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North Carolina Estuarine Striped Bass Fishery Management Plan Amendment 2

By

North Carolina Division of Marine Fisheries
and
North Carolina Wildlife Resources Commission

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EXECUTIVE SUMMARY

The North Carolina Estuarine Striped Bass Fishery Management Plan (FMP) is jointly developed by the North Carolina Division of Marine Fisheries and Wildlife Resources Commission. Striped bass fisheries that occur in the sounds and coastal rivers of North Carolina are managed under this FMP, while the striped bass fisheries that occur in the Atlantic Ocean are managed through the Atlantic States Marine Fisheries Commission Interstate FMP for Atlantic Striped Bass. There are four estuarine striped bass stocks managed under two management units in North Carolina. 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 Central-Southern Management Area (CSMA).

The 2020 stock assessment of the Albemarle Sound-Roanoke River striped bass indicated the stock is overfished and undergoing overfishing. North Carolina law requires management action to end overfishing in two years and recover from the overfished status within 10 years. Stock status is not available for the other North Carolina 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, 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, 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.

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 and 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.
- 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.
- 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.

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INTRODUCTION

This is Amendment 2 to the North Carolina Estuarine Striped Bass Fishery Management Plan (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 Division of Marine Fisheries (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 North Carolina striped bass (*Morone saxatilis*) stocks are managed within four distinct areas: (1) Albemarle Sound Management Area (ASMA), (2) Roanoke River Management Area, (3) Central Southern Management Area (CSMA), and (4) Atlantic Ocean. The MFC adopts rules and policies and 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 by the DMF and the North Carolina Wildlife Resources Commission (WRC). The migratory Atlantic Ocean stock is managed by the Atlantic States Marine Fisheries Commission (ASMFC). The ASMA and RRMA are also subject to compliance requirements of the ASMFC Interstate FMP for Atlantic Striped Bass. Until Amendment 2 is approved for management, estuarine striped bass are managed under Amendment 1, the November 2014 and November 2020 Revisions to Amendment 1, and the February 2019 Supplement A (NCDMF 2013, 2014, 2019, 2020).

FISHERY MANAGEMENT PLAN HISTORY

Original FMP Adoption:	November 1993 May 2004
Amendments:	Amendment 1 – May 2013
Revisions:	November 2014 November 2020
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 North Carolina (Figure 1). The northern management unit is comprised of two harvest management areas: the Roanoke River Management Area (RRMA) and the Albemarle Sound Management Area (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 North Carolina Fishery Management Plan for Interjurisdictional Fisheries.

The southern geographic management unit is the Central Southern Management Area (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 North Carolina through the MFC and the WRC.

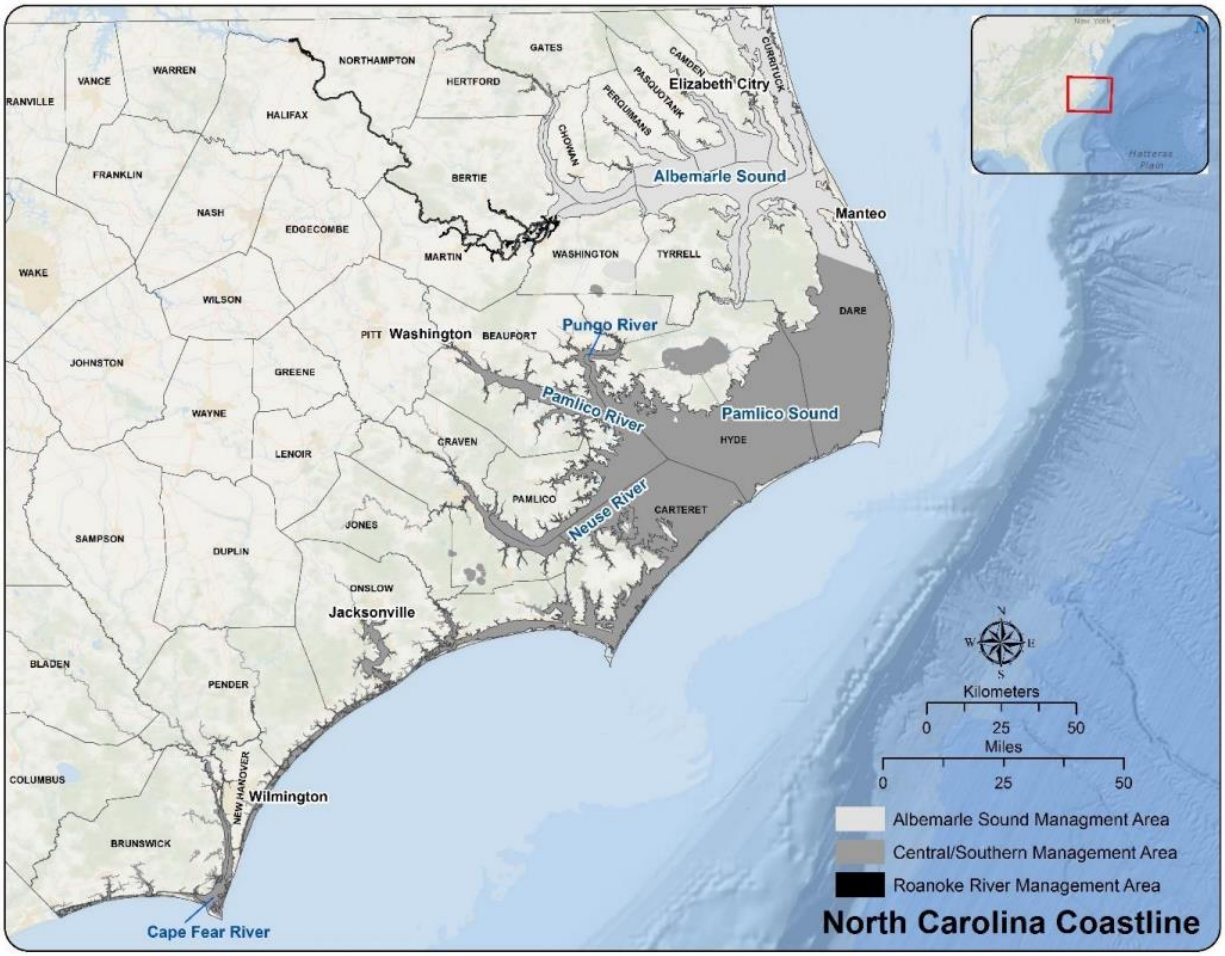

Figure 1. Boundary lines defining the Albemarle Sound Management Area, Central/Southern Management Area, and the Roanoke River Management Area.

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 North Carolina, the species is also known as striper, rockfish, or rock. Stocks from Maine to the A-R in North Carolina are migratory, spending most of their adult life in the estuaries and ocean before moving into fresh water to spawn in the spring. The A-R stock large 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 North Carolina, 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 large distances to spawning grounds located in freshwater portions of coastal rivers. Spawning grounds for the A-R stock are concentrated at the fall line, 130 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 (ability to produce offspring) 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 North Carolina 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 North Carolina: 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 from 1991 through 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 $F_{35\%SPR\ Threshold}$ 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.

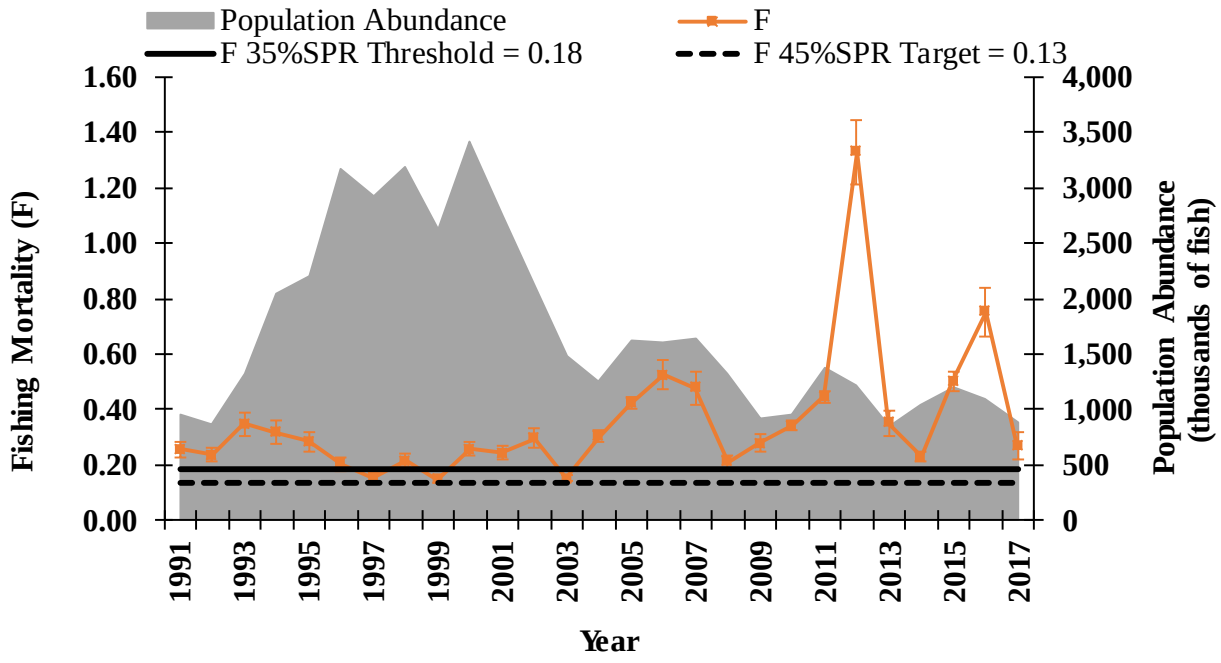

Figure 2. Estimates of fishing mortality (*F*) and population abundance for the Albemarle-Roanoke striped bass stock, 1991–2017. Error bars represent ± two standard errors. Source: Lee et al. 2020.

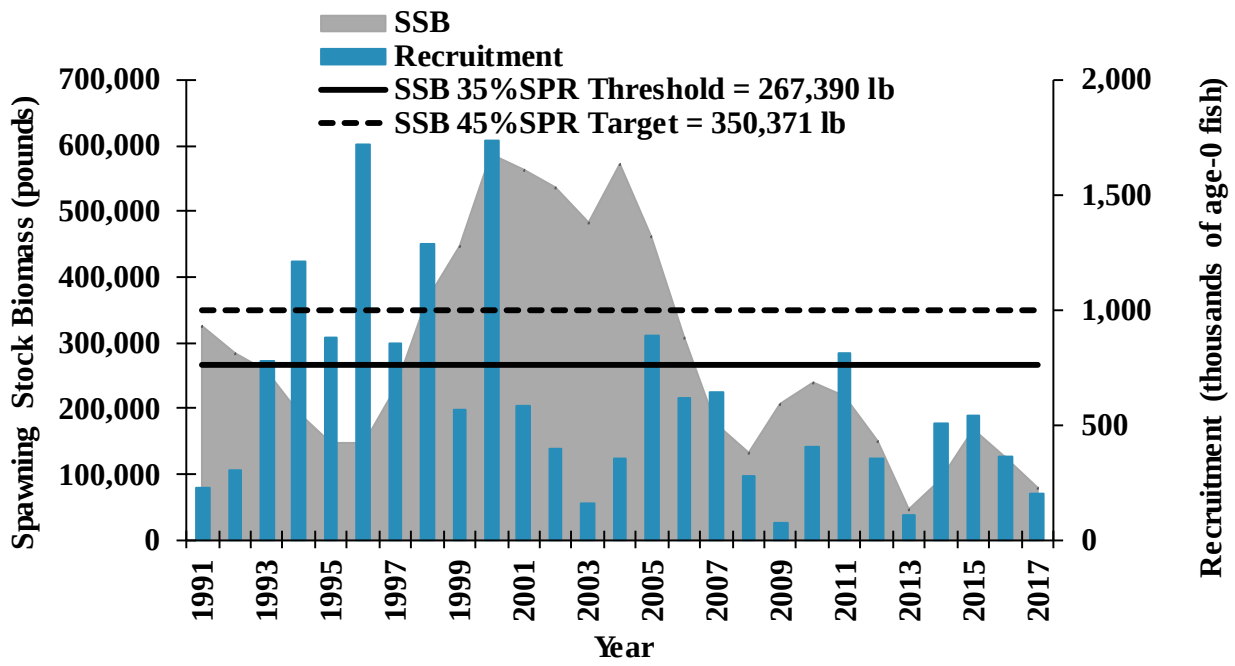

Figure 3. Estimates of spawning stock biomass (SSB) and recruitment of age-0 fish coming into the population each year for the Albemarle-Roanoke striped bass stock, 1991–2017. Source: Lee et al. 2020

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 North Carolina'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, meaning 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 gill 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. From 1990 through 1997 the 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 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 (Figure 4).

The decline in landings during 2005–2009 was due to poor year classes produced from 2001 to 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 (NCDMF 2020).

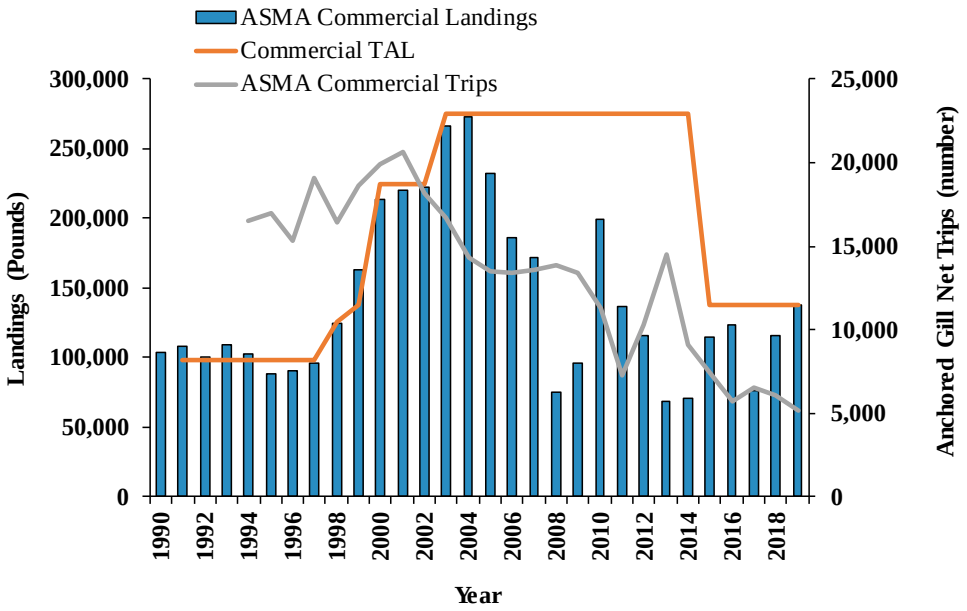

Figure 4. Commercial striped bass landings and the number of all anchored gill net trips in the Albemarle Sound Management Area (ASMA) 1991–2019.

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.

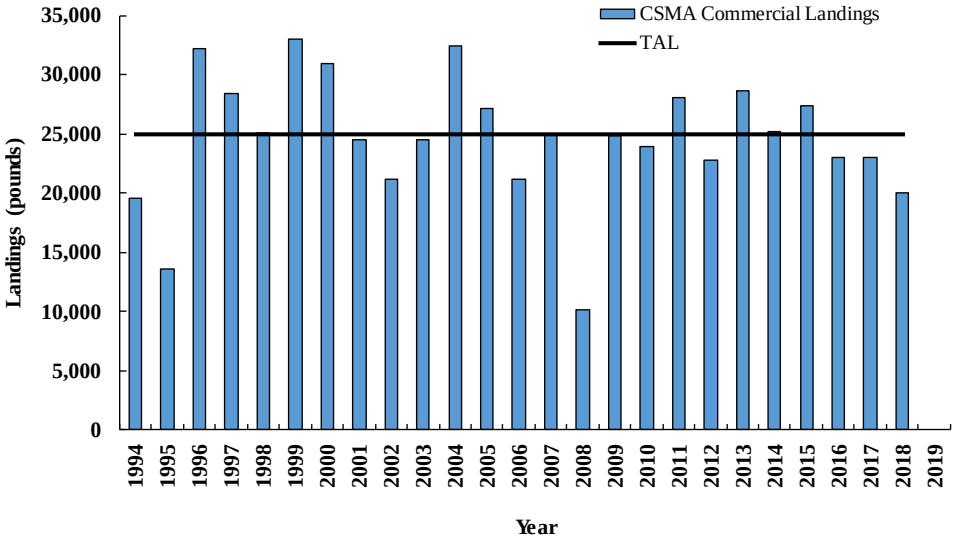

Figure 5. Annual commercial CSMA striped bass harvest and TAL in pounds, 1994–2019. Since 2019 the commercial season has been closed.

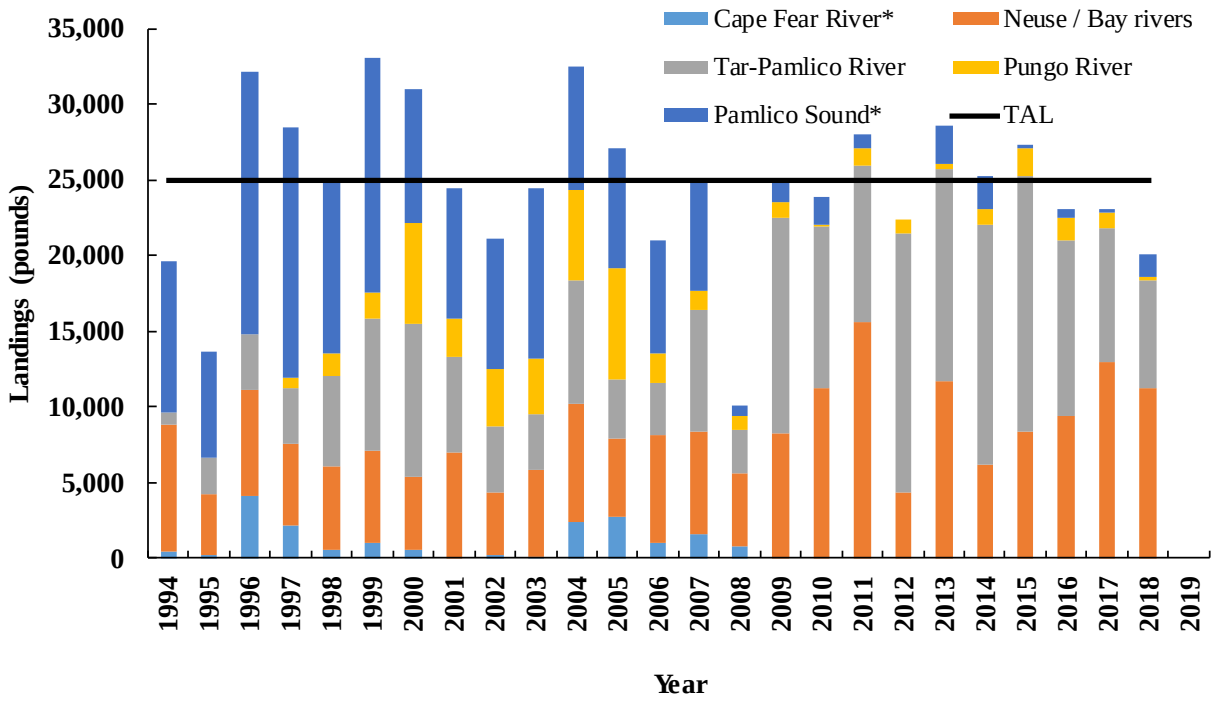

Figure 6. Commercial striped bass harvest by system, and the TAL in the CSMA, 2004–2019. There has been a harvest moratorium in the Cape Fear River since 2008, and a closed season in the CSMA since 2019. *Landings data for the Cape Fear River in 2001 and the Pamlico Sound in 2012 are confidential.

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 sector fisheries 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 age-3 to age-5 fish.

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 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).

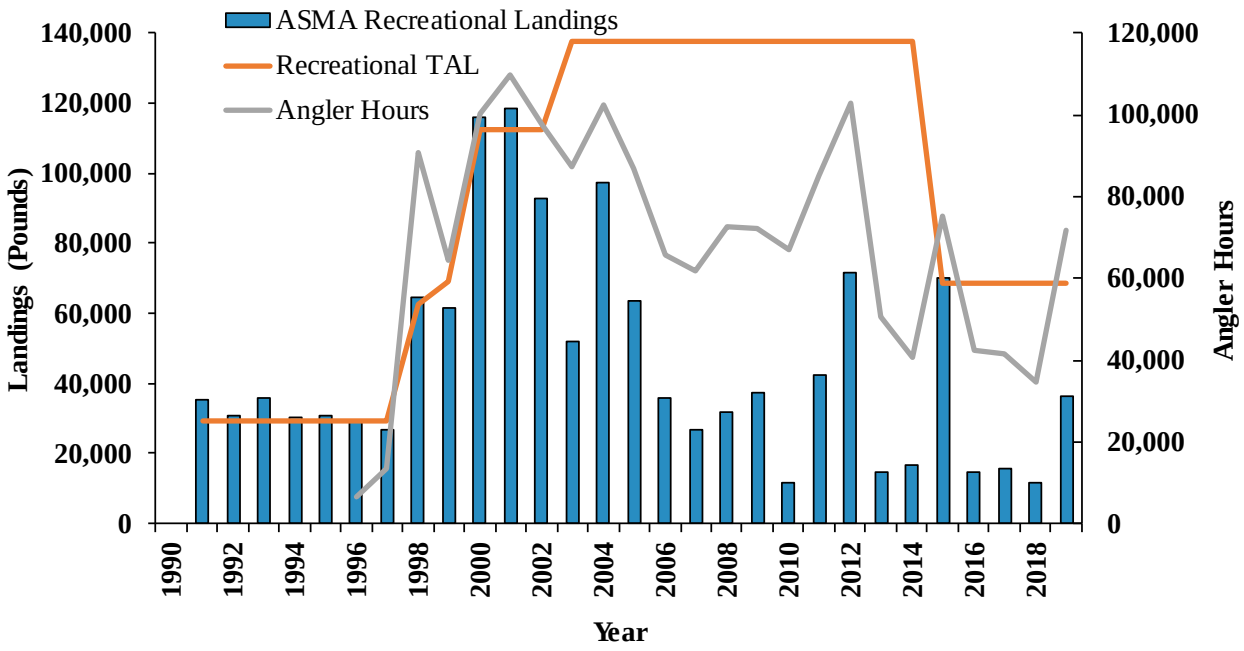

Figure 7. Recreational striped bass landings and the hours of striped bass fishing effort in the Albemarle Sound Management Area (ASMA) 1991–2019.

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	Number of fish caught per trip
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	0.67
2006	10,707	65,757	10,711	35,985	2,490	6,339	626	9,455	0.44
2007	9,629	61,679	7,143	26,633	1,148	12,259	192	13,599	0.81
2008	11,793	72,673	10,048	31,628	391	36,324	260	36,975	1.69
2009	11,326	72,021	12,069	37,313	20	38,683	1,860	40,563	1.73
2010	9,660	66,893	3,504	11,470	569	15,398	233	16,200	1.23
2011	13,114	85,325	13,341	42,536	317	20,114	1,141	21,572	0.82
2012	14,490	102,787	22,345	71,456	1,024	19,977	3,970	24,971	0.68
2013	7,053	50,643	4,299	14,897	31	16,034	316	16,381	1.44
2014	7,264	40,478	5,529	16,867	18	22,558	510	23,086	1.80
2015	11,132	75,009	23,240	70,008	1,573	45,559	2,402	49,534	1.44
2016	7,023	42,276	4,794	14,486	252	8,822	1,278	10,352	0.88
2017	7,658	41,371	4,215	15,480	56	24,004	600	24,660	2.08
2018	9,057	34,764	3,465	11,762	281	21,337	3,970	25,588	2.04
2019	18,833	71,800	10,723	36,351	52	32,020	2,896	34,968	1.18

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	Weight (lb)	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

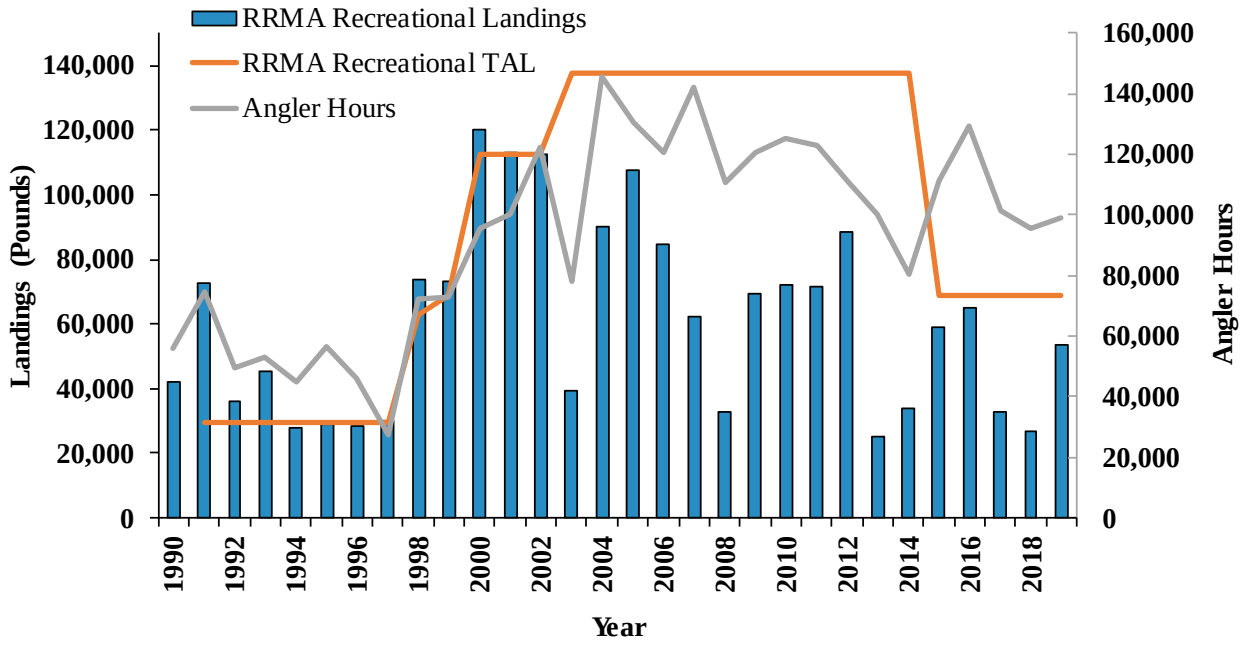

Figure 8. Recreational striped bass landings and the hours of striped bass fishing effort in the Roanoke River Management Area (RRMA) 1991–2019.

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

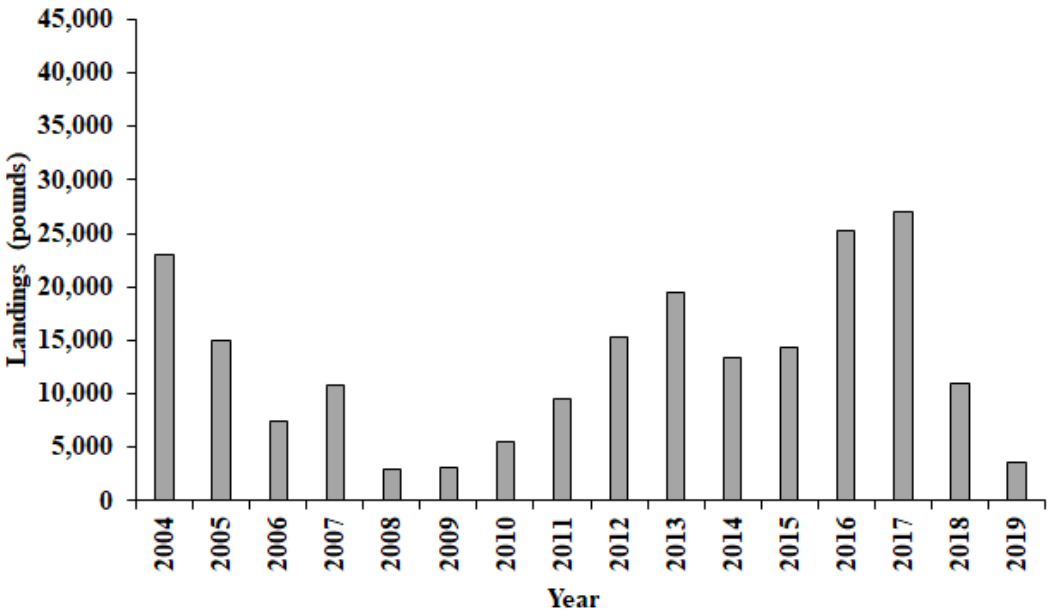

Figure 9. Annual recreational CSMA striped bass landings in pounds, 2004–2019. The 2019 season was January 1–March 19, 2019.

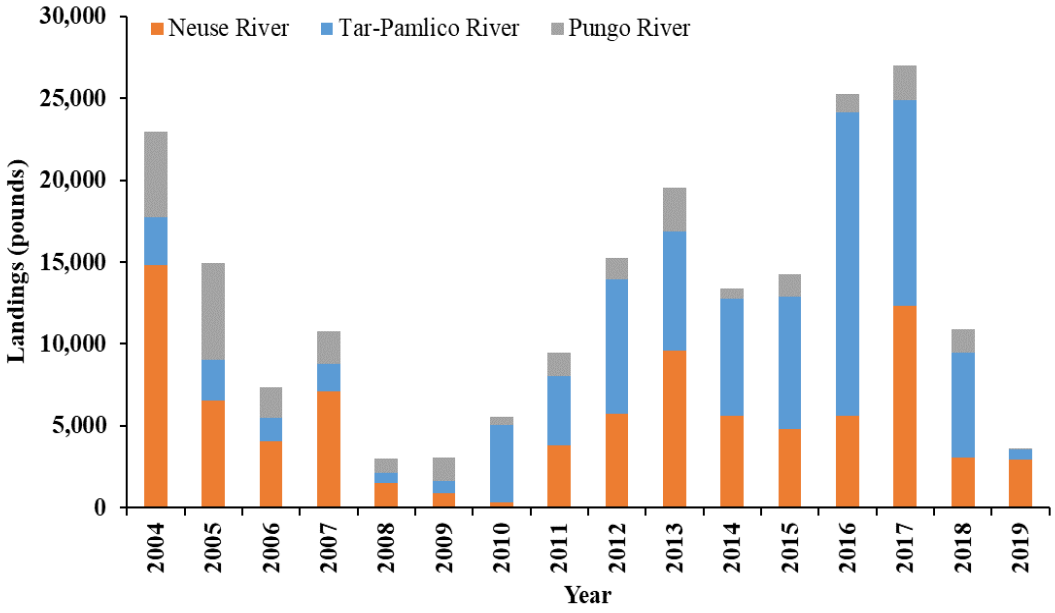

Figure 10. Recreational striped bass harvest in the Tar-Pamlico, Pungo, and Neuse rivers, 2004–2019. The 2019 season was January 1–March 19, 2019.

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.

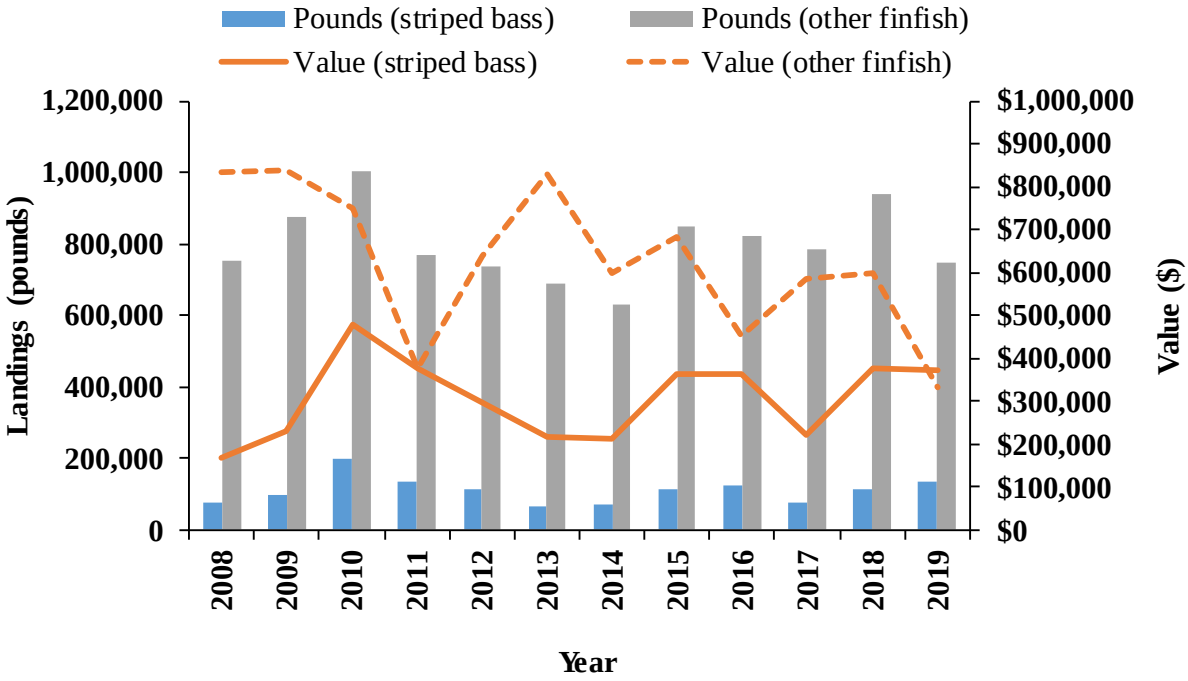

Figure 11. Annual commercial striped bass effort and ex-vessel value data for the ASMA, 2008–2019.

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

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 unique structure, in which striped bass cannot be harvested unless it is in tandem 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.

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).

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

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

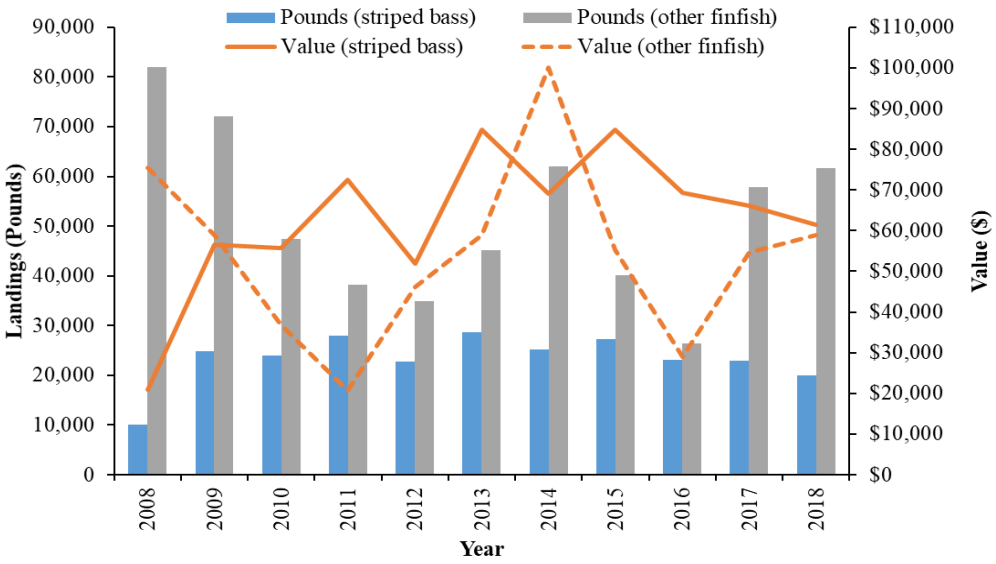

Figure 12. Annual Striped Bass effort and ex-vessel value data for the CSMA, 2008–2019.

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	18,833	71,800	$1,528,169	$532,055	$873,914	12.63	$3,475,633
Average	10,700	63,003	$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. A number of 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.

Across management areas, each operates under different recreational harvest limits, including both season length and size restrictions. For example, while the ASMA is open for harvest from October to April with an 18-inch minimum TL size limit, the RRMA only allows harvest from March to April, and includes an 18-inch minimum TL size limit and a 22–27-inch TL 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 North Carolina 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, North Carolina Environmental Management Commission (EMC), and North Carolina Coastal Resources Commission (CRC) for the protection and enhancement of fishery habitats of North Carolina. 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 North Carolina, 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 is undergoing a mandated five-year review, with adoption planned in 2021. The review 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 North Carolina. 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 North

Carolina. 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 Sounds 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 postulated 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). 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 North Carolina can be found in the APNEP Aquatic Nuisance Species Management Plan.

Manmade barriers also act as impediments to spawning for striped bass stocks in North Carolina. 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 suspended 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, Gaston Dam and Roanoke Rapids Dam, owned and operated by Dominion Energy, 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 multiple years of environmental studies and collaboration with numerous resource agencies and other 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 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.

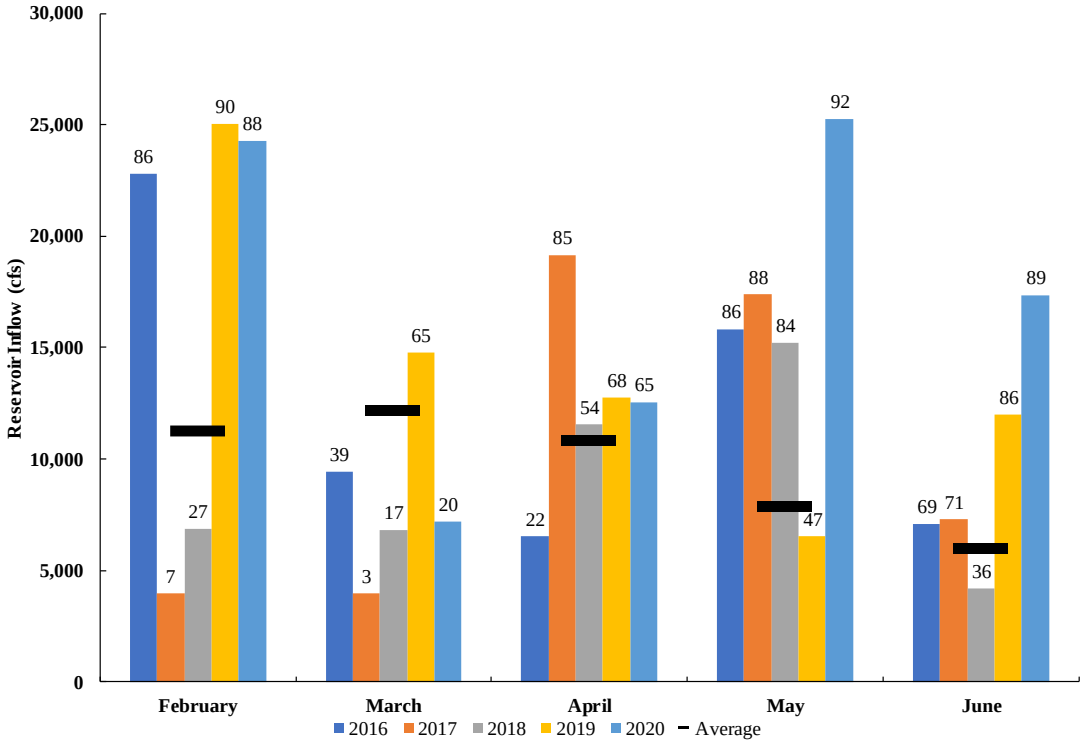

Figure 13. Monthly inflow data for John H. Kerr Reservoir on the Roanoke River during February – June of 2016–2020. Data were provided by USACE staff. Numbers of the columns provide the rank for 92 years of data. A rank of 1 is driest and rank of 92 is wettest.

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 North Carolina 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 (in no particular order) 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 more comprehensive list of research recommendations is provided in the FMP Update and Research Priorities documents (reviewed annually) and can be found at 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 the following 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 U.S. Fish and Wildlife Service (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.

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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.

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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).

	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**
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%

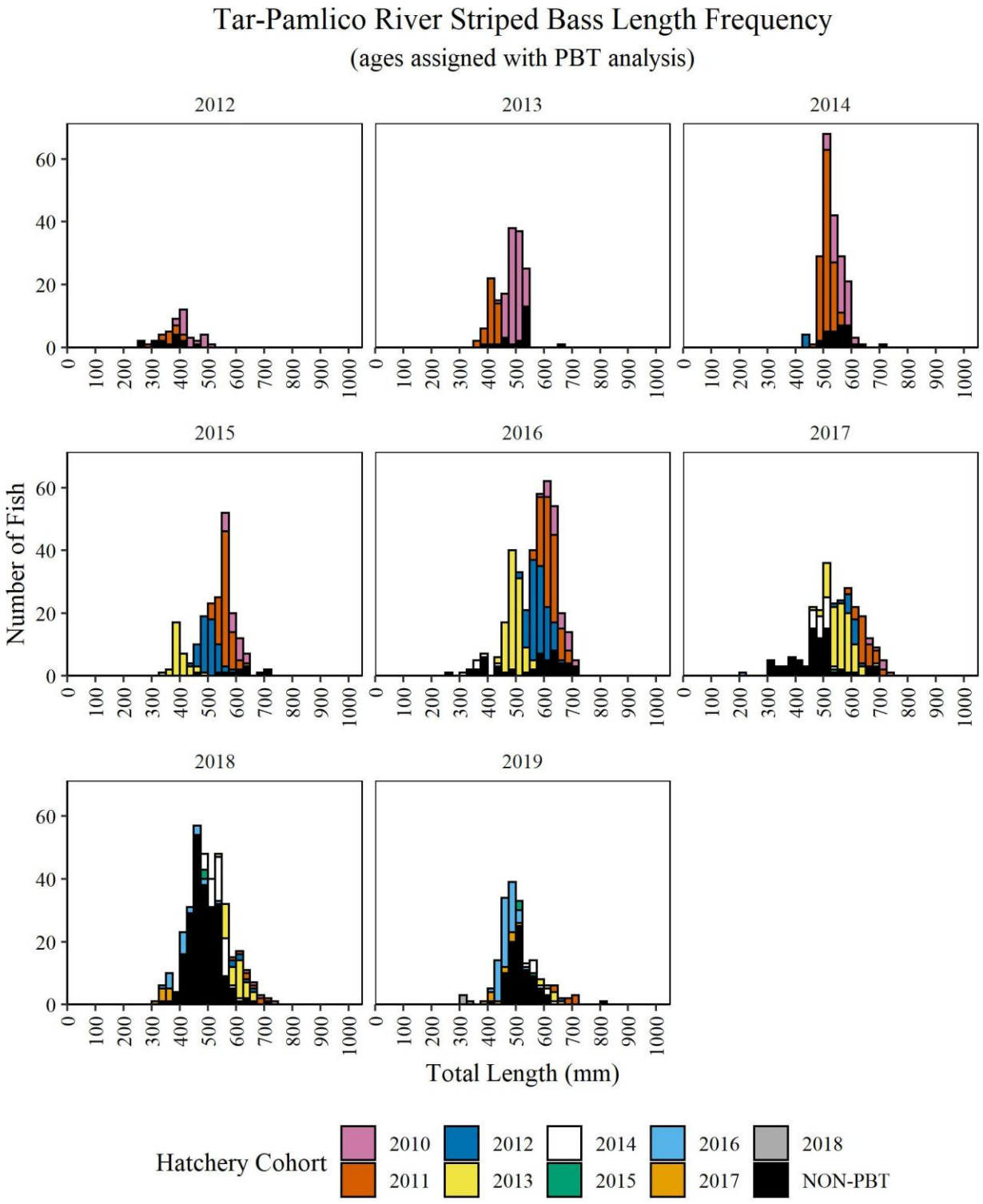

Figure 1.1. Length-frequency histograms for at-large striped bass collected in the Tar-Pamlico River by WRC and DMF, 2012–2019. Hatchery cohorts identified by parentage-based tagging analysis (PBT) are plotted within each 25-mm length group. Fish identified as non-PBT were not assigned to a hatchery cohort because they did not match to a broodstock pair.

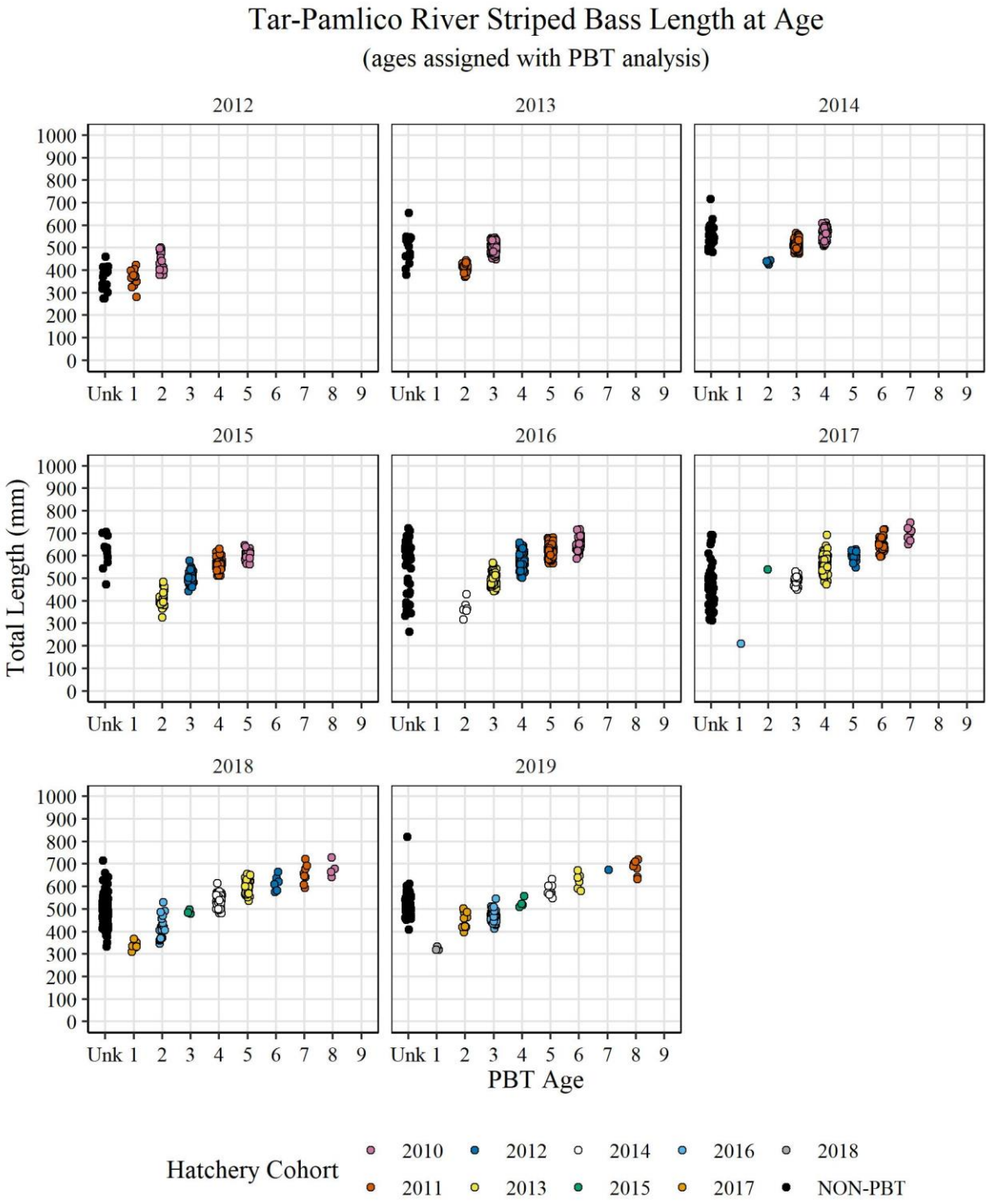

Figure 1.2. Length at age for at-large Tar-Pamlico River striped bass collected by WRC and DMF, 2012–2019. Ages were identified using parentage-based tagging (PBT) analysis. Those fish with an unknown age (Unk) each year were not identified as hatchery cohorts by PBT analysis and could not be assigned 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%

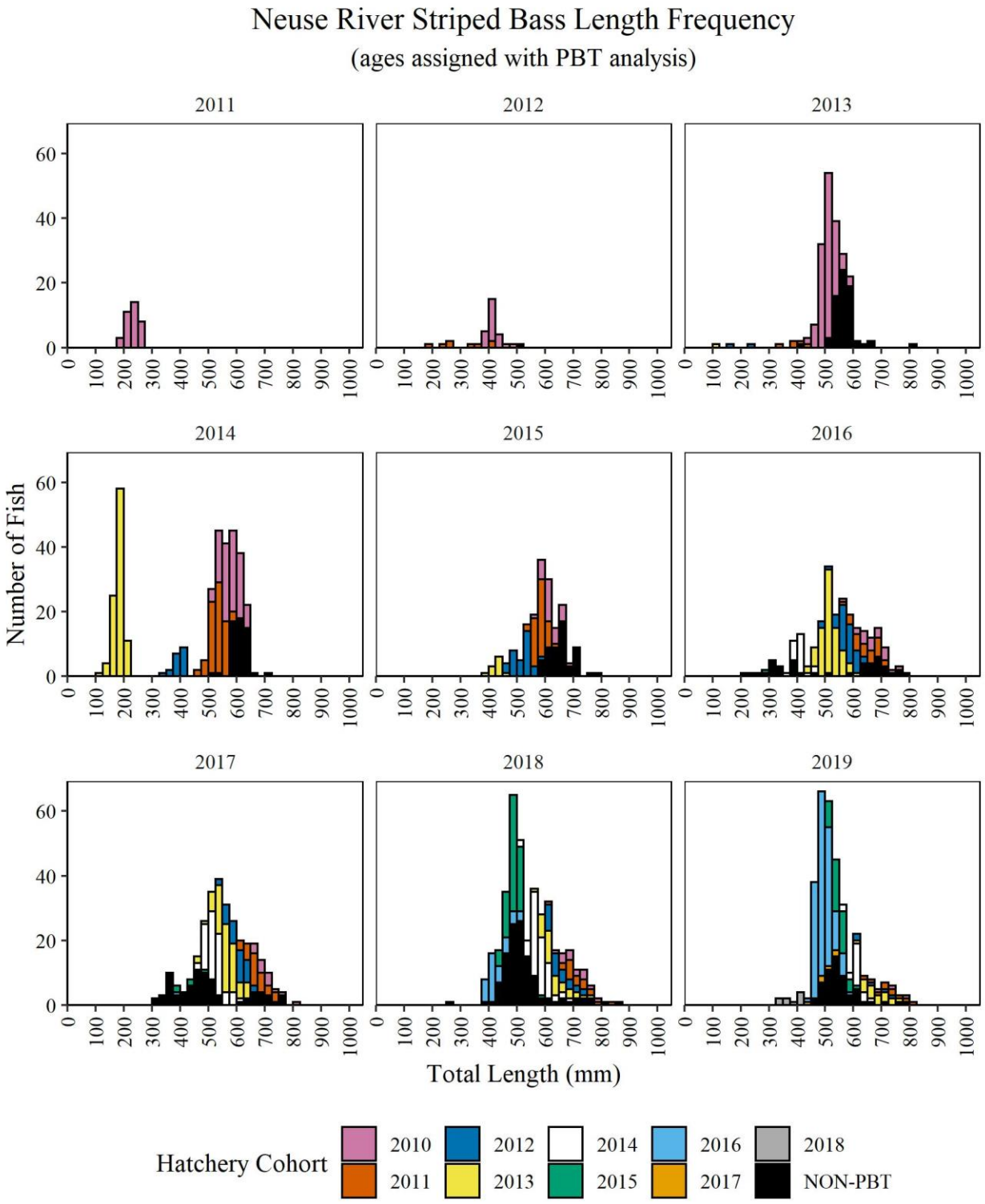

Figure 1.3. Length-frequency histograms for at-large striped bass collected in the Neuse River basin by WRC and DMF, 2011–2019. Hatchery cohorts identified by parentage-based tagging analysis (PBT) are plotted within each 25-mm length group. Fish identified as non-PBT were not assigned to a hatchery cohort because they did not match to a broodstock pair.

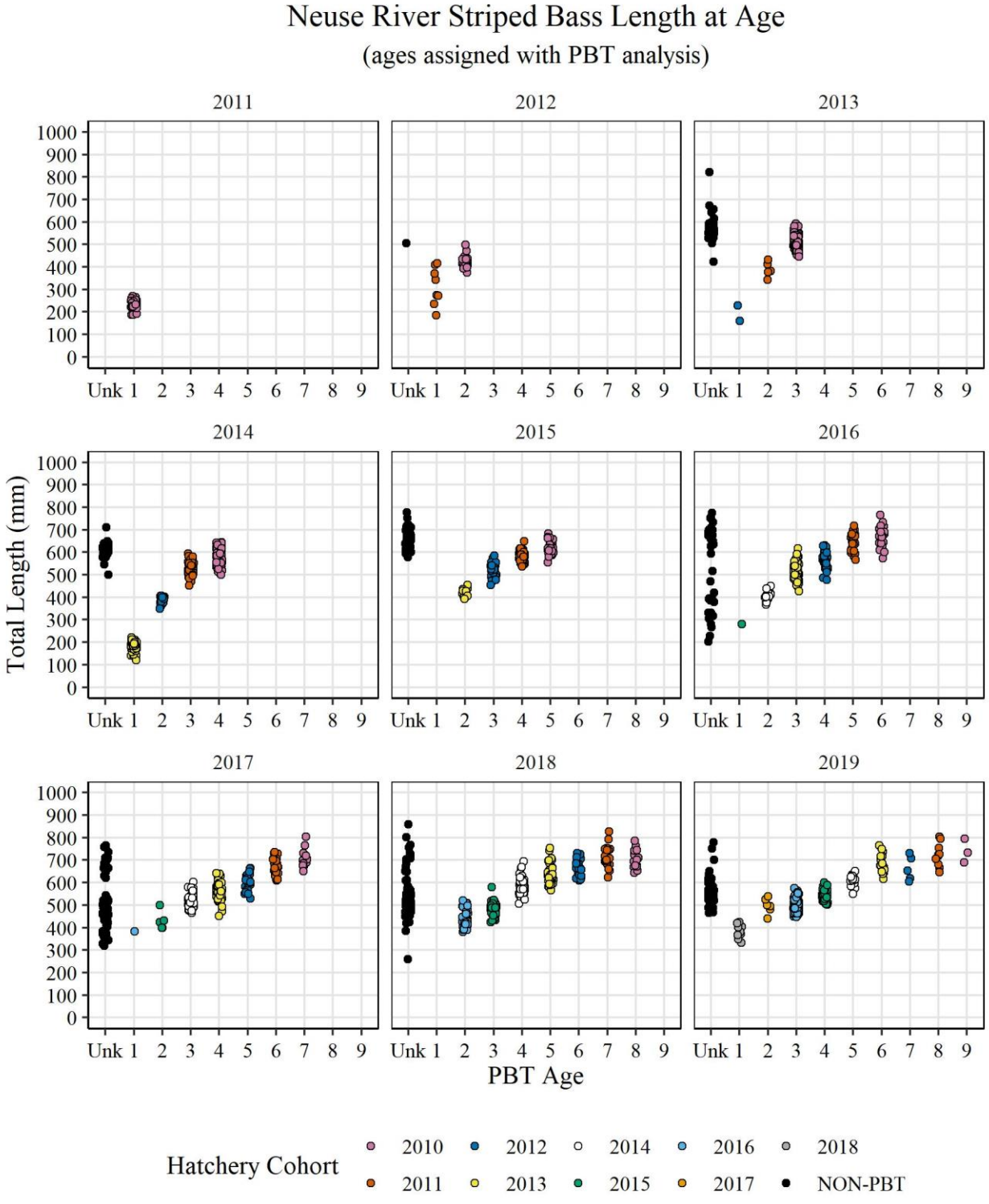

Figure 1.4. Length at age for at-large Neuse River striped bass collected by WRC and DMF, 2011–2019. Ages were identified using parentage-based tagging (PBT) analysis. Those fish with an unknown age (Unk) each year were not identified as hatchery cohorts by PBT analysis and could not be assigned an age. 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.

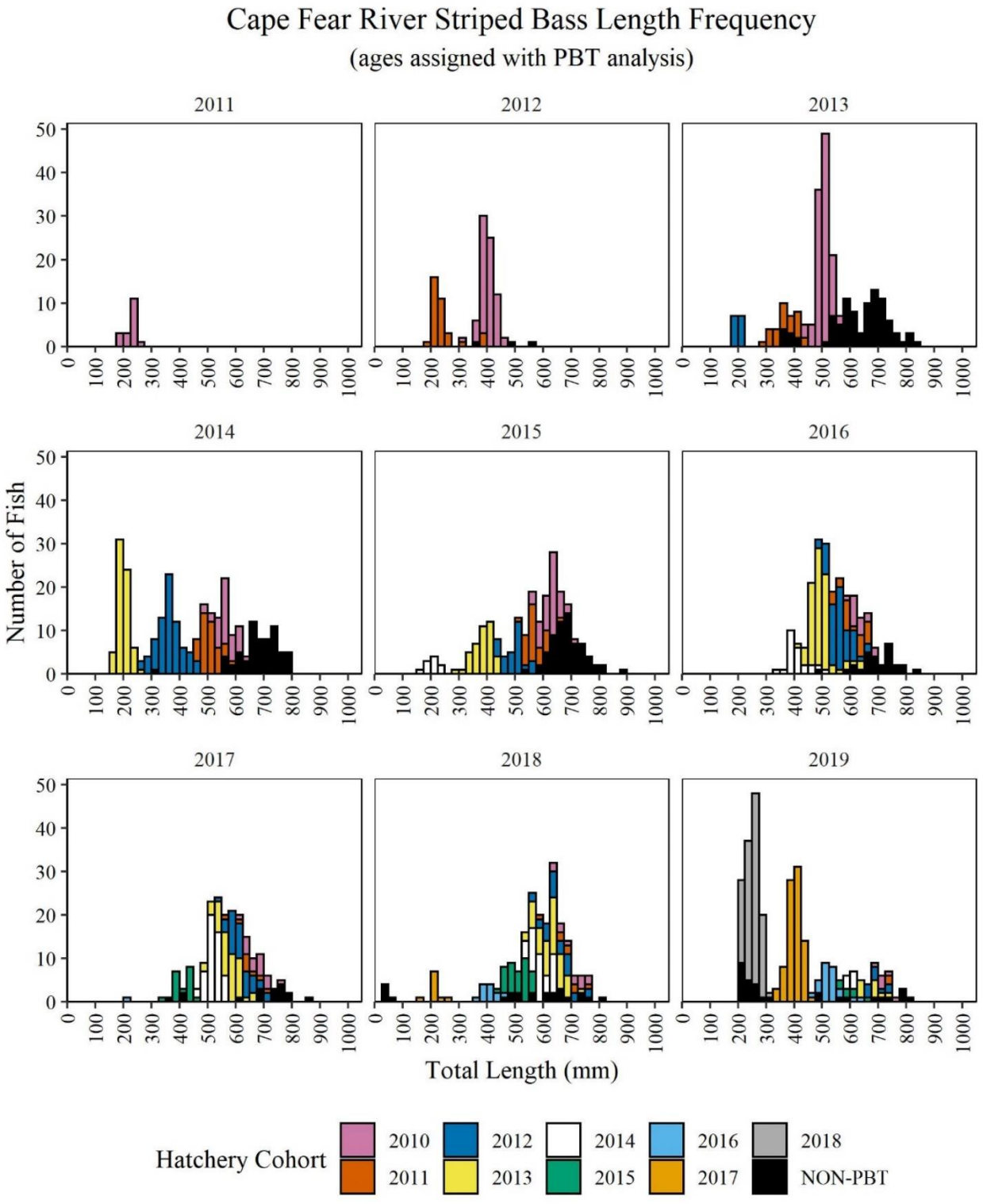

Figure 1.5. Length-frequency histograms for at-large striped bass collected in the Cape Fear River basin by WRC and DMF, 2011–2019. Hatchery cohorts identified by parentage-based tagging analysis (PBT) are plotted within each 25-mm length group. Fish identified as non-PBT were not assigned to a hatchery cohort because they did not match to a broodstock pair.

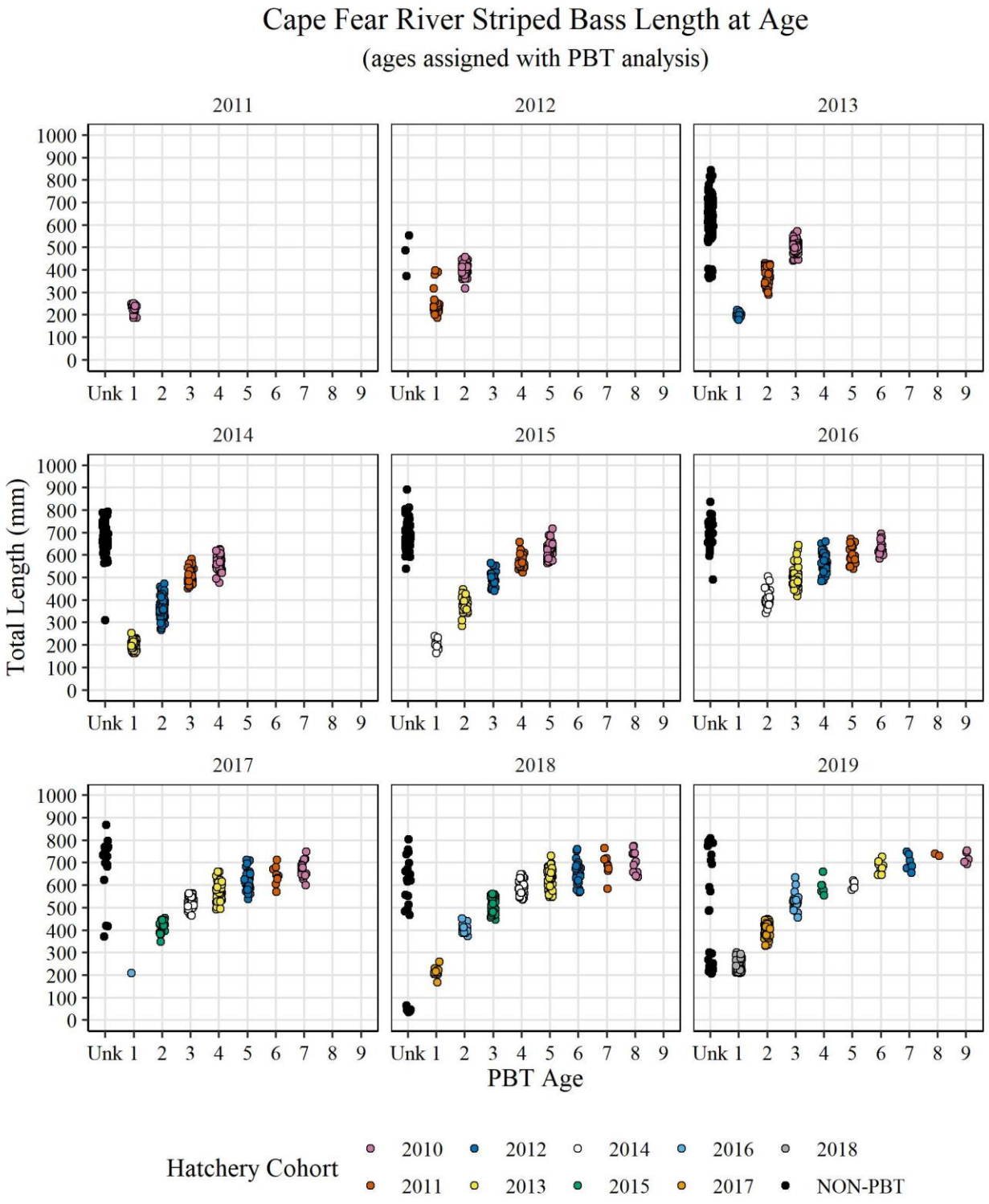

Figure 1.6. Length at age for at-large Cape Fear River striped bass collected by WRC and DMF, 2011–2019. Ages were identified using parentage-based tagging (PBT) analysis. Those fish with an unknown age (Unk) each year were not identified as hatchery cohorts by PBT analysis and could not be assigned an age. Points are jittered about each age column to clarify overlapping data points. Outliers were removed before plotting.

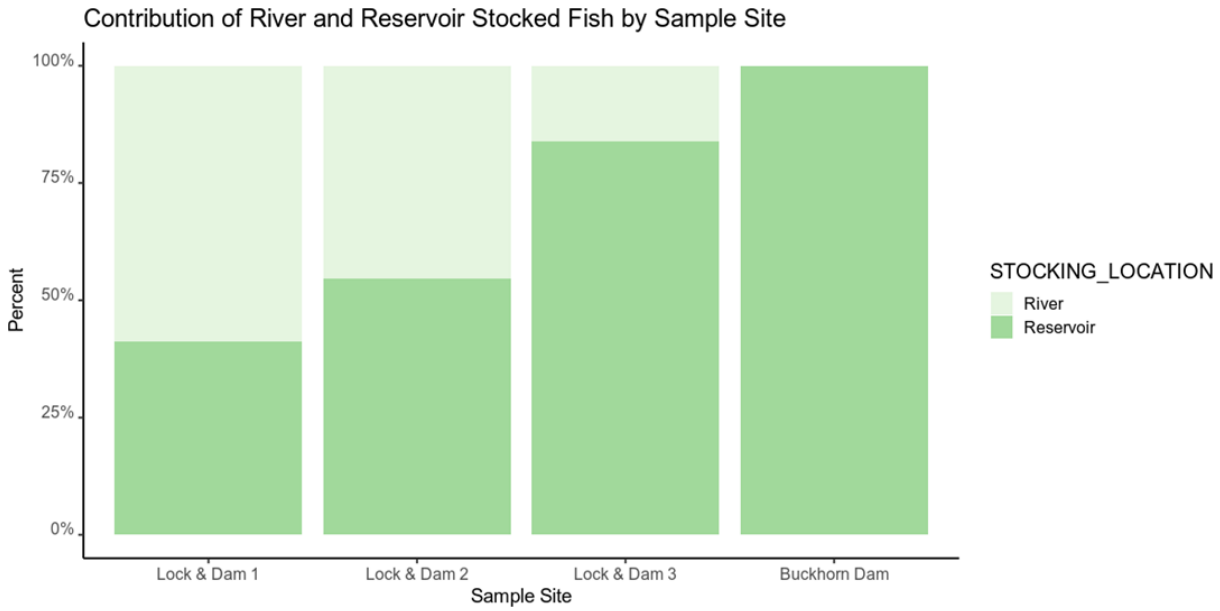

Figure 1.7. Relative contribution of hatchery-origin striped bass by stocking location to each WRC electrofishing sample site in the Cape Fear River, 2015–2019.

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 intrastate agreement between the North Carolina Wildlife Resources Commission 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 $F_{Threshold}$ = 0.18 and overfished BRPs are based on a level of spawning stock biomass (SSB) of SSB_{Target} = 350,371 pounds and $SSB_{Threshold}$ = 267,390 pounds (Lee et al. 2020). In the terminal year of the assessment F=0.27, above the $F_{Threshold}$, meaning overfishing is occurring. Female SSB was 78,576 pounds, below the $SSB_{Threshold}$, 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

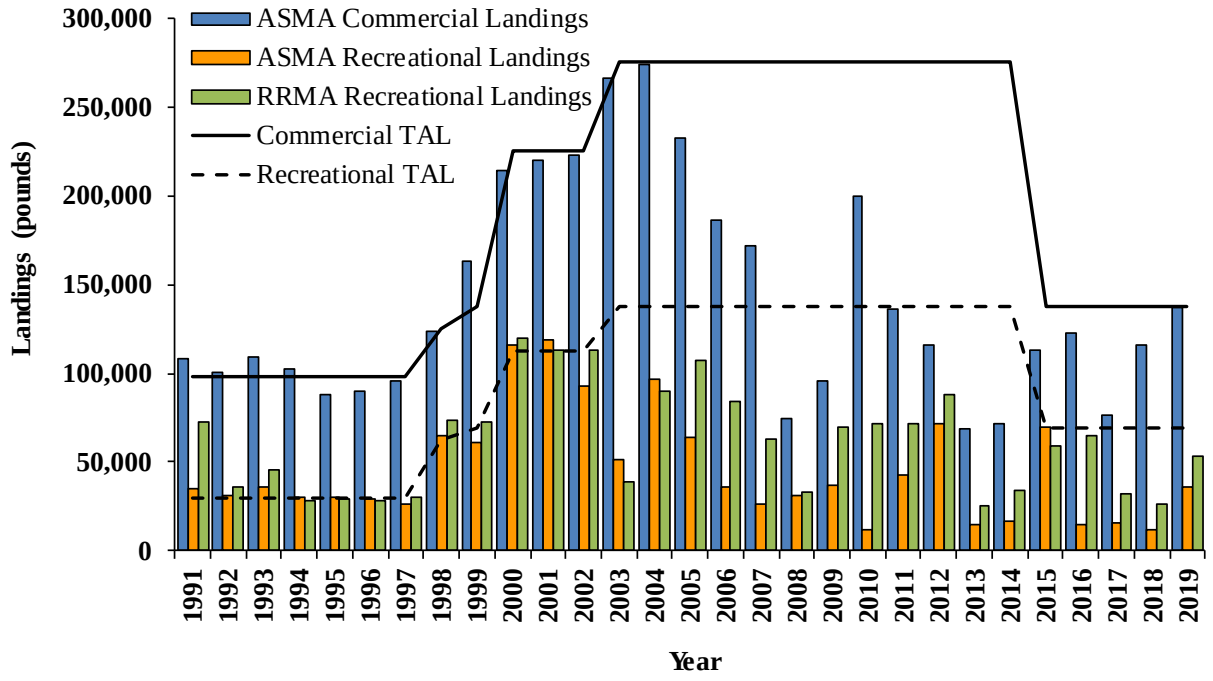

Figure 2.1. Striped bass landings from the Albemarle Sound Management Area (ASMA) commercial and recreational sectors, the Roanoke River Management Area (RRMA) recreational sector, and the annual total allowable landings (TAL) by sector, 1991–2019.

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				
Year	**TAL**	**Landings**	(+)/-	**TAL**	**Landings**	(+)/-	**TAL**	**Landings**	(+)/-	**Total TAL**	**Total 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	36,351	32,399	68,750	53,379	15,371	275,000	226,886

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 $SSB_{Threshold}$, 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.

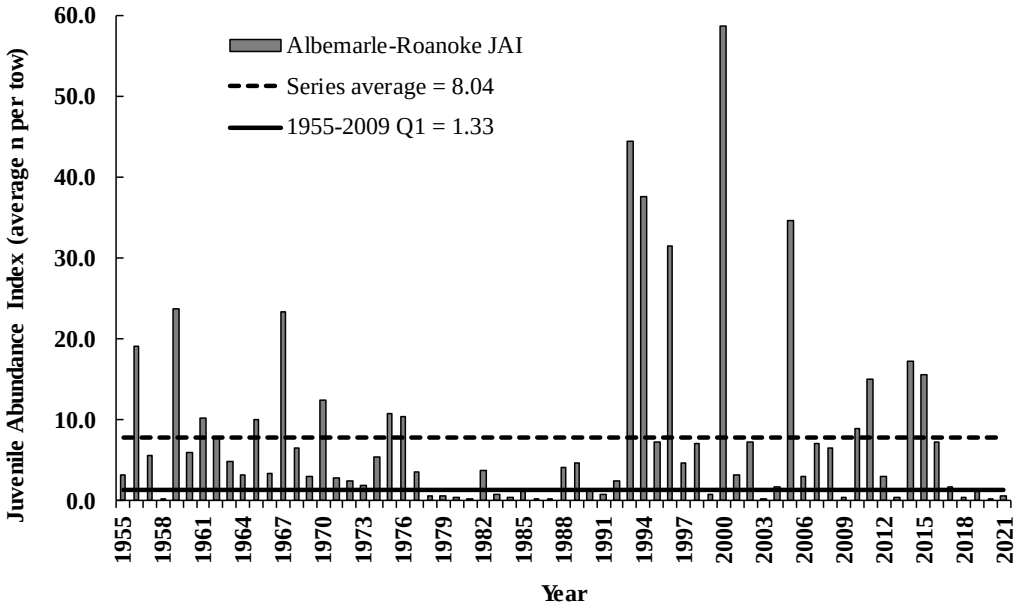

Figure 2.2. The juvenile abundance index (JAI) for Albemarle Sound-Roanoke River striped bass, North Carolina, 1955–2021. A JAI value below the first quartile (Q1 solid black line) is considered a spawning failure.

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.

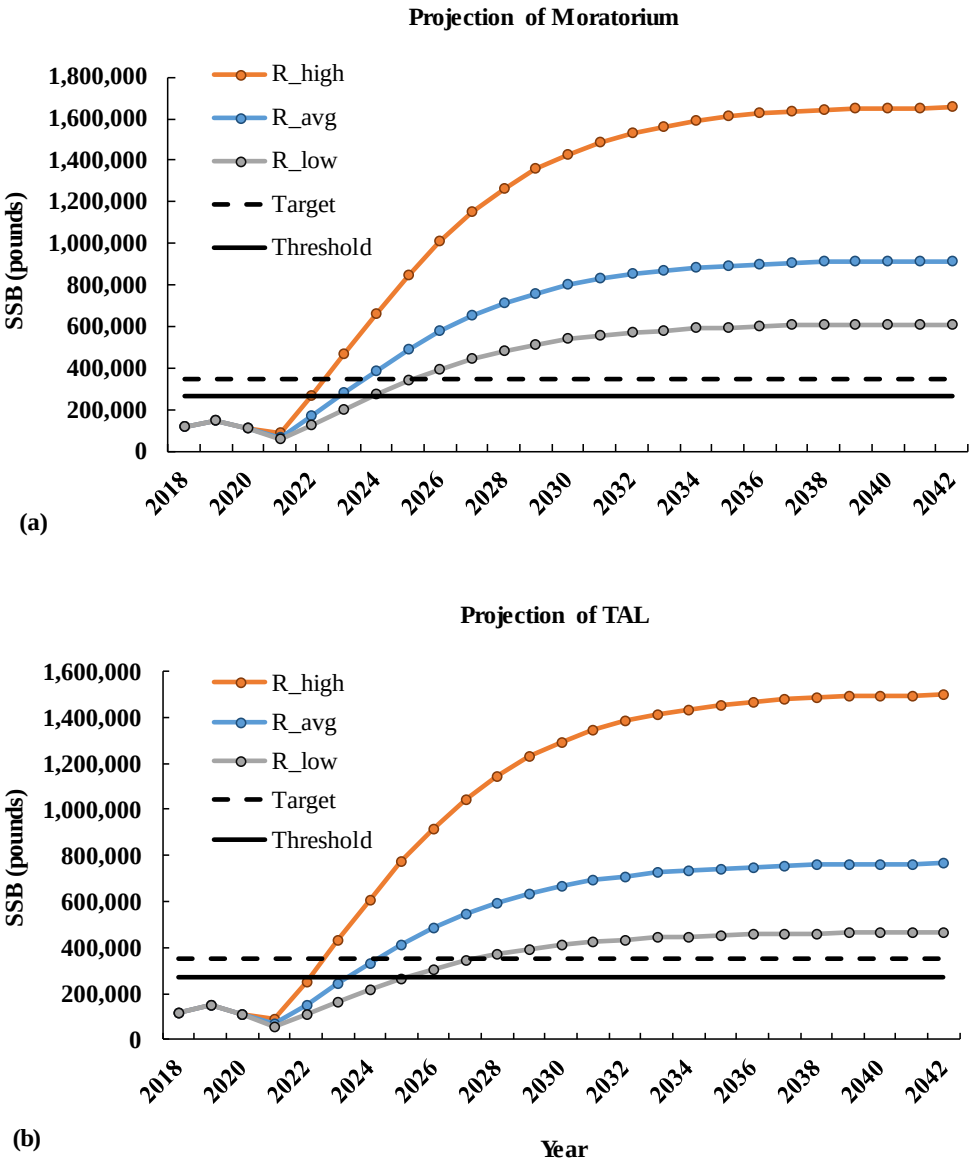

Figure 2.3. Projections of spawning stock biomass (SSB) in pounds for the Albemarle Sound-Roanoke River striped bass stock under the current total allowable landings (TAL) of 51,216 lb (a) and a harvest moratorium (b). Average recruitment (R_avg), low recruitment (R_low), and high recruitment (R_high) 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:

Short-term Overages: 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).

Long-term Overages: 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	
Age	**Percent Mature**
1	0%
2	1%
3	27%
4	97%
5+	100%

Percent Mature at Length	
Length	**Percent Mature**
16.8	50%
17.4	75%
18.8	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).

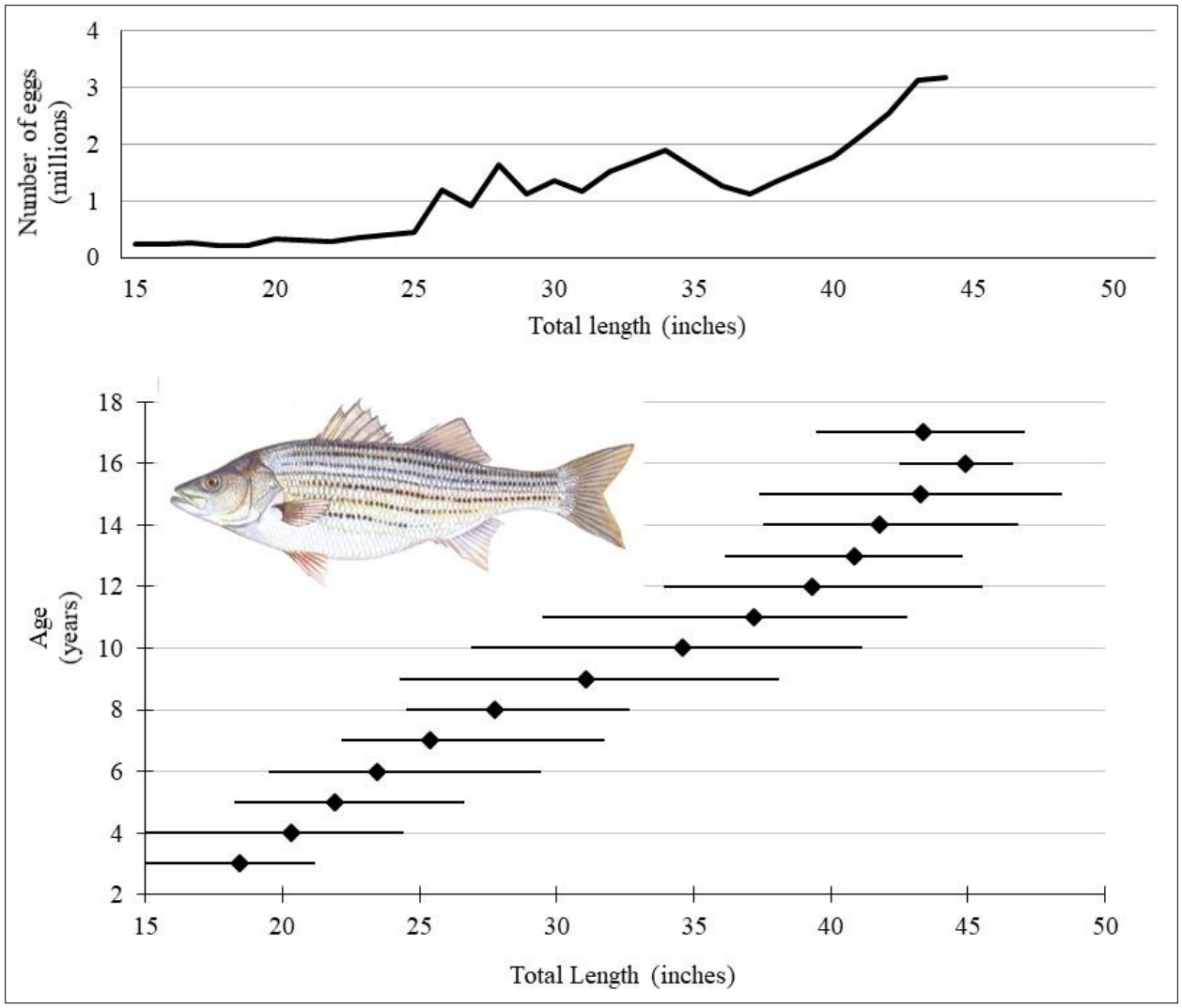

Figure 2.4. Number of eggs produced by female Albemarle-Roanoke striped bass at age and the average length of female striped bass at age. The diamond represents the average total length, and the lines represent the minimum and maximum observed length. Number of eggs at age data from Boyd 2011. Length 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.

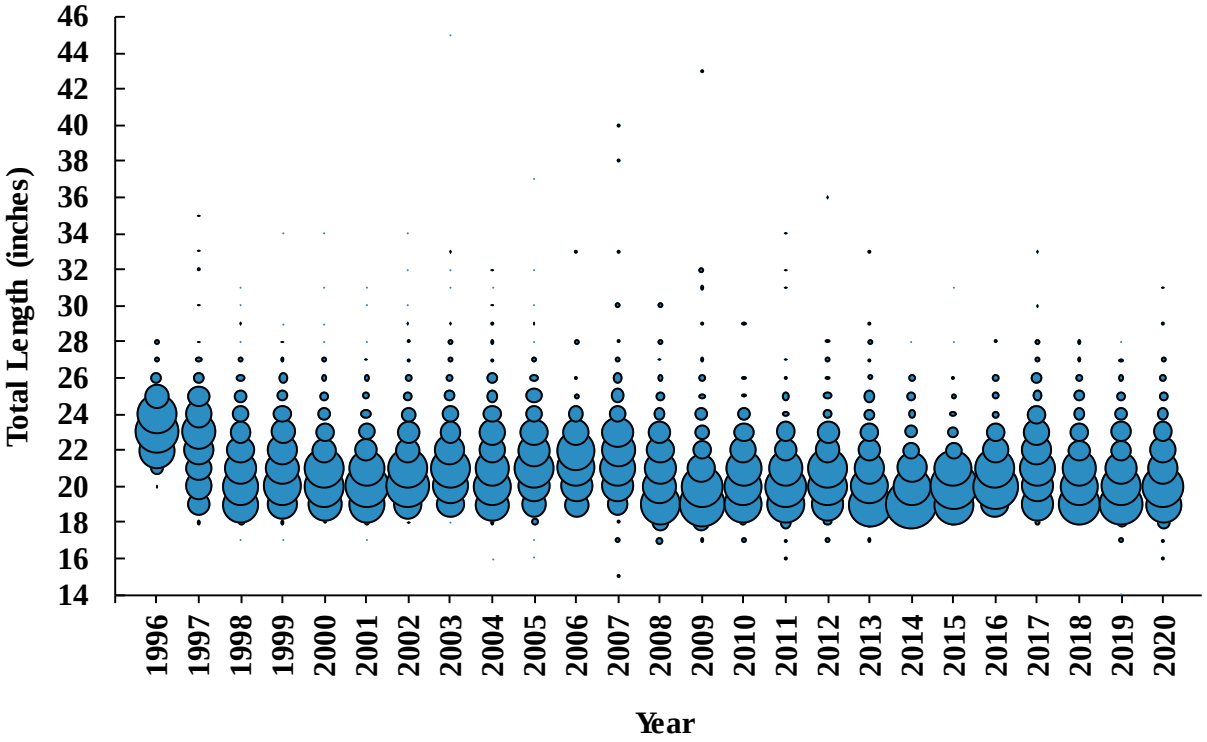

Figure 2.5. Recreational length frequency (total length, inches) of striped bass harvested in the ASMA, NC, 1996–2020. Bubble size represents the proportion of fish at length.

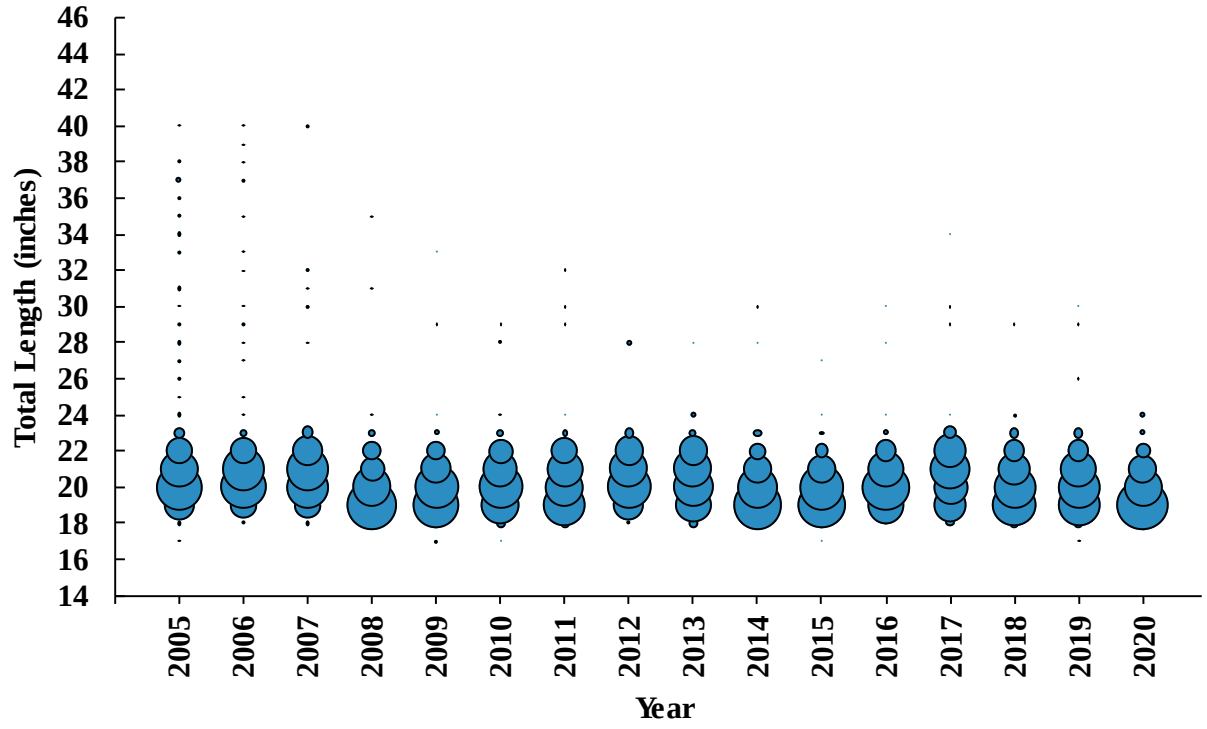

Figure 2.6. Recreational length frequency (total length, inches) of striped bass harvested in the RRMA, NC, 2005–2020. Bubble size represents the proportion of fish at length.

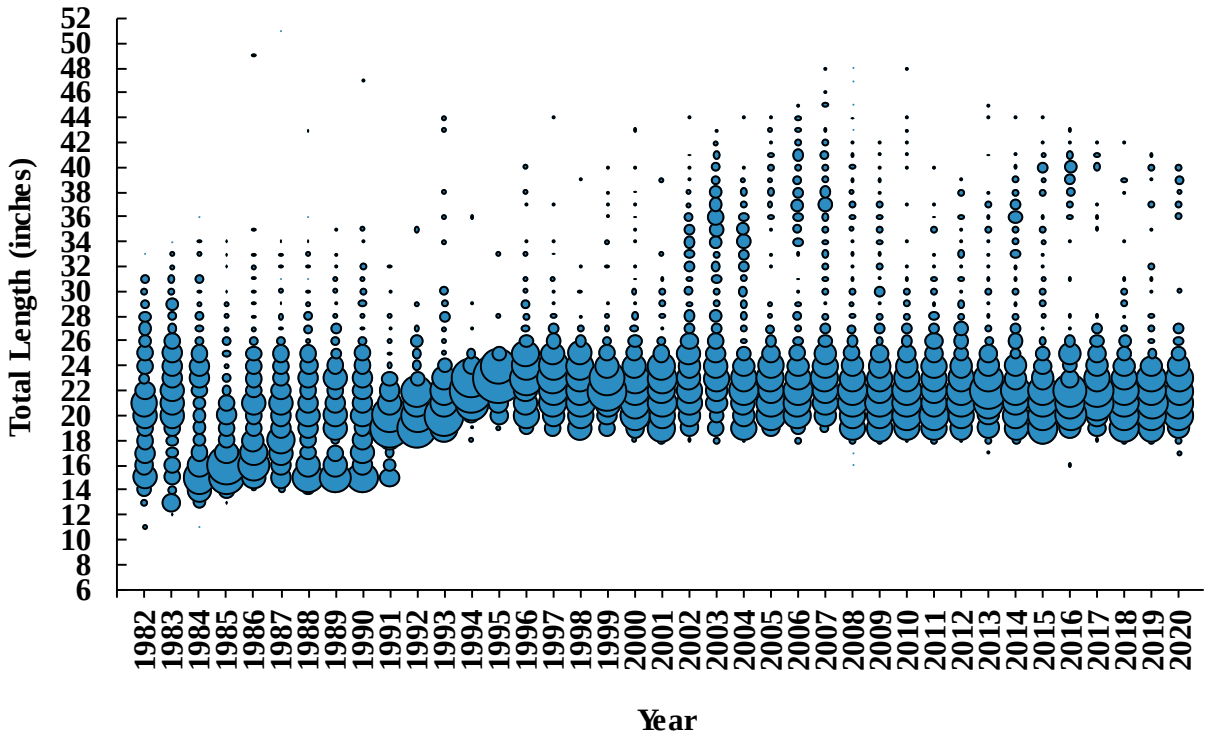

Figure 2.7. Commercial length frequency (total length, inches) of striped bass harvested in the ASMA, NC, 1982–2020. Bubble size represents the proportion of fish at length.

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).

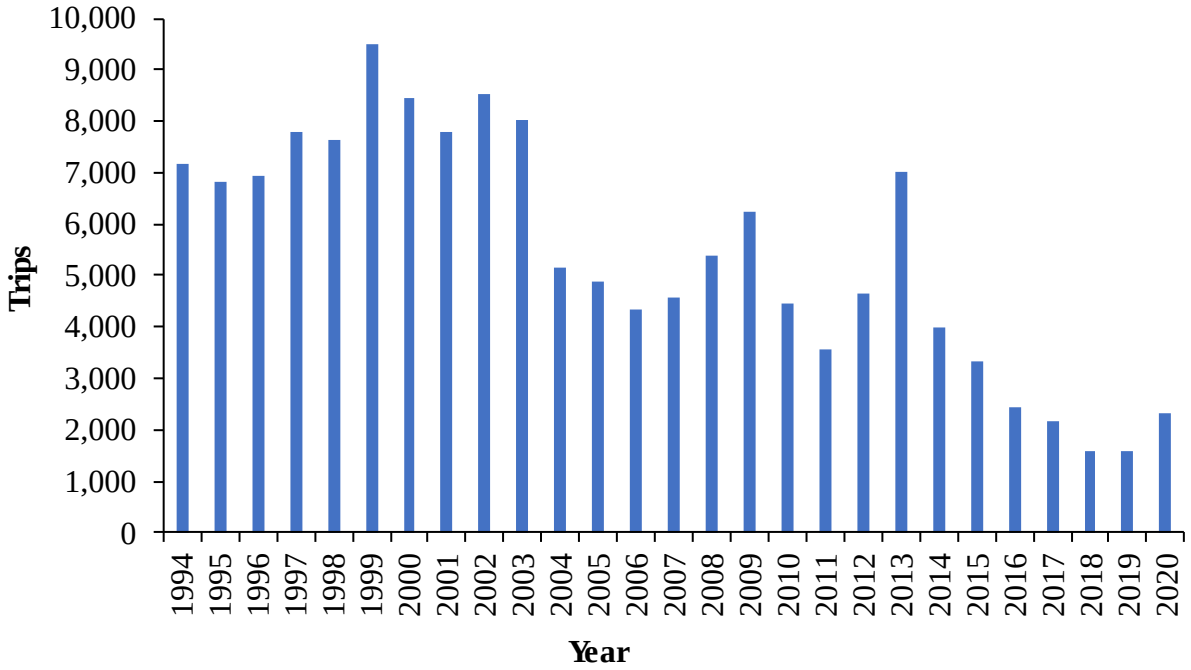

Figure 2.8. Number of anchored gill net trips in the ASMA that landed either river herring, white perch, striped mullet, spotted seatrout, yellow perch, or spot. These species were selected to determine a "small mesh" gill net trip in the ASMA.

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).

<u>Tar-Pamlico and Neuse Rivers Striped Bass Stocks Life History</u>
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.

Striped Bass Fisheries

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.

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.

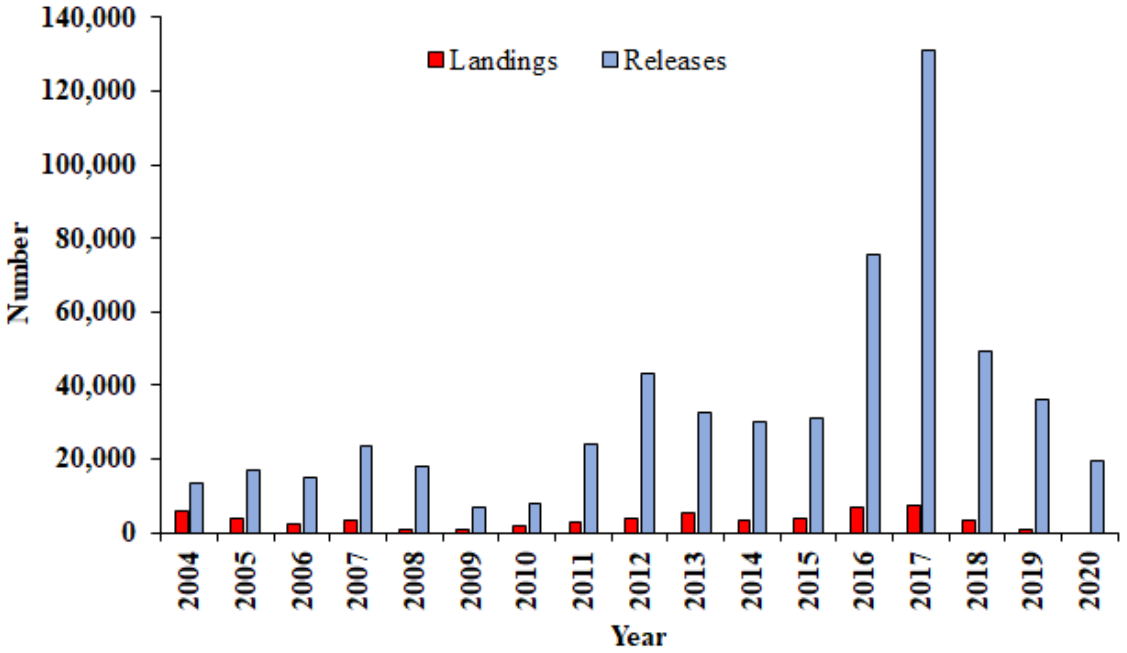

Figure 3.1. Annual recreational catch (harvested and/or released) of striped bass in the CSMA, 2004–2020. There was a limited recreational harvest season in 2019 prior to the closure, lasting from January 1 to March 19, 2019.

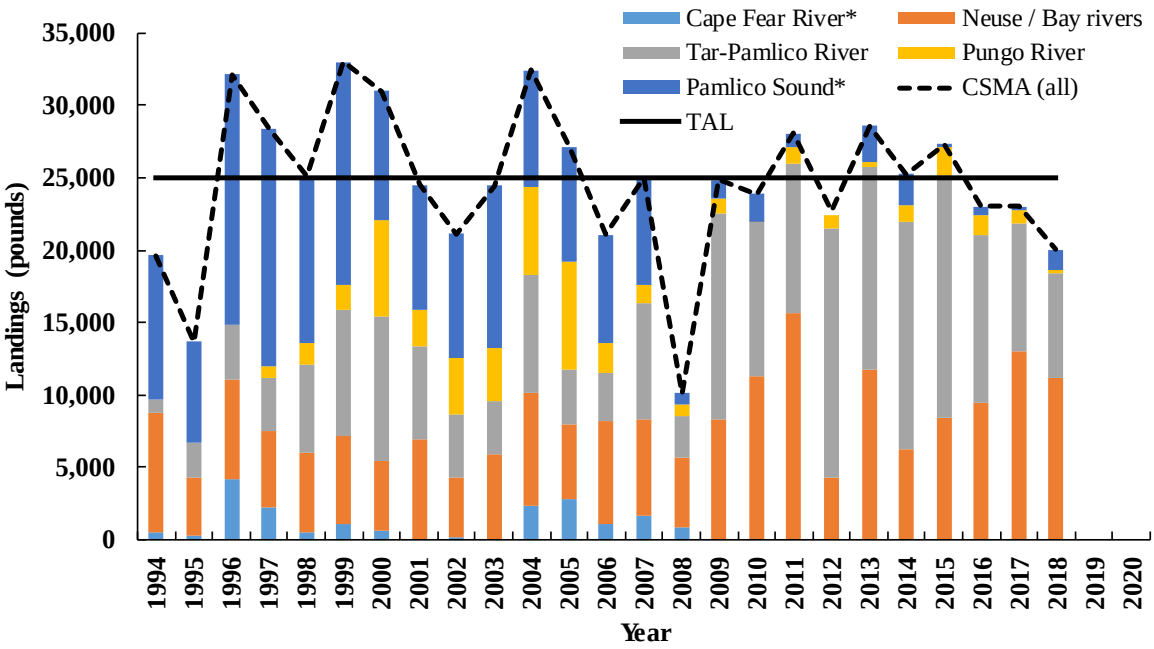

Figure 3.2. Commercial striped bass harvest by system, and the TAL in the CSMA, 1994–2020. There has been a harvest no-possession measure in the Cape Fear River since 2008 and in the CSMA since 2019. *Landings data for the Cape Fear River (2001) and for the Pamlico Sound (2012) are confidential.

Stock Concerns

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).

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.

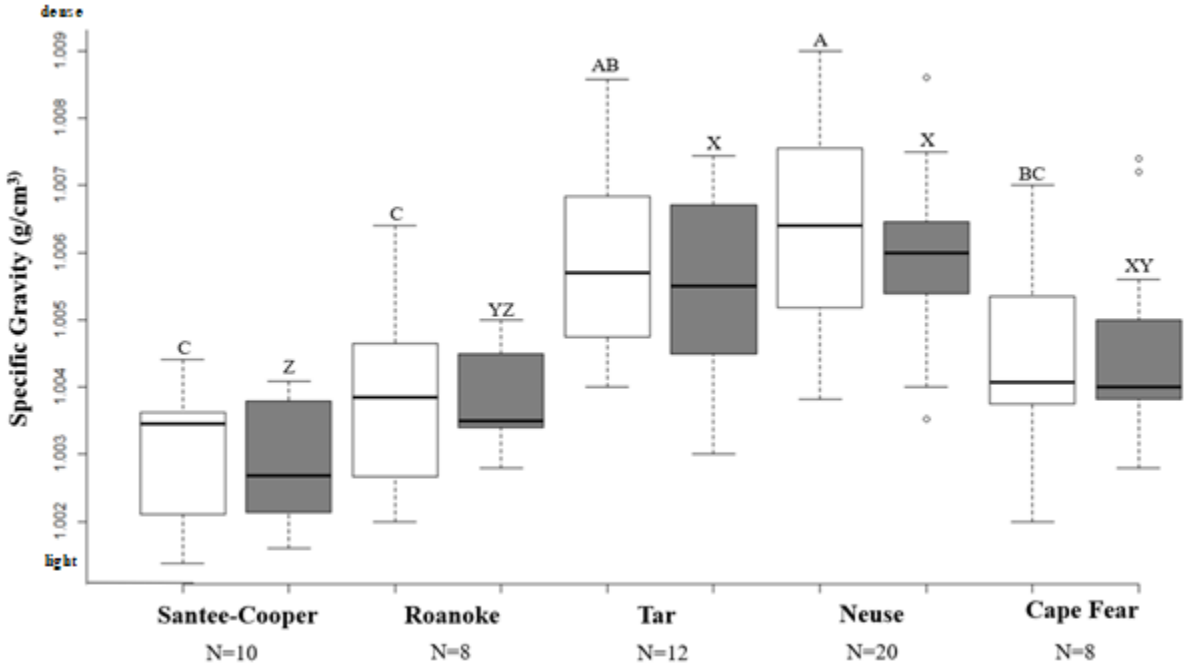

Figure 3.3. Specific gravity (buoyancy; g/cm^3) measurements from stage 1 (white boxes) and 4 (gray boxes) fertilized eggs from 2018/2019 hatchery broodstock sampling. Tukey pair wise comparisons are labeled above the boxplots with ABC indicating stage 1 significant differences and XYZ indicating stage 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.

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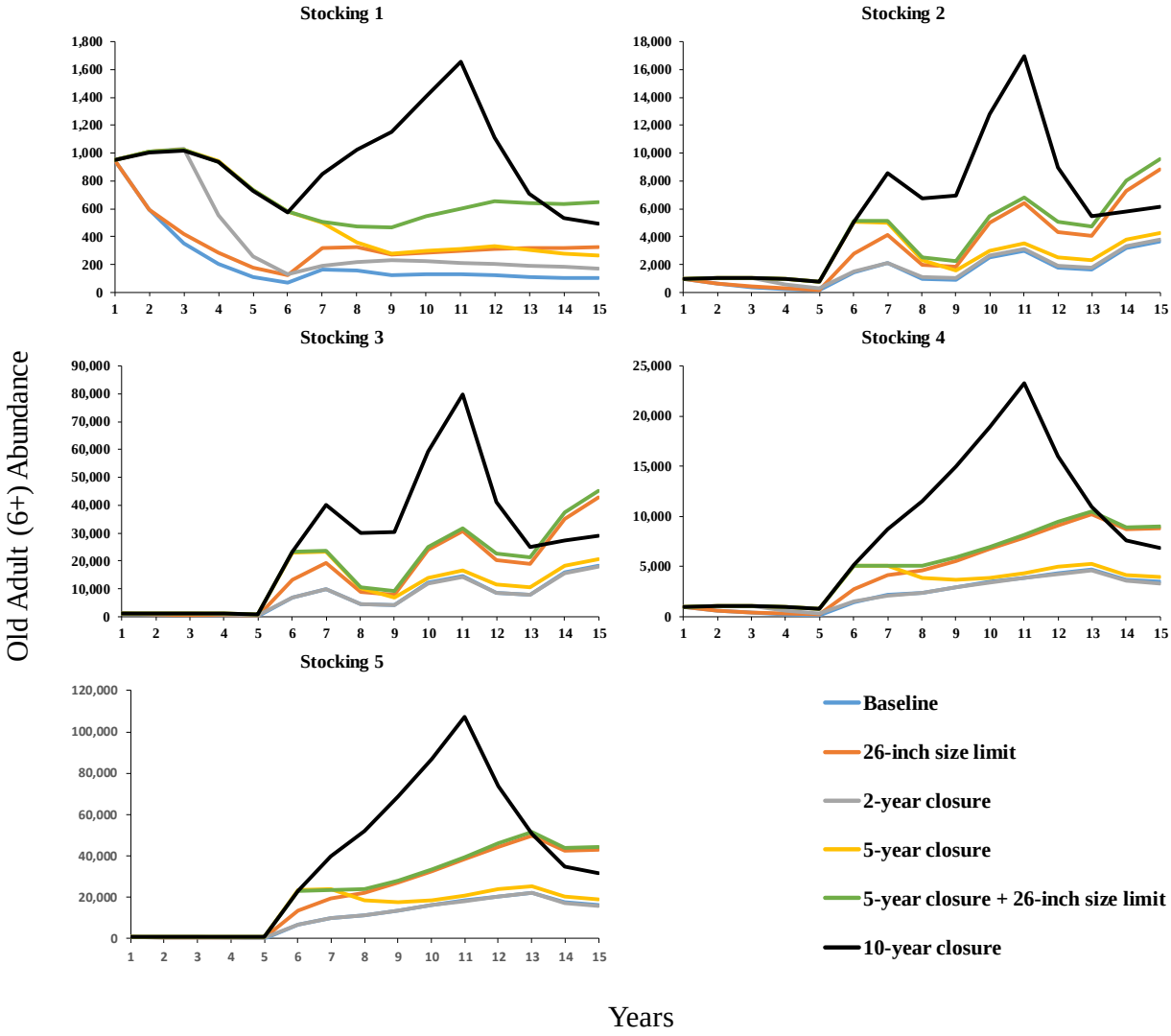

Figure 3.4. Abundance of old adults (age 6+) projected under five stocking strategies and six fishing strategies. Stocking 1 - no stocking; Stocking 2 - stocking 100,000 fish per year with 2-year stocking and 2-year no stocking alternating for 15 years (8 years of stocking in total); Stocking 3 - stocking 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

From 2012 to 2020, recreational striped bass dead discards in the Tar-Pamlico and Neuse rivers averaged 3,340 fish (Table 3.1). Measures to reduce recreational angling discard mortality may be necessary for the Tar-Pamlico and Neuse stocks. The use of single barbless hooks is required by WRC on the Roanoke River to reduce discard mortality. Similar measures and other methods, such as requiring circle hooks for natural bait and restricting the use of treble hooks, could be considered in the Tar-Pamlico and Neuse rivers. This type of restriction could be done seasonally or year-round. However, recreational gear limitations would likely impact other fisheries.

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.

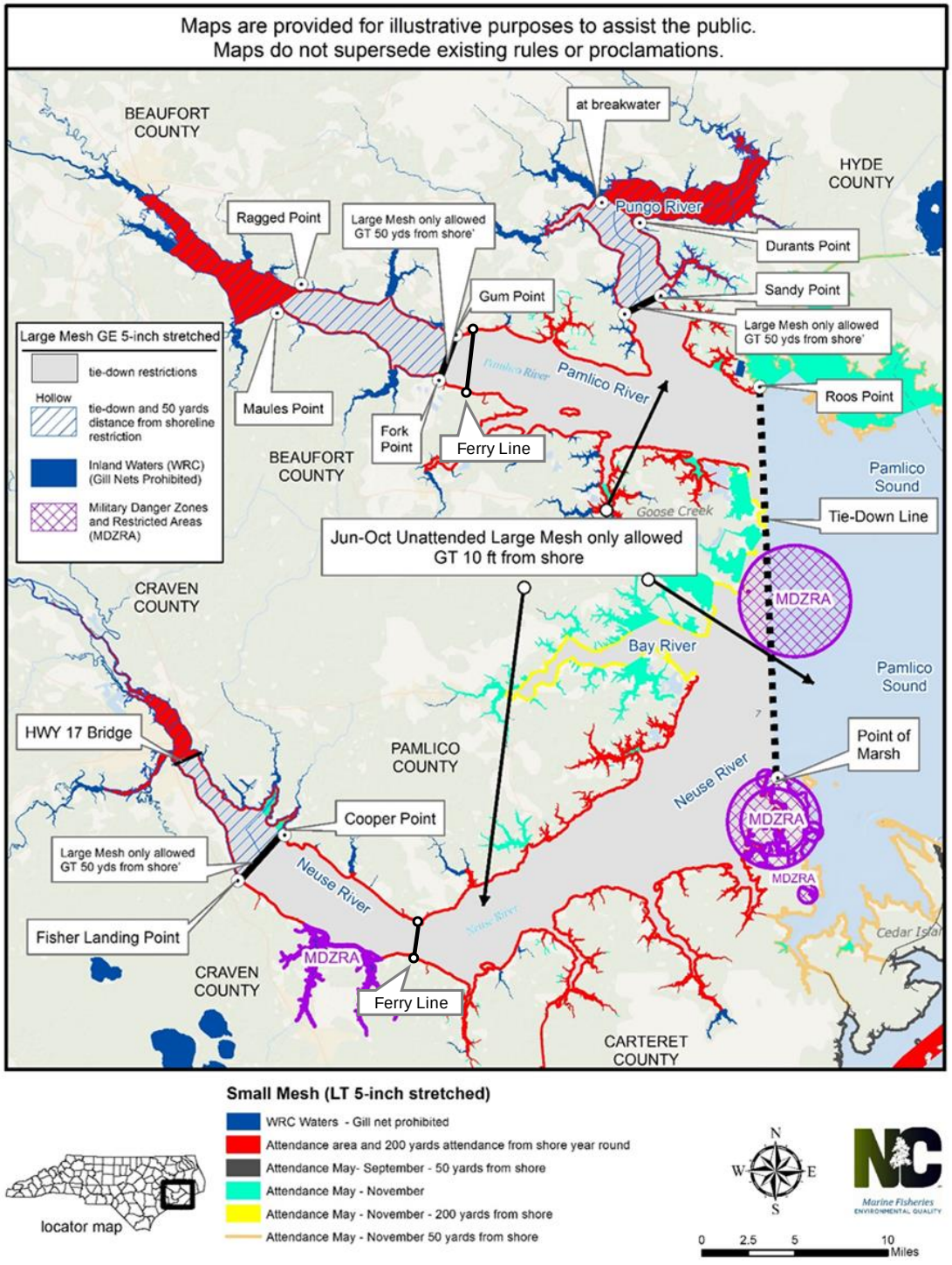

Figure 3.5. Gill net regulation map for various gill net types and seasons in the Central Southern Management Area.

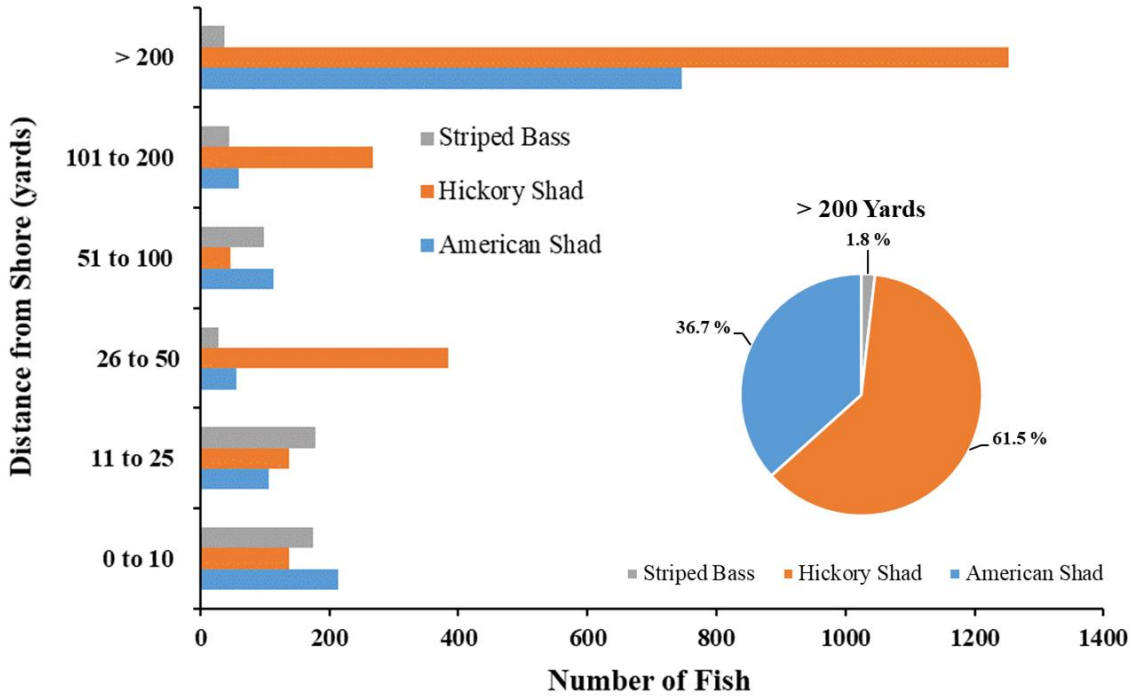

Figure 3.6. DMF observer data for striped bass, hickory shad, and American shad from gill nets set above the ferry lines on the Tar-Pamlico and Neuse rivers (2012–2020; Feb 15 – Apr 14; n=162 trips), separated by the distance from shore (yards). The insert shows the percentage of fish that were observed 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.

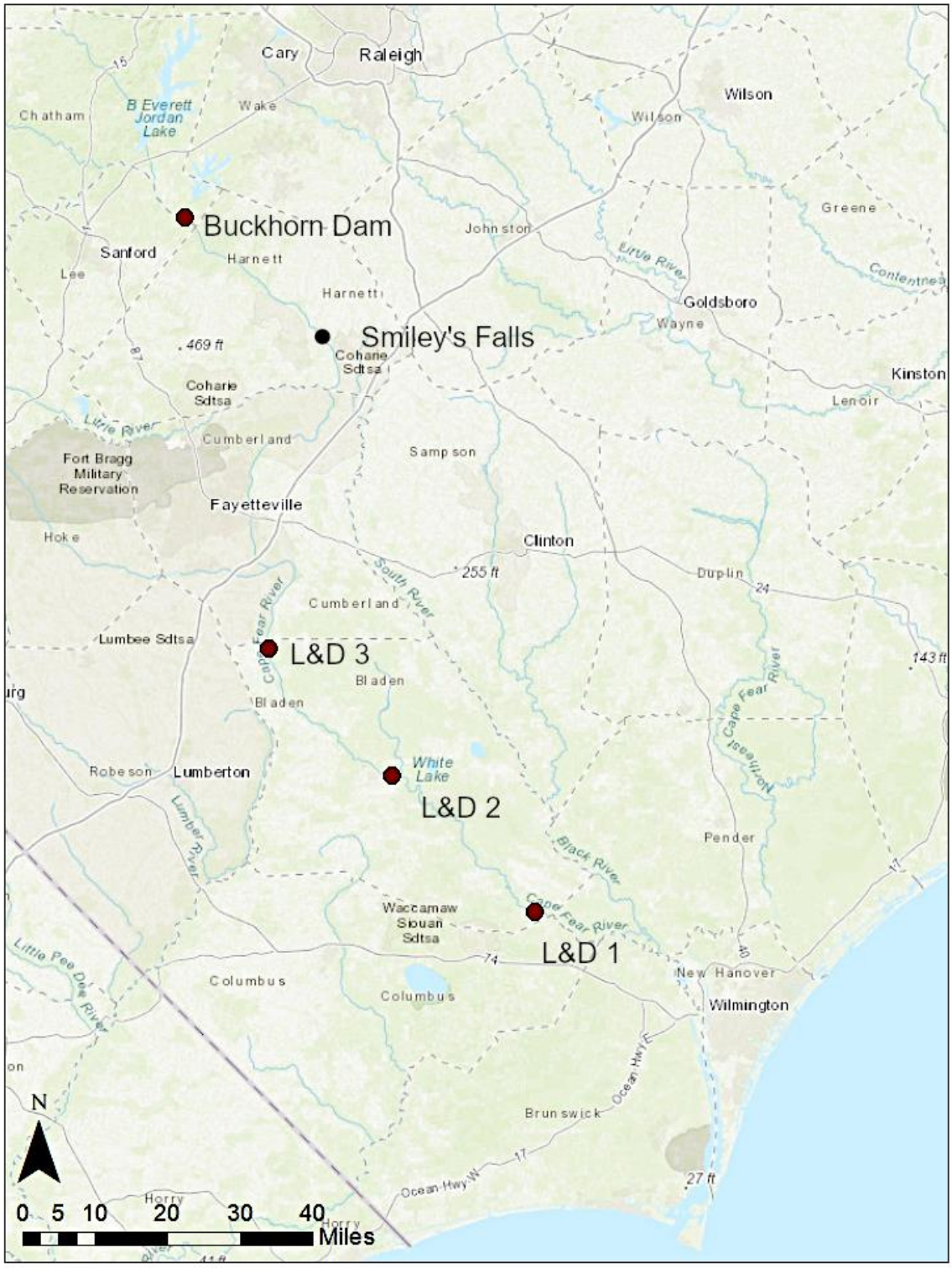

Figure 4.1. A map showing the locations of the three locks and dams on the mainstem of the Cape Fear River downstream of the historic spawning area near Smiley's Falls.

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).

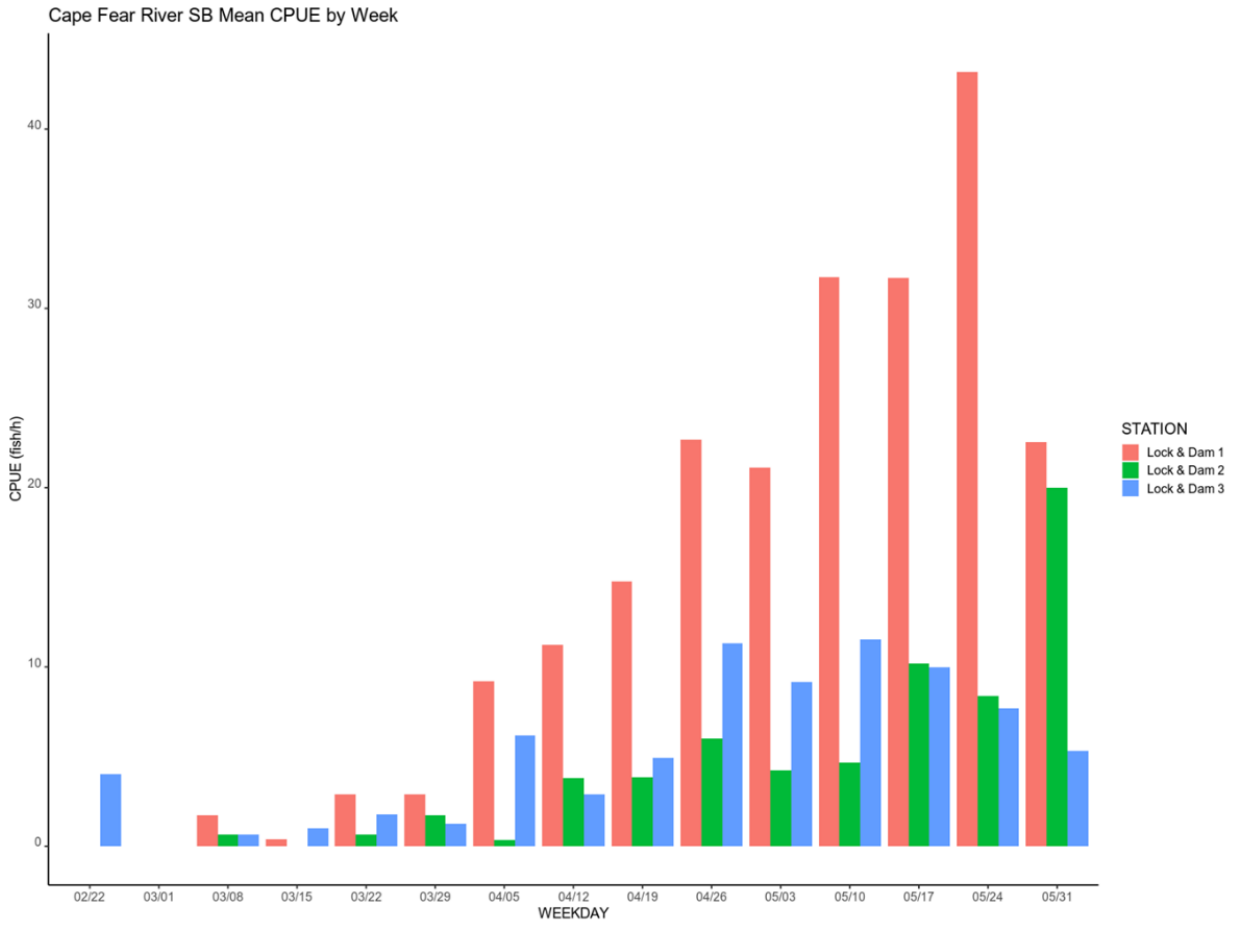

Figure 4.2. Weekly striped bass catch-per-unit-effort (CPUE) by sample site February through May 2008–2019.

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.

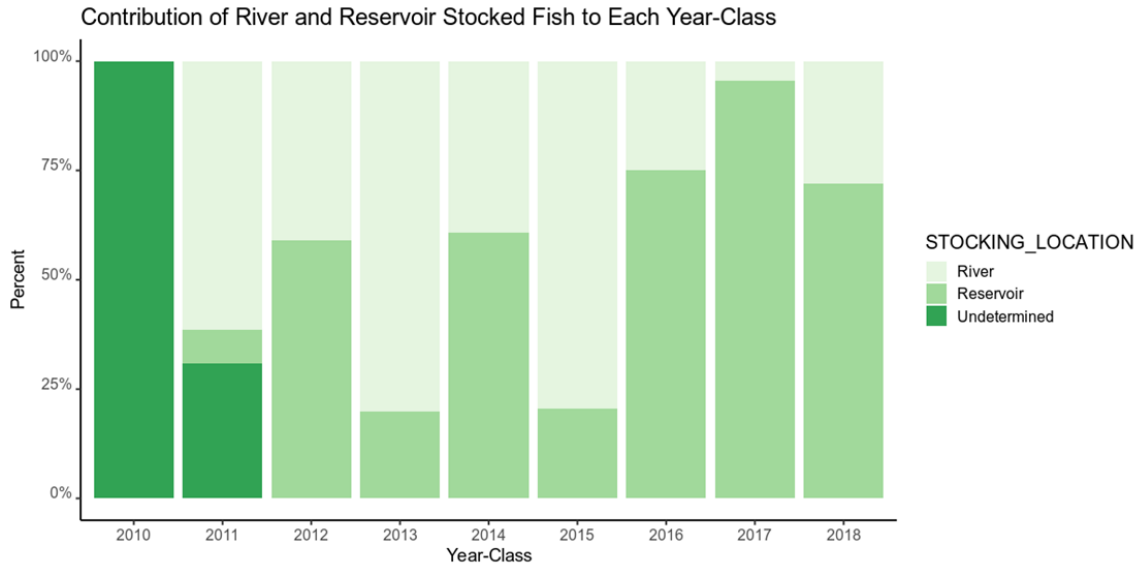

Figure 4.3. Relative contribution of hatchery-origin fish to the hatchery-origin year-class by stocking location of fish collected in WRC electrofishing surveys, 2010–2018.

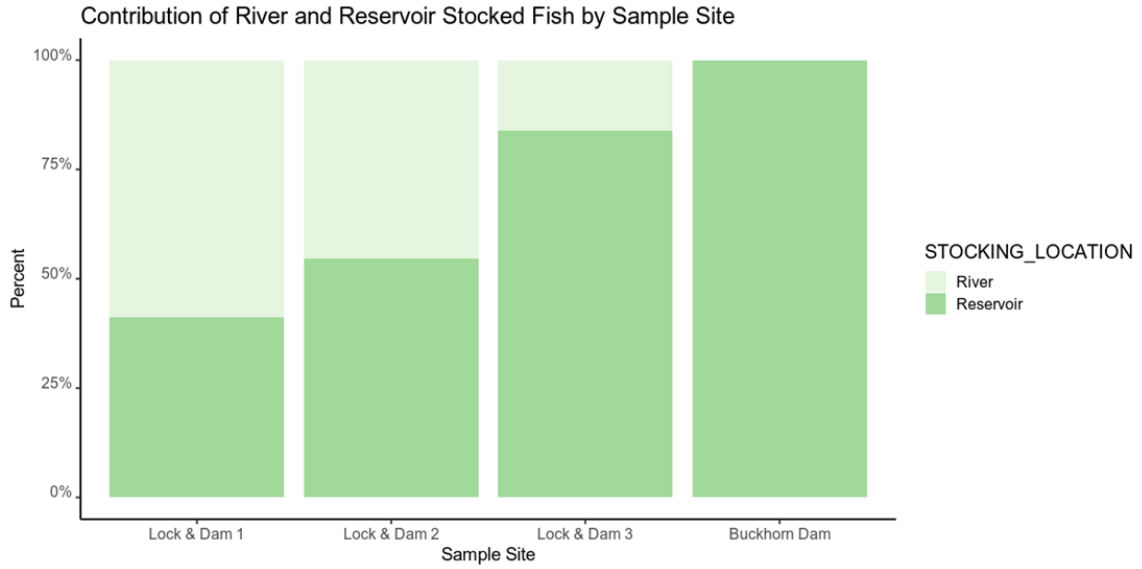

Figure 4.4. Relative contribution of hatchery-origin fish by stocking location to each WRC electrofishing sample site, 2015–2019.

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 existing rock arch ramp design at Lock and Dam #1 does 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 has 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 2.4 Use of Hook and Line as a Commercial Gear in the Estuarine Striped Bass Fishery.

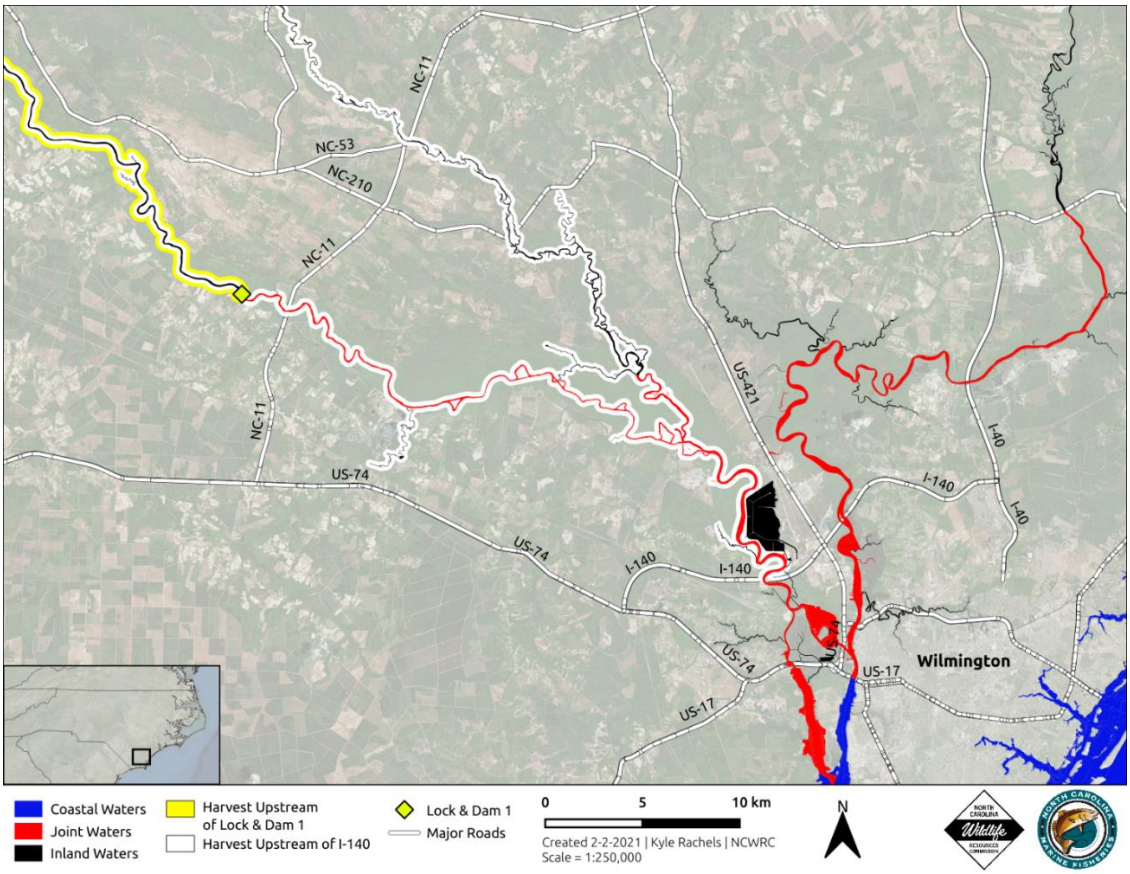

Figure 4.6. A map showing Inland, Joint, and Inland Fishing waters, as well as the harvest area boundaries for the proposed management options.

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.

<u>NCMFC Preferred Management Strategy</u>
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 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).

    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.

DRAFT – SUBJECT TO CHANGE

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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