery. However, an additional management tool which may be necessary to consider given current stock status and the very low TAL, is limited entry. North Carolina General Statute 113-182.1 states the MFC can only recommend the General Assembly limit participation in a fishery if the commission determines sustainable harvest in the fishery cannot otherwise be achieved. In North Carolina General Statute 143B-289.52 (d1) the MFC can already regulate participation in a federal fishery, subject to a federal fishery management plan, if that plan imposes a quota on the State for the harvest and landing of fish in the fishery. As both the ASMA and CSMA striped bass stocks are in poor condition, maintaining sustainable harvest is a concern. Because the ASMA striped bass stock is overfished the MFC can consider whether the only way to achieve sustainable harvest goals in this fishery is by limiting participation.

Adaptive Management

Adaptive management allows managers to change management strategies when new information or data becomes available. Management options, which are selected during the FMP process, account for the most recent data on the biological and environmental factors that affect the stock. After implementation of the FMP, if additional data are available about a fishery or key factors change, adaptive management provides the flexibility to incorporate this new information to inform alternative and/or additional actions needed for sustainable fisheries management. A range of adaptive management actions, as well as criteria for their application, can be established within the FMP management framework to improve both short- and long-term management outcomes.

Targeted data collected from the Striped Bass Hook and Line Permit, Marine Patrol enforcement activity, as well as DMF License and Statistics TTP and Quota Monitoring data will be used to evaluate effort, participation, and striped bass hook and line landings.

The proposed adaptive management framework for the use of hook and line as a commercial gear in the estuarine striped bass fishery consists of the following:

1. Allow hook and line as a commercial gear for the harvest of striped bass.
    a. If hook and line is allowed for the commercial harvest of striped bass and TTP and Quota Monitoring data indicate the TAL will <u>either</u> be quickly exceeded <u>or</u> unable to be met during the potential striped bass season, then management measures may be re-evaluated and adjusted by the proclamation authority granted to the Fisheries Director (as is currently occurring under the existing management strategy).
    b. If hook and line is allowed for the commercial harvest of striped bass and Marine Patrol enforcement activity or License and Statistics data suggest significant amounts of unreported commercial striped bass catch is occurring, then additional tagging or reporting requirements may be developed and implemented.

2. Management measures that may be adjusted include means and methods, harvest area, as well as season, size, and quantity.
3. Implementation of adaptive management measures to enact additional increased tagging or reporting requirements is contingent on evaluation of these measures by the Striped Bass Plan Development Team and consultation with the MFC.

MANAGEMENT OPTIONS

+ (Potential positive impact of the action)
- (Potential negative impact of the action)

1. Hook and Line as a Commercial Gear
   - A. Do not allow hook and line as a commercial gear in the estuarine striped bass fishery at this time
   - \+ No incentive for increased effort on overfished/overfishing stock
   - \+ No additional regulatory burden to harvesters (additional TTP reporting)
   - \- Does not provide an alternate gear for harvest with increasing regulation on gill nets
   - \- Does not provide DMF additional harvest data collection (via permits and TTP)
   - B. Allow hook and line as a commercial gear in the estuarine striped bass fishery at this time
   - \+ Provides an alternate gear for harvest with increasing regulation on gill nets
   - \+ Provides DMF additional harvest data collection (via permits and TTP)
   - \- Incentive for increased effort on overfished/overfishing stock

2. Adaptive Management
   - If hook and line is allowed for the commercial harvest of striped bass and NC TTP and Quota Monitoring data indicate the TAL will <u>either</u> be quickly exceeded <u>or</u> unable to be met during the potential striped bass season, then management measures may be re-evaluated and adjusted by the proclamation authority granted to the Fisheries Director (as is currently occurring under the existing management strategy).
   - If hook and line is allowed for the commercial harvest of striped bass and Marine Patrol enforcement activity or License and Statistics data suggest significant amounts of unreported commercial striped bass catch is occurring, then additional tagging or reporting requirements may be developed and implemented.
   - Management measures that may be adjusted include means and methods, harvest area, as well as season, size and limit.
   - Implementation of adaptive management measures to enact additional increased tagging or reporting requirements is contingent on evaluation of these measures by the Striped Bass Plan Development Team and consultation with the Marine Fisheries Commission.

RECOMMENDATIONS

See Appendix 6 for DMF, WRC, and advisory committees recommendations and a summary of online public.

NCMFC Preferred Management Strategy

Options: 1.A. and 2.

APPENDIX 6: SUMMARY OF DMF, WRC, MFC ADVISORY COMMITTEE RECOMMENDATIONS, AND ONLINE SURVEY RESPONDENTS FOR ISSUE PAPERS IN THE NORTH CAROLINA ESTUARINE STRIPED BASS FMP AMENDMENT 2

Table 6.1. Summary of DMF, WRC, MRC standing and regional Advisory Committee recommendations, and summary of online survey respondents for management options in the North Carolina Estuarine Striped Bass FMP Amendment 2.

Issue Paper	DMF and WRC Recommendations	Northern Regional Advisory Committee Recommendation	Southern Regional Advisory Committee Recommendation	Finfish Standing Advisory Committee Recommendation	Online Questionnaire Summary of Support *
APPENDIX 2: ACHIEVING SUSTAINABLE HARVEST FOR THE ALBEMARLE SOUND-ROANOKE RIVER STRIPED BASS STOCK	DMF: Option 1.A. WRC: Option 1.A.	No recommendation passed	Support the DMF and WRC staff initial recommendation, Option 1.A.	Support the DMF and WRC staff initial recommendation, Option 1.A.	53% Option 1.B. 41% Option 1.A. If a moratorium was in place 56% would still target striped bass for recreational catch-and-release
	DMF: Option 2.A. WRC: Option 2.A.	Support the DMF and WRC staff initial recommendation, Option 2.A.	Support the DMF and WRC staff initial recommendation, Option 2.A.	Support the DMF and WRC staff initial recommendation, Option 2.A.	70% Option 2.A. 8% Option 2.B.
	DMF: Option 3.D. WRC: Do not support any options as written; support the following modified option:	Support the DMF recommendation, Option 3.D.	Support the DMF recommendation, Option 3.D.	Support the DMF recommendation, Option 3.D.	68% single fishery payback above TAL 9% divide across all fisheries 8% single fishery pay back a portion of landings above TAL (buffer) 5% no payback
	WRC language: If the landings in any one of the three fisheries (RRMA recreational, ASMA recreational, and ASMA commercial) exceed their allocated TAL by 5% in a calendar year, any landings in excess of their allocated TAL and 5% buffer will be deducted from that fishery's allocated TAL the next calendar year. If the payback for a fishery exceeds the next year's allocated TAL, the fishery will be closed the subsequent year with no additional payback required.				
	DMF: Options 4.C. and 4.E. WRC: Options 4.C. and 4.E.	Support the DMF and WRC staff initial recommendation, Options 4.C. and 4.E.	Support the DMF and WRC staff initial recommendation, Options 4.C. and 4.E.	Support the DMF and WRC staff initial recommendation, Options 4.C. and 4.E.	83% size limit changes to increase older fish 71% Options 4.C. and 4.E. 11% status quo.

Table 6.1. Continued.

Issue Paper	DMF and WRC Recommendations	Northern Regional Advisory Committee Recommendation	Southern Regional Advisory Committee Recommendation	Finfish Standing Advisory Committee Recommendation	Online Questionnaire Summary of Support *
APPENDIX 2: CONTINUED	DMF: Options 5.A. and 5.E. WRC: Options 5.A. and 5.E.	Support the DMF and WRC staff initial recommendation, Options 5.A. and 5.E.	Support the DMF and WRC staff initial recommendation, Options 5.A. and 5.E.	Support the DMF and WRC staff initial recommendation, Options 5.A. and 5.E.	49% Option 5.B. 19% Option 5.D. 17% Option 5.E. 11% Option 5.C.
	DMF: Support all Adaptive Management measures WRC: Support all Adaptive Management measures	Support the DMF and WRC staff initial recommendation to support all Adaptive Management measures	Support the DMF and WRC staff initial recommendation to support all Adaptive Management measures	Support the DMF and WRC staff initial recommendation to support all Adaptive Management measures	N/A
APPENDIX 3: ACHIEVING SUSTAINABLE HARVEST FOR THE TAR-PAMLICO AND NEUSE RIVERS STRIPED BASS STOCKS	DMF: Option 1.A. WRC: Option 1.A.	Recommend to end no-possession measure.	Support the DMF and WRC staff initial recommendation, Option 1.A.	Support the DMF and WRC staff initial recommendation, Option 1.A.	59% Option 1.A. 32% Option 1.B.
	DMF: No recommendation WRC: Option 2.A.	Ask the MFC to end the gill net closure above the ferry lines and return to NCDMF regulations prior to the 2019 closure.	Recommend to MFC to remove the gill net moratorium above the ferry lines and re-implement the management measures prior to the 2019 closure.	No recommendation.	60% support maintaining closure above ferry lines and 3-foot tie down use below ferry lines 12% opposed
	DMF: Support all Adaptive Management measures WRC: Support all Adaptive Management measures with additional language	Support the DMF and WRC staff initial recommendation to support the Adaptive Management measure	Support the DMF and WRC staff initial recommendation to support the Adaptive Management measure	Support the DMF and WRC staff initial recommendation to support the Adaptive Management measure	N/A

Table 6.1. Continued.

Issue Paper	DMF and WRC Recommendations	Northern Regional Advisory Committee Recommendation	Southern Regional Advisory Committee Recommendation	Finfish Standing Advisory Committee Recommendation	Online Questionnaire Summary of Support *
APPENDIX 4: ACHIEVING SUSTAINABLE HARVEST FOR THE CAPE FEAR RIVER STRIPED BASS STOCK	DMF: Option 1.A. WRC: Option 1.B.	Support the DMF initial recommendation, Option 1.A.	Support the DMF initial recommendation, Option 1.A.	Support the DMF initial recommendation, Option 1.A.	65% Support continued harvest moratorium 14% opposed
	DMF: Support all Adaptive Management measures WRC: Support all Adaptive Management measures	Support the DMF and WRC staff initial recommendation to support all Adaptive Management measures	Support the DMF and WRC staff initial recommendation to support all Adaptive Management measures	Support the DMF and WRC staff initial recommendation to support all Adaptive Management measures	N/A
APPENDIX 5: THE USE OF HOOK AND LINE AS A COMMERCIAL GEAR IN THE ESTUARINE STRIPED BASS FISHERY	DMF: Option 1.A. WRC: Option 1.A.	Support the DMF initial recommendation, Option 1.A.	Support the DMF initial recommendation, Option 1.A.	Support the DMF initial recommendation, Option 1.A.	65% Option 1.A If harvest is allowed: 15% Option 1.B. 16% Option 1.C. 16% Option 1.D. 54% uncertain or no opinion.
	DMF: Support all Adaptive Management measures WRC: Support all Adaptive Management measures	Support the DMF initial recommendation to support all Adaptive Management measures	Support the DMF initial recommendation to support all Adaptive Management measures	Support the DMF initial recommendation to support all Adaptive Management measures	N/A

Breakdown of respondents: Recreational Fishing (84%), Charter/For-Hire (5%), Seafood Consumer (4%), Other (4%), Commercial Fishing (2%), NGO (2%), Seafood Dealer/Retail/Restaurant (0%), and Academic (0%).

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North Carolina General Assembly
State Legislative Building
Raleigh, North Carolina 27601

July 14, 2022

Secretary Elizabeth Biser
NC Dept. of Environmental Quality
217 W. Jones St.
Raleigh, NC 27603

VIA Email: elizabeth.biser@ncdenr.gov

Dear Secretary Biser:

Re: Striped Bass

On behalf of the Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources, a Non-Standing Committee of the North Carolina General Assembly, we would like to make the following comment regarding the Striped Bass issue:

These issues continue to be of critical interest to a wide variety of our citizens. Given the substantial final effect that adopting this amendment will have on all interested segments and with respect for the resource itself, we recommend additional analysis and verification of the data upon which this proposed amendment is based before it is adopted. Stated simply, you need to measure this one again before you cut it.

If you any have questions, please feel free to contact us. Thank you for your attention to this matter.

Sincerely,

Rep. Jimmy Dixon, House Co-Chair
Rep. Pat McElraft, House Co-Chair
Rep. Bobby, Hanig, House Deputy Majority Whip

Sen. Brent Jackson, Senate Co-Chair
Sen. Norman Sanderson, Senate Vice Chair

CC: Joy Hicks