APPENDIX 3: ACHIEVING SUSTAINABLE HARVEST FOR THE TAR-PAMLICO AND NEUSE STRIPED BASS STOCKS

ISSUE

Consider existing factors that prevent a self-sustaining population in the Tar-Pamlico and Neuse rivers, and implement management measures that provide protection for and access to the striped bass resource.

ORIGINATION

North Carolina Division of Marine Fisheries (DMF) and North Carolina Wildlife Resources Commission (WRC)

BACKGROUND

Natural reproduction is the primary mechanism responsible for maintaining self-sustaining fish populations at levels that support sustainable recreational and commercial harvest. In self-sustaining populations, the numbers of offspring produced by natural reproduction are greater than can be stocked by managers. Striped bass stocks that allow harvest and can self-replace through natural reproduction are considered sustainable. Until there are naturally reproducing populations in these rivers capable of self-replacement, the sustainable harvest objective of this plan cannot be met.

The Tar-Pamlico and Neuse rivers striped bass fisheries have been sustained by continuous stocking to maintain the populations while allowing recreational and commercial harvest (O'Donnell and Farrae 2017; see Appendix 1). Roanoke River origin striped bass have either been stocked or used as broodstock in the Tar-Pamlico and Neuse rivers for decades (Bayless and Smith 1962; Woodroffe 2011; see Appendix 1). It is likely there are no Tar-Pamlico or Neuse River endemic strains of striped bass remaining in the river systems (Reading 2020; LeBlanc et al. 2020). The need for continued conservation management efforts are supported by persistent recruitment failure, multiple mortality sources, absence of older fish on the spawning grounds, non-optimal environmental conditions on the spawning grounds in the spring, impacts from hatchery reared juveniles and escaped hybrid striped bass, and the high percentage of stocked fish in the populations (Bradley et al. 2018; Rachels and Ricks 2018; Mathes et al. 2020). Reliable population estimates have never been determined for Tar-Pamlico River, and in 2018, Bradley et al. (2018) provided an estimate for Neuse River striped bass; however, by most accounts striped bass are abundant in these systems as a result of continuous stocking efforts (Mathes et al. 2020; NCDMF 2020a).

<u>Tar-Pamlico and Neuse River Striped Bass Stocks Life History</u>
For a comprehensive review of striped bass life history in the Tar-Pamlico and Neuse rivers see Mathes et al. (2020) and NCDMF (2013).

The age structure of striped bass in the Tar-Pamlico and Neuse rivers remains truncated, with few fish over ten years old collected in surveys conducted by the DMF and WRC. Sampling by

WRC in 2007 shows age-4 and age-6 fish are commonly encountered in both rivers (Barwick et al. 2008); however, older, larger individuals were seldom encountered. Since adoption of the striped bass FMP (DMF 2004), there has been little change in the size and age distribution in the Tar-Pamlico and Neuse rivers, with few age-6 and older fish observed in either system. However, abundance of age-6 and older striped bass began increasing in 2008, peaking in 2014 (Rachels and Ricks 2015). On the Tar River, abundance of age-6 fish has varied considerably with a peak in 2012 (Rundle 2016). WRC scale-aged fish suggest a maximum age of 17 on the Tar-Pamlico River (Homan et al. 2010), and 11 on the Neuse River (WRC - unpublished data 2017). DMF otolith and genetic age data indicate maximum ages of twelve in both rivers (DMF 2020a). Survey data indicates limited numbers of larger striped bass in these systems, though gear selectivity likely excludes larger striped bass from the sample. Few striped bass larger than 27 inches are commercially harvested in these systems (NCDMF 2020a); however, fishery independent sampling using gill nets with larger mesh sizes (up to 10 inch stretched mesh) indicates the presence of larger older striped bass in deeper regions of the Tar-Pamlico River (Cuthrell 2012).

Striped bass populations in the Tar-Pamlico and Neuse rivers have a primarily endemic riverine life history. Tagging data indicates limited movement of striped bass from the Neuse and Tar-Pamlico rivers into other systems and the Atlantic Ocean (Setzler et al. 1980; Rulifson et al. 1982, Winslow 2007; Callihan 2012; Callihan et al. 2014; Rock et al. 2018; DMF – unpublished data 2020). Multiple studies have shown striped bass make spawning migrations in the Tar-Pamlico and Neuse rivers and fertilized eggs are released, indicating reproduction is occurring; however, there is very limited if any striped bass recruitment to the larval and juvenile life stages (Humphries 1965; Kornegay and Humphries 1975; Jones and Collart 1997; Smith and Rulifson 2015; Rock et al. 2018). Surveys suggest egg abundance is not sufficient to provide recruitment of juveniles to the population.

Over the past several decades, few larval and juvenile striped bass have been collected from CSMA systems (Marshall 1976; Hawkins 1980; Nelson and Little 1991; Burdick and Hightower 2006; Barwick et al. 2008; Smith and Rulifson 2015; and Buckley et al. 2019). In 2017, the DMF began an exploratory juvenile abundance survey in the Tar-Pamlico and Neuse rivers using trawl and seine nets. No juvenile striped bass have been collected in this survey (Mathes et al. 2020; Darsee et al. 2020).

Striped bass are broadcast spawners that produce non-adhesive, semi-buoyant eggs that must remain neutrally buoyant in the water column as they float downriver for the best chance of survival to larvae. Sufficient current velocity is critical to keep eggs suspended in the water column for a minimum of 48 hours after fertilization (Bain and Bain 1982) preventing contact with the bottom.

The density and buoyancy of eggs differ among striped bass stocks (e.g., Roanoke River and Chesapeake Bay) and are ideally suited for certain river flows. Chesapeake Bay stock eggs are lighter and maintain their position in the water column of calmer tidal waters, whereas Roanoke River stock eggs are heavier and maintain their water column position in the more turbulent, high energy Roanoke River system (Bergey et al. 2003). While Chesapeake Bay stock eggs appear genetically predisposed to being lighter, Roanoke River stock eggs are thought to be more adaptable to varying environmental conditions (Kowalchyk 2020). Neuse River water velocities are variable, but appear sufficient to keep heavier striped bass eggs suspended until hatching (Burdick and Hightower 2006; Buckley et al. 2019) based on the minimum required water velocity (30 centimeters per second).

In 2017, North Carolina State University initiated research to provide insight into striped bass recruitment by evaluating genetic and environmental influences on egg development. Results reveal the stock with the heaviest and smallest eggs collected in 2018 and 2019 were from Tar-Pamlico and Neuse river striped bass broodstock (Kowalchyk 2020). The Tar-Pamlico and Neuse rivers were also found to have significantly different levels of key proteins required to maintain egg hydration compared to other North Carolina river systems, possibly contributing to differences in buoyancy and critically timed nutrient delivery.

It is clear striped bass reproduction is influenced by complex interactions between population structure, environmental, and physiological factors. In addition, because the striped bass stocks in the Tar-Pamlico and Neuse rivers are a non-endemic strain and the physical environment in these systems has changed through time reproductive success is likely confounded further.

<u>Striped Bass Fisheries</u>

Estuarine striped bass in North Carolina are managed under Amendment 1 to the N. C. Estuarine Striped Bass FMP and its subsequent revisions (NCDMF 2014; DMF 2020b). Management measures in Amendment 1 consist of daily possession limits, open and closed harvest seasons, seasonal gill-net attendance and other gill-net requirements, minimum size limits, and slot limits to maintain sustainable harvest and reduce regulatory discard mortality in all sectors. Amendment 1 also maintains the stocking measures in the major CSMA river systems (NCDMF 2013). Supplement A to Amendment 1 (NCDMF 2019) implemented a no-possession provision for striped bass in the internal coastal and joint waters of the CSMA to protect two large year classes of striped bass. Additionally, commercial gill-net restrictions required tie-downs and distance from shore (DFS) measures year-round (M-5-2019).

Recreational

The DMF recreational angler survey started collecting recreational striped bass harvest, discard, effort, and economic data for the Tar-Pamlico and Neuse rivers in 2004. Recreational landings fluctuated between 2004 - 2018, ranging from a low in 2008 (2,990 pounds) to a high of 26,973 pounds in 2017 (NCDMF 2020a). Only 959 pounds were harvested in 2019 because the season closed early when Supplement A (February 2019) was approved. From 2016 - 2017, recreational trips and hours spent targeting striped bass increased with a moderate decline observed in 2018. On average 3,327 fish were harvested annually from the Tar-Pamlico and Neuse rivers combined. (NCDMF 2020a). Recreational releases during 2009 - 2018 averaged 43,255 fish per year (Mathes et al. 2020). Due to the number of undersized striped bass available in 2017, there was a more than fivefold increase in discards (Figure 1).

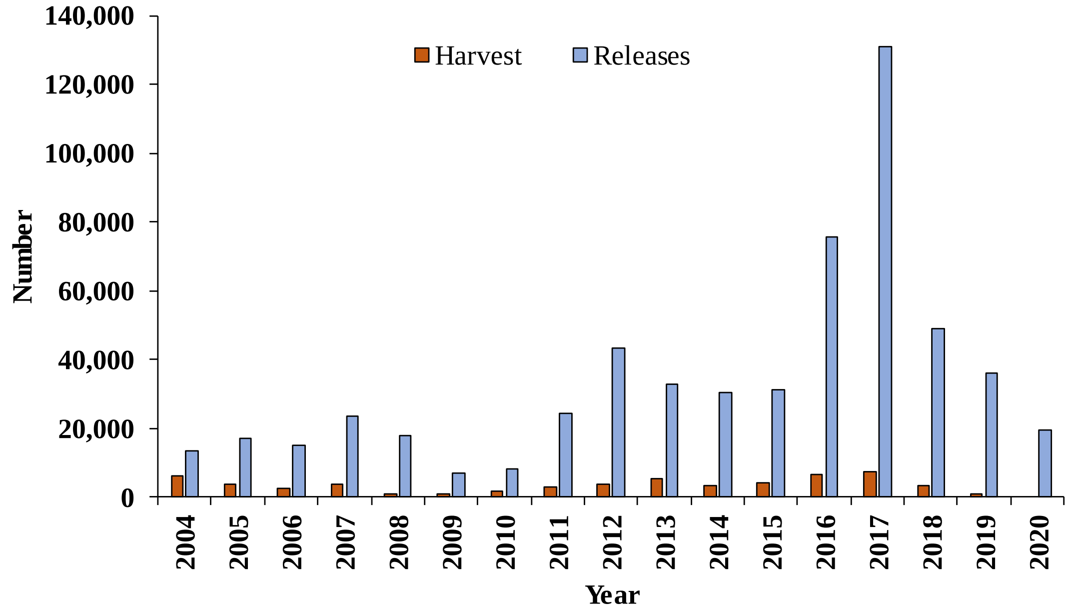

Figure 1. Annual recreational catch (released and/or harvested) of striped bass in the CSMA, 2004-2020. There was a limited recreational harvest season in 2019 prior to the closure, lasting from Jan 1 to Mar 19, 2019.

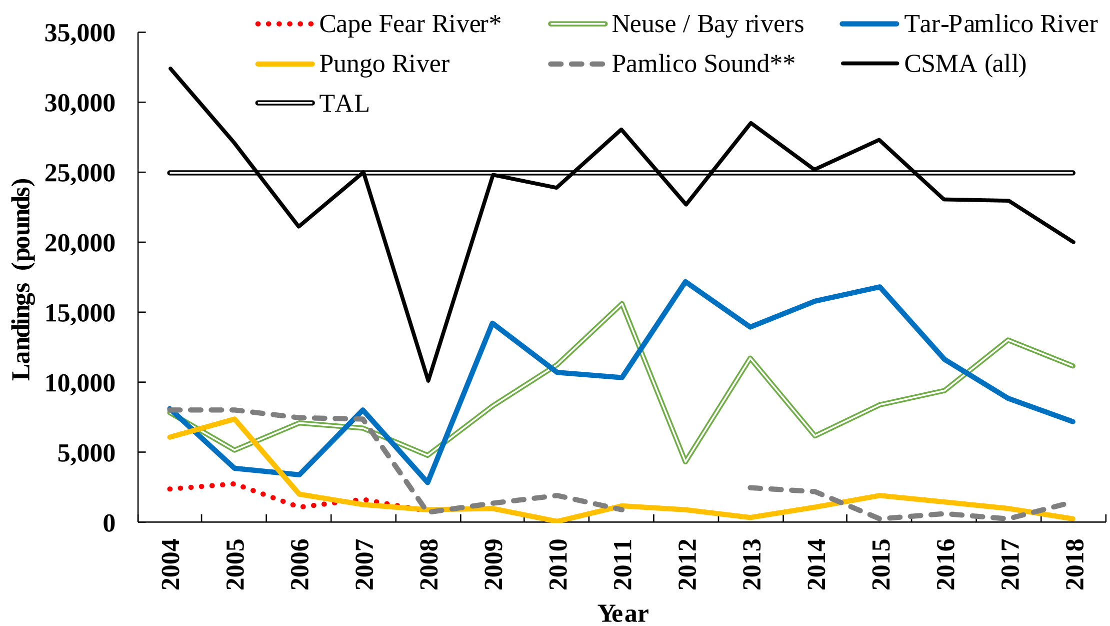

Figure 2. Commercial striped bass harvest by system, and the TAL in the CSMA, 2004–2018. *There has been a harvest no-possession measure in the Cape Fear River since 2008 and in the CSMA since 2019. **Landings data for the Pamlico Sound in 2012 are confidential.

Commercial
Supplement A closed the commercial striped bass fishery in 2019. From 1994 - 2018 commercial landings in the CSMA were limited by an annual total allowable landings (TAL) of 25,000 pounds. The TAL was nearly met in all years except for 2008, when less than half of the TAL was landed (Figure 2). From 2004 - 2018, the commercial season opened March 1 and closed when the TAL was reached.

<u>Stock Concerns</u>
Lack of natural recruitment is the biggest factor affecting striped bass stocks in the Tar-Pamlico and Neuse rivers. There has been no measurable year class produced in the Tar-Pamlico and Neuse rivers for decades, and therefore, the stocks require continuous stocking to sustain their populations. A demographic matrix model was developed for striped bass in the CSMA to evaluate different stocking and management strategies (Mathes et al. 2020). Stock evaluation results provide further evidence that natural recruitment is the primary limiting factor influencing Tar-Pamlico and Neuse river stocks and if stocking was stopped the populations would decline (Mathes et al. 2020). Stock evaluation results indicate that striped bass populations in the CSMA are depressed to an extent that sustainability is unlikely at any level of fishing mortality, and that no level of fishing mortality is sustainable (Mathes et al. 2020).

Female striped bass in these systems are 100% mature at age-4 (Knight 2015), and are common to age-8, indicating abundance of mature females in these populations should be sufficient to produce some level of annual natural recruitment. In the Roanoke River, even during poor flow years coupled with periods of low spawning stock biomass, consistent, measurable year classes are detected in fishery independent surveys and in the Northeast Cape Fear River juveniles are captured despite very low stock abundance and truncated age structure (Darsee et al. 2020; Lee et al. 2020).

Reasons for low recruitment
Factors affecting natural recruitment in the Tar-Pamlico and Neuse rivers are not well understood, but several factors have been suggested as potentially affecting natural recruitment, including spawning stock abundance, truncated age structure (Bradley et al. 2018; Rachels and Ricks 2018; Buckley et al. 2019), and egg abundance. The absence of older individuals in the populations (≥age-10) may not be sufficient to provide natural recruitment because of lower egg production from younger, smaller fish.

Eggs produced by hatchery stocked fish may not be adapted to environmental conditions found in the Tar-Pamlico and Neuse rivers. Unlike the Roanoke River there is no agreement with the U.S. Army Corp. of Engineers (USACOE) to maintain adequate flows for striped bass spawning on the Tar-Pamlico or Neuse rivers. Due to the watershed and storage capabilities it is not possible to manipulate flows in these rivers in the same manner as the Roanoke River. The USACOE is consulted weekly regarding water releases in the Neuse River, and the ability to manipulate releases may become important as we get more information on flows in these systems. If flows are too low during the spawning period, heavy eggs may be more likely to contact the bottom before hatching successfully.

Stocking Considerations
Stocking striped bass is handled through the North Carolina Interjurisdictional Fisheries Cooperative annual work plan between DMF, WRC, USFWS (COOP; see Appendix 1), and will continue to play a key role recovering striped bass populations. Specific objectives for stocking striped bass included attempts to increase spawning stock abundance while promoting self-sustaining population levels appropriate for various habitats (see Amendment 1, Section 11.2; NCDMF 2013). The annual number stocked was increased starting in 2010 to a goal of 100,000 hatchery reared striped bass in each of the major river systems (Tar-Pamlico, Neuse, and Cape Fear rivers).

Stocking will continue to play a key role recovering striped bass populations. As part of the COOP, consideration of future stocking measures should include evaluation of stocking bass with eggs adapted to environmental conditions in the rivers. In addition, because management and stocking strategy simulation results show the populations would likely benefit from stocking more striped bass, discussions related to the number of striped bass stocked annually should be discussed as part of the COOP agreement. See Appendix 1for additional stocking considerations.

AUTHORITY

North Carolina's existing fisheries management system for striped bass is adaptive, with rulemaking authority vested in the MFC and the WRC within their respective jurisdictions. The MFC also has the authority to delegate to the fisheries director the ability to issue public notices, called proclamations, suspending or implementing particular commission rules that may be affected by variable conditions. Management of recreational and commercial striped bass regulations within the Tar-Pamlico and Neuse rivers is the responsibility of the MFC in Coastal and Joint Waters, and recreational regulations are the responsibility of the WRC in Joint and Inland Waters. It should also be noted that under the provisions of the North Carolina Estuarine Striped Bass FMP Amendment 1 the DMF Director maintains proclamation authority to establish seasons, authorize or restrict fishing methods and gear, limit quantities taken or possessed, and restrict fishing areas as deemed necessary to maintain a sustainable harvest. The WRC Executive Director maintains proclamation authority to establish seasons.

NORTH CAROLINA GENERAL STATUTES

<u>*N.C. General Statutes*</u>

G.S. 113-134.	RULES
G.S. 113-182.	REGULATION OF FISHING AND FISHERIES
G.S. 113-182.1.	FISHERY MANAGEMENT PLANS
G.S. 113-221.1.	PROCLAMATIONS; EMERGENCY REVIEW
G.S. 113-292.	AUTHORITY OF THE WILDLIFE RESOURCES COMMISSION IN REGULATION OF INLAND FISHING AND THE INTRODUCTION OF EXOTIC SPECIES.
G.S. 143B-289.52.	MARINE FISHERIES COMMISSION—POWERS AND DUTIES

NORTH CAROLINA RULES

N.C. Marine Fisheries Commission and N.C. Wildlife Resources Commission Rules 2020 (15A NCAC)

15A NCAC 03M .0201	GENERAL
15A NCAC 03M .0202	SEASON, SIZE AND HARVEST LIMIT: INTERNAL COASTAL WATERS
15A NCAC 03M .0512	COMPLIANCE WITH FISHERY MANAGEMENT PLANS
15A NCAC 03Q .0107	SPECIAL REGULATIONS: JOINT WATERS
15A NCAC 03Q .0108	MANAGEMENT RESPONSIBILITY FOR ESTUARINE STRIPED BASS IN JOINT WATERS
15A NCAC 03Q .0109	IMPLEMENTATION OF ESTUARINE STRIPED BASS MANAGEMENT PLANS: RECREATIONAL FISHING
15A NCAC 03R .0201	STRIPED BASS MANAGEMENT AREAS
15A NCAC 10C .0110	MANAGEMENT RESPONSIBILITY FOR ESTUARINE STRIPED BASS IN JOINT WATERS
15A NCAC 10C .0111	IMPLEMENTATION OF ESTUARINE STRIPED BASS MANAGEMENT PLANS: RECREATIONAL FISHING
15A NCAC 10C .0301	INLAND GAME FISHES DESIGNATED
15A NCAC 10C .0314	STRIPED BASS

DISCUSSION

The Tar-Pamlico and Neuse river populations are not self-sustaining and cannot support any level of harvest (Mathes et al. 2020). Increasing spawning stock biomass and advancing the female age-structure to older individuals may lead to improved natural recruitment (Goodyear 1984). A 10-year closure was most effective in increasing adult (age 3+) abundance over the entire 15-year simulation time period and increasing old adult (age 6+) abundance. (Mathes et al. 2020). A sufficient time period will be required (at least ten years retroactive to the adoption of Supplement A in 2019) to achieve an expansion of the age structure and abundance of older fish to promote natural recruitment. Evaluations must account for natural fluctuations in striped bass spawning success due to environmental conditions.

<u>Continue or discontinue the no-harvest measure</u>

Management measures implemented in Supplement A, closed the fishery to commercial and recreational harvest and must be incorporated into Amendment 2 to be maintained. If Supplement A management measures are not maintained, alternative management strategies to promote sustainable harvest can be considered.

Closing the fishery to commercial and recreational harvest provides the opportunity to evaluate the population response in the absence of fishing mortality. If there are no other significant sources of mortality (i.e., natural mortality or discard mortality) or other losses to the population (i.e., emigration from the system), no-harvest should allow for expansion of the age structure to include fish greater than age-10.

The no-possession measure in the internal coastal and joint waters of the CSMA was implemented based on genetic evidence suggesting two successful natural spawning events occurred in the Tar-Pamlico and Neuse rivers in 2014 and 2015 (NCDMF 2019). This was an unusual event for Tar-Pamlico and Neuse river stocks. However, Rulifson (2014) concluded 53% of fish sampled from the Neuse River in 2010 were not of hatchery origin providing evidence that sporadic, low levels of natural recruitment may occur in these systems. Supplement A was adopted to protect striped bass from the 2014- and 2015-year classes from harvest as they mature and contribute to the spawning stock.

Based on matrix model results, no level of fishing mortality is sustainable. Continuing the no-possession measure is important to increase the age structure and abundance of Tar-Pamlico and Neuse river striped bass, which should promote natural reproduction (Mathes et al. 2020). Fishing activities typically select larger fish; thus, increases in fishing mortality disproportionally impact the abundance of older fish, which constricts the age structure of the population, and limits reproductive contribution (Mathes et al. 2020). Past management measures may have maintained an artificially young age structure for a species documented to live up to age 30 (Greene et al. 2009).

An additional potential benefit of no-harvest in the CSMA is protection of A-R striped bass using various juvenile and adult habitats found in the Pamlico Sound and the Tar-Pamlico and Neuse river systems. Conventional tag return data has documented movement of smaller A-R stock striped bass into CSMA rivers and preliminary acoustic tag results from 30 adult (ages 4-5) non-hatchery origin striped bass tagged in the Tar-Pamlico and Neuse rivers indicates 63% were detected in the Albemarle Sound or Roanoke River spawning grounds in spring 2020 and 2021 (Callihan et al. 2014; DMF unpublished data).

If the no-possession measure is discontinued in Amendment 2, alternative management strategies must be considered to manage harvest. Prior to 2019, management measures limited harvest seasons to the cooler months to reduce discard mortality. Recreational fishermen were subject to a two fish per person per day creel limit and commercial fishermen were subject to a 10 fish per person per day limit with a maximum of two limits per commercial operation. Commercial and recreational fishermen were subject to an 18-inch total length (TL) minimum size limit for striped bass, and a protective measure in joint and inland waters, made it unlawful for recreational fishermen to possess striped bass between 22 to 27 inches TL. In 2018, a 26-inch TL minimum size limit was established in inland waters. If harvest was allowed, changes to the size limits, or slot limits, could be considered to protect larger (≥30 inch), older (≥age-10) striped bass. Among the six fishing strategies evaluated by the matrix model, the strategy with a 5-year closure combined with a 26-inch TL size limit after closure was second most effective at increasing the abundance of older fish (Mathes et al. 2020). Additionally, commercial harvest was managed by an annual TAL of 25,000 pounds. With a goal of achieving self-sustaining populations in the Tar-Pamlico and Neuse rivers, lower harvest levels, alternative seasons, or area closures could be considered. Because striped bass populations in the CSMA are depressed to an extent that sustainability is unlikely at any level of fishing mortality (Mathes et al. 2020) if the harvest moratorium is not maintained, alternative management strategies, no matter how conservative, are unlikely to result in a self-sustaining stock.

Gear restrictions/limits

In 2004, DMF tested the effectiveness of various tie-down and gill net setting configurations in reducing striped bass bycatch. Results indicated distance from shore is a significant factor in striped bass catch rates, with up to a ~60% reduction in striped bass catch when nets are set greater than 50 yards from shore (NCDMF 2013). Also, tie-downs were shown to reduce striped bass catch by ~85-99% in water depths greater than 3 feet depending on season (NCDMF 2013). In 2008, the MFC approved requiring the use of 3-foot tie downs in large mesh gill nets in internal coastal fishing waters and establishing a minimum setback distance from shore of 50 yards to reduce striped bass discards (NCDMF 2013). Supplement A prohibited the use of gill nets upstream of the ferry lines from the Bayview Ferry to Aurora Ferry on the Tar-Pamlico River and the Minnesott Beach Ferry to Cherry Branch Ferry on the Neuse River and maintains tie-down and distance from shore restrictions for gill nets with a stretched mesh length 5 inches and greater in the western Pamlico Sound and rivers (Figure 3).

Rock et al. (2016) compared striped bass dead discard estimates from observer data before and after the tie down and distance from shore management measures were implemented (2004 - 2009 and 2011 - 2012). Average annual striped bass discards in the commercial gill net fishery in the Tar-Pamlico and Neuse rivers were reduced by 75%. The persistent availability of striped bass within 50 yards of shore as indicated by fishery independent sampling, and low numbers of out of season observations from commercial gill net trips show the 50-yard setback from shore and tie-down measures for large mesh gill nets was effective in reducing gill net interactions with striped bass (Rock et al. 2016).

Relative annual variation in commercial gill net effort, commercial harvest, annual variation in recreational effort and recreational discards are significant factors contributing to the total mortality of striped bass in the Neuse River (Mathes et al. 2020). Reducing mortality, including dead discards, may increase spawning stock biomass and advance the age structure of spawning females (Rachels and Ricks 2018). Estimates of total dead striped bass discards in the Tar-Pamlico River were higher than in the Neuse River ranging from 306 in 2017 to 709 in 2013 (Table 1). Estimates of total dead striped bass discards from gill nets in the Neuse River ranged from 140 in 2017 to 342 in 2013 (Table 2). Relatively low estimates of dead discards are an indicator that distance from shore and tie-down requirements enacted in 2008 have been successful in reducing the number of striped bass discards in the commercial gill net fishery in the Tar-Pamlico and Neuse rivers (Rock et al. 2016). Lowering mortality on a stock that cannot sustain itself at any level of fishing mortality is likely to have benefits to the population.

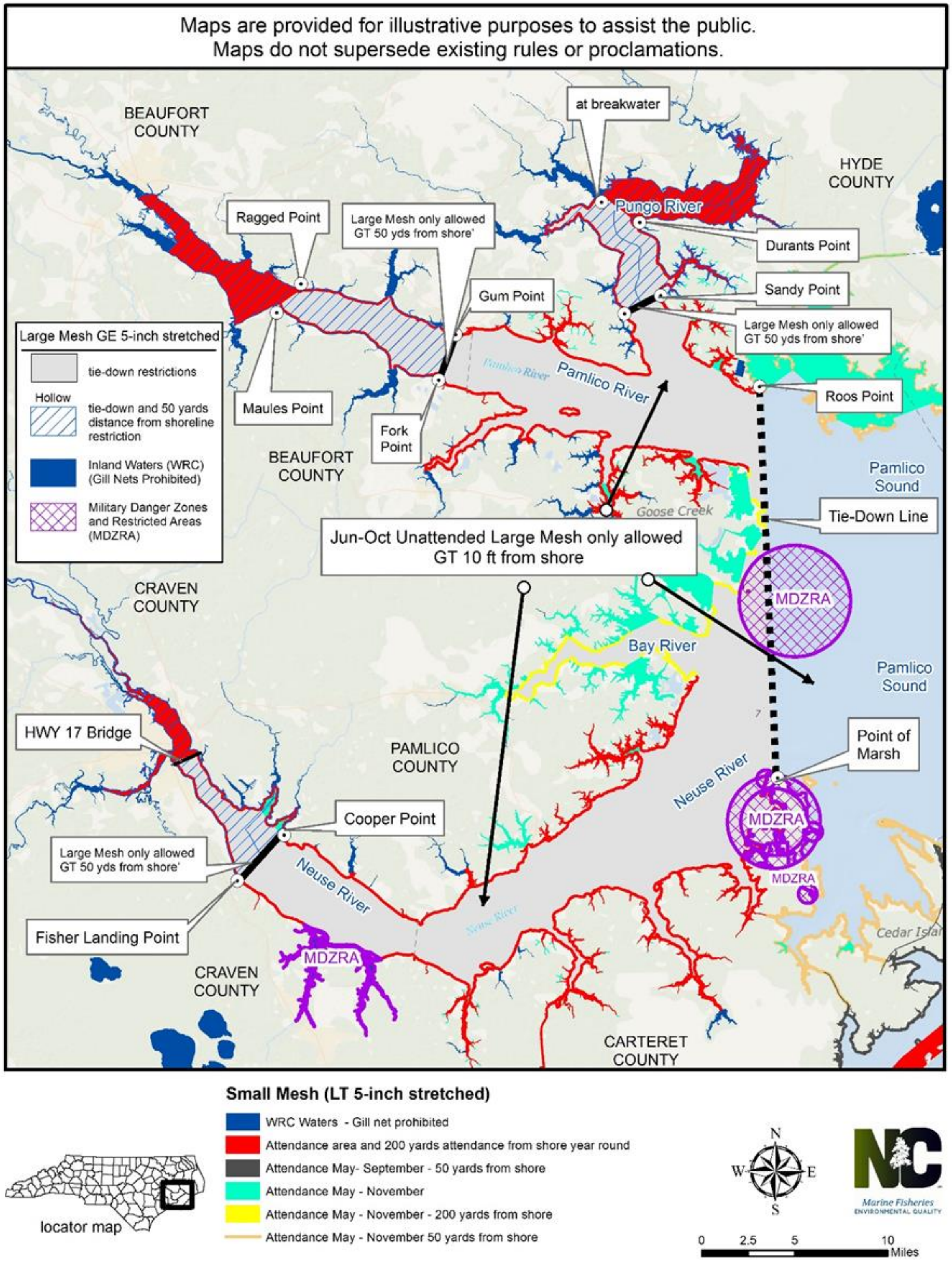

Figure 3. Gill-net regulation map for various gill-net types and seasons in the Central Southern Management Area.

Table 1. Commercial estimates of striped bass discards (standard error in parentheses) in the Tar-Pamlico/Pungo rivers by mesh size, 2013–2018.

	Live Releases			Dead			Release Mortalities		Total Dead	
Year	**Small Mesh**	**Large Mesh**	**Combined**	**Small Mesh**	**Large Mesh**	**Combined**	**Small Mesh**	**Large Mesh**	**Small Mesh**	**Large Mesh**
2013	484 (123)	490 (150)	975 (244)	59 (13)	230 (73)	289 (85)	208	211	267	442
2014	258 (83)	490 (133)	749 (143)	33 (11)	233 (80)	266 (91)	112	212	145	445
2015	149 (46)	145 (51)	296 (87)	41 (15)	184 (75)	224 (90)	65	63	106	246
2016	421 (97)	470 (171)	891 (242)	30 (11)	131 (36)	161 (46)	181	203	210	333
2017	269 (104)	143 (64)	411 (159)	37 (13)	93 (38)	130 (51)	115	60	152	154
2018	416 (214)	346 (145)	762 (344)	25 (7)	86 (30)	111 (36)	179	148	204	234

Table 2. Commercial estimates of striped bass discards (standard error in parentheses) in the Neuse/Bay rivers by mesh size, 2013–2018.

	Live Releases			Dead			Release Mortalities		Total Dead	
Year	**Small Mesh**	**Large Mesh**	**Combined**	**Small Mesh**	**Large Mesh**	**Combined**	**Small Mesh**	**Large Mesh**	**Small Mesh**	**Large Mesh**
2013	110 (32)	132 (45)	243 (69)	34 (8)	204 (53)	237 (61)	47	58	81	261
2014	182 (61)	74 (22)	256 (76)	54 (20)	108 (35)	162 (54)	78	32	133	139
2015	56 (20)	14 (6)	71 (25)	45 (17)	68 (27)	112 (43)	23	7	68	74
2016	57 (14)	91 (36)	149 (47)	10 (3)	88 (25)	98 (28)	25	39	36	127
2017	51 (22)	35 (17)	86 (37)	20 (7)	81 (31)	101 (38)	21	15	44	96
2018	180 (96)	117 (48)	297 (138)	29 (8)	96 (29)	124 (37)	78	51	107	145

Year-round gill net closures above the ferry lines on the Tar-Pamlico and Neuse rivers impact commercial harvest of other species, such as American shad. The American shad commercial season in the Tar-Pamlico and Neuse rivers occurs from February 15 - April 14 and most American shad are harvested during the March striped bass gill net fishery. From 2012 - 2017, commercial fishermen harvested an average of 16,805 pounds of American shad in the months of January–March in the Tar-Pamlico and Neuse rivers (NCDMF 2013). After the gill net closure in March 2019, landings and the number of trips were greatly reduced in both river systems (NCDMF 2020c). No American shad were harvested in 2019 and only 125 pounds were harvested in 2020 in the Tar-Pamlico River system. In the Neuse River system, commercial harvest of American shad in 2019 was reduced to 1,539 pounds and was only 109 pounds in 2020.

Measures to reduce recreational angling discard mortality may also be necessary for the Tar-Pamlico and Neuse stocks. The use of single barbless hooks is required by WRC on the Roanoke River to reduce discard mortality. Similar measures and other methods, such as requiring circle hooks for natural bait and restricting the use of treble hooks, could be considered in the Tar-

Pamlico and Neuse rivers. This type of restriction could be done seasonally or year-round. Recreational gear limitations would likely impact other fisheries.

The decision in the Tar-Pamlico and Neuse rivers on opening or closing the striped bass fishery and establishing areas open or closed to gill netting is a tradeoff between providing protection and promoting self-sustaining populations given unknown factors affecting natural recruitment or providing opportunities to harvest limited numbers of striped bass. For this reason, if the harvest moratorium is not maintained, the gill net closure should be reevaluated as it would be ineffective to continue the current closure as a means of protecting striped bass while allowing directed harvest.

Adaptive Management

Adaptive management allows managers to pivot and change management strategies when new information or data becomes available. Management options which are selected during the FMP process take into account the most up to date data on the biological and environmental factors which affect the stock. After implementation of the FMP, if additional data is available about a fishery or key factors change, adaptive management provides the flexibility to incorporate this new information to inform alternative and/or additional actions needed for sustainable fisheries management. A range of adaptive management actions, as well as the criteria for their application can be established within the FMP management framework to improve both short and long term management outcomes.

Promotion of a self-sustaining population is paramount, and management must first focus on establishing annual juvenile recruitment in the Tar-Pamlico and Neuse rivers. Fishery independent and fishery dependent surveys will continue to be used to monitor striped bass stocks in the Tar-Pamlico and Neuse river systems. If survey data, genetic analysis, age data, or other information indicate existing management measures are achieving the goals of expanding the age structure and promoting consistent natural recruitment, then management measures may be re-evaluated. If annual monitoring shows either continuous recruitment or expansion of the age structure, the matrix model will be updated to re-examine if alternative harvest strategies may be advisable; available data will be evaluated to determine if a stock assessment is possible. Alternatively, if annual data evaluation does not indicate expansion of the age structure or natural recruitment, evaluation of available information should occur to identify potential causes.

PROPOSED MANAGEMENT OPTIONS

(+ potential positive impact of action)
(- potential negative impact of action)

1. Striped Bass Harvest
   - A. Continue the no-harvest measure in Supplement A to Amendment 1.
     - + Provides an opportunity to evaluate the population response in the absence of fishing mortality.
     - + Increases abundance and expands the age structure

+ Provides protection of A-R striped bass that are found in the Tar-Pamlico and Neuse river systems
+ Provides the best chance of achieving sustainable harvest
- Does not allow for limited harvest of the resource by commercial and recreational fishermen
- May not achieve desired results if other factors influence recruitment
- Discards in commercial and recreational fishery will still occur

B. Discontinue the no-harvest measure in Supplement A to Amendment 1 (Open harvest)
+ Allows for limited harvest of the resource by commercial and recreational fishermen
+ Reduces discards
+/- Environmental and other factors may prevent natural recruitment from occurring regardless of stock condition
- Cannot achieve goal of sustainable harvest at any level of fishing mortality

2. Gill Net Restrictions/Limits

A. Maintain gill net closure at the ferry lines
+ Reduces dead discards from the gill net fishery
+ Could help increase abundance and expand age structure
+ Maintains reduced protected species interactions
+ Makes it easier for managers to measure any potential impacts
- Impacts commercial harvest of many species, such as, American shad
- May not increase chances of achieving sustainable harvest

B. Remove the gill net closure at the ferry lines
+ Allows for limited harvest of the resource, as well as American shad
+ Discards from gill net fishery may be low enough that abundance and expansion of age structure would still occur
- Removes added protection to striped bass
- May have protected species interactions
- Cannot achieve goal of sustainable harvest at any level of fishing mortality

3. Adaptive Management

+ Adaptive management allows for management adjustments to any of the selected management options as new data becomes available
+ Will help achieve the goal of increased abundance and expanded age structure
- Creates management uncertainty if not clearly defined

RECOMMENDATIONS

Maintain harvest moratorium in the CSMA and maintain the current gill net closure in the Tar-Pamlico and Neuse rivers until at least 2029.

Support formalizing discussions on controlling flows in Tar-Pamlico and Neuse rivers with USACE.

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