Analysis of Striped Bass Fishery-Independent and Fishery-Dependent Data from the Tar-Pamlico and Neuse Rivers for Purposes of Amendment 2 Adaptive Management

August 1, 2025

ISSUE

- Determine whether striped bass populations in the Tar-Pamlico and Neuse rivers are self-sustaining and if sustainable harvest can be determined
- Assess the impact of the 2019 no-possession provision and the gill net closure (closures) on the stocks
- Assess the impact of the 2019 gill net closure above the ferry line in each river system on the stocks

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.

ORIGINATION

Amendment 2 to the North Carolina Estuarine Striped Bass Fishery Management Plan (FMP) adopted an adaptive management strategy where data through 2024 will be reviewed in 2025 to determine if populations are self-sustaining and if sustainable harvest can be determined. In addition, the approved North Carolina Marine Fisheries Commission (MFC) motion included language to: “maintain the gill net prohibition through 2024 to allow for assessment of its performance”.

The Amendment 2 adaptive management strategy further stated 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 scheduled FMP Amendment is developed starting in 2027. 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 stock 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. 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.

BACKGROUND

Natural reproduction is required 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 the Tar-Pamlico and Neuse rivers capable of self-replacement, the sustainable harvest objective of Amendment 2 cannot be met.

The Tar-Pamlico and Neuse rivers striped bass populations have been sustained by continuous stocking since at least the early 2000’s (O’Donnell and Farrae 2017; see NCDMF 2022, Appendix

1), providing harvest opportunities for recreational and commercial fisheries in the rivers which generally harvested between 5,000 and 10,000 striped bass annually (Table 1).

Table 1. Recreational harvest (number of fish landed and weight in pounds) and releases (number of fish) and commercial harvest (number and weight in pounds) of CSMA striped bass from North Carolina, 2004–2024.

	Recreational			Commercial		
Year	Number Landed	Number Released	Weight Landed	Number Landed	Weight Landed	Total Weight Landed
2004	6,141	13,557	22,958	3,950	32,479	55,437
2005	3,832	16,854	14,965	3,723	27,132	42,097
2006	2,481	14,895	7,352	2,850	21,149	28,501
2007	3,597	23,527	10,794	3,608	25,008	35,802
2008	843	17,966	2,990	1,719	10,115	13,105
2009	895	6,965	3,061	4,140	24,847	27,908
2010	1,757	7,990	5,537	4,486	23,888	29,425
2011	2,728	24,188	9,474	4,083	28,054	37,528
2012	3,922	43,313	15,240	3,693	22,725	37,964
2013	5,467	32,816	19,537	4,439	28,597	48,134
2014	3,301	30,209	13,368	5,830	25,245	38,613
2015	3,934	31,353	14,269	6,029	27,336	41,605
2016	6,697	75,461	25,260	4,123	23,041	48,301
2017	7,334	131,129	26,973	4,382	23,018	49,991
2018	3,371	49,122	10,884	3,788	20,057	30,941
2019	959	36,080	3,562	0	0	3,562
2020	0	19,420	0	0	0	0
2021	0	23,216	0	0	0	0
2022	0	30,026	0	0	0	0
2023	0	13,536	0	0	0	0
2024	0	9,795	0	0	0	0
Mean	3,579	31,020	12,889	4,056	24,179	35,557

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). Although North Carolina rivers, including the Tar-Pamlico and Neuse rivers, may have once supported genetically distinct populations, evidence suggests there is little genetic differentiation between populations (Reading 2020). The need for continued conservation management efforts are supported by persistent recruitment failure, multiple mortality sources, absence of older, larger fish, low water flow levels on the spawning grounds in the spring, poor environmental conditions in the nursery areas, 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.

Life History

Striped bass are an estuarine dependent species found from the lower St. Lawrence River in Canada to the west coast of Florida through the northern shore of the Gulf of Mexico to Texas. Striped bass migrate long distances to spawning grounds located in freshwater portions of coastal rivers. The Albemarle-Roanoke (A-R) stock is considered migratory, meaning they spend most of their adult life in estuarine and nearshore ocean waters, migrating to fresh water to spawn in the spring. Striped bass stocks from the Tar-Pamlico and Neuse rivers stocks south through Florida, are considered riverine, meaning they do not make extensive seasonal ocean migrations like northern (Roanoke River and north) striped bass stocks and, instead, spend their entire life in the upper estuary and riverine system (Setzler et al. 1980; Rulifson et al. 1982; Callihan 2012).

Historically there were naturally reproducing stocks of striped bass in many of the large coastal rivers in South Carolina, Georgia, and Florida. Similar to North Carolina, the striped bass stocks in these states started showing declines in abundance and reduced natural spawning success in the 1970s or earlier. While there remain a few coastal rivers in these states that have naturally reproducing populations of striped bass, reproduction is limited and harvest management strategies are supported by extensive striped bass stocking programs in these states (GADNR; FLFWC SCDNR).

A maximum age of 15 years has been observed for striped bass in the Tar-Pamlico and Neuse rivers, and fish older than eight are rare. Striped bass in the Central Southern Management Area (CSMA; Tar-Pamlico, Neuse and Cape Fear rivers) grow at a faster rate and have a greater total length at age compared to the A-R stock (Knight 2015) and Neuse River striped bass exhibit the fastest growth rate in the CSMA (NCDMF 2020).

In the Tar-Pamlico and Neuse rivers, 50% of female striped bass are mature at 2.7 years and 98% are mature by age-3 (Knight 2015). Length at 50% maturity (L50) in the Tar-Pamlico and Neuse rivers was estimated at 467.8 mm TL (18.4 inches TL) and fish were estimated to be 100% mature at 537.3 mm TL (21.2 inches TL). Female striped bass produce large quantities of eggs which are broadcast into riverine spawning areas and fertilized by age-2 and older males. In the Tar-Pamlico and Neuse rivers, fecundity ranged from 223,110 eggs for an age-3 female to 3,273,206 eggs for an age-10 female.

In 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 at river mile (rm) 130 to Raleigh (rm 236). Successful juvenile recruitment occurs infrequently and at low levels in the Tar-Pamlico and Neuse rivers. The Tar-Pamlico and Neuse rivers stocks are supported by continuous stocking efforts as evidenced by stocked fish comprising nearly 100% of the striped bass on the spawning grounds and up to 70% in downriver coastal fishing waters in some years (O'Donnell and Farrae 2017; Cushman et al. 2018; Farrae 2019; Harris and Farrae 2020; Mathes et al. 2020; Harris and Farrae 2021; Harris and Farrae 2022; Doll and Farrae 2023; Doll and Farrae 2024).

Management History

Amendment 1

Management measures in Amendment 1 consisted 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. Tie down and

distance from shore gill net management measures from the 2004 Estuarine Striped Bass FMP (NCDMF 2004) that were maintained in Amendment 1 were implemented using science-based decision-making processes. Rock et al. (2016) estimated these measures decreased striped bass discards by 82% compared to estimates prior to implementation, indicating effectiveness of these measures. Amendment 1 also maintained the stocking measures in the major CSMA river systems (NCDMF 2013).

Supplement A to Amendment 1

In 2017 and 2018, available Parentage-Based Tagging (PBT) data, which is a genetic method used to identify parentage of hatchery origin fish, suggested there were potentially one or two successful striped bass spawning events in the Tar-Pamlico and Neuse rivers in 2014 and 2015 that produced 'wild' fish and was particularly evident in the Neuse River (Table 2). Additionally, 2016–2018 CSMA Creel Survey angler data showed a significant increase in recreational catch of under-sized striped bass in the Pungo, Tar-Pamlico and Neuse rivers (Figure 1). 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 (Tar-Pamlico and Neuse rivers) with the objective of providing additional protection for these potentially naturally produced year classes in support of the Amendment 1 goal to achieve sustainable harvest through science-based decision-making processes that conserve adequate spawning stock and provide and maintain a broad age structure. Supplement A maintained commercial gill net restrictions requiring 3-foot tie-downs and 50-yard distance from shore measures year-round (M-5-2019).

Table 2. PBT results from Tar-Pamlico and Neuse rivers striped bass showing the number and percentages of hatchery origin versus 'wild' origin fish, 2016–2024.

River System	Year	Number of PBT Samples	Hatchery (n)	'Wild' (n)	Hatchery (%)	'Wild' (%)
Tar-Pamlico	2016	190	164	26	86.0	14.0
	2017	147	102	45	70.0	31.0
	2018	206	74	132	36.0	64.0
	2019	108	48	60	44.4	55.6
	2020	56	39	17	69.6	30.4
	2021	103	53	50	51.5	48.5
	2022	81	75	6	92.6	7.4
	2023	47	44	3	93.6	6.4
	2024	21	20	1	95.2	4.8
Neuse	2016	150	142	8	95.0	5.0
	2017	118	66	52	56.0	44.0
	2018	86	46	40	54.0	47.0
	2019	102	68	34	66.7	33.3
	2020	24	17	7	70.8	29.2
	2021	114	56	58	49.1	50.9
	2022	34	29	5	85.3	14.7
	2023	35	33	2	94.3	5.7
	2024	23	22	1	95.7	4.3

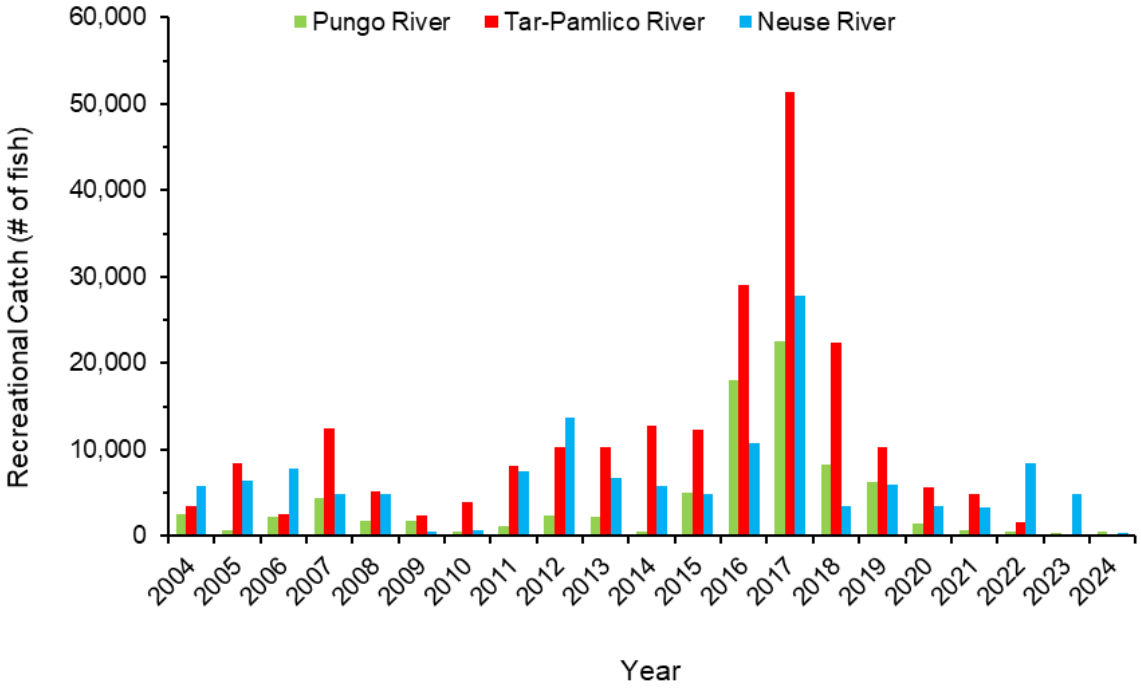

Figure 1. CSMA Creel Survey estimates of under-sized recreationally caught striped bass in the Pungo, Tar-Pamlico, and Neuse rivers, 2004–2024.

Ferry Line Gill Net Closure

Independent of Supplement A but also at the February 2019 NCMFC business meeting, the following motion passed:

> "Ask the director of the NCDMF to issue a proclamation, effective in conjunction with the Supplement, that restricts the use of gill nets that interact with striped bass upstream of the ferry lines and requires attendance of gill nets that interact with striped bass upstream of the tie-down lines."

After careful consideration, the DMF Director declined the request concluding that scientific data did not support the requested management measure (see Appendix 2 DMF Director Memo to MFC, March 4, 2019). On March 13, 2019, the MFC held an emergency meeting to request the North Carolina Wildlife Resources Commission (WRC) adopt concurrent regulations regarding recreational harvest of striped bass in joint waters. At the emergency meeting the MFC passed a motion directing the division to issue a proclamation regarding gill nets beyond what was contained in Supplement A.

An emergency meeting called under N.C. General Statute section 113-221.1(d), authorizes the commission to review the desirability of directing the fisheries director to issue a proclamation. Once the commission votes under this provision to direct issuance of a proclamation, the fisheries director has no discretion to choose another management option and is bound by law to follow the commission decision. In these cases, under existing law, the decision of the commission to direct the director to issue a proclamation is final and can only be overruled by the courts. Given this requirement Proclamation M-6-2019 implemented the following:

- Prohibits the use of all gill nets upstream of the ferry lines from the Bayview Ferry to Aurora Ferry on the Pamlico River and the Minnesott Beach Ferry to Cherry Branch Ferry on the Neuse River.
- Maintains tie-down (vertical net height restrictions) and distance from shore restrictions for gill nets with a stretched mesh length 5 inches and greater in the western Pamlico Sound and rivers (superseded M-5-2019).

Amendment 2
Amendment 2, adopted in November of 2022, contained management measures for the Tar-Pamlico and Neuse rivers stocks that maintained the no-possession measure, the gill net closure above the ferry lines, and the use of 3-foot tie-downs below the ferry lines. Additionally, the Amendment 2 adaptive management strategy prescribed that in 2025, data through 2024 will be reviewed to determine if populations are self-sustaining and if sustainable harvest can be determined. In addition, Amendment 2 maintained the gill net prohibition through 2024 to allow for assessment of its performance.

DATA

Methods
To assess if the 2019 no-possession provision and ferry line gill net closures have increased relative abundance of striped bass and expanded the age structure of the stock, and to assess whether striped bass populations in the Tar-Pamlico and Neuse rivers have achieved a level of sustainability through successful natural reproduction, several fishery-independent and dependent data sources were reviewed. The DMF Independent Gill Net Survey and the WRC Electrofishing Survey data sets are the primary data sources for the evaluation; however, the CSMA Striped Bass Creel survey and DMF gill net observer program data were also evaluated.

For further information about survey methodology, design and data collection see Mathes et al. (2020) and NCDMF (2024).

Adult Relative Abundance

Fisheries-Independent Gill Net Survey (Program 915)
Program 915 employs a random survey design stratified by area and depth that has sampled in the Tar-Pamlico, Pungo, and Neuse rivers since 2003. Striped bass abundance calculations exclude Pungo River data due to elevated presence of A-R stock fish in this river (Mathes et al. 2020). Only shallow sets during April, and October–November were used in relative abundance calculations because striped bass are most available to the survey in these areas and months.

WRC Spawning Grounds Electrofishing Survey
Electrofishing surveys have been conducted by the WRC on the Tar-Pamlico River spawning grounds since 1996 and on the Neuse River spawning grounds since 1994. The objectives of the WRC spawning ground surveys are to monitor and quantify population metrics of striped bass migrating to the spawning grounds during spring each year. The survey uses a stratified random sampling design in the Tar-Pamlico and Neuse rivers. In the Tar-Pamlico River, striped bass sampling typically begins in March and continues into May until water temperatures consistently exceed optimal temperatures for spawning (18–22 °C) and spawning appears complete. Sampling on the Neuse River is conducted a minimum of once at each stratum per week during the spawning season and generally occurs from April–May. Sampling upstream strata is highly dependent on streamflow, with low flow conditions causing sampling to only occur in lower river strata. In these instances, striped bass using upper river habitats would not be sampled; however,

striped bass access to upriver habitats is also limited during low water levels. Relative abundance is calculated as the number of fish captured per hour of electrofishing.

Age Data

Striped bass otoliths and fin clips were collected opportunistically from DMF fishery-independent and dependent sampling programs. Age samples were primarily collected from Program 915, but DMF also uses an electrofishing boat to collect striped bass to increase the sample size and collect a representative size range of striped bass including older, larger fish.

Juvenile Relative Abundance (Program 100)

Program 100 sampling has been conducted in the Tar-Pamlico and Neuse rivers since 2017. The survey employs beach seines (June–July) and trawls (July–October) to monitor striped bass recruitment and assess the effectiveness of management measures aimed at promoting natural reproduction. Seine and trawl survey stations are located in the upriver sections of the Tar-Pamlico and Neuse rivers, near Washington and New Bern, respectively. A sample consisted of one trawl tow or one pull of the seine per station (Mathes et. al 2020). A fin clip was collected from all YOY striped bass to determine if they are of hatchery or 'wild' origin using genetic methods.

Parentage-Based Tagging (PBT)

Analysis using microsatellite markers has been used by the WRC since 2010 and the DMF since 2016 to genetically identify stocked fish in the Tar-Pamlico and Neuse rivers. PBT techniques identify a fish as hatchery reared or non-hatchery by using genetic microsatellite markers to match stocked fish with broodfish used in hatchery production (Denson et al. 2012). 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 PBT techniques. Striped bass fin clip samples were collected opportunistically from DMF fishery-independent and dependent sampling programs, as well as from the WRC spawning ground surveys to identify fish as either hatchery or non-hatchery origin.

Mann-Kendall (M-K) Trend Test

The M-K test is a non-parametric statistical test used to detect significance of increasing or decreasing trends over time, without requiring the data to be normally distributed. M-K tests were used to assess the impact of the 2019 no-possession provision on the stocks. The test provides a p-value, which indicates the probability of observing the results if there is no trend in the time series. If the p-value is below a certain significance level (e.g., 0.05), the null hypothesis is rejected, suggesting there is a statistically significant trend. In an M-K Trend Test, Kendall's Tau is a correlation coefficient used as a measure of the relationship between two variables. Kendall's Tau measures the strength and direction of the trend in a time series. It indicates whether the values tend to increase or decrease over time. A positive Tau suggests an increasing trend, a negative Tau indicates a decreasing trend, and a value close to zero suggests no trend.

Randomization Test

The Randomization test is a non-parametric statistical test used to detect significant differences between groups that relies on randomly shuffling observed data to determine if observed differences are statistically significant. Randomization tests shuffle data many times to evaluate mean catch per unit effort differences. Additionally, after each shuffle, the means computed from

the shuffled data are compared with the observed mean difference. The p-value for the randomization test is the percentage of times the absolute value of the shuffled mean difference is equal to or greater than the absolute value of the observed mean. Randomization tests were applied to fisheries-independent data (Program 915 and WRC Electrofishing Survey) to assess if striped bass catch was significantly different after the harvest closure compared to before the harvest closure and if striped bass catch was significantly different above the ferry lines after the gill net closure.

Results

Adult Relative Abundance

Program 915

Striped bass relative abundance from Program 915 in the Tar-Pamlico and Neuse rivers ranged from 0.8 to 9.0 fish per sample during 2004–2024. Striped bass relative abundance in the Tar-Pamlico River was the lowest in the time series during 2021–2024, and well below the time series average of 4.3 striped bass per set before the 2019 closure (Figure 2). After the management measures went into place in the Tar-Pamlico River there was a decrease in relative abundance (61% reduction, 4.3 to 1.7 fish per set; Figure 2).

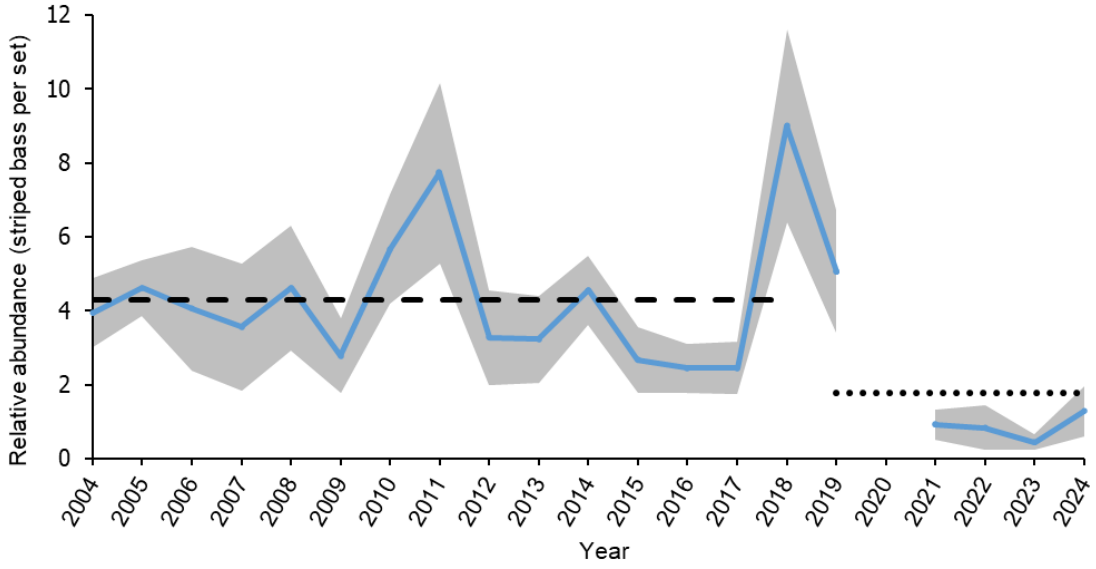

Figure 2. Annual index of adult striped bass relative abundance from Program 915 in the Tar-Pamlico River during April, and October–November, in shallow water sets, 2004–2024. No sampling occurred in 2020, and limited sampling occurred in 2021 (July–December). Error bars represent ± 1 standard error. Dashed line is mean abundance from 2004–2018 (pre-closure), dotted line is mean abundance from 2019–2024 (post-closure).

In the Neuse River, striped bass relative abundance has declined since 2021 and in 2022–2024 had the lowest values in the time series, well below the time series average of 3.6 striped bass per set before the 2019 closure (Figure 3). After the closure went into place in the Neuse River there was a decrease in relative abundance (42% reduction, 3.6 to 2.1 fish per set; Figure 3).

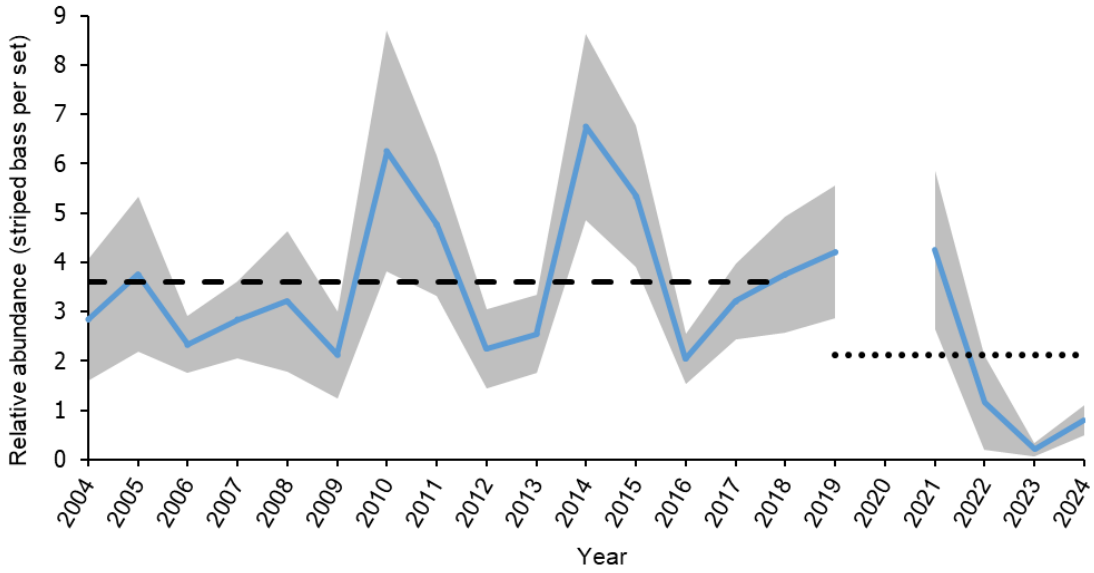

Figure 3. Annual index of adult striped bass relative abundance from Program 915 in the Neuse River during April, and October–November, in shallow water sets, 2004–2024. No sampling occurred in 2020, and limited sampling occurred in 2021 (July–December). Error bars represent ± 1 standard error. Dashed line is mean abundance from 2004–2018 (pre-closure), dotted line is mean abundance from 2019–2024 (post-closure).

Striped bass length frequencies from Program 915 in the Tar-Pamlico and Neuse rivers are shown in Figure 4. Length frequency distributions are variable between years but generally range from 10–25 inches total length (TL), however in the Tar-Pamlico River from 2016–2017 (Figure 4A) and in the Neuse River from 2015–2017 (Figure 4B) there was a higher percentage of small fish that could represent the two-year classes of striped bass thought to be the result of successful natural reproduction in 2014 and 2015. In 2023, catch was composed of high percentages of fish greater than 20 inches which could be tracking continued growth and perpetuation of the 2014- and 2015-year classes. During 2021–2023 there were few smaller fish, less than 15 inches, in the gill net survey catch. In 2024, there was an even distribution of striped bass lengths in the Tar-Pamlico River ranging from 12-29 inches TL, while lengths in the Neuse River were centered around 20 inches TL. The decrease in the proportion of larger fish may be reflective of A-R fish from the 2014- and 2015-year classes leaving the rivers and entering the Atlantic Ocean migratory stock. Due to the low numbers of striped bass captured (N=17 during April, and October–November from shallow water sets), the length-frequency distribution may not be reflective of the populations size distribution.

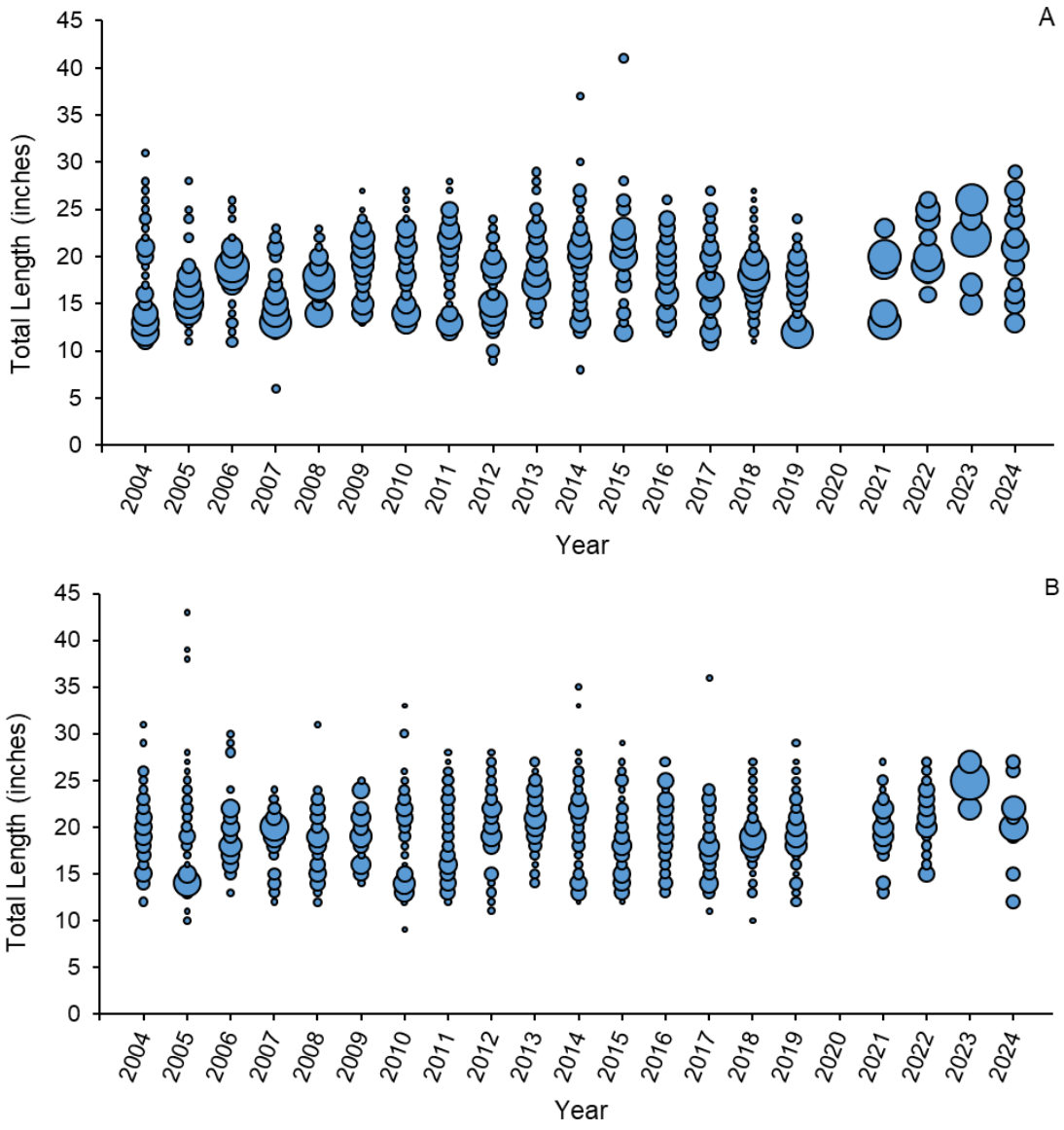

Figure 4. Length frequency of striped bass captured in Program 915 in the Tar-Pamlico River (A), and the Neuse River (B) during April, and October–November, in shallow water sets (2004–2024). No sampling occurred in 2020 and limited sampling occurred in 2021 (July–December). Bubbles represent fish at length and the bubble size is proportional to the number of fish at that length.

WRC Spawning Grounds Electrofishing Survey

Striped bass relative abundance from the WRC spawning grounds electrofishing survey in the Tar-Pamlico River has ranged from a low of 18.2 striped bass per hour in 2018 to a peak of 100.0 per hour in 2010 (Figure 5). Since the harvest closure in 2019, relative abundance has increased approaching levels near the 1996–2018 time series average of 40.8 fish per hour; however, there was a decrease in relative abundance after the 2019 closures went into place (20% reduction, 40.8 to 32.7 fish per sample; Figure 5). Additionally, the percentage of Age 6+ (~600 mm TL) striped bass on the Tar River spawning grounds has decreased from a 10-year average (2009–2018) of 18% by approximately 12% since the 2019 closures.

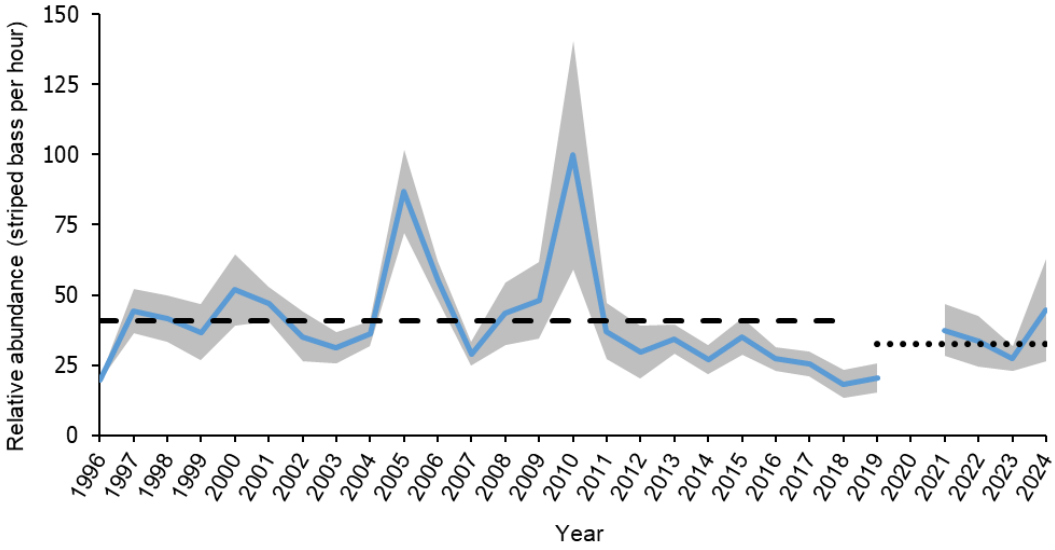

Figure 5. Relative abundance of Tar-Pamlico River striped bass from the WRC spawning grounds electrofishing survey, 1996–2024. No sampling occurred in 2020. Shaded error bars represent ± 1 standard error. Dashed line is mean abundance from 2004–2018 (pre-closures), dotted line is mean abundance from 2019–2024 (post-closures).

From 1994 through 2024, striped bass relative abundance in the Neuse River has been highly variable, ranging from 4.4 fish per hour in 2008 to 20.4 fish per hour in 1999 (Figure 6).

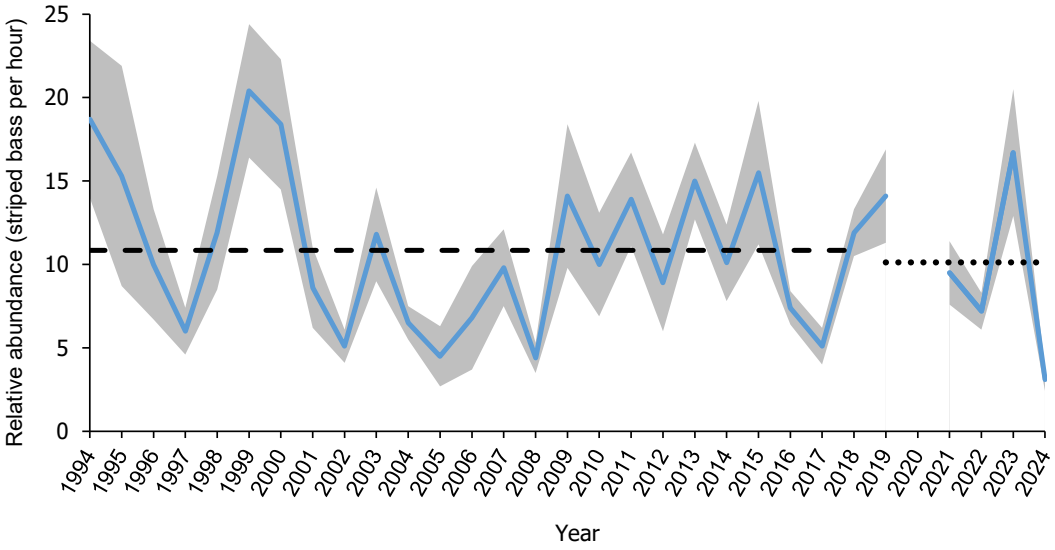

Figure 6. Relative abundance of Neuse River striped bass from the WRC spawning grounds electrofishing survey, 1994–2024. No sampling occurred in 2020. Shaded error bars represent ± 1 standard error. Dashed line is mean abundance from 2004–2018 (pre-closures), dotted line is mean abundance from 2019–2024 (post-closures).

Although relative abundance has continued to be highly variable since the 2019 closures, ranging from 16.7 fish per hour in 2023 to 3.1 fish per hour in 2024, the mean value during 2019–2024 (7% reduction, 10.1 fish per hour) is at the 1994–2018 time series average (10.8 fish per hour). Relative abundance from the WRC electrofishing surveys in the Tar-Pamlico and Neuse rivers shows little to no trend since the 2019 closures.

Age Data

Fishery-independent and fishery-dependent age data (2004–2024) collected from otolith and genetic samples show no expansion of the age structure (increased numbers of age-10+ fish) in the Tar-Pamlico or Neuse rivers since implementation of the harvest and gill net closures in 2019. Modal and maximum age has not increased beyond what was observed prior to 2019 (Table 3, modal age=3; maximum age=12).

Table 3. Tar-Pamlico and Neuse rivers striped bass otolith and genetic age data from fishery dependent and independent surveys, 2004–2024. PBT age data for 2024 are not yet available.

	Modal Age		Minimum Age		Maximum Age		Total Number Aged	
Year	otolith	genetic	otolith	genetic	otolith	genetic	otolith	genetic
2004	3	-	1	-	11	-	50	-
2005	2	-	1	-	9	-	78	-
2006	3	-	1	-	9	-	111	-
2007	3	-	1	-	9	-	86	-
2008	3	-	1	-	8	-	103	-
2009	4	-	1	-	6	-	37	-
2010	5	-	1	-	9	-	154	-
2011	3	-	1	-	6	-	56	-
2012	3	-	1	-	7	-	205	-
2013	3	-	1	-	8	-	156	-
2014	3	-	1	-	11	-	172	-
2015	3	-	1	-	9	-	113	-
2016	2	3	1	2	8	6	38	323
2017	2	4	1	1	9	7	98	247
2018	3	4	1	1	12	8	109	201
2019	4	3	1	1	11	9	307	183
2020	5	4	1	1	9	9	147	99
2021	3	3	1	1	10	10	352	109
2022	3	4	1	0	11	11	114	128
2023	3	3	1	0	9	8	95	84
2024	4	-	1	-	10	-	65	45

Striped bass up to age-6 are commonly encountered and striped bass age-6 and under make up around 90% of the DMF otolith age samples in the Tar-Pamlico and Neuse rivers (Figure 7).

However, fish older than age-10 are rare and make up less than 10% of the age samples in all years since 2013.

Two tagged striped bass, raised at Edenton National Fish Hatchery and released into the Tar-Pamlico River as phase-II sized fingerlings in 2008, were recaptured in November 2023 by an angler along the railroad bridge over the Tar-Pamlico River in Washington, NC. These tag returns indicate an increase in the maximum observed age of Tar-Pamlico River striped bass from 12 years to 15 years.

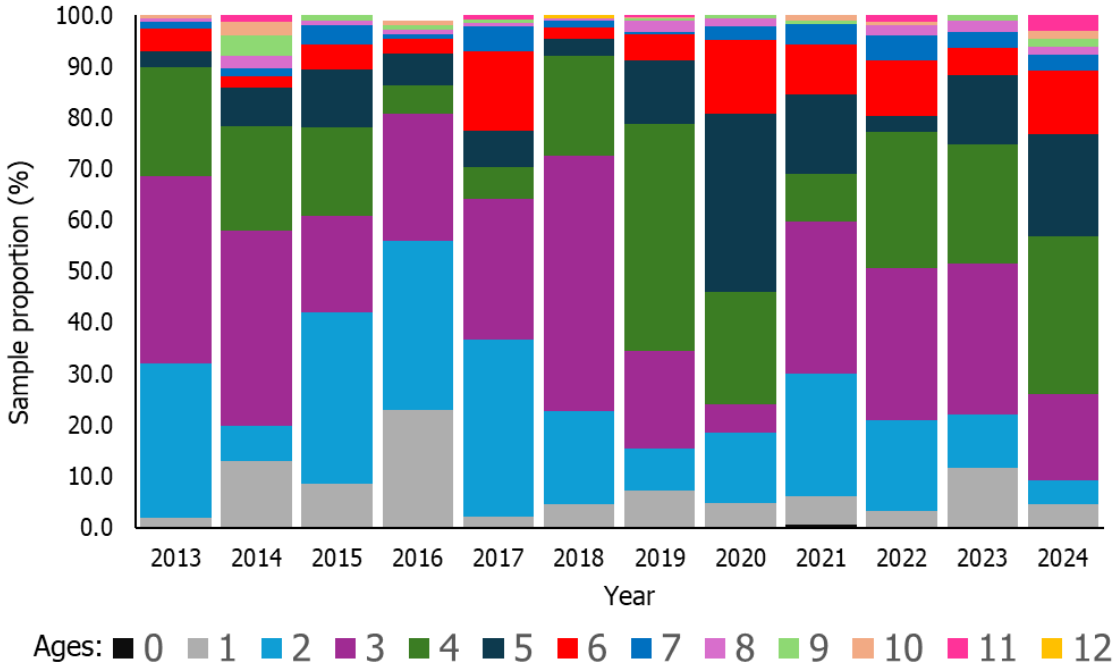

Figure 7. Proportion (%) at age (otolith ages) for striped bass collected from DMF sampling programs in the Tar-Pamlico and Neuse rivers, 2013–2024.

Juvenile Relative Abundance

As of 2024, only two 'wild' (non-hatchery) juvenile striped bass were collected from the Tar-Pamlico River (2021), with no 'wild' juvenile striped bass collected in the Neuse River. Stocked phase-I size (1–2 inch) juvenile striped bass were collected from the Tar-Pamlico (n=35) and Neuse rivers (n=8) in 2022 and 2023 (Table 4). Because no striped bass were captured in trawl sampling 2017–2022, trawl sampling was discontinued after the 2022 season and additional seine sampling was added.

Table 4. Relative abundance (Index) of striped bass (number of individuals per sample), total number of striped bass collected, and the number of beach seine and trawl samples (N) in the Tar-Pamlico and Neuse rivers, 2017–2024.

	Tar-Pamlico River						Neuse River					
	Seine			Trawl			Seine			Trawl		
Year	Striped bass (N)	Samples (N)	Index	Striped bass (N)	Samples (N)	Index	Striped bass (N)	Samples (N)	Index	Striped bass (N)	Samples (N)	Index
2017	0	54	0.00	0	48	0.00	0	54	0.00	0	48	0.00
2018	0	30	0.00	0	36	0.00	0	30	0.00	0	36	0.00
2019	0	36	0.00	0	48	0.00	0	36	0.00	0	48	0.00
2020	0	48	0.00	0	48	0.00	0	48	0.00	0	48	0.00
2021*	2	48	0.04	0	48	0.00	0	48	0.00	0	48	0.00
2022†	21	48	0.44	0	36	0.00	4	48	0.08	0	36	0.00
2023†	14	71	0.20	-	-	-	4	70	0.06	-	-	-
2024	0	63	0.00	-	-	-	0	64	0.00	-	-	-
Total	37	398	0.09	0	264	0.00	8	398	0.02	0	264	0.00

*non-hatchery or ‘‘wild’’ fish
† phase-I hatchery origin

Parentage Based Tagging

PBT analysis of samples collected on the spawning grounds and from internal coastal waters of the Tar-Pamlico and Neuse rivers indicates stocked striped bass can make up greater than 90% of the fish sampled in some years (2013–2016); 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; Figure 8). From 2019 to 2023, the percentage of stocked fish continued to increase. However, results from 2021 DMF samples (n=220) showed a noticeable drop in the percentage of hatchery fish to a 50/50 split with ‘wild’ striped bass. Upon further investigation of the 2021 PBT data, DMF striped bass collections in the Tar-Pamlico and Neuse rivers from January through March consisted of nearly 100% ‘wild’ origin striped bass. Interestingly, ages 6 and 7 represented 29% of the catch which could be ‘wild’ A-R stock striped bass from the 2014- and 2015-year classes produced in the Roanoke River. Additionally, age-3 striped bass represented 27% of the samples which could indicate successful natural recruitment in the Tar-Pamlico and Neuse rivers from the 2018-year class, or recruitment from the A-R system even though the 2018 A-R juvenile abundance index was low.

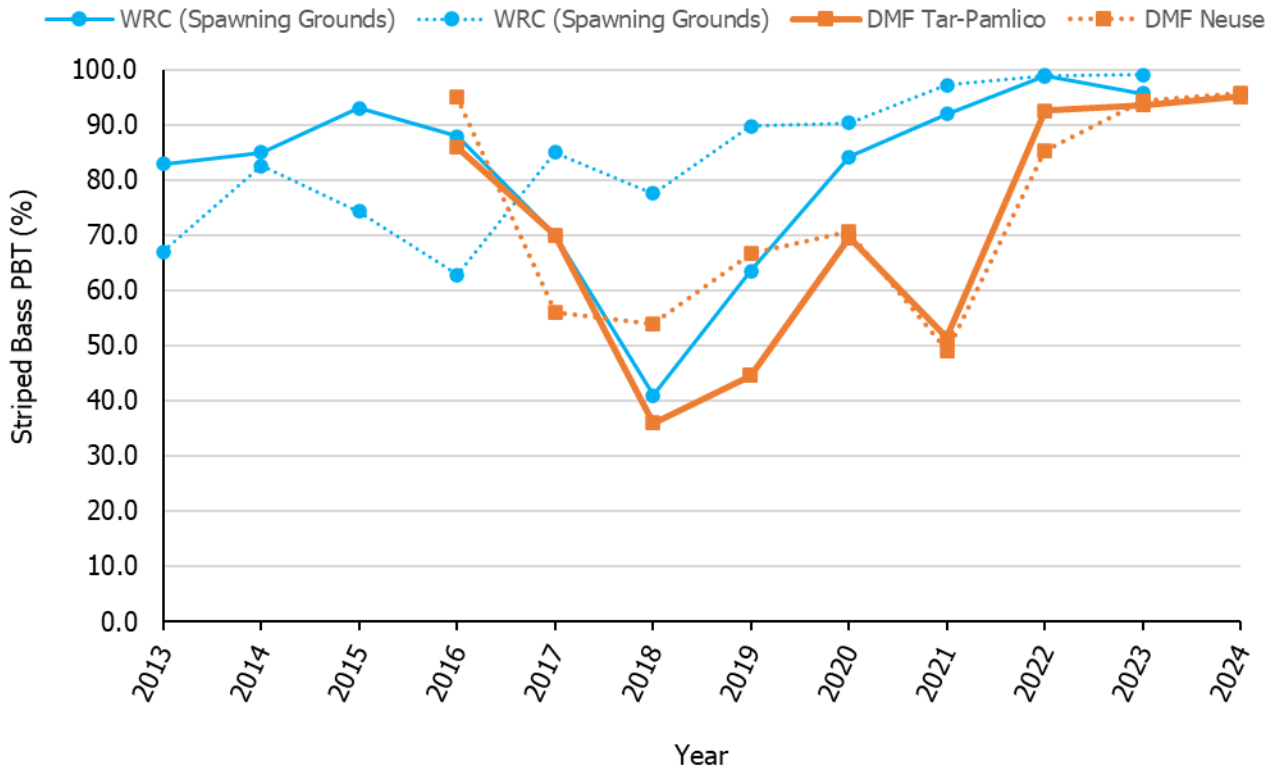

Figure 8. Hatchery contribution from the DMF Fisheries Independent and Dependent sampling programs (2016–2024) and the WRC Electrofishing Surveys (2013–2023) on the spawning grounds in the Tar-Pamlico and Neuse rivers. WRC PBT data for 2024 are not yet available.

Creel Survey

A comprehensive creel survey was initiated in January 2004 to identify and estimate recreational striped bass effort and catch in the CSMA, particularly the Tar-Pamlico and Neuse rivers. Although the recreational striped bass season in the CSMA has remained closed since March 2019, data collection characterizing fishing effort and release disposition has continued. Within the CSMA there is a significant catch-and-release fishery and releases during the past ten years (2015–2024) have averaged 43,168 fish annually (Table 5). In 2024, the number of striped bass caught and released as discards was 6,971 fish which was a decrease from 12,957 fish in 2023, and below the ten-year average. Under-sized discards peaked in 2017 mainly due to the large number of sub-legal striped bass available in the Tar-Pamlico River system; however, the number of under-sized discards has declined since, and in 2024 there were only an estimated 944 under-sized striped bass discards.

Table 5. Recreational striped bass effort (trips and hours), harvest, and discards from the Pungo, Tar-Pamlico, and Neuse rivers (2004–2024). There was a limited recreational harvest season in 2019 (January 1–March 19, 2019) prior to the closures.

			Harvest		Discard				
Year	Number Striped Bass Trips	Number Striped Bass Hours	Number	Pounds	Over Creel	Under-Sized	Legal-Sized	Slot	Catch # Fish
2004	12,782	63,791	6,141	22,958	85	11,729	1,743	0	19,698
2005	16,414	69,370	3,832	14,965	152	15,609	1,016	77	20,671
2006	10,611	42,066	2,481	7,352	33	12,548	2,314	0	17,376
2007	10,971	46,655	3,597	10,794	147	21,673	1,707	0	27,124
2008	6,621	28,413	843	2,990	2,838	11,721	3,316	91	18,809
2009	5,642	26,611	895	3,061	7	4,471	1,769	718	7,860
2010	6,559	25,354	1,757	5,537	29	5,200	2,401	360	9,747
2011	12,606	51,540	2,728	9,474	9	16,659	5,397	2,123	26,916
2012	18,338	71,964	3,922	15,240	439	26,343	13,621	2,910	47,236
2013	20,136	86,049	5,467	19,537	447	19,302	10,356	2,357	37,928
2014	15,244	68,153	3,301	13,368	728	19,185	7,104	1,641	31,959
2015	17,950	78,696	3,934	14,269	40	22,272	8,029	813	35,088
2016	23,283	108,989	6,697	25,260	203	57,874	9,977	6,779	81,529
2017	26,100	119,522	7,334	26,973	549	101,787	26,487	2,293	138,450
2018	16,369	69,856	3,371	10,884	871	34,128	12,092	1,890	52,353
2019	8,796	40,485	959	3,562	924	22,375	7,817	2,481	34,557
2020	2,839	13,247	0	0	0	10,440	7,575	1,406	19,420
2021	4,641	17,596	0	0	0	8,815	12,311	1,769	22,895
2022	3,953	13,727	0	0	0	10,601	12,159	4,701	27,462
2023	3,020	10,923	0	0	0	5,268	5,860	1,829	12,957
2024	1,604	7,867	0	0	0	944	4,724	4,055	9,722
Total	244,480	1,060,873	57,258	206,224	7,502	438,943	157,776	38,293	699,758

Observer Program

Program 466

Onboard Observer Monitoring was designed to monitor fisheries for protected species interactions in the large and small mesh anchored commercial gill-net fishery by providing onboard observations. During onboard trips, this program also monitors finfish catch and discards and characterizes effort in the fishery. Program 466 does not conduct observations on commercial trips using gill nets that are exempt from the Division's Incidental Take Permit, including runaround, strike, drop, or drift gill nets. Number of striped bass observed in the Tar-Pamlico and Neuse rivers commercial large and small mesh gill net fisheries averaged 102 fish per year with a high of 302 fish in 2014 and a low of zero fish in 2020 and 2021 (Table 6). Since the harvest and gill net closures (2019), the number of observed striped bass has averaged 5.3 fish per trip. The decrease in number of observed striped bass is due in part to prohibiting the use of gill nets above the ferry lines and harvest restrictions in other fisheries, most notably southern flounder, that have significantly limited the use of anchored large mesh gill nets.

Table 6. Number of observed (Program 466) gill net trips and number of striped bass harvested and discarded, including disposition observed by mesh size in the Tar-Pamlico and Neuse rivers (all trips west of tie down line), 2012–2024. Note: observations in 2020 and 2021 were limited due to COVID restrictions.

	Large Mesh				Small Mesh				Total Numbers				
Year	Trips	Harvested	Dead Discard	Alive Discard	Trips	Harvested	Dead Discard	Alive Discard	Trips	Harvested	Dead Discard	Alive Discard	Striped Bass Captured
2012	70	19	1	8	17	0	1	12	87	19	2	20	41
2013	104	58	14	12	11	0	0	0	115	58	14	12	84
2014	252	167	41	83	39	2	0	9	291	169	41	92	302
2015	149	202	16	42	39	4	4	9	188	206	20	51	277
2016	153	119	25	14	23	0	4	12	176	119	29	26	174
2017	163	110	12	134	35	0	0	36	198	110	12	170	292
2018	122	37	15	45	23	1	2	10	145	38	17	55	110
2019	60	0	8	12	45	0	2	5	105	0	10	17	27
2020	0	0	0	0	7	0	0	1	7	0	0	0	1
2021	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	3	0	0	0	0	0	0	0	3	0	0	0	0
2023	8	0	0	3	4	0	0	3	12	0	0	3	3
2024	4	0	0	1	4	0	0	1	8	0	0	1	1
Totals	1,088	712	132	355	247	7	13	98	1,335	719	145	447	1,312

Analysis of Pre and Post Closures Abundance Trends

The M-K Trend Test was used to compare Program 915 and the WRC Electrofishing Survey abundance trends before and after the striped bass harvest and gill net closures to determine if striped bass abundance trends were significant after the closures.

Randomization Tests were used to compare striped bass abundance from Program 915 and the WRC Electrofishing Survey before and after the harvest and gill net closures to determine if striped bass abundance increased significantly after the closures.

Program 915 M-K Trend Test

M-K Trend Test results showed for the period before the closures (2004–2018) there was no significant trend in Program 915 striped bass catch in the Tar-Pamlico River (P value greater than 0.05; Table 7). In the Neuse River, M-K Trend Test results indicated no significant trend in striped bass catch before or after the closures.

Table 7. M-K Trend Test for striped bass relative abundance from Program 915 indicating the direction of the trend in the Tar-Pamlico and Neuse rivers before (2004–2018) and after (2019–2024) the closures (P-value < α; α = 0.05). NS = not a significant trend.

System	Closures	P-value < a; a = 0.05	Trend
Tar-Pamlico River	Before (2004 - 2018)	0.28	NS
	After (2019 - 2024)	0.46	NS
Neuse River	Before (2004 - 2018)	0.65	NS
	After (2019 - 2024)	0.22	NS

Program 915 Randomization Test

The Randomization Test for the Tar-Pamlico River indicated abundance of striped bass in Program 915 was significantly lower after the closures compared to before the closures (Figure 9, *p-value = 0.0002). Results of the Neuse River Randomization Test indicated abundance of striped bass was significantly lower after the closures compared to before the closures (Figure 10, *p-value = 0.0006).

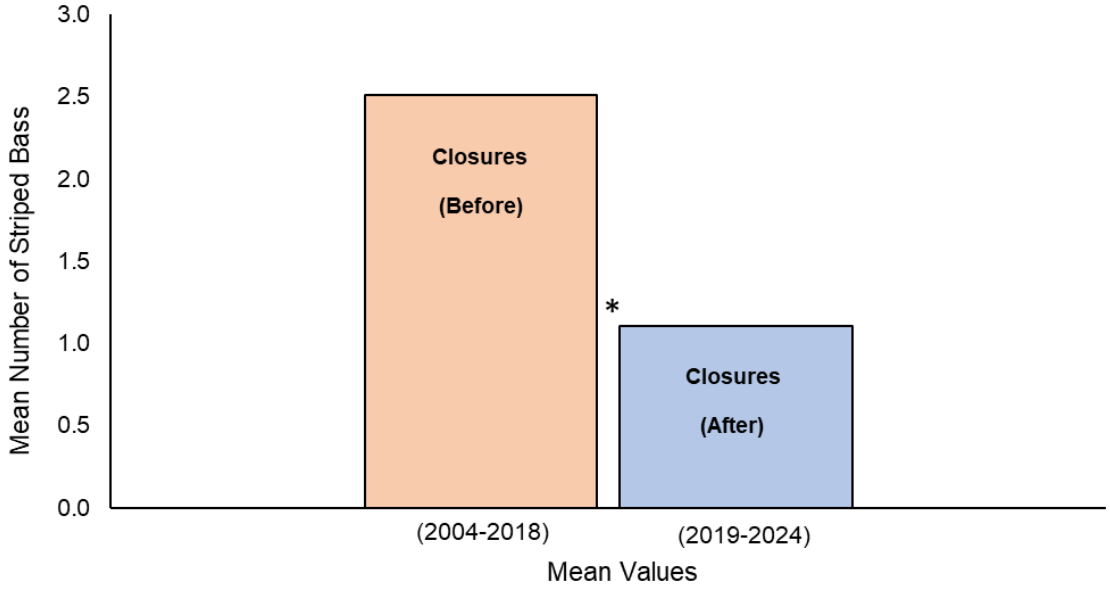

Figure 9. Abundance of Tar-Pamlico River striped bass from Program 915 before (2004–2018) and after (2019–2024) the closures. *Represents a statistically significant difference (p-value ≤ 0.05).

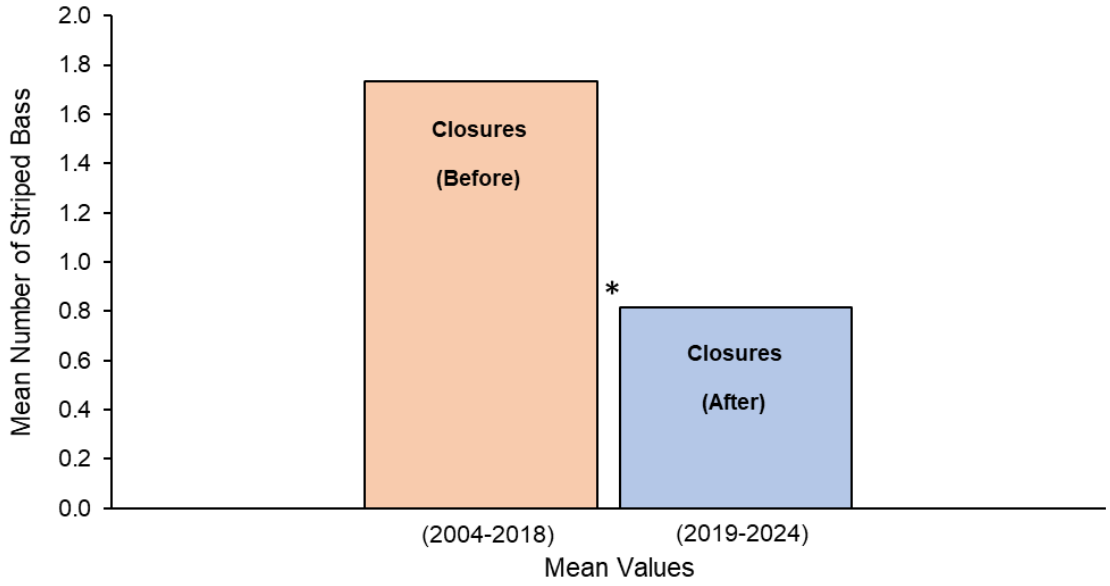

Figure 10. Abundance of Neuse River striped bass from Program 915 before (2004–2018) and after (2019–2024) the closures. *Represents a statistically significant difference (p-value ≤ 0.05).

WRC Electrofishing Survey M-K Trend Test

In the Tar-Pamlico River, M-K Trend Test results indicated a negative abundance trend on the spawning grounds before the closures (1996–2018); however, a p-value of exactly 0.05 is on the borderline but still considered significant at the 5% level (Table 8). Results of the Kendall's Tau correlation for the period before the closures indicated a decreasing trend (Tau=-0.3). There was

no significant trend in abundance after (2019–2024) the closures in the Tar-Pamlico River. In the Neuse River, M-K Trend Test results indicated no significant trend before or after the closures.

Table 8. M-K Trend Test of annual striped bass relative abundance from the WRC Electrofishing Spawning Ground Survey indicating the direction of the trend (P-value < α; α = 0.05) in the Tar-Pamlico (1996–2024) and Neuse rivers (1994–2024). NS = not a significant trend.

System	Closures	P-value < a; a = 0.05	Trend
Tar-Pamlico River	Before (1996–2018)	0.05	↓
	After (2019–2024)	0.46	NS
Neuse River	Before (1994–2018)	0.48	NS
	Ater (2019–2024)	0.46	NS

WRC Electrofishing Survey Randomization Test

The Randomization Test indicated striped bass abundance on the Tar-Pamlico River spawning grounds was significantly lower after the closures compared to before (Figure 11; *p-value=0.03).

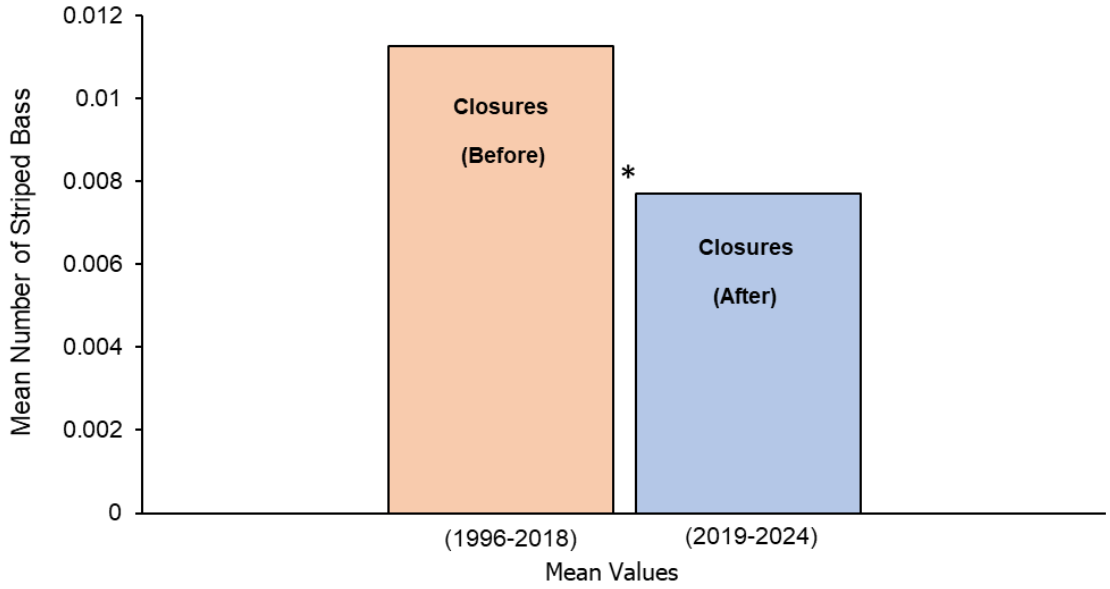

Figure 11. Abundance of Tar-Pamlico River striped bass from the WRC Electrofishing Survey before (1996–2018) and after (2019–2024) the closures. *Represents a statistically significant difference (p-value ≤ 0.05).

While striped bass abundance from the WRC electrofishing survey on the Neuse River spawning grounds was higher after the closures the Randomization Test indicated the difference before and after was not significant and therefore considered to be equal or not different (Figure 12; *p-value=0.08).

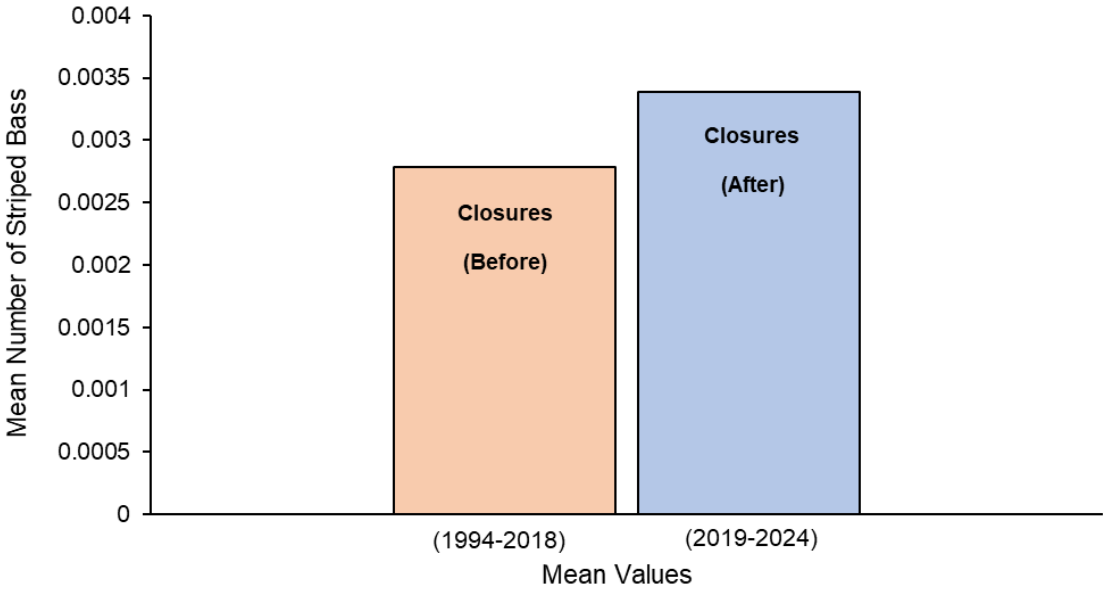

Figure 12. Abundance of Neuse River striped bass from the WRC Electrofishing Survey before (1994–2018) and after (2019–2024) the closures.

Ferry Line Gill Net Closure Analysis

Program 915 data was used to evaluate performance of the gill net closure above the ferry lines by comparing striped bass abundance upstream of the lines before and after the gill net closure and striped bass harvest closure were put in place.

M-K Trend Test

M-K Trend Test results for the Tar-Pamlico River indicated there was no significant trend in striped bass abundance above the ferry line for the period before or after the closures. In the Neuse River, M-K Trend Test results indicated no significant trends in abundance above the ferry line before or after the closures.

Table 9. M-K Trend Test of annual striped bass relative abundance from Program 915 for the areas above the ferry lines indicating the direction of the trend in the Tar-Pamlico and Neuse rivers, before (2004–2018) and after (2019–2024) the closures (P-value < α; α = 0.05). NS = not a significant trend.

System	Closures	P-value < a; a = 0.05	Trend
Tar-Pamlico River	Before (2004–2018)	0.30	NS
	After (2019–2024)	0.46	NS
Neuse River	Before (2004–2018)	0.88	NS
	After (2019–2024)	0.09	NS

Randomization Test

Abundance of striped bass above the ferry lines in the Tar-Pamlico River was significantly lower after the closures compared to before the closures (Figure 13; p-value=0.0002).

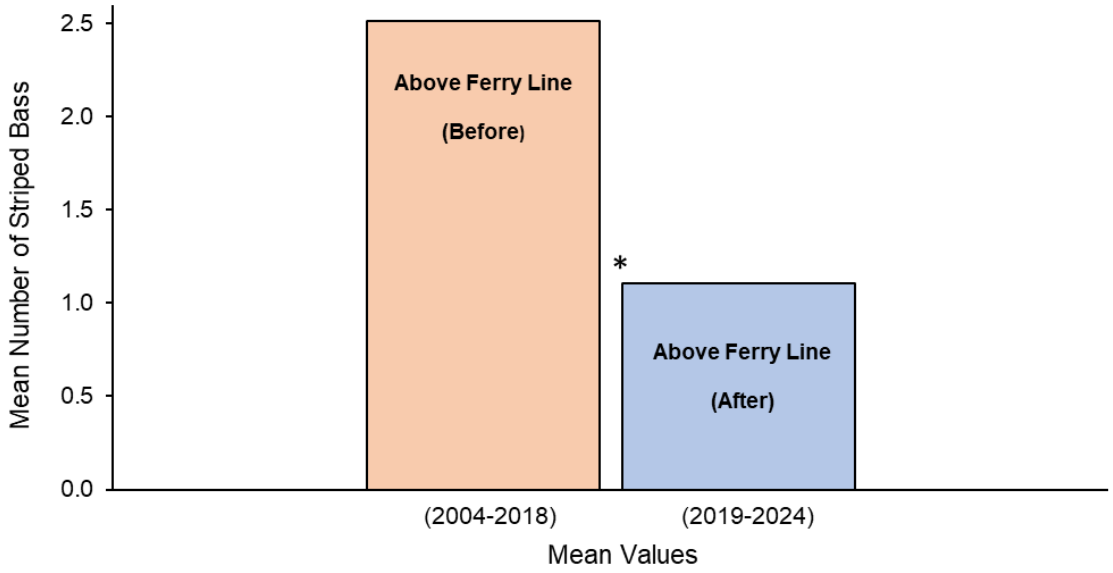

Figure 13. Abundance of Tar-Pamlico River striped bass from Program 915 above the ferry line closure area before (2004–2018) and after (2019–2024) the closures. *Represents a statistically significant difference (p-value ≤ 0.05).

Abundance of striped bass above the ferry lines in the Neuse River was significantly lower after the closures compared to before the closures (Figure 14; p-value=0.003).

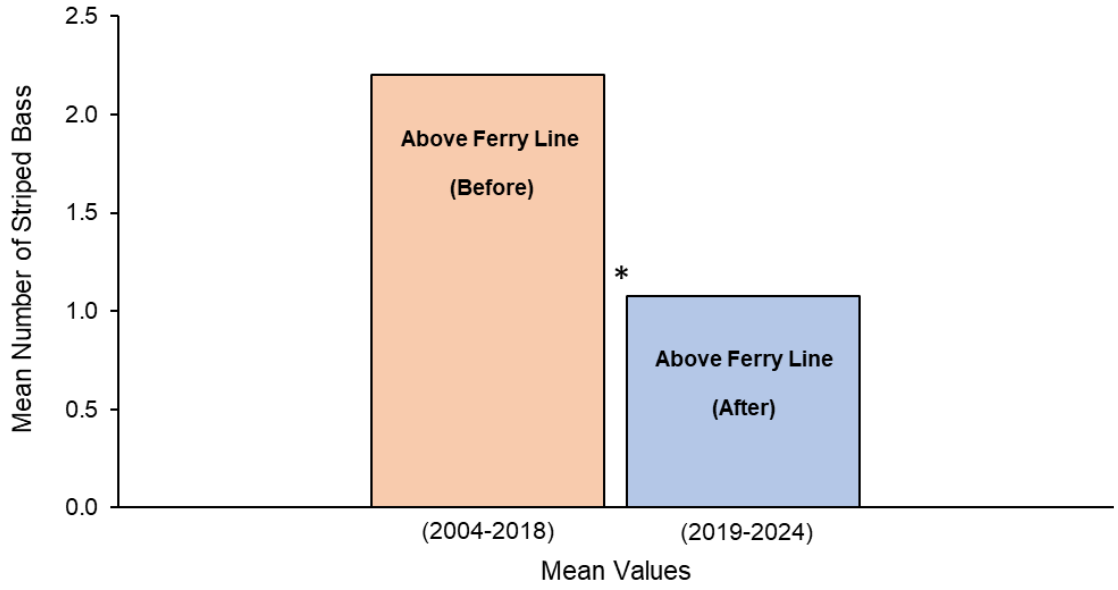

Figure 14. Abundance of Neuse River striped bass from Program 915 above the ferry line closure area before (2004–2018) and after (2019–2024) the closures. *Represents a statistically significant difference (p-value ≤ 0.05).

DISCUSSION

Amendment 2 to the North Carolina Estuarine Striped Bass FMP adopted an adaptive management strategy to review data through 2024 to determine if striped bass populations in the Tar-Pamlico and Neuse rivers are self-sustaining and if sustainable harvest can be determined. In addition, Amendment 2 included language to: “maintain the gill net prohibition through 2024 to allow for assessment of its performance”. Adaptive management allows adjustments to management measures as new information or data becomes available. Trends in key population parameters including natural recruitment, adult abundance, age structure, and hatchery contribution were evaluated to determine the impact of the 2019 no-possession provision and the gill net closure above the ferry lines on the stocks.

As part of Amendment 2 development, a demographic matrix model was used to evaluate stocking and management strategies for striped bass in the Tar-Pamlico and Neuse rivers (Mathes et al. 2020). Matrix model results indicated natural recruitment is the primary factor limiting Tar-Pamlico and Neuse rivers stocks and if stocking was stopped the populations would decline. Based on matrix model results, the striped bass populations in the Tar-Pamlico and Neuse rivers were depressed to an extent that no level of fishing mortality is sustainable.

The matrix model results indicated a 10-year closure was most effective at increasing adult (age-3+) and old adult (age-6+) abundance (Figure 15; Mathes et al. 2020). The stocking strategy in the Tar-Pamlico and Neuse rivers during the closure has been to stock 100,000 phase-II fish per year in each river (stocking scenario 4; Figure 15). Under this stocking scenario and a 10-year closure, adult abundance is not projected to increase significantly for the first five years of the closure before starting to increase in year six. In this stocking and management scenario, abundance of age-3+ striped bass was projected to begin increasing in year two of the closure.

The striped bass harvest and ferry line gill net closures in the Tar-Pamlico and Neuse rivers were implemented in 2019 and as of 2024 have been in place for six years and have significantly decreased the number of striped bass removed from these rivers by fishing each year (Table 1). Fishery-independent monitoring since 2019 does not indicate abundance increases in downriver areas and abundance on the spawning grounds remains at levels similar to what was observed before the closure. Abundance of age-3+ and age-6+ striped bass has declined or remained consistent and there appears to be little expansion of the age structure past age-6.

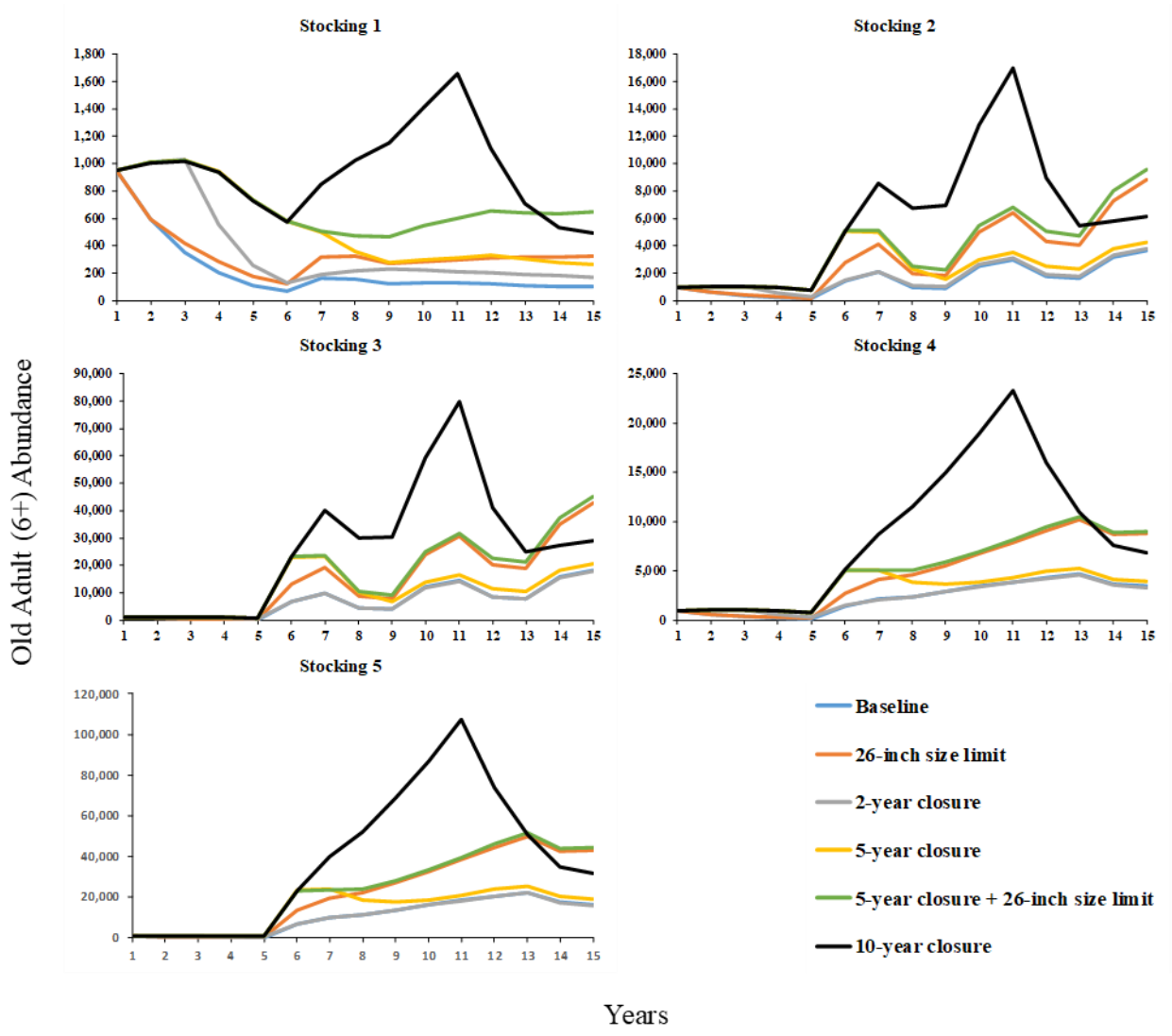

Figure 15. Abundance of old adults (age 6+) projected under five stocking strategies and six fishing strategies. Stocking 1 - no stocking; Stocking 2 - stocking 100,000 fish per year with 2-year stocking and 2-year no stocking alternating for 15 years (8 years of stocking in total); Stocking 3 - stocking 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 (figure from Mathes et al. 2020).

Since 2019 the percentage of stocked fish on the spawning grounds has increased to nearly 100% suggesting the 'wild' fish present in 2018 and 2019 are not making spawning runs in these systems and are not contributing to natural reproduction. In the lower rivers, the percentage of 'wild' fish has been more variable, and examination of age data suggests some persistence of the 2014- and 2015-year classes, at least through 2020.

It is difficult to pinpoint specific reasons why abundance has not increased, and the age structure has not expanded despite significant reductions in fishing mortality. The Tar-Pamlico and Neuse rivers striped bass stocks are supported by a stocking program with an annual goal of stocking

100,00 phase-II striped bass per river system; however, actual stocking numbers are variable from year to year and since implementation of the harvest and ferry line gill nets closures in 2019, an average of 55,541 phase-II fish were stocked in the Tar-Pamlico River each year and 66,036 phase-II striped bass were stocked in the Neuse River each year (Table 10). Additionally, environmental conditions, such as low dissolved oxygen and warm water temperatures play a role in successful striped bass recruitment and increasing stock size. There is evidence total mortality (especially natural mortality) is high in these systems. A telemetry tagging study conducted on the Neuse River from December 2013 through September 2015 estimated a discrete annual total mortality of 66.3% for phase II stocked juveniles (202–227 mm TL), a discrete annual total mortality of 54.0% for adults (349–923 mm TL), and a discrete natural mortality of 20.1% for adults (Bradley et al. 2018). Analysis of tagging data showed that striped bass stocked in the Neuse and Tar-Pamlico rivers experienced higher mortality (instantaneous total mortality of 0.48–0.51) than in the Roanoke River/Albemarle Sound habitat (instantaneous total mortality of 0.33; Callihan et al. 2014).

Mathes et al. (2020) and Rachels and Ricks (2018) documented commercial effort as an important predictor of striped bass mortality in the Neuse River. Model averaging analysis by Rachels and Ricks (2018) indicated commercial gill-net effort was far more influential than other parameters that were examined. Although Rachels and Ricks (2018) did not include recreational effort or harvest in the model due to the benefits of a longer available time series for commercial data, the study acknowledged the potential importance of recreational angling on total mortality of Neuse River striped bass. Results of analysis from Mathes et al. (2020) indicated recreational effort and recreational discards may indeed be as influential on annual striped bass mortality as commercial effort and commercial harvest. While recreational and commercial harvest and commercial discard mortality of striped bass have been minimized by the harvest closure and concurrent gill net restrictions, recreational discards remain a source of mortality and may confound capacity for the stock to grow. Since the harvest closure, recreational striped bass discards remain similar to those observed prior to the harvest closure in some years (Table 5; NCDMF 2024).

In response to increased abundance of non-hatchery origin (wild) striped bass present in the Tar-Pamlico and Neuse rivers in 2017 and 2018, DMF initiated an acoustic telemetry study to track movements of ‘wild’ fish. Because striped bass return to natal rivers to spawn, the objective of the acoustic tagging study was to infer origin of wild striped bass found in the lower-middle Tar-Pamlico and Neuse rivers by tracking spring spawning migrations. Fifty adult striped bass (ages 4–5) from the lower-middle Tar-Pamlico and Neuse rivers were implanted with acoustic tags. Fin clips were taken from each fish, and PBT analysis was conducted to determine if the fish were hatchery or wild origin. PBT results indicated 30 of the tagged striped bass were wild. Of the 30 wild striped bass, 70% (n=21) were later detected in the Albemarle Sound or on the Roanoke River spawning grounds in the spring (see Appendix 3). Most (53%) wild fish entering the Albemarle Sound were detected on the spawning grounds near Weldon, N.C. Several of these wild striped bass (n=5) made repeated annual migrations in the spring back to the Roanoke River spawning grounds. The remaining wild acoustic tagged striped bass did not move out of the Tar-Pamlico and Neuse rivers and were not detected in Albemarle Sound. A single wild striped bass tagged in the Tar-Pamlico River was later detected on the spawning grounds in the Tar River and one wild striped bass tagged in the Neuse River was later detected on the spawning grounds in the Neuse River suggesting limited natural recruitment in these rivers or straying of A-R stock fish to the Tar and Neuse rivers spawning grounds. Additionally, one wild striped bass tagged in the Neuse River was later detected on the spawning grounds in the Tar River (see Appendix 3).

Results of the acoustic study add additional support to the existing body of evidence indicating annual movement of striped bass between the Albemarle Sound and Tar-Pamlico and Neuse

rivers. Conventional tag return data has documented increased movement of smaller A-R stock striped bass into the Tar-Pamlico and Neuse rivers during periods of increased A-R stock abundance (Callihan et al. 2014). While abundance of A-R stock striped bass is currently very low, 2014 and 2015 represent the most recent strong year classes produced (Figure 16). Striped bass from the strong 2014 and 2015 A-R year classes likely migrated to the Tar-Pamlico and Neuse rivers: increasing abundance and providing the appearance of successful natural reproduction. Callihan et al. (2014) indicated up to 31% of the A-R stock could use areas outside the Albemarle Sound during times of higher abundance. Rulifson (2014) concluded 53% of striped bass sampled from the Neuse River in 2010 were not of hatchery origin. While the exact origin of these fish is unknown, they could be fish from the strong 2005 A-R year class. Potential spillover of the 2005 A-R year class into the Tar-Pamlico and Neuse rivers may also explain the 2010 and 2011 striped bass abundance peaks from Program 915 in the Tar-Pamlico and Neuse rivers (Figures 2 and 3) and the 2010 abundance peak from the WRC Electrofishing Survey on the Tar River spawning grounds (Figure 5).

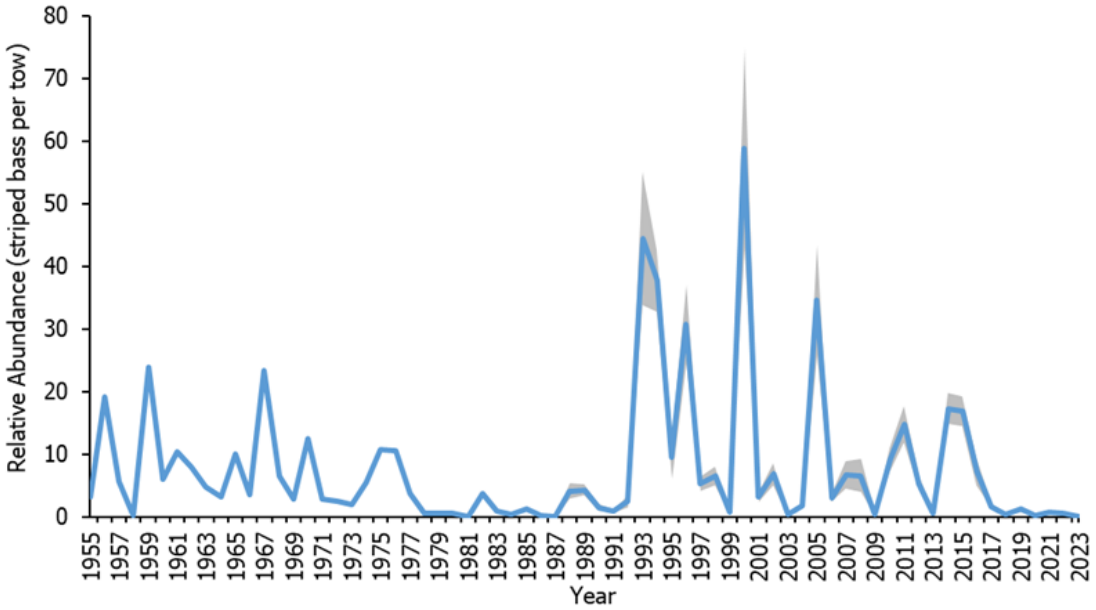

Figure 16. Juvenile abundance index (JAI) of Albemarle-Roanoke striped bass from the DMF juvenile trawl survey, western Albemarle Sound, NC, 1955–2023.

Striped bass are generally thought to exhibit low levels of straying to non-natal rivers and Roanoke River striped bass are suspected to have high spawning site fidelity (Callihan et al. 2015); though, potential straying to non-natal systems has been suggested for other stocks (Secor et al. 2020). In addition, striped bass have been documented to reside in non-natal estuaries in Maine and New Jersey, including moving upriver during expected spawning seasons suggesting an attempt to reproduce (Grothues et al. 2009), and Roanoke River striped bass have been documented in river systems in other states outside of the spawning season (Callihan et al. 2015). This suggests it would not be unlikely for A-R stock striped bass to reside in the adjacent Tar-Pamlico and Neuse rivers and for some small portion of the stock to make spawning runs in these systems.

There has been little change in abundance or the age structure of the Tar-Pamlico and Neuse rivers striped bass stocks since implementation of the harvest and gill net closures. It appears abundance of striped bass in the lower Tar-Pamlico and Neuse rivers is highly influenced by year-

class strength of the A-R stock. Abundance on the spawning grounds, while highly variable, is generally more stable, likely due to stocking. Matrix model results suggested stocking more fish provides the most benefit to the stocks (Figure 15; stocking scenario 5). During the closure period the goal has been to stock 100,000 phase-II fish per river system, though this goal has not always been met (Table 10). Recently (beginning in 2023) stocking resources have shifted toward maintaining and restoring the A-R stock. Given hatchery and resource constraints it is unlikely the number of fish stocked in the Tar-Pamlico and Neuse rivers can be increased by any significant amount, and without increased stocking, the populations may not be able to grow beyond current levels, though recovery and expansion of the A-R stock is likely to increase abundance of striped bass in the Tar-Pamlico and Neuse rivers.

Table 10. Number of Phase-I and Phase II size striped bass stocked in the Tar-Pamlico and Neuse rivers, 2010–2024.

	Tar-Pamlico River			Neuse River	
Year-Class	Phase-I	Phase-II	Year-Class	Phase-I	Phase-II
2010	0	114,012	2010	0	107,142
2011	0	107,767	2011	0	102,089
2012	0	45,667	2012	50,180	91,985
2013	257,404	123,416	2013	181,327	113,784
2014	138,889	92,727	2014	79,864	78,866
2015	0	52,922	2015	0	109,107
2016	234,718	121,190	2016	80,910	134,559
2017	0	101,987	2017	0	14,203
2018	0	120,668	2018	96,900	86,556
2019	0	97,920	2019	0	85,694
2020	0	90,614	2020	0	96,933
2021	0	23,082	2021	31,208	80,122
2022	175,633	55,465	2022	91,569	33,560
2023	116,989	66,165	2023	62,885	71,527
2024	0	0	2024	0	0

Based on historical stocking efforts for striped bass, population abundance can increase dramatically from just a few individuals, provided adequate environmental conditions exist. In 1879, 132 young striped bass from the Navesink River, New Jersey, were released into the Carquinez Strait, the tidal estuary where the Sacramento and San Joaquin rivers drain into San Francisco Bay. A second batch of 300 young fish from the Shrewsbury River, New Jersey, were introduced in 1882. Commercial harvest started in the early 1880s, and by 1900 exceeded 99,208 lb. (450,000 kg) annually. The greatest catch occurred in 1903 when over 1,984,160 lb. (900,000 kg) were harvested (Craig 1928).

The striped bass population in the southern Gulf of St. Lawrence, Canada, declined to less than 5,000 spawners in the late 1990s which led to the closure of the commercial fishery in 1996 and recreational and indigenous fisheries in 2000 (DFO 2023). Between 2002 and 2009 a stocking program stocked 6,475,000 striped bass fry and 6,321 striped bass ages 0–6 (Robitaille, et al. 2011) into the systems. The striped bass population subsequently increased to an estimated 900,000 spawners by 2017 (DFO 2023).

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, NCDMF 2024). 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. Even in the absence of most fishing mortality, abundance has not increased, and the age structure has not expanded suggesting biological and/or environmental factors are preventing self-sustaining populations and that additional management changes aimed at achieving sustainable striped bass populations in these rivers are unlikely to be successful unless significant environmental improvements occur.

One possible confounding factor is that eggs produced by Tar-Pamlico and Neuse rivers broodstock are very small, heavy (dense) eggs, which are more likely to sink than float (Kowalchyk 2020). Egg densities have been shown to be influenced by both genetic and environmental factors (Kowalchyk 2020). Spawning grounds in these river systems are predominantly 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 potentially impacting striped bass spawning success (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 Corps 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 the Neuse River like it is in the Roanoke River. The USACE, in cooperation with DMF and WRC staff, is currently studying flows in the Neuse River in an attempt to identify conditions that could be beneficial for striped bass spawning. Flows on the Tar-Pamlico River are based on pulse rainfall events. The ability to manipulate releases, while limited, 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 and die before hatching successfully.

CONCLUSIONS

Based on data from DMF and WRC fishery-independent and dependent sampling programs which were reviewed through 2024, the striped bass populations in the Tar-Pamlico and Neuse rivers are currently not self-sustaining. However, it is worth noting again that striped bass have been shown to quickly rebound even at low population levels given favorable environmental conditions. Evaluation of the harvest and gill net closures has shown these measures to be ineffective at promoting natural recruitment, increasing adult abundance, or expanding the age structure and increasing the number of older, larger (age-10+) striped bass through year six of implementation. Even if these closures had resulted in a measurable effect on striped bass populations, it would be impossible to attribute the effect to either the harvest or gill net closures individually because they occurred concurrently. Factors other than fishing mortality and inadequate spawner stock abundance are preventing successful reproduction and self-sustaining populations of the Tar-Pamlico and Neuse rivers striped bass stocks. Environmental factors and declines in the A-R stock have contributed to reduced striped bass abundance in the Tar-Pamlico

and Neuse rivers. Additional management aimed at trying to achieve sustainability of these stocks is unlikely to be effective unless significant environmental improvements occur.

Acoustic telemetry and PBT data suggest there are three groups of striped bass in the Tar-Pamlico and Neuse rivers. Most of the fish are hatchery reared stocked fish, followed by wild fish originating from the A-R (see Appendix 3), with a very small portion of fish originating from the spawning grounds on the Tar-Pamlico or Neuse rivers. Acoustic data revealed that striped bass stocked in the Tar-Pamlico and Neuse rivers do not leave the system where they were released and fish can be found throughout the entire system; however, a portion of adult wild fish were shown to reside within the lower portions of both the Tar-Pamlico and Neuse rivers and return annually to the Roanoke River spawning grounds in spring (April\May).

Based on Amendment 2 adaptive management, 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.

ADAPTIVE MANAGEMENT NEXT STEPS

In accordance with the Amendment 2 adaptive management framework, the DMF and WRC will develop harvest management measures that allow access to and protection for the resource. Harvest will be allowed, but harvest will be restricted to levels low enough that mature striped bass abundance in the rivers is maintained so in the event of favorable environmental conditions, natural reproduction could occur. Confounding this management strategy, however, is the fact the A-R stock has had very poor spawning success since 2017 and is currently under a harvest moratorium. The harvest management strategy will focus harvest on stocked fish in the Tar-Pamlico and Neuse rivers but limit harvest of A-R striped bass to the greatest extent possible.

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Appendix 1

Motions
N.C. Marine Fisheries Commission Emergency Meeting
March 13, 2019

Motion by Cameron Boltes to approve the agenda. Second by Chuck Laughridge.
Motion carries unanimously.

Motion by Cameron Boltes to direct the director of the Division of Marine Fisheries to issue a proclamation, effective in conjunction with the Supplement, that prohibits the use of gill nets upstream of the ferry lines, dock to dock from the Bayview to Aurora Ferry on the Pamlico River and dock to dock from the Minnesott Beach to Cherry Branch Ferry on the Neuse River, within the Central Southern Management Area. Second by Pete Kornegay.
Motion carries 5-4.

Motion by Chuck Laughridge to ask the N.C. Wildlife Resources Commission to adopt concurrent regulations for recreational harvest in Supplement A in joint coastal waters. Second by Pete Kornegay.
Motion carries with no opposition.

Appendix 2

ROY COOPER
Governor
MICHAEL S. REGAN
Secretary
STEPHEN W. MURPHEY
Director

March 4, 2019

Dear Chairman Bizzell,

At the February 2019 Marine Fisheries Commission (MFC) meeting the MFC passed Supplement A to Amendment 1 of the Estuarine Striped Bass Fishery Management Plan. As approved, Supplement A specifies a no-possession limit, essentially a closed season for striped bass, in the Central Southern Management Area (CSMA). There are, however, complicating jurisdictional issues between MFC and the Wildlife Resources Commission (WRC).

Last week, Department of Environmental Quality (DEQ) and Division of Marines Fisheries (DMF) staff met with the Director and staff of the WRC. The WRC Director indicated that because of the joint jurisdictional language in N.C.G.S. §113-132 that the Supplement A measure would be inconsistent with existing WRC recreational limits in joint waters of the CSMA. After consulting with WRC and with legal counsel for both Commissions and DEQ it was decided that the best approach forward would be to convene a special meeting of the MFC to formally request that the WRC implement management measures consistent with Supplement A for the joint coastal waters of the CSMA to harmoniously resolve the jurisdictional conflict. I think this could be done over the phone with at least one listening station and it would be up to you to decide if any additional public comment would be warranted.

If a special meeting is not called, then it is important to have this on the May agenda for the MFC meeting. The recreational season closes April 30 by rule (15A NCAC 03M .0202) so if we do hold a special meeting it would only buy a brief period with the no-possession limit was in place for the recreational spring season. However, it is important to address it to implement the no-possession limit in the fall recreational fishery. The next regularly scheduled meeting of the WRC is in April.

Considering this, I plan to issue proclamations this week to implement the following:

1. Close the remainder of the recreational season on striped bass in the coastal waters of the CSMA. This closes the season year-round.
2. Allowing the joint coastal water recreational season to remain open with current catch limits until the MFC can request from concurrence from the WRC and they concur.
3. Implementing in the coastal and joint coastal waters 36-inch tie-down and 50-yard distance from shore regulations in the western Pamlico Sound including the Tar-Pamlico and Neuse rivers and their tributaries. This is required under the management measures of the FMP whenever the striped bass season is closed. The MFC, in the adoption of the Supplement confirmed that action.

4. The CSMA commercial season which opens by proclamation will not be opened due to the adoption of Supplement A.

This will present a situation where our coastal waters include stronger recreational conservation measures for striped bass than the joint coastal waters until this consistency issue is resolved. It is likely the recreational season for spring 2019 will close before this can happen (April 30). Because WRC does not regulate any commercial gear, there is not an inconsistency with existing rule to prevent our implementing the commercial no-possession and gill net measures in the joint coastal waters as well.
Finally, after the passage of Supplement A, the MFC approved a motion to "ask" the DMF Director to issue a proclamation, effective in conjunction with the supplement, that restricts the use of gill nets that interact with striped bass upstream of the ferry lines and requires attendance of gill nets that interact with striped bass upstream of the tie-down lines. I have received dozens of emails supporting this measure both in form letters and in original letters.

While I respect the concerns of both the public and the MFC, after careful consideration I have concluded that such a measure is not supported by the scientific data that support gill nets as the primary or even the most significant source of discard mortality. As you are aware, recreational effort will not be controlled under the Supplement and catch and release will be a source of discard mortality as well. The motion to remove nets was also not a part of the supplement measure approved by the DEQ Secretary. The DMF Director's proclamation authority acts within the bounds of the FMP.
Therefore, I respectfully decline to act on this request to issue a proclamation further restricting gill nets beyond those measures outlined in Supplement A. I would, however, like to provide some supporting information underlying the basis for this decision.

SUPPORTING INFORMATION FOR DECISION
The journal article by Rachels and Ricks (2018), explores causal factors of spawning stock mortality sources in the N.C. riverine striped bass fishery, and notes that their inability to include recreational angling as an exploitation factor reduces the amount of variability in spawning stock mortality that can be accounted for in their study. The authors go on to include that it is likely that the inclusion of recreational harvest and discard would perform comparably to the results of the commercial harvest in their modeling.

In Supplement A, the DMF used the CSMA creel survey data, (not a part of MRIP), to determine recreational harvest, discards and discard mortality. From 2012-2017 all but the last two years' total removals of striped bass (harvest + dead discards) were nearly equal between the recreational and commercial sector. The increase in recreational discard mortality in the last two years is due to what appears to be a successful natural spawning event in the rivers during 2014 and possibly 2015.

Moreover, the following is a list of gill net regulations that are either already in place or will be implemented by proclamation in the areas upstream of the tie down lines. The purpose of these regulations is to reduce regulatory discards of striped bass and important estuarine finfish and protected species. On-board observer data and empirical *in-situ* field studies by the DMF has shown these large mesh regulations have decreased striped bass discards significantly

(potentially up to 75%) compared to pre-2008 estimates of striped bass discards before the tie-downs and distance from shore regulations were implemented. Striped bass gill-net discards mortality estimates for 2012-2017 in the Tar-Pamlico and Neuse rivers combined, range from 507 to 986 fish annually.

Regulations for gill nets with stretched mesh of 5 inches and greater:

- It is unlawful to fail to equip gill nets with tie-downs spaced no farther apart than 10 yards to restrict the vertical distance between the top and bottom lines to 36 inches or less. If the vertical height of the net (distance between the top and bottom line) is 36 inches or less, no tie-downs are required. Nets must be set to fish on the bottom and not exceed a vertical height of 36 inches. (Tie- down regulation see map)
- It is unlawful for any portion of the net to be within 50 yards of any point on shore when set or deployed in the following river areas: (distance from shore regulation - see map)

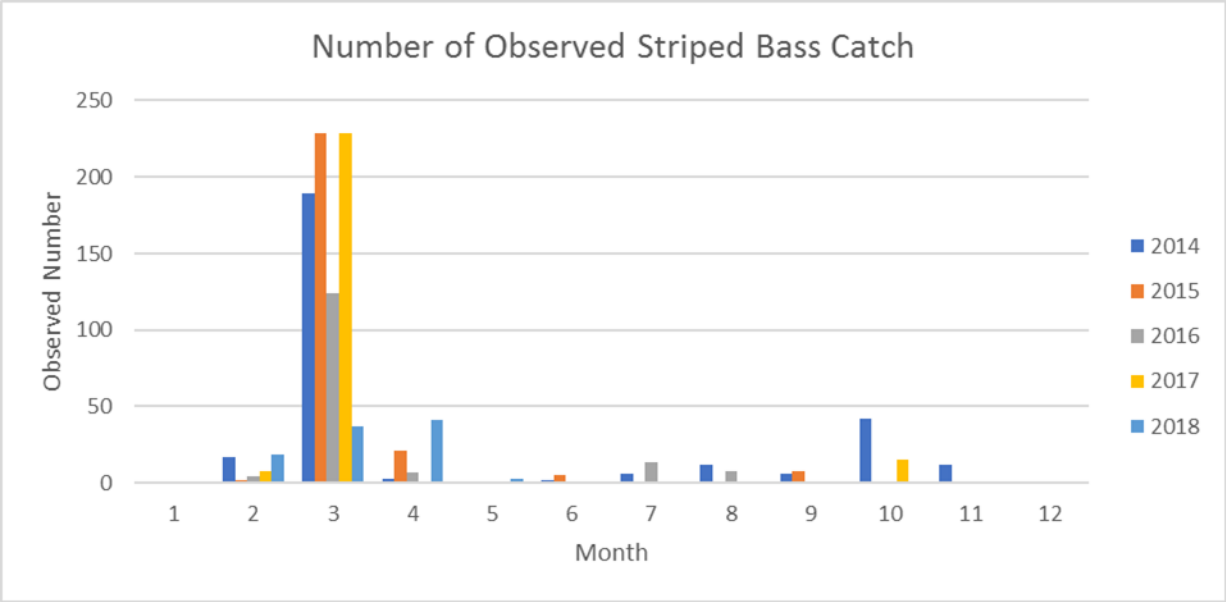
The previous years estuarine striped bass commercial seasons in the CSMA have been as follows:

Year	Day Open	Day Closed*
2014	03/01/14	03/20/14
2015	03/01/15	03/18/15
2016	03/01/16	03/21/16
2017	03/01/17	04/03/17
2018	03/01/18	04/30/18

*Closings before 4/30 of a year are early closures due to the 25,000 lb. quota being met or exceeded.

In the figure below, interactions with striped bass drop significantly in the large mesh gill net fishery above the tie-down line following the closure of the commercial striped bass season. Remember that the tie-down requirement and distance from shore requirements are not in place when the commercial season is open. With a no possession limit under Supplement A, the commercial season will not open and tie-down and distance from shore requirements will be in effect year-round. Gill net bycatch is anticipated to be more reflective of the May-February figures.

Figure 1. All striped bass (striped bass and hybrid bass) observed during Program 466 trips on the Pamlico, Neuse, Trent, and Pungo rivers. Data are from the previous 5-year period, 2014 to 2018. These data were selected to mirror the area that would be affected by the Proclamation requested at the February 2019 MFC meeting.



Regulations for gill nets with stretched mesh of less than 5 inches:

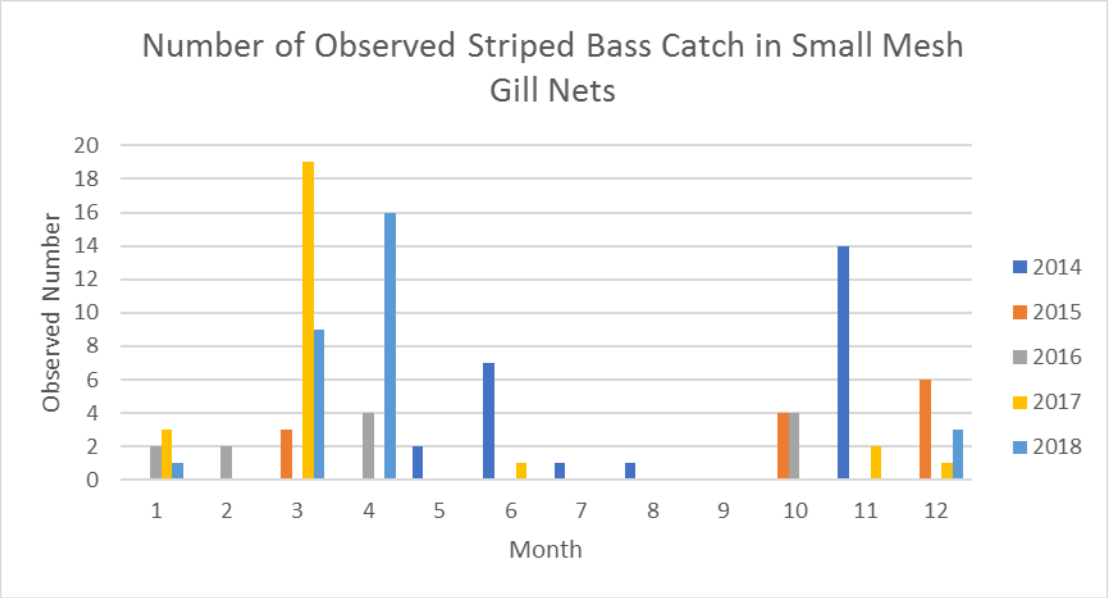
- Attendance of small mesh gill nets (<5 ISM) is required year-round in the following areas based on NCMFC rule 15A NCAC 3R.0112 (a):
    - Upper portions of the Pamlico, Pungo, Neuse, and Trent rivers
    - Within 200 yards of shore in the lower portions of the Pamlico, Pungo, Neuse, and Trent rivers

Regulations in effect statewide, large and small mesh gill nets:

- All unattended gill nets ≥ 5 ISM must be at least 10 feet from shore from June through November (NCDMF 2008).
- Gill nets with a mesh size ≥ 5 ISM and <5 ½ ISM is prohibited from April 15 through December 15 (NCDMF 2005).
- 2,000 yard/vessel limit on gill nets ≥ 5 ISM (NCDMF 2005).
- Gill nets with a mesh size < 5 ISM must be attended in all primary and secondary nursery areas and no-trawl areas described in NCMFC Rule 15A NCAC 3R.0106(2), (4), (5), (7), (8), (10), (11), and (12) from May 1 through November 30 (NCDMF 2001).
- It is unlawful to set gill nets in joint waters from midnight on Friday to midnight on Sunday each week, except in Albemarle Sound and Currituck Sound north of the Highway 158 Wright Memorial Bridge (NCDMF 2012).
- The use of gill nets > 6 ½ ISM stretch mesh is prohibited in all waters.
- It is unlawful to use gill nets with a mesh size < 2 ½ inches ISM stretch mesh.

In the figure below, interactions with striped bass are more mixed in the small mesh gill net fishery above the tie-down line. This data is less robust due to lower observation numbers in the small mesh fishery and these data do not indicate whether fish were alive or dead. However, there are attendance requirements in place for small mesh nets above the tie-down line which are put in place to reduce dead discards in the small mesh fishery as outlined above (see map – attachment 1).

Figure 3. Data included are all striped bass (striped bass and hybrid bass) observed during Program 466 trips on the Pamlico, Neuse, Trent, and Pungo rivers. Data are from the previous 5-year period, 2014 to 2018 and are for small mesh gill nets. These data were selected to mirror the area that would be affected by the Proclamation requested at the most recent MFC meeting.



In conclusion, the implementation of gill net restrictions is best served through the continued development of the Estuarine Striped Bass Fishery Management Plan. The Supplement A measures will certainly not stop discards and dead discards from occurring in the commercial or recreational fishery. However, the DMF's data supports that Supplement A will reduce the overall number of fish being removed from the stock, thereby providing additional and more conservative protection to the two successful spawning year classes moving through the area of the CSMA. Observer coverage will continue, and we will try to increase observer coverage as much as is feasible during 2019. If significant spikes of discards are observed, I certainly reserve the right to consider additional measures if warranted.

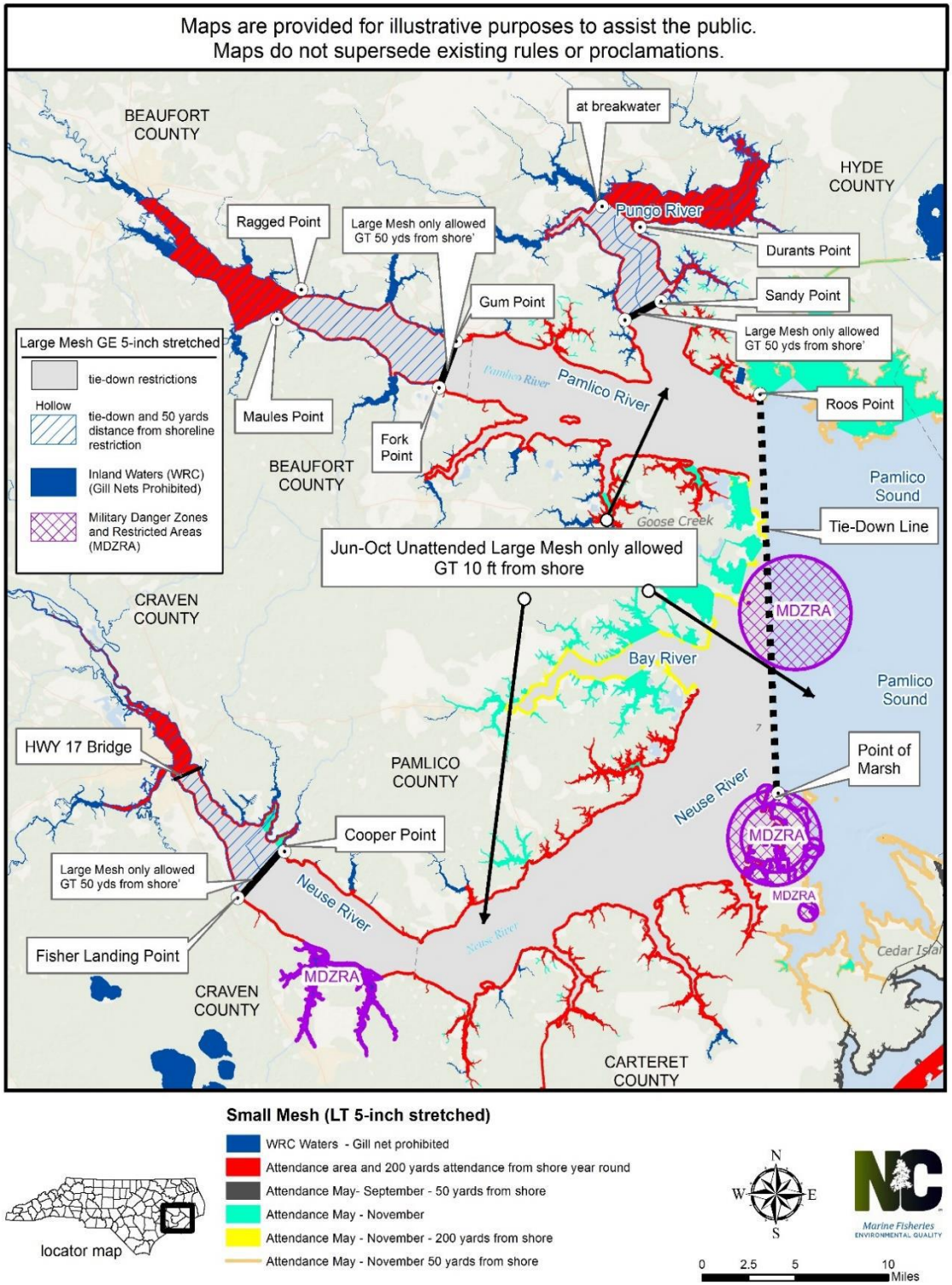
Sincerely,
Steve Murphey, Director

NC Division of Marine Fisheries

Cc: Marine Fisheries Commission
John Nicholson
Shawn Maier
John Batherson
Gordon Myers

Attachment 1

Gill-net regulation map for various gill-net types and seasons in the Central Southern Management



Appendix 3

ROY COOPER
Governor
ELIZABETH S. BISER
Secretary
KATHY B. RAWLS
Director

November 1, 2022

MEMORANDUM

TO: North Carolina Marine Fisheries Commission

FROM: Todd Mathes, Striped Bass Fishery Management Plan Co-Lead

SUBJECT: Acoustic Tagging Striped Bass in the Tar-Pamlico and Neuse Rivers Summary of Results

Goal
To deploy acoustic tags in striped bass from the 2014 and 2015 year-classes captured in the Tar-Pamlico and Neuse rivers to determine movement patterns during the summer, fall, and winter months and spring spawning migrations.

Background
Parentage based tagging (PBT) of striped bass stocked in the Central Southern Management Area (CSMA) began in 2010. Genetic stock identification of striped bass captured in the Central Southern Management area since 2010 indicates the stocks are near 100% hatchery origin, suggesting there has been minimal successful natural reproduction in these systems (NCDMF 2019). However, more recent PBT analysis of striped bass collected in 2017 shows there may have been successful ‘‘wild’’ striped bass spawning events in 2014 and 2015 in the Tar-Pamlico and Neuse rivers (Farrae and Darden 2018). Results of PBT analysis from fish captured in 2017 revealed a decrease in the contribution of hatchery fish found in these rivers. Striped bass <22 inches total length (TL) identified by PBT analysis as non-hatchery or ‘‘wild’’ fish collected in 2017 are potentially the result of successful natural spawning events in the Tar-Pamlico and Neuse rivers. Otolith ages of the non-hatchery fish <22 inches TL indicate these fish collected in 2017 are all from the 2014 and 2015 year classes (Farrae and Darden 2018; NCDMF 2019).

Based on this information, the North Carolina Marine Fisheries Commission (MFC) approved Supplement A to Amendment 1 to the N.C. Estuarine Striped Bass Fishery Management Plan in February 2019 implementing a no-possession limit for striped bass in the Internal Coastal and Joint fishing waters of the CSMA. In March 2019, the North Carolina Wildlife Resources Commission (NCWRC) passed a concurrent measure prohibiting the possession of striped bass in Inland and Joint Fishing Waters. Supplement A to Amendment 1 was adopted by the MFC to protect these two important year classes of striped bass while Amendment 2 to the N.C. Estuarine Striped Bass Fishery Management Plan was being developed.

Though a portion of striped bass collected from this period in the CSMA are classified as non-hatchery produced, it is not possible to identify the river system where these ‘‘wild’’ striped bass were spawned. Conventional tag return data suggests density-dependent movement occurs from Albemarle-Roanoke

stock striped bass moving into the CSMA rivers (Callihan et al. 2014). Juvenile sampling for striped bass in the Albemarle Sound indicated above average abundance of juveniles for the 2014 and 2015 year-classes (Figure 1), so it is possible the increased abundance of ‘‘wild’’ striped bass from the 2014 and 2015 year classes observed in the Tar-Pamlico and Neuse Rivers are actually related to an expansion from the Albemarle-Roanoke stock for these two year-classes. If these fish are from the Albemarle-Roanoke stock, they will likely not make spawning runs in the Tar-Pamlico and Neuse rivers. Albemarle-Roanoke stock striped bass exhibit size dependent migrations to the ocean and exhibit natal homing to the Roanoke River (Callihan et al. 2015) whereas CSMA striped bass stocks are considered non-migratory and do not exhibit the anadromous behavior of the Albemarle-Roanoke stock. Alternatively, Rock et al. (2018) noted that some larger acoustic tagged striped bass in the Tar-Pamlico and Neuse rivers later migrated to the ocean and at least one was detected in the Chowan River and Albemarle Sound providing additional evidence for overlap between the Albemarle-Roanoke and CSMA stocks. It is also possible the presence of the 2014 and 2015 cohorts were the result of spawning success from one of either the Tar-Pamlico or Neuse rivers, and not in both systems. If this is the case, it is critical to determine the river system these fish were spawned in and understand movement patterns between the Tar-Pamlico and Neuse rivers to guide future management should natural reproduction continue to occur.

Understanding the movement and migration patterns of these two year classes of striped bass is important in gauging the success of Supplement A and directing future management. Striped bass from these year classes were tagged with acoustic transmitters following the methods of Rock et al. (2018) and movements within the Tar-Pamlico and Neuse rivers are tracked using existing acoustic receiver arrays in place in these rivers. In addition, any movement of these fish in the Albemarle Sound and Roanoke River is detected from existing acoustic arrays in that system. If these striped bass were naturally produced in the CSMA rivers this acoustic study would collect initial migration data for these cohorts of striped bass from these rivers. If these striped bass were naturally produced in the Albemarle-Roanoke, additional data about movement patterns of striped bass between the CSMA and Albemarle Sound will provide valuable information to inform future assessment and management of this stock.

Because there is a no-possession limit for striped bass in the CSMA, fishing mortality on tagged striped bass should be minimized allowing for maximum rates of detection. Tagging fish with Vemco V16 (10-year tags) allows for long term monitoring of movement patterns and potentially multiple spawning runs.

Objectives

The objectives of this project are:

1. Insert acoustic tags, as well as conventional tags, into striped bass from the 2014 and 2015 year classes captured in the Tar-Pamlico and Neuse rivers.
2. Determine if these striped bass make spawning runs in the Tar-Pamlico and Neuse rivers.
3. Determine if these striped bass move between the CSMA and ASMA and RRMA.
4. Determine if these striped bass migrate to the ocean.

Methods

Striped bass were collected using electrofishing gear in the Tar-Pamlico and Neuse rivers. Effort was made to capture fish throughout the river and to deploy tags across multiple tagging days. Only fish at lengths that would be in the 2014 and 2015 year classes (ages 4 and 5) were tagged (Table 1). All striped bass were tagged with Vemco V16 (10-year tags) acoustic tags following the methods of Rock et al. (2018), along with a PIT tag and an internal anchor tag. All acoustic tagged fish were measured to the nearest millimeter (FL and TL), weighed, and a fin clip was collected to determine hatchery origin. When possible, sex was recorded. Acoustic tags were deployed during the winter when low water temperatures

provided the greatest chance of survival and provided time for the fish to recover prior to the spawning period (March–May).

Receiver downloads in RRMA, ASMA, and CSMA rivers occurred quarterly, and this schedule has been maintained to collect additional detections.

Results

All acoustic tagging occurred in the Tar-Pamlico and Neuse rivers. Between December 2019 and January 2020, Division staff tagged 50 striped bass (25 from the Tar-Pamlico River and 25 from the Neuse River) with acoustic, PIT, and conventional tags. In addition, 48 striped bass (23 from the Tar-Pamlico River and 25 from the Neuse River) were collected and sacrificed in conjunction with the acoustic tagged fish to provide ages of ''wild'' striped bass. Since ages derived from PBT analysis can only be achieved with fish of hatchery origin, there was a need to sample a subset of fish to determine ages for ''wild'' fish from structures (otoliths). Results from length and age data indicate success in targeting fish from the 2014 and 2015 year classes. Acoustic tagged striped bass varied in size from 20.8 to 25.6 inches TL, with a mean of 22.7 inches TL (Table 2). Striped bass that were determined to be ''wild'' varied in size from 20.8 to 25.0 inches TL, with a mean of 22.9 inches TL (Table 2). Additionally, ''wild'' striped bass that were collected and sampled for age determination using otoliths ranged in age from four to six and had a modal age of four years old in the Neuse River, and five years old in the Tar-Pamlico River.

The acoustic tag detection data for this analysis covers a period beginning in December 2019 through March 2022.

PBT analysis from the 50 acoustically tagged striped bass revealed that 30 were non-hatchery origin and classified as ''wild'', with the remaining 20 fish being classified as hatchery origin. Twenty of the 25 fish tagged in the Tar-Pamlico River were classified as ''wild'' while 10 of the 25 fish tagged in the Neuse River were classified as ''wild''. Of the 20 fish determined to be hatchery fish, five were tagged in the Tar-Pamlico River and 15 were tagged in the Neuse River.

''wild'' origin striped bass

Of the 30 total tagged ''wild'' striped bass, 70% (n=21) were determined to likely be ''wild'' Roanoke River striped bass because they left the CSMA river systems where they were tagged and were detected within the Albemarle Sound and/or Roanoke River (Figure 2). Most of the ''wild'' Roanoke River striped bass that left the CSMA and moved into the Albemarle Sound migrated up the Roanoke River (60%; n=18) and were ultimately detected on the spawning grounds near Weldon, N.C. (53%; n=16). Many of the ''wild'' Roanoke River striped bass had detection patterns indicating these fish reside in CSMA rivers throughout the year prior to undertaking migrations to the spawning grounds in the Roanoke River in the spring, then returning to the CSMA rivers after spawning is complete. The three remaining ''wild'' Roanoke River striped bass that left the CSMA system, were only detected as far as the Alligator River end of the Intracoastal Waterway (ICW) and the Alligator River Bridge. One of these was presumed dead due to repeated detections at the same location for an extended period and the other two had limited detections during the study period.

The remaining ''wild'' acoustic tagged striped bass (n=9) did not move out of the CSMA rivers and were not detected in Albemarle Sound; however, six of these fish did not have enough detection data to analyze movement patterns. Results indicate that a limited number of ''wild'' striped bass make spawning runs in the Tar-Pamlico and Neuse rivers. A single ''wild'' striped bass tagged in the Tar-Pamlico River was

later detected on the spawning grounds in the spring near Rocky Mount, N.C. and one ‘‘wild’’ striped bass tagged in the Neuse River was later detected on the spawning grounds in the Neuse River (Figure 2). Additionally, one ‘‘wild’’ striped bass tagged in the Neuse River was later detected in the Tar-Pamlico River and ultimately on the spawning grounds near Rocky Mount, N.C. ‘‘wild’’ fish moving to the spawning grounds within the river systems they were tagged, or adjacent CSMA rivers, suggests some striped bass from other stocks may stray into CSMA rivers to attempt spawning or some low level of successful natural reproduction occurs.

Noteworthy movement data of ‘‘wild’’ striped bass:

- 53% (n=16) of the ‘‘wild’’ fish were detected on the spawning grounds near Weldon, N.C. Several of these ‘‘wild’’ striped bass (n=5) made repeated annual migrations in the spring back to the Roanoke River spawning grounds.

- 50% (n=4) of the ‘‘wild’’ fish tagged in the Neuse River were detected moving through Manns Harbor, and 13% (n=1) moved into the Albemarle Sound through the Pungo River/Alligator River ICW.

- 31% (n=4) of the ‘‘wild’’ striped bass tagged in the Tar-Pamlico River entered the Albemarle Sound through the Pungo River/Alligator River ICW

- One ‘‘wild’’ striped bass tagged in the Tar-Pamlico River was detected two years in a row on the Roanoke River spawning grounds and resided in the Tar-Pamlico the first year and in the Neuse River the second year.

- One ‘‘wild’’ striped bass after being detected on the spawning grounds at Weldon, NC, was later detected at Oregon Inlet presumably out-migrating to join the Atlantic migratory stock.

- One ‘‘wild’’ striped bass was commercially harvested in Edenton Bay on May 14, 2020.

Hatchery origin striped bass

Movement patterns of hatchery origin striped bass (n=20) show they did not leave the river system where they were tagged. Results indicate hatchery striped bass make spawning runs in the Tar-Pamlico and Neuse rivers. Due to the low sample size of hatchery origin fish collected in the Tar-Pamlico River (n=5) there is minimal data to infer movement patterns; however, a single hatchery origin striped bass was detected on the spawning grounds (n=1; 20%; Figure 3). In the Neuse River, 10 of 15 hatchery origin striped bass (62%) were detected on the spawning grounds (Figure 4).

Next Steps

All striped bass were tagged with 10-year acoustic tags; however, detections decreased substantially within the first two years after tagging (Figure 5). Currently, there are approximately seven ‘‘wild’’ and four hatchery origin striped bass that are still being detected routinely on acoustic receivers throughout the tracking area. A total of three striped bass are considered mortalities because they have been detected at the same location for an extended period, and one striped bass was harvested in the commercial fishery in the ASMA. Division staff will continue to download the acoustic receiver array to monitor for additional striped bass detections for the duration of the tag life.

Literature Cited

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Callihan, J.L., J.E. Harris, and J.E. Hightower. 2015. Coastal migration and homing of Roanoke River striped bass. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 7(1):301-315.

Farrae, D., and T. Darden. 2018. North Carolina Division of Marine Fisheries 2017 Striped Bass Genotyping Report. South Carolina Department of Natural Resources. Charleston, SC. 9 p.

NCDMF. 2019. Supplement A to Amendment 1 to the N.C. Estuarine Striped Bass Fishery Management Plan. Implementation of a Striped Bass No-Possession Limit in the Internal Coastal and Joint Fishing Waters of the Central Southern Management Area. North Carolina Department of Environmental Quality. Division of Marine Fisheries. Morehead City, NC. 37 p.

Rock, J, D. Zapf, J. Facendola, C. Stewart. 2018. Assessing critical habitat, movement patterns, and spawning grounds of anadromous fishes in the Tar/Pamlico, Neuse, and Cape Fear rivers using telemetry tagging techniques. North Carolina Department of Environmental Quality. Division of Marine Fisheries. Morehead City, NC. CRFL Grant 2013-F-013 Final Report. 120 pp.

Table 1. Striped bass length at age (2016-2017 PBT ages) for the Neuse and Tar-Pamlico rivers. Shaded cells are size ranges that were targeted for acoustic tagging.

			TL (mm)			TL (inch)		
Age	**River System**	**n**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
3	Neuse	70	517	446	616	20.4	17.6	24.3
	Tar-Pamlico	18	498	460	568	19.6	18.1	22.4
4	Neuse	54	572	451	641	22.5	17.8	25.2
	Tar-Pamlico	119	574	473	659	22.6	18.6	25.9
5	Neuse	30	632	489	717	24.9	19.3	28.2
	Tar-Pamlico	79	618	528	681	24.3	20.8	26.8
6	Neuse	21	669	573	735	26.3	22.6	28.9
	Tar-Pamlico	40	657	587	718	25.9	23.1	28.3
7	Neuse	7	704	651	766	27.7	25.6	30.2
	Tar-Pamlico	2	696	668	723	27.4	26.3	28.5

Table 2. Acoustic tagged striped bass lengths for the Neuse and Tar-Pamlico rivers separated by treatment (tagged or sampled for aging structure) and origin.

				TL (mm)			TL (inch)		
River	**Treatment**	**Origin**	**n**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Neuse	tagged	hatchery	15	581	537	650	22.9	21.1	25.6
		‘wild’	10	597	539	635	23.5	21.2	25.0
	sampled	hatchery	16	591	527	665	23.3	20.7	26.2
		‘wild’	9	586	533	641	23.1	21.0	25.2
Tar-Pamlico	tagged	hatchery	5	545	531	572	21.5	20.9	22.5
		‘wild’	20	572	529	633	22.5	20.8	24.9
	sampled	hatchery	7	558	535	626	22.0	21.1	24.6
		‘wild’	16	567	533	642	22.3	21.9	25.3

Table 3. Striped bass ages (otolith and PBT) for the Neuse and Tar-Pamlico rivers separated by treatment (tagged or sampled for aging structure) and origin.

			Age							
			Modal		Min		Max		Total Number Aged	
River	Treatment	Origin	otolith	PBT	otolith	PBT	otolith	PBT	otolith	PBT
Neuse	tagged	hatchery	-	4	-	4	-	6	-	15
		'wild'	-	-	-	-	-	-	-	-
	harvested	hatchery	4	4	3	3	7	7	16	16
		'wild'	4	-	4	-	6	-	9	-
Tar-Pamlico	tagged	hatchery	-	4	4	-	4	-	-	5
		'wild'	-	-	-	-	-	-	-	-
	harvested	hatchery	4	4	4	4	6	6	7	7
		'wild'	5	-	5	-	6	-	16	0

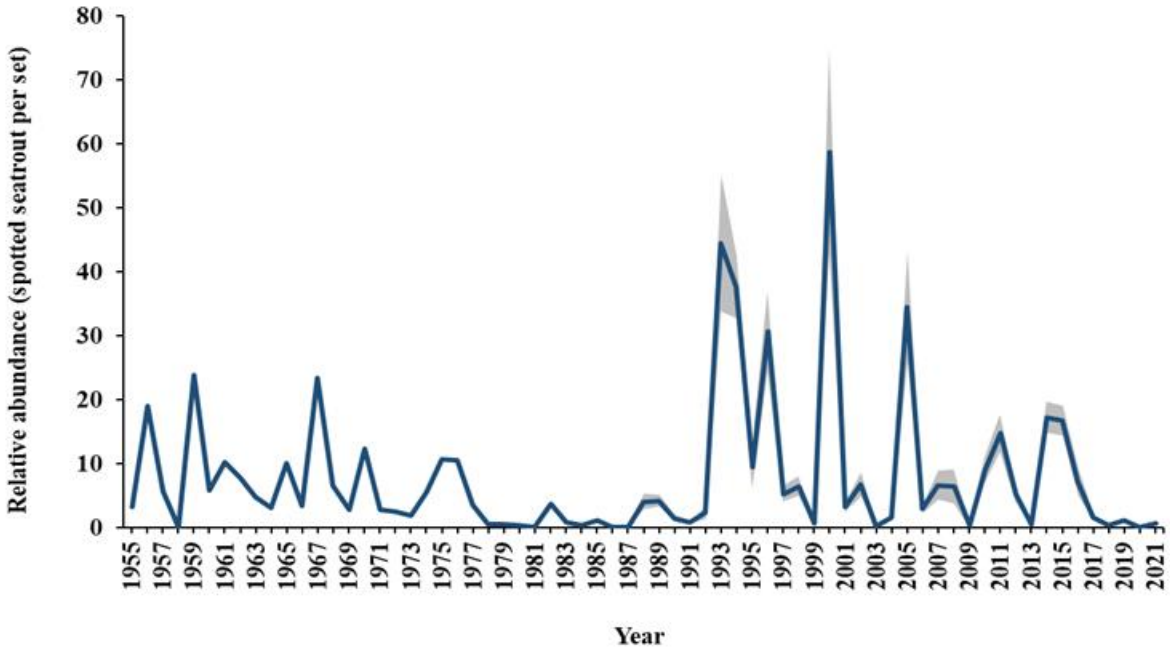

Figure 1. Juvenile abundance index (JAI) of Albemarle-Roanoke striped bass from the NCDMF juvenile trawl survey, western Albemarle Sound, NC, 1955–2021.

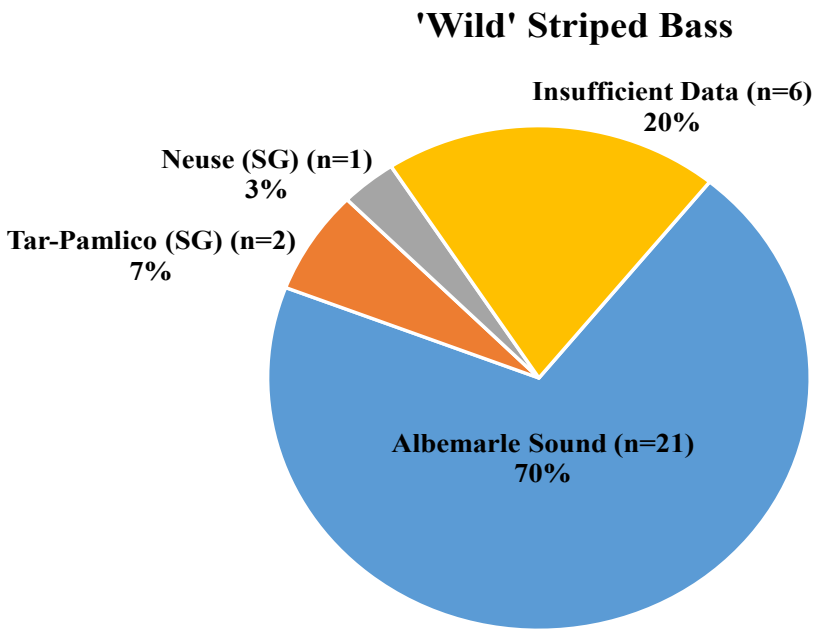

Figure 2. Detection location (%) of all acoustic tagged ‘‘wild’’ striped bass (n=30) by area (Tar-Pamlico and Neuse Rivers spawning grounds (SG), and Albemarle Sound). All original tagging events occurred in the Tar-Pamlico and Neuse River systems.

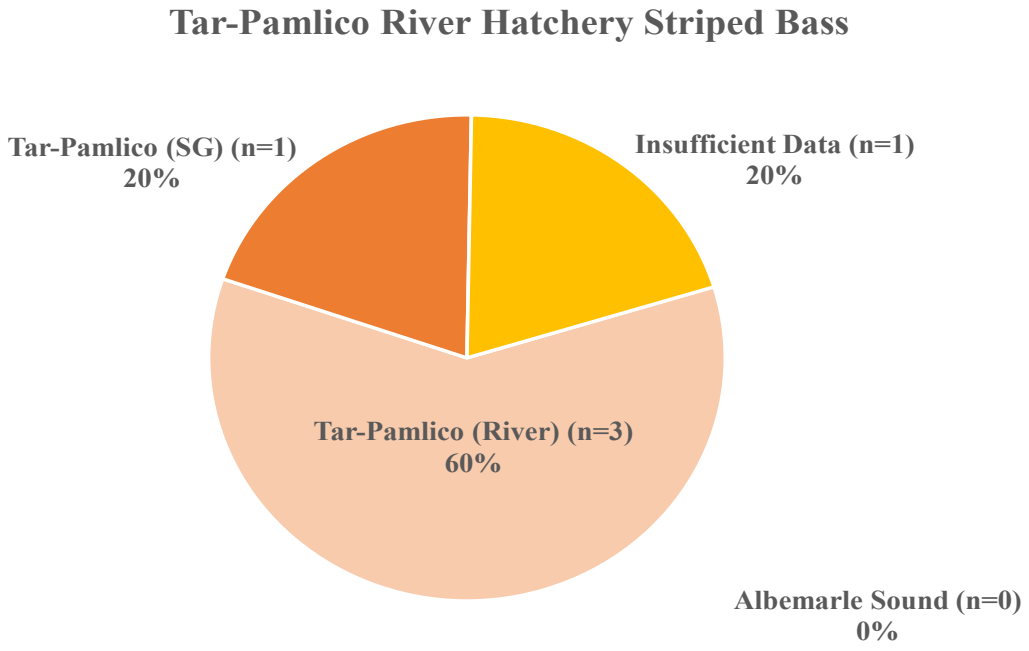

Figure 3. Detection location (%) for acoustic tagged hatchery origin striped bass in the Tar-Pamlico River system (n=5) by area (detection on spawning grounds (SG) or river residence). No hatchery origin fish from the Tar-Pamlico River system were detected in the Albemarle Sound area.

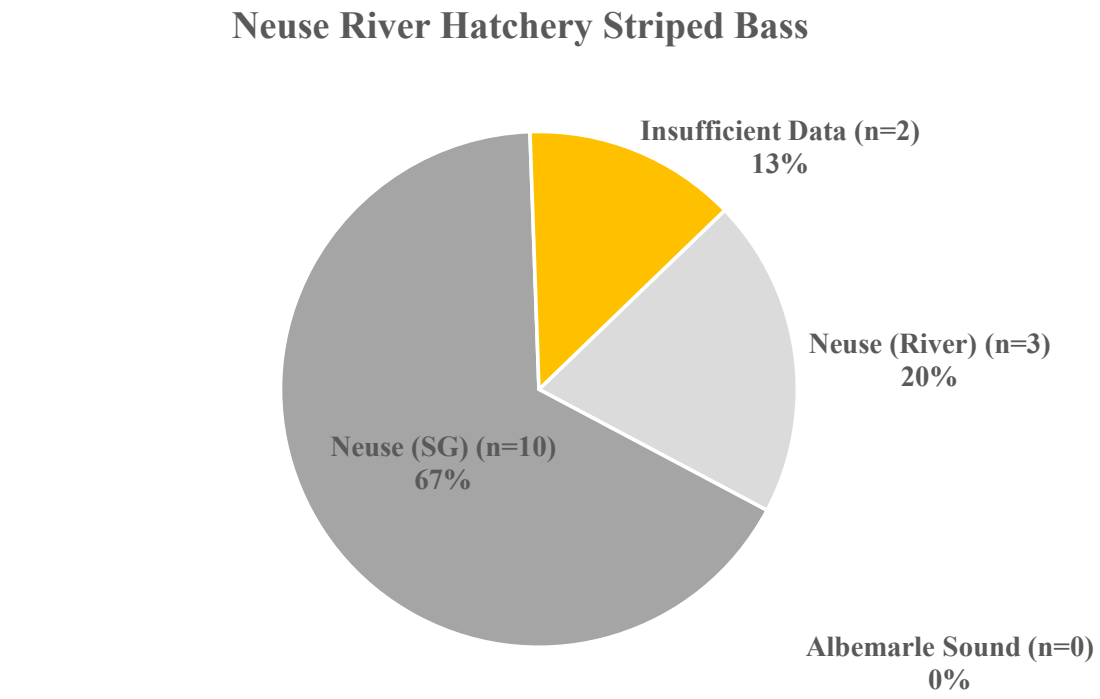

Figure 4. Detection location (%) for acoustic tagged hatchery origin striped bass in the Neuse River system (n=15) by area (detections on the spawning grounds (SG) or river residence). No hatchery origin fish from the Neuse River system were detected in the Albemarle Sound area.

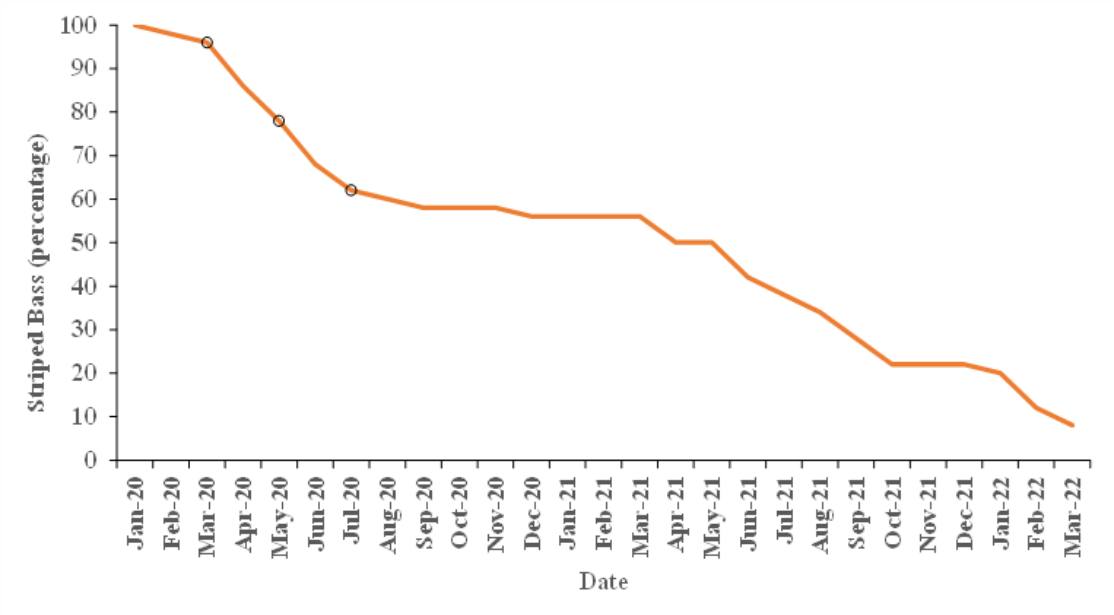

Figure 5. Tag detection loss (%) of acoustic tagged striped bass. Black circles represent known mortalities (n=4).