FISCAL IMPACTS OF PROPOSED RULES FROM PETITION FOR RULEMAKING SUBMITTED BY NORTH CAROLINA WILDLIFE FEDERATION

Rule Changes:	15A NCAC 03I .0101 DEFINITIONS 15A NCAC 03L .0101 SHRIMP HARVEST RESTRICTIONS 15A NCAC 03L .0103 PROHIBITED NETS, MESH LENGTHS AND AREAS 15A NCAC 03M .0523 SPOT 15A NCAC 03M .0524 ATLANTIC CROAKER 15A NCAC 03N .0105 PROHIBITED GEAR, SECONDARY NURSERY AREAS 15A NCAC 03R .0105 SPECIAL SECONDARY NURSERY AREAS
Name of Commission:	North Carolina Marine Fisheries Commission
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Impact Summary:

State government:	Yes
Local government:	Yes
Private industry:	Yes
Substantial impact:	Yes
Federal government:	No

Authority: G.S. 143B-289.52. Marine Fisheries Commission - powers and duties and G.S. 113-134. Rules provide the North Carolina Marine Fisheries Commission authority to adopt rules for the management, protection, preservation, and enhancement of the marine and estuarine resources within its jurisdiction, as described in G.S. 113-132. Any person wishing to adopt, amend, or repeal a rule of the Marine Fisheries Commission can submit a rulemaking petition to the Chairman of the Commission in accordance with G.S. 150B-20 of the North Carolina Administrative Procedure Act and 15A NCAC 03P .0300.

Necessity: The North Carolina Marine Fisheries Commission passed a motion Feb. 16, 2017 to grant in full the North Carolina Wildlife Federation's Petition for rulemaking originally submitted on Nov. 2, 2016 and as amended by its Jan. 12, 2017 modification. In accordance with G.S. 150B-20, if an agency grants a rulemaking petition, it must initiate rulemaking proceedings. Per G.S. 150B-21.4, before an agency publishes in the *North Carolina Register* the proposed text of a permanent rule change that would require the expenditure of state funds, it must submit a fiscal note on the proposed rule change.

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ACRONYMS

AC	Advisory Committee
APAIS	Access Point Angler Intercept Survey
ASMFC	Atlantic States Marine Fisheries Commission
BACI	Before-After Control-Impact
BRD	Bycatch Reduction Device
CFVR	Commercial Fishing Vessel Registration
CHPP	Coastal Habitat Protection Plan
CPUE	Catch Per Unit Effort
CRFL	Coastal Recreational Fishing License
CSMA	Central Southern Management Area
EBFM	Ecosystem-Based Fisheries Management
ESA	Endangered Species Act
F	fishing mortality rate
FDA	United States Food and Drug Administration
FEUS	Fisheries Economics of the United States
FMP	Fishery Management Plan
FRA	North Carolina Fisheries Reform Act
FY	Fiscal Year
ITP	Incidental Take Permit
M	natural mortality rate
MAFMC	Mid-Atlantic Fishery Management Council
MFC	Marine Fisheries Commission
MRFSS	Marine Recreational Fisheries Statistics Survey
MRIP	Marine Recreational Information Program
NCDEQ	North Carolina Department of Environmental Quality
NCDMF	North Carolina Division of Marine Fisheries
NCREDC	North Carolina Rural Economic Development Center
NCTTP	North Carolina Trip Ticket Program

NCWF	North Carolina Wildlife Federation
NCWRC	North Carolina Wildlife Resources Commission
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PDT	Plan Development Team
PNA	Primary Nursery Area
PSE	Percent Standard Error
RCGL	Recreational Commercial Gear License
RSCFL	Retired Standard Commercial Fishing License
SAFMC	South Atlantic Fishery Management Council
SAV	Submerged Aquatic Vegetation
SCFL	Standard Commercial Fishing License
SCMRD	South Carolina Marine Resources Division
SEAMAP	Southeast Area Monitoring and Assessment Program
SELC	Southern Environmental Law Center
SNA	Secondary Nursery Area
SPR	Spawning Potential Ratio
SSB	Spawning Stock Biomass
SSNA	Special Secondary Nursery Area
TAC	Total Allowable Catch
TC	Technical Committee
TED	Turtle Excluder Device
TLA	Traffic Light Analysis
UNC-G	University of North Carolina - Greensboro
Z	total morality rate

EXECUTIVE SUMMARY

The North Carolina Wildlife Federation submitted a petition for rulemaking on Nov. 2, 2016 to the Chairman of the North Carolina Marine Fisheries Commission (MFC), pursuant to and in accordance with the North Carolina Administrative Procedure Act, G.S. 150B-20, and 15A NCAC 03P .0301. The Petitioner filed clerical edits to the Petition on Nov. 16 and filed a modification to the original Petition on Jan. 12, 2017. The Petitioned rules were granted in full for rulemaking by the MFC Feb. 16, 2017. Per G.S. 150B-21.4, before an agency publishes in the *North Carolina Register* the proposed text of a permanent rule change that would require the expenditure of state funds, it must submit a fiscal note on the proposed rule change. The Division concludes this document represents an objective fiscal analysis to inform the public to the greatest extent possible, recognizing uncertainties and unknowns in assessing the economic impact of the proposed rules, that meets the requirements of the North Carolina Administrative Procedure Act.

Both state and federal fishery management bodies develop and adopt fishery management plans (FMPs) to manage fish stocks in their jurisdiction. The FMP process is a comprehensive way to consider the cumulative effect of management of a significant species or fishery that is based on sound, reasonably available scientific, technical, economic, and other relevant information. The goal of these plans is to ensure long-term viability of these fisheries. The use of FMPs provides basic direction for managers, provides long-range certainty for the regulated fishing community, and builds accountability into the fisheries management system. In North Carolina, the contents of the plans are specified, advisory committees are required, and reviews by the hierarchy of government are mandated. These requirements are set forth in state statutes and begin with conducting stock assessments.

In its Petition, the North Carolina Wildlife Federation states concerns about bycatch of juvenile fish, including Atlantic Croaker, Spot, and Weakfish, in the shrimp trawl fishery in the estuarine and near shore waters of North Carolina under the MFC's jurisdiction (NCWF 2016a). In addition, the Petitioner states the "MFC's efforts to minimize bycatch of juvenile finfish have proven unsuccessful" and that the recently adopted 2015 North Carolina Shrimp Fishery Management Plan Amendment 1 fell short of necessary actions to protect habitat and reduce bycatch of juvenile finfish (NCWF 2016a). The Petitioner put forth seven rules aimed at habitat protection, reduction of bycatch, and limiting possession of Spot and Atlantic Croaker through minimum size limits to allow these species to mature and spawn at least once before recruiting to the fishery.

While trying to assess the impact of the Petitioned rules, which includes costs and benefits, numerous unknowns were discovered and there was a lack of data to quantify the impacts for some sections of the analysis. Without information to quantify all costs and benefits of the proposed rules, the total impact cannot be determined. Positive changes to habitat and water quality and reduced fishing mortality over time could result in stock improvements, holding all other factors equal and assuming high compliance, but the time it would take to have an effect is unmeasurable. How effective the proposed rules would be at improving stock abundance for species important to North Carolina and how a change in stock abundance would affect commercial and recreational fisheries is unknown because of the many unpredictable human and natural factors that affect fish stock abundance. Habitat quality and fish stock abundance is influenced by directed fishing, but is also influenced by factors that cannot be controlled through fishery management strategies, such as environmental fluctuations (e.g., pH, temperature, dissolved oxygen, storms), habitat loss due to land development, water quality, and natural morality rates specific to each species (see section 2). Furthermore, it is not possible to predict with confidence the behavioral responses of fishermen to the Petitioned rules. Due to the scope of the proposed rule changes and lack of sufficient market and business operation data, it is difficult to estimate the participants' net change in fishing effort, temporal and geographic shifts in fishing patterns, and changes in gear and targeted species that could affect fishing mortality and bycatch both positively and negatively. As a result, changes in stock abundance and habitat quality attributable to the proposed rules and associated economic impacts are difficult to predict and quantify.

A species' response to changes in directed fishing activity is not always predictable due to the many factors that affect stock status, and a regulatory intervention may not have the same effect across species. For example, in 1994, the MFC prohibited the use of flynets south of Cape Hatteras because large quantities of juvenile Weakfish were being caught as bycatch. This did not result in increased Weakfish abundance due to high levels of natural mortality for this species, which is ultimately out of a manager's control (see section 5.1.4.3). Even though overfishing is not occurring, this species is still in a depleted status despite years of management. Other species have responded positively to management measures that focus on reducing fishing mortality, including Atlantic Ocean Striped Bass (see section 5.1.4.1) and Summer Flounder (see section 5.1.4.2). There is uncertainty that Atlantic Croaker, Spot, and Weakfish would respond in a similar way under the proposed rules.

Estimating how fish stocks may respond in the future to different management strategies through stock assessment models (projections) is a common practice and is discussed in section 5 of this document. Projections program the varying magnitudes of changes in fishing or natural mortality being assessed directly into the model and do not reflect a response to a particular management action. It is important to note that the magnitude of the change in fishing and natural mortality attributable to the Petitioned rules is unknown, so it is not possible to model how these rules would change the stock status. There is no association between the Petitioned rules and the stock projections produced by Nesslage and Dumas (2017) described in section 5; the models represent various "what-if" scenarios to help answer questions such as, "If bycatch was reduced by a certain amount, how much would the fish stock change?" Although not reflective of the proposed rules, these stock projections can be used to understand the direction, timing, and relative magnitude of the effect of reducing fishing or natural mortality, as well as how much change would be needed to achieve a desired stock status. Projections were only available for two of the main species identified in the Petition as needing additional protection (i.e., Atlantic Croaker and Weakfish).

The economic impact of increased stock abundance due to improvements in the recreational fishing industry is discussed in section 6.4.1. If additional management successfully reduces both fishing and natural mortality rates, there is potential for an increase in economic benefits across the 30-year period that was examined by Nesslage and Dumas (2017). The economic analyses performed for Atlantic Croaker and Weakfish were based on the stock projections mentioned above, but used assumptions that may have inflated the impact; therefore, the actual increases to the economy from improved recreational fishing resulting from the Petitioned rules is unknown.

Studies are needed to determine the status of current habitats in the areas that are proposed to be new special secondary nursery areas (SSNAs) under the Petition to detect any improvements and if those improvements were the result of the proposed rules. Table 2.1 describes 2.8 million additional acres of coastal and joint fishing waters (including the ocean 0–3 miles) that are not already designated as nursery areas of any type but would become SSNAs under the Petitioned rules. This helps to demonstrate the magnitude of the affected area and thus, the subsequent regulations and enforcement. Documenting the current condition of the habitat in the areas affected by the proposed rules could take 18 years (see Appendix 4). Another unknown is any shift in effort that might impact areas currently less utilized. Without more information, it is difficult to determine the effect the Petitioned rules would have on the environment and to what extent.

The biggest cost from the Petitioned rules would be on the commercial fishing industry, specifically those participating in the shrimp trawl fishery. There are uncertainties in how the proposed rules would be implemented with regards to existing management actions, especially concerning closing days of the week (see section 6.1.1). The Petitioner commented that the days to be closed to satisfy the Petition would be picked by the Fisheries Director, but the Petitioner did not comment on how the current weekend closure fits into their proposed rules. The current weekend closure is for estuarine waters only and occurs from 9 p.m. Friday to 5 p.m. Sunday. State ocean waters are currently not restricted. To estimate potential losses to the commercial fishing industry from closing four days in estuarine waters and three days in the ocean, the landings by weekday were used, but these represent the day of landing or unloading at the seafood dealer, not the fishing day. Landings could not be evaluated by fishing day because the North Carolina Trip Ticket Program does not collect those data. In other words, multiday fishing trips (a common occurrence) confound the determination of when fishing actually occurred. Estimates presented below are based on the best available data and may not reflect the actual amounts that would result from the Petitioned rules. Based on date of landing, limiting trawling to three days in estuarine waters could have an annual impact of $2.4 million to $10.7 million in the shrimp fishery and an additional impact from $48,589 to $73,405 per year for non-shrimp species caught in shrimp trawls, depending on which four days are selected to be closed. Limiting trawling to four days in state ocean waters could have an annual impact from $1.0 million to $1.4 million in the shrimp fishery and an additional impact of $28,876 to $37,399 per year for non-shrimp species caught in shrimp trawls, depending on which three days are selected to be closed.

Other trawl gears used in the commercial fishing industry in estuarine and state ocean waters would also be impacted by the weekday closure restrictions proposed in the Petition as written (see section 6.2.1). In estuarine waters, fisheries that would be impacted include hard crab trawl, peeler crab trawl, skimmer trawl, and clam trawl (or clam kicking). Hard crab trawling would have an estimated impact of $458,897 to $885,837 per year. Peeler crab trawling would have an estimated impact of $923 to $1,597 per year. Skimmer trawl fisheries for non-shrimp species would have an estimated impact of $1,277 to $2,636 per year. Finally, clam trawling would have an estimated impact of $3,313 to $3,529 per year. Trawl fisheries in state ocean waters that would be impacted include flynets, with an estimated impact of $120,264 to $194,062 per year, and flounder trawls, with an estimated impact of $28,139 to $48,531 per year.

The proposed rules for nighttime trawling restrictions, opening the shrimp season based on shrimp count size, reducing headrope length, and limiting tow times would have impacts to both the shrimp trawl fishery and non-shrimp fisheries, but because of a variety of uncertainties surrounding implementation of these rules and a lack of data to evaluate the impacts for these specific management strategies, the total impact cannot be calculated or monetized (see sections 6.1.2–6.1.5).

Minimum size limits are proposed for Spot (8 inches) and Atlantic Croaker (10 inches), which currently do not have size limits. These minimum size limits would impact the commercial shrimp fishery (see section 6.1.6) and both directed commercial and recreational fisheries for Spot and Atlantic Croaker (see section 6.2.2).

Spot and Atlantic Croaker both have targeted commercial fisheries as well as landings that are attributed to bycatch from other gears, such as shrimp trawls. Based on an 8-inch minimum size limit for Spot, an estimated 99–100% of these fish would be discarded from a shrimp trawl trip. The value of Spot caught in estuarine waters as bycatch from shrimp trawls ranges from $734 to $14,276 per year (see section 6.1.6). The value of Spot caught in state ocean waters as bycatch from shrimp trawls ranges from $1,384 to $10,382 per year. The reductions to the directed Spot commercial fishery due to an 8-inch minimum size limit is estimated to be $135,767 per year (see section 6.2.2). Approximately 100% of Atlantic Croaker caught and previously sold in the shrimp trawl fishery would be discarded (not sold) based on a 10-inch minimum size limit. The value of Atlantic Croaker in estuarine waters caught as bycatch from the shrimp trawl fishery is estimated to be from $61 to $3,983 per year (see section 6.1.6). The value of Atlantic Croaker in state ocean waters caught as bycatch from the shrimp trawl fishery ranges from $19 to $1,780 per year. The reductions to the directed Atlantic Croaker commercial fishery due to a 10-inch minimum size limit is estimated to be $311,247 per year (see section 6.2.2).

Recreational harvest reductions are estimated to be from 34–67% for Spot and from 72–84% for Atlantic Croaker. A dollar value related to the impact of these reductions in the recreational fishery could not be calculated due to the lack of data on the non-market values of this fish to recreational fishermen. Due to the disproportionate sizes on average between males and females for both species, the proposed size limits would potentially shift harvest to primarily females, resulting in unknown consequences on the stocks.

Additional impacts on the commercial industry from the proposed rules include disproportionate impacts based on vessel size, changing operational expenses, potential changes in fishing behavior to conform with the Petitioned rules to recoup lost effort, displacement of existing effort into other areas or fisheries, and lastly, the potential for fishermen to exit commercial fishing completely. Due to the broad scope of the Petitioned rules, displacement of effort could cause harvest to potentially shift from the new SSNAs to current SSNAs, increased user conflicts, and increased fishing pressure on other species. Currently, defined SSNAs are less restrictive than the rules proposed for the newly defined SSNAs. More detail on the types of displacement anticipated are discussed in sections 4.1, 5.4, and 6.3.4. The amount of displacement cannot be estimated, so the net impact these rules would have on the habitats and fisheries in North Carolina cannot be determined.

The impact the Petitioned rules would have on consumers is also unknown, as well as their impact on local governments and communities (see sections 7 and 8). Many communities in eastern North Carolina are strongly rooted in commercial fishing and this way of life supports their local government. There is a substantial lack of data with regards to costs throughout the supply chain from the fisherman to the consumer, as well as a lack of data to estimate how many small communities rely on commercial fishing and to what extent. These data are necessary to estimate the total impact of the proposed rules.

It is unknown if additional enforcement officers would be needed due to the uncertainty around the behavioral choices of fishermen responding to the new rules. There is the potential for increased workload for North Carolina Division of Marine Fisheries (NCDMF) Marine Patrol to enforce the proposed rules that could be more than what current staff can do with all other job duties continuing, but to an unknown extent. There may be a significant change in the amount of time an officer spends patrolling closure days and times for the shrimp trawl fishery. Instead of patrolling for a lack of fishing during the single closure period currently in estuarine waters (Friday night to Sunday night), enforcement officers would have to patrol daily closure times in both estuarine and state ocean waters to ensure a lack of fishing activity during closures. Fishermen could potentially shift to other gears, shift to other fisheries, continue fishing regardless of changes in requirements and potential consequences of failing to comply with them, or exit fishing completely. Initially, as both officers and fishermen become accustomed to the requirements of the Petitioned rules, there would likely be a learning curve that would take more effort by all parties until there is familiarity with the new requirements. This learning curve would likely be more pronounced than for previous regulation changes due to the magnitude of the Petitioned rules. Due to this high variability, the number of potential new officers cannot be quantified.

Existing NCDMF Marine Patrol would have to balance any new responsibilities from the Petitioned rules with existing responsibilities. The opportunity costs presented quantify the value of the hours used by Marine Patrol to perform typical job duties that would now be needed to enforce the proposed rules. They do not represent new costs to NCDMF. The estimated total number of hours that would be spent by existing NCDMF Marine Patrol each year (12 months) to properly enforce the Petitioned rules could amount to approximately 52,000 hours, which equates to all 50 field officers each working 20 hours per week during each week of the year. This is based on additional time needed to check gear requirements and net sizes, proper licensure, size and creel limits, monitor tow time limits, closure lines, closure days, user conflicts, and the transit time to patrol a vast geographical area, especially in larger water bodies like Pamlico Sound. Additionally, it is important to understand the temporal nature of any patrol. For example, in the course of patrolling for fishing activities related to the Petitioned rules, if an officer encounters a fisherman harvesting shellfish in a polluted area, the officer would address the immediate violation and cease the former effort. This adds to the difficulty in quantifying the impacts to enforcement from the Petitioned rules. Additionally, when an officer encounters a potential violation (regardless of the type of offense), there is significant time spent to process it, displacing effort on additional patrols. Processing a violation can include identifying who is on board the vessel, plotting the location on a chart for court, escorting the vessel to the dock, offloading the catch, securing three bids to sell the catch to the highest bidder, and processing criminal charges brought against the captain and/or crew to include potential arrest. Based on the estimated total number of hours that would be spent by existing officers as a result of the Petitioned rules, at an average salary plus benefits of $32.26 per hour, the opportunity costs on NCDMF Marine Patrol could be as high as $1,677,520 per year. Diverting resources away from existing programs and activities to implement and enforce the proposed rules would be detrimental to the effectiveness of those programs and activities. The foregone societal benefits associated with the reallocation of resources is not addressed in this analysis.

Additional sampling in Pamlico Sound would be needed to determine the opening of the shrimp season based on shrimp count size (see section 9.2). It is unclear if sampling would need to occur in the bays of the sound, open waters of the sound, or both. At a minimum, new sampling costs could be as low as $4,359 or as high as $21,814 per year, including sampling costs and opportunity costs for existing staff.

Lastly, revenue from the sale of commercial licenses would be affected if the impacts to the commercial shrimp fishery are great enough that fishermen choose to exit commercial fishing completely (see section 9.4). Because the Petitioned rules reach a variety of fisheries in addition to shrimp, there is no way to estimate the potential decline in license revenue due to fewer commercial licenses being sold. A decline in recreational license sales due to the Petitioned rules is unlikely.

1 PROBLEM STATEMENT

Fisheries and aquaculture are essential to people around the world as a source of food, recreation, and trade, but also influence the livelihoods of millions. Stewardship of aquatic resources is needed to ensure these valuable resources are available in the future. Achieving and maintaining sustainable fisheries and aquaculture industries are a global concern and a coordinated effort is required (FAO 2018).

"Sustainable fisheries management is an adaptive process that relies on sound science, innovative management approaches, effective enforcement, meaningful partnerships, and robust public participation. Sustainable fisheries play an important role in the nation's economy by providing opportunities for commercial, recreational, and subsistence fishing, marine aquaculture, and sustainable seafood for the nation. Combined, U.S. commercial and recreational saltwater fishing generated more than $208 billion in sales and supported 1.6 million jobs in 2015. By ending overfishing and rebuilding stocks, the value of U.S. fisheries to the economy, our communities, and marine ecosystems is strengthened" (NOAA 2017a).

Fishery managers have a range of goals. They strive to maintain healthy fish populations and a healthy fishing industry, both recreational and commercial, by preventing fish stocks from becoming overfished and to ensure overfishing is not occurring. Overfished is defined as "a stock exploited to a level of abundance considered too low to ensure safe reproduction" and overfishing is defined as "harvesting from a stock at a rate greater than the stock's reproductive capacity to replace fish removed through harvest" (ASMFC 2009a). Managers rely on a variety of tools to achieve their goals, including quotas, size limits, gear restrictions, fishing seasons, and area closures. Additionally, managers provide outreach about their activities so those in the fishing industries and the general public can better understand what goes into management decisions. For North Carolina's managers to determine which combinations of tools will best accomplish their goals and to choose the best approach to managing a fish stock, managers must equip themselves with as much information as possible. The collection and analysis of such data is a large part of the day-to-day operations of the North Carolina Division of Marine Fisheries (NCDMF).

A study of North Carolina's entire coastal fisheries management process was conducted from 1994–1996 due to a wide range of concerns expressed by the commercial and recreational fishing communities. The central concept in the proposed new coastal fisheries management system designed to resolve the concerns was the development of fishery management plans (FMPs) by the NCDMF. The use of FMPs was intended to re-orient North Carolina's coastal fisheries management efforts by: (1) providing basic direction for the NCDMF and the North Carolina Marine Fisheries Commission (MFC), (2) providing long-range certainty for the regulated fishing community, and (3) building accountability into North Carolina's coastal fisheries management system. The Moratorium Steering Committee that conducted the study recommended the MFC implement FMPs through rulemaking changes.

The North Carolina Fisheries Reform Act of 1997 (FRA) and its subsequent amendments requires the NCDMF to prepare FMPs for adoption by the MFC for all North Carolina's commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources (G.S. 113-182.1). The goal of these plans is to ensure long-term viability of these fisheries. The contents of the plans are specified, advisory committees (ACs) are required, and reviews by the North Carolina Department of Environmental Quality (NCDEQ) secretary and the Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources are mandated. The original 1997 legislation mandated the Blue Crab FMP be completed first and the MFC used the NCDMF annual stock status review to prioritize the order of species that would be addressed in subsequent plans. All initial FMPs identified on the priority list have been developed. FMPs normally take about two years to complete and are required to be reviewed at least once every five years. Upon review, amendment of a plan is required when changes to management strategies are necessary. North Carolina has 13 state FMPs.

The FMP process is a comprehensive way to consider the cumulative effect of management of a significant species or fishery that is based on sound, reasonably available scientific, technical, economic, and other relevant information. It is a sequential, deliberative process where each issue is thoroughly examined and all options for addressing the issue are carefully examined. An FMP is the product that ultimately brings all the information and management considerations into one document and is intended to provide long-range certainty for the regulated fishing community and get away from “hot topic” management. Management measures are designed to be in place for several years, which helps assess if they had the desired effect or if something else was in play.

The NCDMF and MFC are the only authorities in North Carolina coastal fishing waters that can implement plans and regulations to manage North Carolina marine and estuarine fisheries. The MFC adopted the North Carolina Fishery Management Plan for Interjurisdictional Fisheries, which selectively adopts management measures contained in approved federal council or Atlantic States Marine Fisheries Commission (ASMFC) FMPs by reference as minimum standards. The goal of the state interjurisdictional FMP is to adopt these other plans, consistent with state law, approved by the federal Councils or the ASMFC by reference, and implement corresponding fishery regulations in North Carolina to comply with or complement them.

North Carolina is an active, voting member on the ASMFC, the Mid-Atlantic Fishery Management Council (MAFMC), and the South Atlantic Fishery Management Council (SAFMC). North Carolina’s participation in these organizations is critical to ensure that North Carolina’s fishermen and fisheries resources are considered and adequately protected. To that end, North Carolina, through its Division staff, ASMFC, or federal council members, and citizen advisors, participates fully in the development of these federal and regional FMPs that have an impact on commercial and recreational fisheries in North Carolina.

In a perfect world, all measures needed to conserve the marine and estuarine resources of North Carolina would be developed and implemented solely under the FMP adoption and amendment process. In the real world, there are numerous initiatives ongoing at the same time. The Coastal Habitat Protection Plan (CHPP) is a parallel initiative under the FRA and the FMP sections addressing habitat and water quality recognize the CHPP as the lead. This type of overlap with the Federal Council and ASMFC FMPs was recognized with the creation of the North Carolina FMP for Interjurisdictional Fisheries, described above, that established which process took precedence and under what circumstances those priorities could be changed. Actions concerning compliance with the Endangered Species Act of 1973 (ESA) demonstrates there are other over-riding situations that cause the NCDMF to use different mechanisms to institute management measures. Not all management issues are revealed during development of each plan or amendment; it can be understood that other factors can come to light that appear valid to consider via adaptive management measures built into an FMP. In doing so, it must be determined and clearly stated in each FMP the amount of flexibility allowed for each management strategy. The ASMFC has addressed this same issue by providing for adaptive management in a number of its FMPs. Also, several North Carolina FMPs set the stage and bounds for subsequent action after the FMP has been approved, conditioned on new data or legislative action, or other limitations existing at the time the FMP is adopted. Examples of this include management triggers for the Kingfishes and Striped Mullet FMPs, as well as the Traffic Light assessment in the Blue Crab FMP. Each of the aforementioned items speaks to the complexity of fisheries management as a whole.

The North Carolina Wildlife Federation (NCWF) submitted a petition for rulemaking on Nov. 2, 2016 to the Chairman of the MFC, pursuant to and in accordance with the North Carolina Administrative Procedure Act, G.S. 150B-20, and 15A NCAC 03P .0301. The Petitioner filed clerical edits to the Petition on Nov. 16 and filed a modification to the original Petition on Jan. 12, 2017. This Petition and modifications seek amendments to the following sections of Title 15A of the North Carolina Administrative Code: 03I .0101 (definitions), 03L .0101 and .0103 (shrimp), 03N .0105 (fish habitat areas), and 03R .0105 (descriptive boundaries). In addition, the Petitioner urges the adoption of two new rules: 03M .0522 and 03M .0523 (finfish). It should be noted that at the time the Petition was submitted, rulemaking not related to the Petition was already underway proposing adoption of 03M .0522 Spotted Seatrout. Consequently, the adoption of the Petitioned rules would be adjusted to result in new rules 03M .0523 and 03M .0524. The Petitioned rules were granted in full for rulemaking by the MFC Feb. 16, 2017.

A review of the Petition by the NCDEQ Office of General Counsel is needed to evaluate the MFC's authority to implement rules independent of the adopted management strategies in the 2015 Shrimp FMP Amendment 1 and the North Carolina FMP for Interjurisdictional Fisheries, which includes Spot, Atlantic Croaker, Weakfish, Summer Flounder, and Atlantic Ocean Striped Bass. The Petition may also interact with other FMPs, such as those for blue crabs and hard clams.

Reasons provided by the Petitioner for the proposed rule amendments include concerns about "adequate habitat protections and declining and depleted status of many of our coastal fish stocks" (NCWF 2016a, p. 5). The Petitioner is concerned about bycatch of juvenile fish, including Atlantic Croaker, Spot, and Weakfish, in the shrimp trawl fishery in the estuarine and near shore waters of North Carolina under the MFC's jurisdiction. In addition, the Petitioner states the MFC's effort to minimize bycatch of juvenile finfish has been unsuccessful and that the recently adopted 2015 North Carolina Shrimp FMP fell short of necessary actions to protect habitat and reduce bycatch of juvenile finfish (NCWF 2016a, p. 7). The intent of the proposed new rules for possession of Spot and Atlantic Croaker is to allow these species to mature and spawn at least once (NCWF 2016a, p. 6).

The Petitioner supports these reasons as follows:
"It is estimated that for every pound of shrimp harvested in North Carolina waters, over four pounds of non-target catch, including juvenile finfish, are discarded. These juvenile finfish and other organisms constitute, bycatch, which is defined as "the portion of a catch taken incidentally to the target catch because of non-selectivity of the fishing gear to either species or size differences." In 2014, an estimated 15 million pounds of juvenile Atlantic Croaker, Spot, and Weakfish were caught by trawl nets and thrown overboard. Nearly all of the fish caught in trawl nets die in the net or shortly after culling on board" (NCWF 2016a, p. 2).

The Petitioner further supports these reasons as follows:
"Despite efforts to reduce the documented bycatch that occurs in this fishery through the use of bycatch reduction devices (BRDs), closed seasons, and restricted areas, hundreds of millions of juvenile fish continue to die each year from shrimp trawls, which contributes to declining stocks. The critical importance of all these species to the recreational and commercial fisheries of North Carolina, as well as their ecosystem function as forage and energy transfer, cannot be overstated" (NCWF 2016a, p. 34).

1.1 Summary of Proposed Rules

The following rules were identified in the Petition. A summary of each proposed rule change is provided below. More detailed information on the estimated impact of these rules is provided in sections 4–9. Actual rule text changes are provided in Appendix 1.

15A NCAC 03I .0101 Definitions

The effect of proposed changes would be to change the definition of secondary nursery areas (SNA) to include the Atlantic Ocean from 0 to 3 miles offshore.

15A NCAC 03L .0101 Shrimp Harvest Restrictions

The effect of proposed changes would be to limit the use of the Fisheries Director's proclamation authority in opening the shrimping season until the shrimp count size reaches 60 shrimp per pound, heads-on, in the Pamlico Sound.

15A NCAC 03L .0103 Prohibited Nets, Mesh Lengths and Areas

The effect of proposed changes from the original Nov. 2 Petition would be to restrict the maximum headrope length to 90 feet in the Atlantic Ocean (from 0 to 3 miles) and in estuarine waters under the MFC's jurisdiction, to become effective Jan. 1, 2018. This change includes areas where existing maximum headrope length is 220 feet. The Jan. 12, 2017 modification to the Petition would change the maximum headrope length in the Atlantic Ocean (from 0 to 3 miles) to 110 feet.

Other proposed changes would be to create a rule requiring the use of two BRDs in shrimp trawls correctly installed and operational. Two BRDs in shrimp trawls are already required in North Carolina by proclamation authority (SH-2-2015).

15A NCAC 03M .0523: Spot (new rule)
15A NCAC 03M .0524: Atlantic Croaker (new rule)

The Petitioner proposed the adoption of two new rules: 03M .0522 and 03M .0523 (finfish). It should be noted that at the time the Petition was submitted, rulemaking not related to the Petition was already underway proposing adoption of 03M .0522 Spotted Seatrout. Consequently, the adoption of the Petitioned rules would be adjusted to result in new rules 03M .0523 Spot and 03M .0524 Atlantic Croaker.

The effect of the proposed changes would be to implement a minimum size limit of 8-inches for Spot and 10-inches for Atlantic Croaker. There is currently no size limit on either species.

15A NCAC 03N .0105 Prohibited Gear, Secondary Nursery Areas

The effect of proposed changes would be to allow the Fisheries Director to open all or part of the Atlantic Ocean (0 to 3 miles) and estuarine waters under the jurisdiction of the MFC, excluding waters already designated as primary, secondary and all other special secondary nursery areas (SSNAs), with the following restrictions: Only shrimp and crab trawling may occur during the open shrimp season and are restricted to a total of three days a week. No shrimp or crab trawling may occur at night and tow times are restricted to a maximum of 45 minutes. The Jan. 12 modification to the Petition would change the number of days allowed to fish in the Atlantic Ocean (0 to 3 miles) to a total of four days a week.

15A NCAC 03R .0105 Special Secondary Nursery Areas

The MFC has jurisdiction in waters out to three miles offshore in the Atlantic Ocean under G.S. 113-134.1 and 146-64. The effect of proposed changes would be to designate all undesignated areas in all coastal fishing waters under the MFC's jurisdiction (i.e., estuarine and ocean out to 3 miles offshore) as a SSNA. This does not include waters under the jurisdiction of the North Carolina Wildlife Resources Commission (NCWRC; i.e., inland fishing waters).

2 DEMONSTRATE PROBLEM

The lack of adequate habitat protection as well as the declining and depleted status of many coastal fish stocks in North Carolina is cited in the Petition as the main reasons for the need to change existing rules put into place by the MFC (NCWF 2016a). The Petitioner provides two technical reviews to demonstrate the problem with current habitat protections and depleted coastal fish stocks (Exhibits B and E; NCWF 2016a). These reviews discuss the need for a rigorous and scientifically-informed process for habitat protection for fish in early life stages, as well as for juvenile, sub-adult, and first time spawning fish. They conclude that N.C. nursery area definitions do not include habitats that protect sub-adults or young adult fish that may have only spawned once and not met their reproductive potential. The bycatch and discard mortality of juvenile marine and estuarine fish from the shrimp trawl fishery is also discussed in these reviews, which state that the shrimp trawl fishery is the largest source of bycatch mortality and proper management of this fishery would have a measurable impact for restoring these stocks.

Overfishing and declining fish stocks are not unique to North Carolina. An analysis by Britten et al. (2016) concluded that the ability of fish stocks to reproduce and replenish themselves is declining throughout the world due to both environmental changes and biological changes brought about by overfishing. The authors do note that the trends they found represent broad-scale patterns and more in-depth analysis of factors related to habitat quantity and quality is needed to understand changes in productivity of individual stocks. In contrast, Dr. Ray Hilborn recently testified to the U.S. Congress that fish stocks are increasing in abundance throughout the U.S. and the proportion of stocks at low abundance is consistently decreasing (Hilborn 2017). He stated that ocean acidification, warming temperatures, degraded coastal habitats, exotic species, land-based run off, and pollution are the current major threats to U.S. fish stocks and marine ecosystem biodiversity. He does note that overfishing is a concern for some stocks in the U.S.

North Carolina is not alone in facing challenges to address adequate habitat protection, declining fish stocks, and bycatch issues that are the focus of the Petition. The variation in success and approaches embraced across various management bodies is related to several factors. Agencies have differing jurisdictional abilities to address environmental conditions and habitats. The degree to which anthropomorphic habitat changes impact the stock is more likely in nearshore and estuarine systems that abut concentrated human populations and their land-based activities. Warming water temperatures, associated with climate change, play a significant role in the productivity, distribution, and management of many managed species. Conversely, accounting for cold stun kill events, as was done in the management of Spotted Seatrout, may help mitigate impacts to the remaining spawning stock. The amount of funding and resources available to provide the necessary science is an ongoing and expanding need. For data-poor stocks, fisheries managers struggle to accurately account for catch and determine effective mechanisms to address overfishing. There have been notable success stories for species such as Atlantic Ocean Striped Bass and Summer Flounder (see section 5.1.4), at both the state and federal level, when the paramount cause(s) of a decline has been identified and successfully addressed. As discussed in section 5, stock assessment models may assist in evaluating the relative impact of potential causative mortality factors.

Regardless of their differing jurisdictional boundaries, state and federal fishery management bodies approach their mission in a very similar manner through the development and adoption of FMPs. The goal of these plans, established under the Magnuson-Stevens Fishery Conservation and Management Act or the Atlantic Coastal Fisheries Cooperative Management Act, are similar to the goals of the North Carolina FRA of 1997 to “ensure long-term viability” of their jurisdictional species or fisheries (S.L. 1997-400; G.S. 113-182.1). Each starts with a science based framework of the best available data and assessment techniques to inform the management and conservation decisions by a policy body (i.e., federal council, ASMFC board, MFC). The process requires assessing the recent status of the fish stock, extensive public participation, along with the review, adoption, implementation, and enforcement of chosen management measures.

The status of progress on each plan is made available in annual stock reports found on the respective agency's website. Each exhibits varying degrees of success as shown in their criteria for evaluation (generally overfished and overfishing reference points). Grouping the 2016 evaluations into three broad categories of "unknown", "met" reference point, and "did not meet" reference points for comparative purposes by percent of each category, North Carolina, with 14 stocks has 14% unknown, 29% met, and 57% did not meet (http://portal.ncdenr.org/web/mf/stock-overview). The ASMFC report covers 26 stocks, with 4% unknown, 36% met, and 45% did not meet (http://www.asmfc.org/files/pub/ASMFC_StockStatus_March2017.pdf). Of note, both Spot and Atlantic Croaker are in the ASMFC unknown category and Weakfish is listed as depleted due to causes other than overfishing. Landing trends for these species in other states with major landings mirror those seen in North Carolina and those states do not have the large inshore shrimp trawl fishery that occurs in North Carolina. The federal councils report only on stocks with a known status, and from those stocks, 84–91% have met their reference point targets (https://www.fisheries.noaa.gov/national/2017-report-congress-status-us-fisheries ; NOAA 2017a).

2.1 Identify Causes of Problems

The condition of fish stocks is the result of a combination of factors, including fishing mortality, natural mortality of larval, juvenile, and adult life stages, environmental conditions, and habitat conditions. An upset in the balance of any of these factors could lead to stock decline.

Fishing pressure on any recreationally and commercially important fish species can lead to potential declines in fish stocks. Overfishing a stock occurs when the rate of fishing mortality (harvesting from a stock) exceeds the natural rate of replacement (stock's reproductive capacity; ASMFC 2009a). The size of a fish population is determined primarily by the positive effects of growth and recruitment, and the negative effect of mortality, both natural and due to fishing. Highly efficient technology can increase the ability for fishermen (recreational or commercial) to catch more fish using less effort. Improvements in sonar and navigation technology has greatly increased the capacity to fish. Vessel size and horsepower has also increased along with new, bigger, and better fishing gears, further increasing the efficiency of fish harvest (Cudmore 2009).

Fishing mortality can also occur in the form of bycatch. Bycatch is defined by the ASMFC as "the portion of catch taken in addition to the catch of targeted species because of non-selectivity of gear to either species or size differences" (ASMFC 2009a). Bycatch can be divided into two components: incidental catch and discarded catch. Incidental catch refers to retained catch of non-targeted species. Discarded catch is the portion of catch returned to the sea because of economic, legal, or personal considerations (NCDMF 2015a).

Loss of habitat and water quality can significantly affect the health of fish stocks by introducing mortality not related to fishing. Rapidly increasing human populations, especially along the coast of North Carolina has resulted in habitat loss and degradation, along with water quality degradation. Changes in land-use patterns have increased pollutants and added stressors to the habitat from a diversity of sources and remains a threat to fish habitats; and therefore, impact fish (NCDEQ 2016). Climate change can impact temperatures, salinity, pH, as well as circulation patterns and sea-level rise. These changes can influence abundances and distributions of recreationally and commercially important fish species.

Certain types of bottom disturbing activities (e.g., channel maintenance) and fishing gear (e.g., trawls, dredges) may impact habitats of recreationally and commercially important fish species, as well as alter community composition by disturbing benthic sediments, and crush or bury benthic organisms. Food source trophic level cascades may occur when changes in the biomass of one trophic level results in a series of changes in other trophic levels, resulting in a breakdown of food web interconnections (Myers et. al 2007; Cudmore 2009). Disease, and proliferation of less abundant species, can also impact entire ecosystems.

2.1.1 <u>Natural Mortality</u>

Natural mortality (*M*) is the rate at which an organism dies of natural causes. In fisheries, natural mortality can be defined as the removal of fishes from the stock due to causes other than fishing. Those causes can include predation, disease, competition, cannibalism, senescence, parasitism, starvation, and any other natural causes. The rate of natural mortality is strongly related to the life span of the fish, tending to decrease with increasing age, body mass, and length. Natural mortality rates vary among species, and within species these rates vary by sex, density, food availability, time, space, and other factors. Natural mortality occurs regardless of whether fishing is or is not also occurring.

Natural mortality rates are crucial in describing and understanding population dynamics and is one of the most important parameters in fisheries stock assessment models. It accounts for the “removal” of fish from a stock from one time step to the next in subsequent age classes due to causes not related to fishing. Estimates of stock size are often sensitive to the assumed value for natural mortality. Natural mortality affects the numbers of fish that survive to the size/age that is vulnerable to the fisheries and relates directly to stock productivity, attainable yield, and optimal harvest rates. Without an estimate of natural mortality, fishing mortality cannot be estimated from the size or age composition of fisheries-independent surveys or fisheries catches, and so the expected yield under different management scenarios cannot be predicted.

Despite the importance of knowing the natural mortality rate, its value is often poorly estimated or unknown. This can have considerable implications for management, as the results of stock assessment models serve as the basis for management decisions. That is why it is necessary to propagate the uncertainty associated with the natural mortality rate into assessment results, so as not to underestimate the uncertainty of those results. This is often accomplished through a series of sensitivity analyses, which make different assumptions about the rate of natural mortality and examine the impact on assessment results. It is essential for managers to take this uncertainty into account to make effective management decisions.

Information on the natural mortality of the major species affected by the Petitioned rules (i.e., shrimp, Spot, Atlantic Croaker, and Weakfish) are discussed in sections 2.1.1.1–2.1.1.4 to show the variety of factors that cause mortality to each species that are not related to directed fishing or bycatch.

2.1.1.1 Shrimp

The life span of shrimp varies by species and can range from 16 to 24 months (NCDMF 2015a). Shrimp are preyed upon by numerous finfish, invertebrates, and a wide variety of coastal and wading birds (NCDMF 2015a). Predation is cited as a major source of natural mortality for juvenile penaeid shrimp and decreases as shrimp grow (Zimmerman et al. 2000; Ramirez-Rodriguez and Sanchez 2003; Baker and Minello 2010; Leo et al. 2016). Trends in natural mortality are thought to be the result of age specific predation rates and physiological requirements, as well as the result of the physical environment acting on the different life history stages of penaeid shrimp (Ramirez-Rodriguez and Sanchez 2003).

Shrimp can tolerate a wide range of salinity and temperature gradients, as well as avoid extremes in temperature by moving to deeper water or by burrowing in substrate (NCDMF 2015a; Leo et al. 2016; Minello 2017). However, adverse environmental conditions can limit recruitment and negatively impact adult abundance. Hurricanes and large frontal systems can disrupt the transport of eggs and larvae into the estuary, as well as destroy habitat and food supplies. Excessive rain from these systems can also lead to premature flushing of vegetated marsh habitats, forcing shrimp to move into more open waters, making them more susceptible to predation (Baker and Minello 2010; Mace and Rozas 2017).

Diseases and parasites can also play a significant role in reducing shrimp in natural populations and come in the form of viruses, bacteria, fungi, protozoa, flatworms, and nematodes. Johnson (1978) noted that penaeid shrimp are more vulnerable to disease and parasites when stressed by other physical and chemical factors such as low dissolved oxygen (hypoxia), poisons (pollutants), low temperatures, and salinity extremes. Disease and parasites can inhibit respiration, slow growth, and damage tissue; thus, making shrimp more prone to predation.

2.1.1.2 Spot

Juvenile Spot have higher survival rates in waters with salinities less than 19 parts per thousand, potentially due to lower physiological stress (Ross 2003). While there has been very little research, predation, density dependence, and competition are not thought to be very important, but could play a role in juvenile survival. The predation on Spot occurs at every life stage (Odell et al. 2017).

The impacts of climate change and water quality (e.g., salinity, pH, dissolved oxygen) on Spot are not fully understood; however, hypoxia has been thought to be one of the greatest threats to juvenile Spot. Spot seem to adjust well to warm waters, making increased temperatures due to climate change of less concern (Odell et al. 2017).

The causes of natural mortality in Spot are not well understood, but most of the environmental impacts for Atlantic Croaker are likely to impact Spot as well, as they have similar life history characteristics.

2.1.1.3 Atlantic Croaker

Atlantic Croaker can tolerate a diversity of habitat types encompassing a wide range of salinity, water temperature, dissolved oxygen, and water depth. However, changes to habitat may lead to direct mortality, or hinder the ability of Atlantic Croaker to find prey, avoid predation, or reproduce. Juvenile Atlantic Croaker have higher survival in oligohaline (very low salinity) and mesohaline (moderately salty) waters, potentially due to lower physiological stress (Ross 2003). Hypoxia events can cause habitat shifts (Craig and Crowder 2005; Eby et al. 2005; Tuckey and Fabrizio 2016; Odell et al. 2017) and long-term exposure to hypoxic conditions can affect reproduction, gonadal growth, gametogenesis, endocrine function, hatching success, and larval survival (Odell et al. 2017). Atlantic Croaker can tolerate a wide range of temperatures, but are vulnerable to mortality when exposed to prolonged periods of low temperature, particularly as juveniles (Odell et al. 2017). Higher winter temperatures in estuarine nursery areas has been linked to increased juvenile survival and subsequent increased adult Atlantic Croaker abundance (Hare and Able 2007; Hare et al. 2010).

Due to size and general abundance, Atlantic Croaker are preyed upon at every life stage. Larval Atlantic Croaker and Atlantic Croaker eggs are preyed upon by gelatinous zooplankton and larvae may become infected with ectoparasites (Odell et al. 2017). In addition, at nearly every life stage Atlantic Croaker are in competition with other fish species for food and habitat, though the effects of competition are poorly understood.

Anthropogenic shoreline and habitat alterations, and pollution have negative impacts on juvenile Atlantic Croaker, including reduced abundance in nursery areas with man-made drainage or altered shorelines (bulkhead or rubble) and reduced growth and physical condition of juvenile Atlantic Croaker in areas with high pollution (Odell et al. 2017). The magnitude of the impacts of climate change on Atlantic Croaker are not fully understood, though climate change is associated with changes in water temperature, dissolved oxygen, pH, salinity, and turbidity (Odell et al. 2017). Changes in habitat parameters may lead to direct mortality of Atlantic Croaker or may impact growth, reproduction, and the ability of Atlantic Croaker to locate prey. In addition, warmer winter temperatures in estuaries have been linked with a northward shift of Atlantic Croaker (Hare and Able 2007; Hare et al. 2010).

2.1.1.4 Weakfish

Like many sciaenids, Weakfish can tolerate a wide range of habitat and environmental conditions common to North Carolina's estuarine waters. Juveniles of the species often inhabit deeper waters of the lower estuary, sounds, and nearshore areas, so lethal and sub-lethal effects of low dissolved oxygen (hypoxia), temperature, and salinity are probably minimal (Odell et al. 2017). Mortality of juvenile Weakfish has been correlated with rapid changes in water temperature usually associated with cooler spring time weather patterns (Paperno et al. 2000), but is not observed any other time of the year. Predation of juvenile and adult Weakfish is often cited as a major contributing factor to the observed high natural mortality in recent years (NEFSC 2009; ASMFC 2016a). Gannon and Waples (2004) observed that Weakfish was the most abundant prey item recovered from the stomachs of bottlenose dolphin that had stranded on coastal beaches.

Sources of adult natural mortality were investigated during the 2016 stock assessment by ASMFC and incorporated into the final assessment model (ASMFC 2016a). The assessment committee estimated natural mortality from several sources including food habit data from trawl surveys and climatic patterns. Results from the food habit analysis indicated that the percentage of empty stomachs observed from trawl-collected specimens positively correlate with observed increases in natural mortality in the 1990s. This suggests that competition for food resources may affect survival of Weakfish. Patterns in sea surface temperatures produced by the Atlantic Multidecadal Oscillation appeared to be negatively correlated with commercial and, to a lesser extent, recreational Weakfish harvest dating back to 1929. This suggests that there is a strong link between environmental variability and Weakfish abundance at a coastwide level.

2.1.2 Fishing Mortality

Fishing mortality (*F*) is a term used in fisheries population dynamics defined as the removal of fishes from the stock due to fishing activities. Fishing mortality is strongly related to fishing gear and varies by sex, age, time, space, and other factors. Different gears are designed to optimize harvest efficiency for different species and for a particularly desirable sex or age within the same species, and thus, can cause different fishing mortality rates. Fishing mortality tends to be high in the peak harvest season and on popular fishing hotspots.

Fishing mortality is crucial in describing and understanding the population dynamics of species subject to harvest. Together with natural mortality (the loss of fishes due to natural causes not associated with fishing), fishing mortality determines population trajectory through time. It is one of the most important parameters in fisheries stock assessment models and in fisheries management, as well as one of the parameters in which stakeholders are most interested. In fisheries management, determination of stock status and development of harvest regulations rely on the understanding and estimation of fishing mortality. Biological reference points that determine whether overfishing is occurring are developed using fishing mortality. Closed fishing seasons/areas and size/bag limits could be enacted when fishing mortality goes higher than a pre-specified threshold. Spawning stock biomass (SSB) that one cohort can produce decreases as fishing mortality increases. Yield that one cohort can produce maximizes at a reasonable fishing mortality rate. Estimation of fishing mortality relies heavily on the quality and quantity of catch data, and is influenced by the estimation of natural mortality. Given natural mortality is often poorly estimated or unknown, estimation of fishing mortality is associated with great uncertainties and these uncertainties need to be considered in making management decisions.

Fishing mortality of both directed and indirect fishing should be considered to estimate the total fish being removed from the population. Species experiencing indirect fishing mortality are considered bycatch, as they were caught while targeting a different species. Bycatch in shrimp trawls is a known issue; therefore, one of the management strategies selected by the MFC in its final approval of the 2015 Shrimp FMP Amendment 1 was to convene an industry workgroup to test different gear configurations (e.g., BRDs, turtle excluder devices [TEDs], tailbag mesh sizes, composite/square panels, fisheyes) to reduce bycatch to the extent practicable with a target of a 40% reduction in bycatch (NCDMF 2015a). The Shrimp Bycatch Reduction Industry Workgroup was formed and convened in 2015 and consisted of fishermen, net manufacturers, gear specialists, and scientists from NCDMF, NOAA Fisheries, and N.C. Sea Grant. A series of workshops was held to develop and test different gear configurations in internal waters, ocean waters, and on large and small vessels over a three-year period.

The NCDMF has worked with the commercial fishing industry to reduce the amount of shrimp trawl bycatch. In 2015, five experimental gear combinations were tested during the summer on large vessels in the Pamlico Sound. After reviewing the results of the first year of testing, the work group recommended that new BRD/gear combinations should have an acceptable shrimp loss between 3% to 5%, depending on the reduction in finfish bycatch achieved (Brown 2015). During the summer and fall of 2016, four additional gear combinations were tested on large vessels in the Pamlico Sound (Brown 2017; Brown et al. 2017). In the final year of the study, 2017, three gear combinations were tested on both small and large vessels in the Atlantic Ocean and the Pamlico Sound (Brown et al. 2018). Gear combinations with larger tailbag mesh sizes (>1 ½-inches), reduced TED grid size (3-inch), and larger fisheyes were found to significantly reduce finfish bycatch. Four of the 12 gear combinations tested met or exceeded the 40% target reduction in finfish bycatch, while also minimizing shrimp loss. Overall, finfish bycatch reductions ranged from 4.5% to 57.2%. Differences in shrimp catch between the control and experimental nets ranged from a 16.2% loss to a 9.9% gain.

At its May 2018 business meeting, the MFC voted to require fishermen to use one of four gear combinations tested by the workgroup that achieved at least 40% finfish bycatch. The use of the selected gear configurations tested by the industry work group should help further reduce finfish bycatch in the shrimp trawl fishery and its associated fishing mortality (see section 3.5). For a detailed description of the sampling methodology, gear parameters, and full data analysis, see Brown et al. (2017, 2018).

2.1.2.1 Bycatch

Prior to the ASMFC's 2017 stock assessments for Spot and Atlantic Croaker, there were no estimates of the magnitude of shrimp trawl bycatch occurring in North Carolina for these species in the peer-reviewed literature. The estimates of shrimp trawl bycatch presented by the Petitioner in Exhibit B have not been validated by the NCDMF and are based on ratio extrapolation that was found to be inaccurate in the peer-reviewed literature (Diamond 2003; see also NCDMF 2015a which provides a full literature review on quantifying bycatch). Ratios have been shown to overestimate bycatch by as much as two to seven times higher than those based on catch-per-unit-effort (CPUE) mean per unit estimates (Diamond 2003). The use of a ratio defined as the finfish catch divided by the shrimp catch to estimate bycatch implies the quantities are correlated, which is typically not the case (Nance 1998). Ratios to estimate bycatch also cannot be applied statewide because they are spatially and temporally variable. It is also not reasonable to assume that bycatch rates in neighboring areas can give an accurate approximation of an un-sampled area (Alverson et al. 1994; Alverson and Hughes 1996; Diamond-Tissue 1999; Diamond 2003).

While the ASMFC's 2017 stock assessments were ultimately not endorsed for management, the peer review panel supported the estimates of bycatch of Spot and Atlantic Croaker in the Southern shrimp trawl fishery (ASMFC 2017a, 2017d). See Figures 3.12 and 3.13 for estimates of bycatch in the Southern shrimp trawl fishery by state.

Conducting sensitivity analyses is a routine part of performing fisheries stock assessments to facilitate the understanding of the various aspects of uncertainty associated with natural variability, the data, and the model. The ASMFC's 2017 coastwide stock assessments for Spot and Atlantic Croaker examined the sensitivity of model results to the magnitude of bycatch occurring in the Southern shrimp trawl fishery (J. Kipp, ASMFC, personal communication; L. Lee, NCDMF, personal communication). The magnitude of the shrimp trawl bycatch in the base run was reduced by 10% to 50%. The results for both Spot and Atlantic Croaker suggest that assuming a smaller magnitude of shrimp trawl bycatch relative to the base run would lead to smaller estimates of recruitment and SSB, as the model assumes that less bycatch equates to less fish in the population (J. Kipp, ASMFC, personal communication; L. Lee, NCDMF, personal communication). If the Petitioned rules were implemented, the effect of reduced trawling on stock abundance would not be immediately evident in future stock assessments due to the standard model assumptions about the lower estimates of shrimp trawl bycatch. With regards to fishing mortality, the smaller assumed values of shrimp trawl bycatch evaluated in the sensitivity analyses had minimal impact on the estimated values of fishing mortality for Spot; however, estimated fishing mortality for Atlantic Croaker was lower when the assumed values of shrimp trawl bycatch were reduced.

See sections 3.2, 3.3, and 3.5 for more information on the 2017 stock assessments and bycatch estimates mentioned above. See section 3.5.1 for more information on studies conducted by NCDMF to reduce bycatch in the shrimp trawl fishery.

2.1.3 Insufficient Habitat Protection

The Petitioner put forth several management recommendations. One of these is to designate all inshore and ocean (0–3 miles) waters as nursery habitat. The Petitioner states the "preponderance of data regarding juvenile life stages of fishes in these programs illustrate that all inside waters serve as important locations where juvenile fishes feed and grow to maturity. Juvenile fish are defined here as fishes that have yet to spawn at least once. While some fishes may be harvested, and possess mature gonads, if they are harvested prior to spawning, their contribution to the population is zero, threatening population stability and population growth. In fact, there is no evidence that any areas within the estuarine system of North Carolina do not function as a nursery area. These data, along with the Pamlico Sound survey and the decline of Atlantic Croaker and Spot in the South Atlantic, provide unequivocal support to the argument that the area functions as critical nursery habitat (NCWF 2016a, Exhibit B, p. 17)."

There is numerous scientific literature regarding methodology to identify nursery habitat. Using the best available information, NCDMF has identified several factors that should be considered when defining nursery habitat. Designations should take into account species' spatial-temporal distributions in the estuarine complex, and associated habitat characteristics. Following the most recent advances in ecosystem science, nursery designations should consider the relative value of the area for juvenile growth, predator protection, and movement into adult habitat, in addition to the occurrence and density of juveniles. This includes information not only about abiotic factors, structured habitat conditions, and landscape setting, but where suitable parameters overlap to create an optimal nursery environment. Finally, other factors such as water quality and changing weather patterns play an important role.

Fishery independent data should be used to inform the need for additional critical habitat designations. The NCDMF currently does not conduct ocean-based fishery independent sampling that could then be evaluated for new nursery classifications in the ocean. However, fishery-independent data from the Southeast Area Monitoring and Assessment Program (SEAMAP), a cooperative state/federal program coordinated by ASMFC, combined with the Pamlico Sound Trawl Survey (Program 195), could be evaluated for habitat purposes.

2.1.3.1 Critical Habitat Area Concept[1] and Current Habitat Protection Measures

There are approximately 2.2 million acres of coastal waters (excluding the ocean) in North Carolina, of which 242,000 acres are joint waters (salt/brackish marsh). The MFC has designated 161,830 acres as either primary nursery areas (PNAs), SNAs, or SSNAs, which represent 7% of the total estuarine waters (see Table 2.1; Figure 2.1 and 2.2). Additionally, the NCWRC has designated 30,384 acres of inland waters under their jurisdiction as inland nursery areas. Primary and secondary nursery areas are permanently closed to certain fishing gears, while SSNAs are conditionally opened to certain fishing gears.

NCDMF's habitat designations and selective gear restrictions have been guided by the concept of a critical habitat area, which takes into account multiple species groupings and their spatial-temporal distributions in the estuarine complex, and associated habitat characteristics.

In the 1980s, the NCDMF formed an internal Critical Habitat Committee to work with the MFC Habitat AC to discuss the concept of expanding habitat protections. While not used for any rule designations, analysis of the SNA data was included in the NCDMF's 1991 Classification of Pamlico Sound Nursery Areas; Recommendations for Critical Habitat Criteria report (Noble and Monroe 1991). This study identified other species groupings that were not considered in the nursery designation process. It recommended a better understanding of the spatial-temporal distributions in the estuarine complex and associated habitat characteristics. Staff recommended expanding fish sampling to identify anadromous spawning and nursery areas, estuarine areas important to reef fish like Gag Grouper, Black Sea Bass, and Sheepshead, and mapping of shellfish and submerged aquatic vegetation (SAV) resources due to their importance for numerous economically important species. Critical habitat definitions were put into rule in 1994. Sampling was conducted for anadromous fish spawning and nursery areas, and the division implemented a Bottom Mapping Program (1990). Anadromous fish spawning areas were designated in rule in 2007.

Selective gear restrictions in certain areas (without formal habitat area designations) were also used to provide protection for critical habitats. The MFC prohibited trawling and dredging over SAV beds in Pamlico Sound through a "No Trawl Area" designation (15A NCAC 03R .0106). SAV beds are nursery areas for summer/fall spawners like Spotted Sea Trout, Red Drum, Black Sea Bass, and many others. Trawling was prohibited in Albemarle and Currituck sounds due to user conflicts, but this also provides ancillary protections for habitat and bycatch of juvenile anadromous fish (15A NCAC 03J .0104). Trawl net, long haul seine, and swipe nets are prohibited in any designated Shellfish or Seed Management Area (15A NCAC 03K .0103). Crab Spawning Sanctuaries (15A NCAC 03L .0205) and inlet trawling restrictions (15A NCAC 03J .0401) may provide a "no trawl corridor" around inlets that not only protect crabs, but allow migration of sub-adult fish to the ocean. In the ocean (0–3 miles), there are

[1] The following sections do not address the designation of "Critical Habitats" under the ESA, which is applicable only to species listed as endangered or threatened and has specific meaning as defined in the ESA.

approximately 726,000 acres of water, of which about 8% (59,225 acres) are currently closed to trawling off of Onslow County, Carteret County, and from Oregon Inlet to the Virginia line (Table 2.1; Figure 2.2).

Table 2.1. Designated areas protected from shrimp trawling in coastal and joint waters. Acres of nursery area designations are included in the totals for shrimp trawl net prohibited and managed acres. (Source: NCDMF)

Designation	Acreage	Percent[1]
Nursery Areas (in estuarine waters)		
Primary Nursery Areas	76,927	3.5
Permanent Secondary Nursery Areas	47,462	2.1
Special Secondary Nursery Areas	37,441	1.7
Total	161,830	7.3
Shrimp Trawl Net Prohibited Areas (permanent closure)[2]		
Estuarine Waters	997,470	45.0
Ocean Waters	59,225	8.2
Total	1,056,695	35.9
Shrimp Trawl Net Managed Areas (seasonal openings determined by management)[3]		
Estuarine Waters	65,128	2.9
Ocean Waters	86,174	11.9
Total	151,302	5.1

[1] Percent listed is the percentage from total estuarine waters (coastal and joint) or total ocean waters (0-3 miles). Total estuarine waters: 2,220,168 acres; total ocean waters: 726,007 acres.

[2] Includes Primary and Secondary Nursery Areas, Oyster Sanctuaries, Trawl Net Prohibited Areas, and Military Danger and Prohibited Zones

[3] Includes Special Secondary Nursery Areas, Crab Spawning Sanctuaries, Designated Pot Areas, No Trawl Net Areas, and areas managed by proclamation

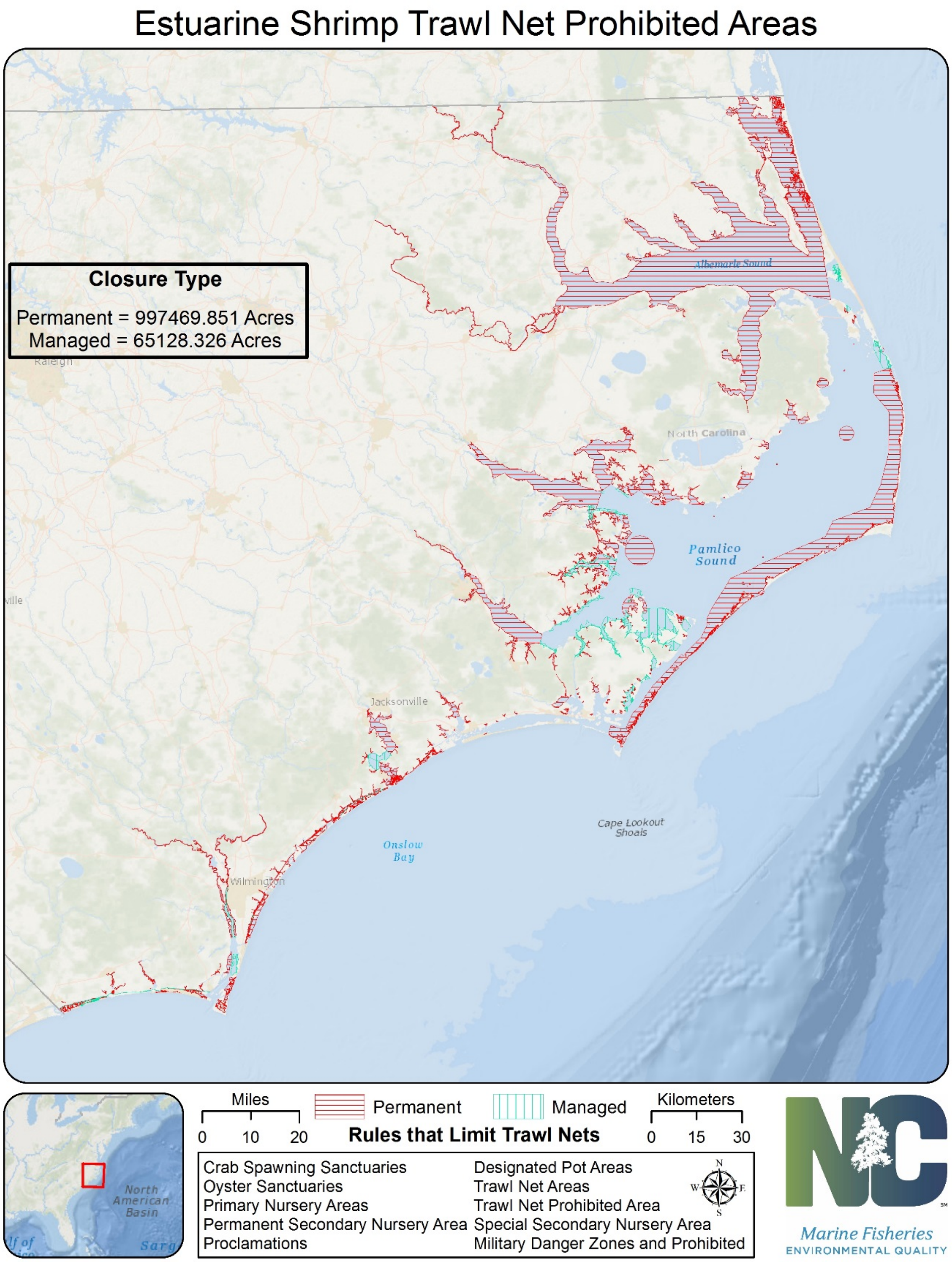

Figure 2.1. Estuarine Shrimp Trawl Net Prohibited Areas. (Source: NCDMF)

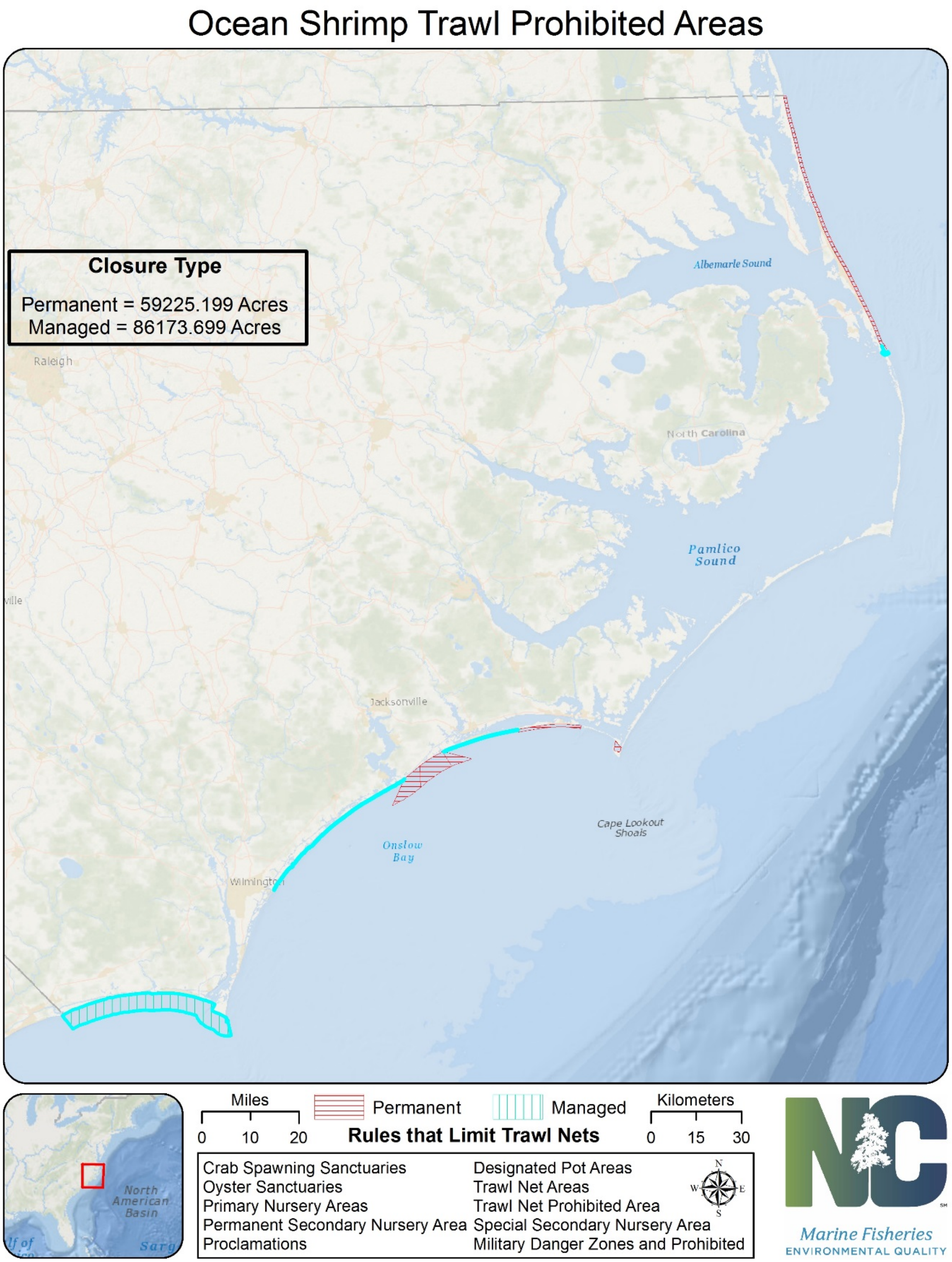

Figure 2.2. Ocean Shrimp Trawl Net Prohibited Areas. (Source: NCDMF)

2.1.3.2 Evolving Scientific Concept of Nursery Area

In recent years, the scientific literature has refined the concept of nursery areas. In earlier days, an entire estuary was initially considered a nursery area because of the occurrence of juveniles. But as ecosystem sciences advance, it has been found that in addition to density, other factors such as growth, predator protection, and movement out of the nursery into the adult habitat influence determination of nursery areas. Based on Beck et al. (2001), Dahlgren et al. (2006), and Peterson (2003), nursery areas are a subset of juvenile habitat that contributes disproportionally more to the production of juveniles that recruit into a population than another area of similar size. Shallow habitats with structure, such as wetlands, SAV, and oyster reefs, provide more predator protection and food than soft bottom habitat, enhancing growth and survival (Lehnert and Allen 2002; Ross 2003; Grabowski et al. 2005). However, juvenile species require specific optimal abiotic conditions, such as salinity and temperature to maximize growth. Productive or optimal nursery areas occur where ideal abiotic factors, structured habitat, and landscape position overlap (Figure 2.3). While all waterbodies may have juvenile fish present at any given time, the combination of the above noted factors may not align, resulting in low nursery value (Beck et al. 2001; Peterson 2003). Shrimp trawling is restricted in the majority of these optimal nursery areas through habitat designations and area and gear restrictions.

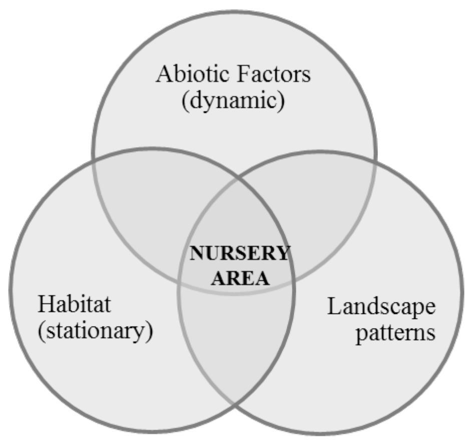

Figure 2.3. Depiction of the nursery area concept – the location where abiotic and habitat conditions, as well as the landscape setting are optimal for productivity. Abiotic factors – salinity, temperature, depth, currents; Habitat factors – wetlands, shell bottom, SAV, substrate; Landscape setting – geomorphology of the waterbody, proximity to inlets or adult habitat, habitat connectivity (adapted from Peterson 2003 and Beck et al. 2001).

There are many other non-fishing activities that have resulted in habitat loss and degradation over time (NCDEQ 2016). In the past, channel dredging has resulted in loss of wetlands, SAV, and oyster reefs. Filling of wetlands to create buildable land also contributes to wetland loss. While rules have been put in place to reduce large scale impacts, small losses continue, resulting in a net loss of habitat. Similarly, bulkheads and marinas can result in cumulatively significant habitat losses over time, particularly wetlands. Wetland loss and degradation in coastal watersheds can be directly traced to population pressures and conversion of wetlands to developed or agricultural uses, with resulting changes in water flow, increased pollution, and habitat fragmentation. Other habitat loss has occurred due to water quality degradation. Channel dredging in the lower estuary has altered flows and increased salinity in some waters. Ditching and draining of uplands and wetlands to accommodate development, agriculture, and forestry in the coastal plain has increased the volume and flashiness (i.e., frequency and rapidity of short term changes in streamflow) of runoff into the upper estuary, resulting in more variable salinity conditions. Dewatering from mining activities to small upper tributaries can alter flow and salinity. These alterations result in less suitable nursery conditions.

Multiple studies have documented that abundance of penaeid shrimp, sciaenids, and other estuarine dependent species is significantly greater in wetlands, SAV, and oyster reef habitat than in soft bottom habitat (Ross and Stevens 1992; Murphey and Fonseca 1995; Stunz et al. 2010; Grabowski et al. 2012; Humphries and La Peyre 2015). Thus, habitat loss contributes to declines in fish populations.

2.1.3.3 Sampling Data Needed for Habitat Designations

In order to protect fish habitat, it is important to be able to designate additional critical habitats based on acceptable data, criteria, and analysis. The NCDMF currently does not conduct ocean-based fishery independent sampling that could then be evaluated for new nursery classifications in the ocean. The NCDMF shrimp trawl characterization study (Program 570), conducted from 2012 to 2015 in the ocean, does evaluate finfish length frequency, biomass, and other metrics, as indicated by the Petitioner. However, it may be inappropriate to designate nursery areas from this study, or any fishery-dependent characterization study, due to sampling bias. Lack of standardization in the gears observed (e.g., mesh size, BRDs, TEDs, net type), tow times, tow speed, and geographic locations in the characterization study do not produce comparable catch rates across tows (Brown 2015). Fishery-independent surveys address sources of bias through standardized techniques.

Under the SEAMAP, South Carolina conducts a fishery-independent Coastal Shallow Water Trawl Survey. The survey has sampled two depth-zones (4 m and 10 m) off the North Carolina coast south of Cape Hatteras beginning in 1989. The “outer deep” zone was dropped in 2001 due to budget cuts and a decision was made to increase samples in the inner strata (ASMFC 2011). There are approximately 40 stations off North Carolina in the inner strata, with an average depth of 8 meters (4 m min and 14 m max). Nearly 4,000 tows have been made, averaging 148 per year. This is an extensive dataset that has primarily been used for shrimp and finfish indices in coastwide stock assessments and could be evaluated for habitat purposes.

With the implementation of the Pamlico Sound Trawl Survey (Program 195) in 1987, there is species abundance and habitat preference data for Pamlico Sound and the lower reaches of Neuse, Pungo, and Pamlico rivers. This data has been provided to the National Oceanic and Atmospheric Administration (NOAA) Fisheries Essential Fish Habitat database, which assembled trawl surveys from state and academic organizations, covering the Gulf of Maine to South Carolina, as well as NOAA groundfish surveys. NCDMF sampling under the Estuarine Trawl Program (Program 120) in SNA and SSNA has decreased in the past 25 years with changes in shrimp management strategies (intended to avoid “grand openings”), as well as with budget reductions to state-funded programs (over 44% reduction since 2008).

2.1.4 <u>Insufficient Water Quality Protection</u>

Water quality degradation is a significant stressor to fish and the habitats they might utilize. Sources include point sources such as industrial or wastewater discharges and nonpoint sources originating from a variety of land use changes. Changes in land use associated with development, agriculture, or forestry increase runoff into surface waters by reducing natural vegetation that would absorb the water (NCDEQ 2016). Ditching to reduce flooding on land or lower the water table accelerates and channels runoff to surface waters. Primary pollutants in runoff are oxygen-consuming wastes, nutrients, suspended sediment, and toxins, which can impact habitats and affect fish survival.

Increased sediment loading can increase turbidity in the water column. Excessive suspended sediments directly impact aquatic animals by clogging gills and pores of juvenile fish and invertebrates, resulting in mortality or reduced feeding (Ross and Lancaster 2002) and can smother oyster reefs and SAV. Sedimentation associated with runoff and shoreline erosion generally occurs close to shore and in the upper portions of the estuary, often in nursery areas. In contrast, sedimentation associated with bottom disturbing fishing gear occurs in deeper and more open areas of the estuary, further away from structured habitat and nursery areas.

Increased nutrient loading can lead to algal blooms and hypoxia (low dissolved oxygen). Hypoxic conditions can be associated with weather conditions causing stratified waters, eutrophication, or hurricanes. These conditions occur more often and for longer in deeper portions of the water column, such as in Pamlico Sound, causing lethal and sublethal stress of benthic infauna (Luettich et al. 2000; Buzzelli et al. 2002). A study using data from the Neuse River, found that benthic invertebrate mortality from intensified hypoxia events reduced total biomass of demersal predatory fish and crabs during the summer by 51% in 1997 and 17% in 1998 (Baird et al. 2004). The decrease in available energy (fewer benthic invertebrates) greatly reduced the ecosystem's ability to transfer energy to higher trophic levels at the time of year most needed by juvenile fish (Baird et al. 2004).

2.1.5 <u>Other Factors</u>

Physical and chemical properties of water are key to the distribution of plant and animal life and influence growth and survival of all habitats. Thus, changes in weather conditions, such as precipitation and water temperatures, influence distribution and abundance of aquatic organisms. Predominant winds, currents, and salinity fluctuations at certain times of year highly affect annual recruitment success of larval fish into nursery habitat (Epperly and Ross 1986; Noble and Monroe 1991; Greene et al. 2009). High sustained air temperatures increase water temperature, which in combination with low winds, can lead to stratification of the water column and hypoxic waters. The latter causes mortality of benthic invertebrates, which is the food base for many juvenile fish species, including Spot and Atlantic Croaker.

Extreme weather events such as droughts, floods, Nor'easters, and hurricanes affect water quality and habitat conditions in positive and negative ways. Reduced runoff during droughts decreases pollutant inputs, increases salinity and improves water clarity within estuarine waters, enhancing conditions favorable for growth of SAV and can potentially lead to shifting fish distribution. In contrast, floods and hurricanes can flush pollutants from the upper estuarine bottom, cause sedimentation over oyster reefs, and erode wetland shorelines. From 1851 to 2014, North Carolina had more direct hurricane landfalls (48 hurricanes) than any other state on the East Coast, except for Florida (141 hurricanes; N.C. Climate Office 2015).

While extreme weather events have always occurred, there is evidence that the frequency and severity of minor (non-storm event) nuisance flooding and hurricanes on the East and Gulf coasts are increasing (IPPC 2014; Melillo et al. 2014; Sweet et al. 2014). Tropical storms, fueled by warm water temperatures and favorable atmospheric conditions, may increase in frequency and intensity with a warming climate (Melillo et al. 2014). A warming trend in air temperature is the primary driver of changing weather patterns that can alter the distribution and health of fish and their habitat. The 2014 National Climate Assessment summarizes observed and expected climate change and impacts regionally and overall in the U.S. (Melillo et al. 2014).

3 ESTABLISH BASELINE

To begin to determine what effects the Petitioned rules would have on the state of North Carolina, the current management and trends in harvest (commercial and recreational) for species affected by the Petitioned rules must be evaluated.

In North Carolina, public resources are managed for the good of the people through the Public Trust Doctrine and fish in state waters are a public trust resource (G.S. 1-45.1; G.S. 113-131). Fishery management includes all activities concerned with maintenance or improvement of estuarine and marine stocks and use of those resources (fisheries), including protection of the habitat. The NCDMF and MFC are the only authorities in North Carolina coastal fishing waters that can implement plans and regulations to manage North Carolina marine and estuarine fisheries.

The MFC's jurisdiction encompasses all coastal waters and extends to three miles offshore. The nine-member MFC and the NCDEQ Secretary establish the NCDMF's conservation policies. As mentioned previously, North Carolina is also a member of regional and federal fishery management commissions and councils including the ASMFC, MAFMC, and SAFMC.

The NCDMF can trace its roots back as early as 1822, when the North Carolina General Assembly enacted legislation to impose gear restrictions on oyster harvest. That was later followed by separate fish and shellfish commissions, which were combined in 1915 to form a commercial regulatory body. In 1965, the scope of the commission was expanded to include regulatory authority over recreational fishing activities in coastal waters.

As mentioned in section 1, the 1997 FRA and its subsequent amendments established the requirement to prepare FMPs for all North Carolina's commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources (G.S. 113-182.1). The Act "recognizes the need to protect our coastal fishery resources and to balance the commercial and recreational interests through better management of these resources" and requires the MFC "to provide fair regulation of commercial and recreational fishing groups in the interest of the public." FMPs normally take about two years to complete and are required to be reviewed at least once every five years. Upon review, amendment of a plan is required when changes to management strategies are necessary. Through this process, the commission also has authority to implement federal fishery regulations (as minimum North Carolina standards) through the N.C. FMP for Interjurisdictional Fisheries, which selectively adopts management measures contained in approved federal Council or ASMFC FMPs by reference. The goal of FMPs is to provide direction for the management of fisheries and to ensure long-term viability of North Carolina fisheries.

Under G.S. 113-182.1, each FMP shall contain necessary information pertaining to the fishery or fisheries, as well as include conservation and management measures that will provide the greatest overall benefit to the State, particularly with respect to food production, recreational opportunities, and the protection of marine ecosystems, and that will produce a sustainable harvest. For these purposes, data are gathered, analyzed, interpreted, and management measures implemented. The NCDMF is empowered to collect such scientific and statistical information as may be needed to determine conservation policy (G.S. 113-181). FMPs are the ultimate product that brings all the information and considerations into one document for a species.

There are two main sources of data necessary for fisheries management and evaluated for each FMP: fishery dependent and fishery independent data. Fishery dependent data are derived from the fishing process itself and are collected through such avenues as self-reporting, fish house surveys, onboard observers, telephone surveys, or vessel-monitoring systems. Fishery dependent sampling allows managers to account for sources of removals and the size and age structure of those removals. Fishery-independent data comes from research and monitoring surveys conducted by state agencies. Scientists take samples throughout the potential range of the target fish(es) based on statistically valid sample designs that are not influenced by changes in fishing activity. Fishery independent sampling allows managers to monitor trends in the relative abundance of a species. Fishery dependent and independent sampling complement one another to provide a more complete picture of the condition of a fish stock. Dependent sampling intended to monitor trends in relative abundance can be biased by changes in: gear specifications, fishing effort, areas fished, level of expertise of fishermen, technology, etc.

The longest running fishery dependent data source in North Carolina is commercial landings that are available back to the late 1880s. Currently, data are collected by the NCDMF Trip Ticket Program (NCTTP), which was legislatively mandated to start in 1994 and required submission of trip level data from seafood dealers. Prior to 1978, commercial landings data were collected voluntarily by the National Marine Fisheries Service (NMFS, now known as NOAA Fisheries) from seafood dealers and completeness and accuracy of the data provided varied. In 1978, the NCDMF began its own statistics program and entered a cooperative program with the NMFS to collect monthly surveys of North Carolina's major commercial seafood dealers. These surveys were still voluntary, so the 1994 NCTTP was legislatively mandated to answer an increased demand for complete and accurate trip-level commercial harvest statistics. The detailed data obtained through the NCTTP allows for the calculation of effort (i.e., trips, licenses, participants, vessels) in each fishery that was not available prior to 1994 and provides a more comprehensive and detailed record of North Carolina's seafood harvest that is sold. A trip ticket is the form used by fish dealers to report commercial landings information for every fishing trip that resulted in seafood being sold to the dealer. Trip tickets collect information about the fisherman, the dealer purchasing the product, the transaction date, the number of crew, area fished, gear used, and the quantity of each species landed for each trip. Ex-vessel value of commercial fisheries in North Carolina can be calculated by looking at the average price paid to the fishermen by the dealer for each species and market grade multiplied by the landings. Prices are collected monthly on a volunteer basis and are not available for every trip captured by the NCTTP.

A complementary NCDMF fishery dependent data source is the collection of biological data at fish houses from predominantly finfish fisheries in North Carolina and has been ongoing since 1982. Predominant fisheries sampled throughout the year include the ocean sink net fishery, estuarine gill net fishery, long haul seine/swipe net fishery, winter trawl fishery, and flounder pound net fishery. The blue crab fishery is the only invertebrate species included in fish house sampling, as it is the largest fishery in North Carolina. Also, through other observer-type programs, NCDMF staff have collected data from shrimp trawl, fish trawl, gill net, long haul seine, trawl net, channel net, and recreational hook and line fisheries. The observer data are collected either on the water from fishermen's vessels or from a NCDMF vessel operated near ongoing fisheries. These types of fishery dependent data provide monitoring of effort, gear specifications, and removals (i.e., landings and discards), and characterize the catch (e.g., species composition, size, age).

The NCDMF License Program is another source of fishery dependent information. The number of licenses issued to various types of fishermen such as the Standard Commercial Fishing License (SCFL), Retired Standard Commercial Fishing License (RSCFL), Commercial Fishing Vessel Registration (CFVR), Recreational Commercial Gear License (RCGL), and Coastal Recreational Fishing License (CRFL) may be used to determine the number of fishermen and vessels involved in various fisheries.

The Marine Recreational Information Program (MRIP) and its predecessor, the Marine Recreational Fishery Statistics Survey (MRFSS), have been providing estimates of recreational catch and fishing effort since 1981. From 1981–1986, NCDMF's role was simply to review estimates and answer questions from the private contractor that NMFS used to conduct MRIP. In 1987, NCDMF assumed the responsibility of conducting the MRIP sampling in North Carolina and conducts angler interviews as part of the Access Point Angler Intercept Survey (APAIS). Additional NCDMF staff were also added to increase APAIS sampling to produce reliable recreational harvest estimates at the state level. MRIP sampling is only conducted in saltwater and brackish water areas, along with tidal portions of sounds, bays, and rivers. Freshwater areas are not included in the survey; therefore, in 2004, NCDMF started a comprehensive intercept survey in the Central Southern Management Area (CSMA) to estimate harvest of anadromous species such as Striped Bass and American Shad. Recreational data collected by NCDMF include the number and type of species kept and discarded, lengths and weight of kept fish, number of anglers, location, as well as socioeconomic information. These data are used to estimate total harvest and total fish discarded. These two estimates added together equal the total catch. Estimates of effort (i.e., trip counts) are also produced. In 2010, NCDMF initiated a series of mail surveys targeting CRFL holders to supplement the MRIP and CSMA intercept surveys. These surveys target fisheries such as shellfish, cast net, and flounder gigging. Surveys were also used to characterize catch from the RCGL.

The NCDMF conducts several fishery independent surveys in state estuarine waters. Fishery-independent monitoring of adult and juvenile populations enhances resource managers' ability to monitor population changes and assess the status of target species. These surveys also may provide a direct measure of habitat utilization by the various species captured. An index of relative abundance can be developed to categorize the sampling areas and establish a pattern of habitat utilization for target species. The survey data has been used to characterize nursery area habitat and to help designate new critical habitat areas. Examples of fishery-independent data include relative abundance indices (CPUE) for select species/life stages from the Estuarine Trawl Survey (Program 120), Pamlico Sound Trawl Survey (Program 195), and Fishery Independent Assessment Gill Net Survey (Program 915).

The main fishery managed by NCDMF that is affected by the Petitioned rules is the shrimp trawl fishery. Other fisheries not solely managed by NCDMF, but also affected include Spot and Atlantic Croaker. Weakfish was also identified by the Petitioner as a species that would benefit from the proposed rule changes (NCWF 2016a). Current landings and management for each of these species is discussed below in sections 3.1–3.4. The value of these fisheries is discussed in section 3.6 and 3.7. Commercial landings in North Carolina are available dating back to the 1800s for some species, but recreational data did not become available until 1981. Therefore, to show how landings have changed over time, trends in commercial landings back to 1972 are provided as well as trends in recreational harvest back to 1981.

3.1 Shrimp

The management unit for shrimp in North Carolina includes the three major species of penaeid shrimp: brown (*Farfantepenaeus aztecus),* pink (*Farfantepenaeus duorarum*), and white (*Litopenaeus setiferus*). Its fisheries occur in all coastal fishing waters of North Carolina, which include the Atlantic Ocean offshore to three miles. Estimates of population size are not available since the fishery is considered an annual crop due to their short life spans. Annual variations in catch are presumed to be due to environmental conditions that, in turn, affect fishing effort and the economics of the fishery.

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

Commercial landings provided by the NCTTP are combined for the three shrimp species (Table 3.1). Annual landings of shrimp vary from year to year based on environmental conditions, but have generally remained fairly stable since 1972 (Figure 3.1). Total landings from 2007 to 2016 have averaged 7,086,786 pounds per year. In 2016, 13,190,728 pounds of shrimp were landed; the highest annual landings in North Carolina since 1953. Total landings increased 45% from 2015 to 2016. Annual shrimping effort has fluctuated with shrimp abundance, but it appears to have gradually declined since 1994 (Figure 3.2). This decline in effort can be attributed to several things including cheaper imported shrimp prices, increasing fuel prices, and fishermen retiring out of the industry. Landings in 2005 were the lowest on record. This was likely due to several reasons, one being that many large trawlers remained scalloping instead of shrimping because prices were high and the days at sea were extended (NCDMF 2015a). Hurricanes Katrina (Aug. 29, 2005) and Rita (Sep. 4, 2005) hit the Gulf Coast, also negatively affecting the fishing industry. Shrimp breading operations in the Gulf shut down with only one operational in September 2005 and some North Carolina shrimpers could not sell their product (NCDMF 2015a). While the overall effort has declined since the 1990s, the number of trips increased over the last couple of years (Figure 3.2). The majority of commercial landings come from the estuarine waters of North Carolina and on average make up approximately 80% of total landings from the state. Of the ocean landings, more than 90% are from 0 to 3 miles (Table 3.1).

Shrimp are harvested recreationally throughout the state by otter trawls, skimmer trawls, seines, cast nets, shrimp pots, and shrimp pounds with specific gear limitations. Since July 1, 1999, anyone wishing to harvest shrimp recreationally with commercial gear is required to purchase a RCGL. The RCGL is an annual license that allows recreational fishermen to use limited amounts of commercial gear to harvest seafood for their personal consumption. Seafood harvested under this license cannot be sold. Fishermen using this license are held to recreational size and possession limits, and gear marking, limits, and configuration requirements. Many of the species taken by recreational users of commercial gear are included in fishery management plans. Until 2002, the influence that RCGL holders may have on these species was unknown. Two survey strategies were used to collect information from RCGL holders: a socioeconomic survey, conducted in 2001, 2004, and 2007, and catch and effort surveys conducted monthly from 2002 through 2008. RCGL holders harvested an average of 52,352 pounds of shrimp a year from 2002 to 2008 (NCDMF 2015a). Landings from RCGLs are currently unknown since these surveys were discontinued in 2008 due to budget constraints.

In 2011, NCDMF initiated mail surveys of CRFL holders for participation in cast net fisheries. Annual cast net harvest estimates for shrimp are available from 2012 to 2016 and average about 90,000 individual shrimp per year (Table 3.2). In 2016, 120,572 shrimp (numbers) were harvested recreationally with cast nets.

Table 3.1. Shrimp commercial landings (pounds, heads-on, all three species combined) in North Carolina by region, 2007–2016. (Source: NCTTP)

Year	Estuarine Landings	Ocean Landings Less Than 3 Miles	Ocean Landings Greater Than 3 Miles	Total Landings	Total Trips
2007	7,879,879	1,483,522	50,950	9,414,351	9,287
2008	7,385,623	1,431,741	160,356	8,977,720	8,079
2009	4,417,229	716,756	94,295	5,228,280	7,770
2010	4,701,523	856,480	12,745	5,570,748	7,861
2011	4,048,526	629,866	3,042	4,681,434	5,359
2012	5,007,607	650,197	7,737	5,665,540	8,922
2013	4,119,572	704,586	7,007	4,831,165	8,682
2014	3,967,480	548,703	3,284	4,519,467	6,477
2015	7,654,742	1,251,946	23,945	8,930,632	8,170
2016	8,518,324	4,480,499	49,700	13,048,523	9,703

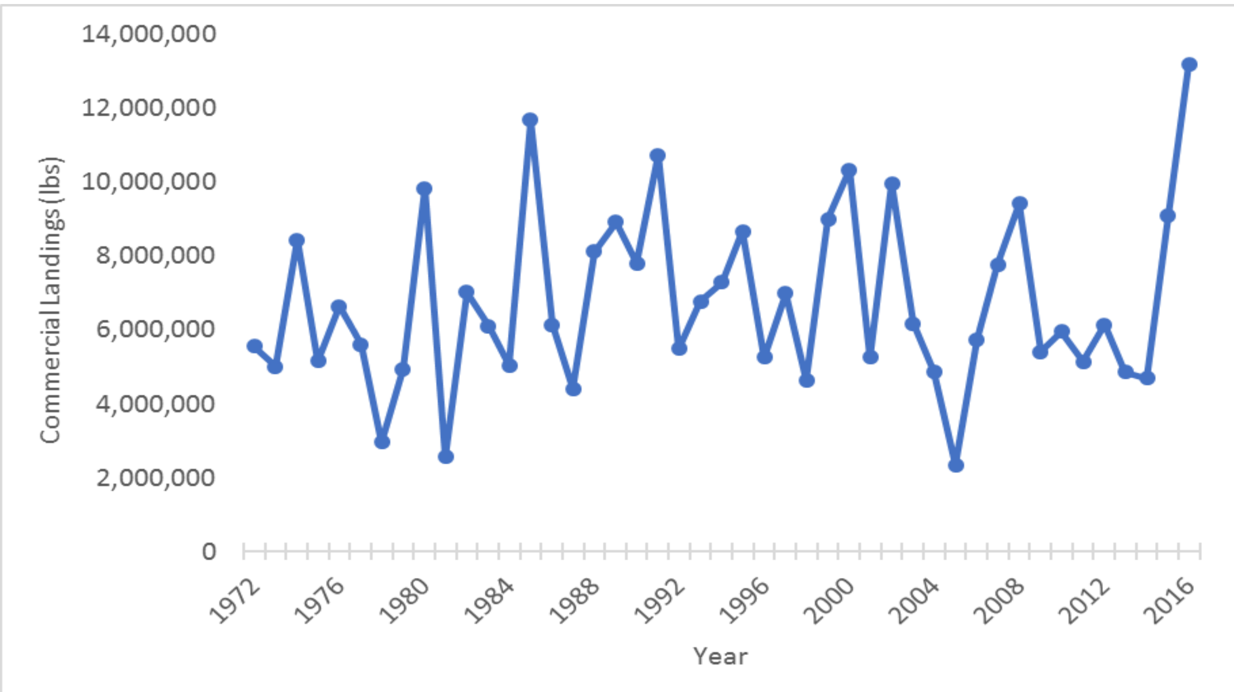

Figure 3.1. Annual commercial landings of shrimp (all three species combined) for North Carolina, 1972–2016. (Source: NCTTP)

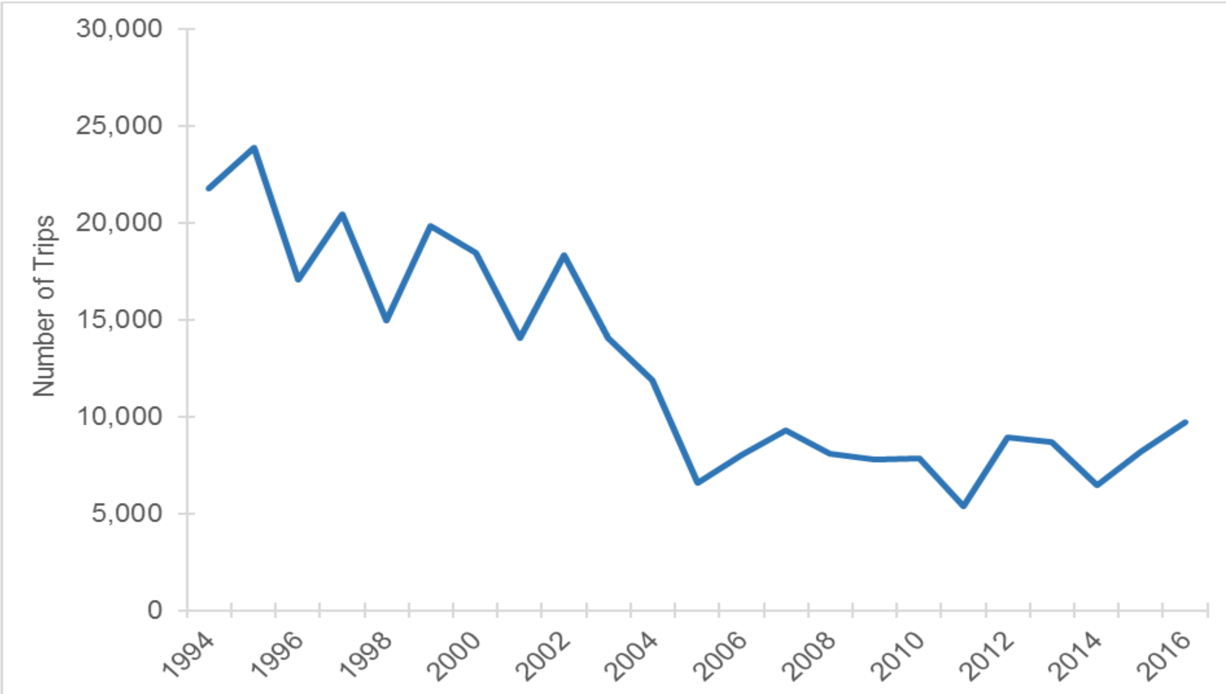

Figure 3.2. Annual number of trips reporting commercial landings of shrimp (all three species combined) in North Carolina, 1994–2016. (Source: NCTTP)

Table 3.2. Recreational cast net effort and catch (in numbers) for shrimp (all three species combined), 2012–2016 (estimates based on CRFL mail survey). (Source: NCDMF)

Year	Total Effort	PSE Effort	Total Shrimp Harvest	PSE Harvest	Total Shrimp Released	PSE Release	Total Shrimp Catch	PSE Total Catch
2012	126,891	6.1	84,335	29.7	19,584	34.8	103,919	26.9
2013	142,037	6.2	30,512	32.5	29,055	27.7	59,568	22.7
2014	202,293	6.5	38,144	37.1	38,044	40	76,187	29.7
2015	220,011	5.9	53,339	34.9	32,981	26.1	86,321	24.8
2016	199,509	6.4	81,177	45.7	39,395	34.9	120,572	37.6

The NCDMF began review of the 2006 Shrimp FMP in 2011 and initially concluded that current management strategies in the plan continued to meet the goals and objectives of the Shrimp FMP and recommended to the Fisheries Director that review of the 2011 Shrimp FMP proceed as a revision to simply update data contained in the plan. However, based on concerns about bycatch in the shrimp trawl fishery voiced at various MFC AC meetings, the NCDMF later recommended amending the 2006 Shrimp FMP. The MFC, at its November 2012 meeting, directed the NCDMF to amend the plan, but limit the scope of the amendment to bycatch issues in the commercial and recreational shrimp fisheries.

Twenty-nine different management options were brought forward to the Shrimp FMP AC to address different bycatch management strategies during monthly meetings held from January through September 2013. Management strategies discussed included:

- alternative fishing gears;
- TEDs in skimmer trawls;
- gear modifications;
- effort management;
- head rope lengths, number of nets, and vessel lengths;
- area restrictions;
- New River trawl fishery; and
- consideration of a live bait shrimp fishery.

Specific management options considered in Amendment 1 to the Shrimp FMP related to this Petition included:

- adding an additional day to the weekend closure in internal coastal waters;
- closing shrimp trawling at night in internal coastal waters;
- reducing maximum headrope length in all internal coastal waters for commercial and recreational fisheries;
- implementing tow time limits; and
- implementing a season.

Tow time limits in internal coastal waters was discussed, but the Shrimp FMP AC voted to eliminate this option in July 2013. Implementing a seasonal closure (December or January through May) was also discussed, but not selected during the development of the amendment and is related to the Petition's proposed rule change to open the shrimp season when the shrimp size is 60-count heads-on in Pamlico Sound.

The MFC approved the Shrimp FMP Amendment 1 at its February 2015 meeting. Management strategies approved by the MFC through the Shrimp FMP Amendment 1 have either been completed or are in progress of completion. Approved management strategies were as follows:

- Continue to prohibit otter trawls in the New River SSNA
- Allow hand cast netting of shrimp in all closed areas and increase the limit to four quarts (heads-on) per person
- Upon federal adoption of TEDs in skimmer trawls, the NCDMF will support the federal requirement.
- Establish a permitted live shrimp bait fishery and for NCDMF to craft the guidelines and permit fees after reviewing permitted operations in other states, and to allow live bait fishermen with a permit to fish until 12 p.m. (noon) on Saturday
- Allow any federally certified BRD in all internal and offshore waters of North Carolina.
- Update the scientific testing protocol for the state's BRD certification program
- Convene a stakeholder group to initiate industry testing of a minimum tail bag mesh size, T-90 panels, skylight panels, and reduced bar spacing in TEDs to reduce bycatch to the extent practicable with 40% target reduction
    - Upon securing funding, testing in the ocean and internal waters will consist of three years of data using test nets compared to a control net with a Florida fisheye, a federally approved TED, and a 1.5-inch mesh tailbag.

    - Results should minimize shrimp loss and maximize reduction of bycatch of finfish. Promising configurations will be brought back to the MFC for consideration for mandatory use
    - This stakeholder group may be partnered with NCDMF and Sea Grant.
    - Members should consist of fishermen, net/gear manufacturers, and scientist/gear specialists.
- Require either a T-90 panel/square mesh tailbag or other applications of square mesh panels (e.g., skylight panel), reduced bar spacing in a TED, or another federal or state certified BRD in addition to existing TED and BRD requirements in all skimmer and otter trawls
- In order to put a cap on fleet capacity as a management tool, establish a maximum combined headrope length of 220 feet in all internal coastal waters where there are no existing headrope length requirements (e.g., current 90-foot requirement in Core Sound and Cape Fear River)
- Prohibit shrimp trawling in the IWW channel from the Sunset Beach Bridge to the S.C. state line, including Eastern Channel, lower Calabash River and Shallotte River
- Recommend the MFC Habitat and Water Quality AC consider changing the designation of SSNAs that have not been opened to trawling since 1991 to permanent SNAs

3.2 Spot

Spot is a short-lived species, maturing at age two, with males maturing at 7.9 inches total length and females maturing at 8.4 inches total length in the South Atlantic (ASMFC 2010a). A coastwide stock assessment for Spot was completed by the ASMFC in 2017, but it was not accepted for management use (ASMFC 2017a). Without a valid, peer-reviewed stock assessment, it cannot be determined if the stock is currently “overfished” or experiencing “overfishing.” The ASMFC lists the status of Spot as unknown due to the lack of an approved stock assessment, but management action has not been triggered based on the TLA analysis through 2016 (ASMFC 2017b).

Coastwide commercial landings of Spot have declined considerably since 1950 (ASMFC 2017b). Commercial landings of Spot in North Carolina have been steadily declining since 1979 (Figure 3.3). Since 2007, landings have been averaging about 978,000 pounds per year (Table 3.3). In 2016, commercial landings dropped well below the average to 235,670 pounds. Currently, no single commercial gear accounts for a significant majority of Spot landings in North Carolina; however, long haul seines have traditionally been a high-volume fishery for Spot. Effort in this fishery has declined dramatically, with just 31 long haul trips landing Spot in 2015. Coastwide recreational landings of Spot have declined since 1981, but have been generally consistent since the late 1980s (ASMFC 2017b). Recreational harvest (pounds) of Spot in North Carolina has fluctuated annually since 1981 with a large peak in harvest occurring in 1985 (Figure 3.3). The largest declines in harvest have occurred in the last 10 years (Table 3.3). Recreational harvest increased from 2012 through 2014 (704,445 pounds) before declining sharply in 2015 (395,268 pounds). Over this same period, recreational discards have fluctuated, but not changed drastically. From 1994–2009, commercial and recreational trips for Spot showed different trends over time with commercial trips being fairly stable through 2002 before declining, where recreational trips saw a steep decline from 1994–1999 and then peaked in 2004 before declining (Figure 3.4). Since 2010, commercial and recreational trips have followed almost identical trends.

The average size (total length) of Spot caught in the recreational fishery has remained fairly constant ranging from 200 mm (7.9 inches) to 230 mm (9.1 inches) while the average size of fish landed in the commercial fishery has been declining (Table 3.4). From 2007–2016, the average size of Spot in the commercial fishery ranged from 267 mm (10.5 inches) to 301 mm (11.9 inches).

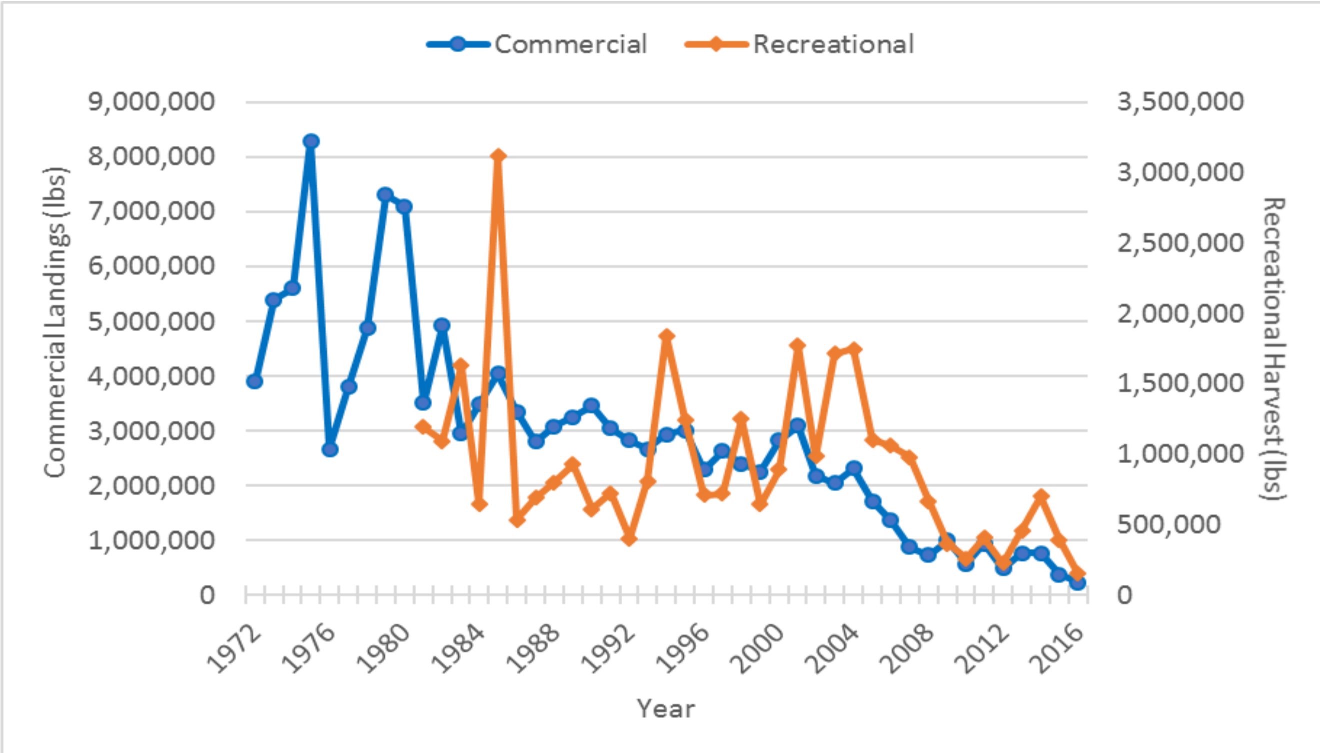

Figure 3.3. Annual commercial and recreational landings (pounds) of Spot in North Carolina, 1972–2016. (Source: NCTTP; MRIP)

Table 3.3. Commercial landings (weight in pounds), recreational harvest (number of fish and weight), and recreational releases (number of fish) of Spot from North Carolina, 2007–2016. (Source: NCTTP; MRIP)

	Commercial	Recreational					
		Number of fish				Weight (pounds)	
Year	Landings (pounds)	Released	PSE	Harvested	PSE	Harvested	PSE
2007	879,082	1,197,005	17.8	3,078,346	17.2	982,463	16.9
2008	736,484	1,322,408	14.4	1,843,343	18.0	670,511	19.4
2009	1,006,500	1,222,053	13.5	1,056,346	18.0	363,998	17.9
2010	572,315	871,054	13.8	834,560	14.2	260,341	13.8
2011	936,970	1,000,566	11.6	1,207,335	15.8	410,317	16.8
2012	489,676	759,081	11.9	784,272	22.1	230,250	24.0
2013	768,592	1,314,199	12.1	1,464,592	15.3	460,928	16.8
2014	766,224	890,831	12.1	2,111,880	20.5	704,445	21.8
2015	377,358	708,122	14.5	1,081,083	28.0	395,268	29.1
2016	235,670	498,424	19.2	513,320	23.1	151,352	23.2

The percent standard error (PSE) represents the standard error of the harvest estimate as a percentage.

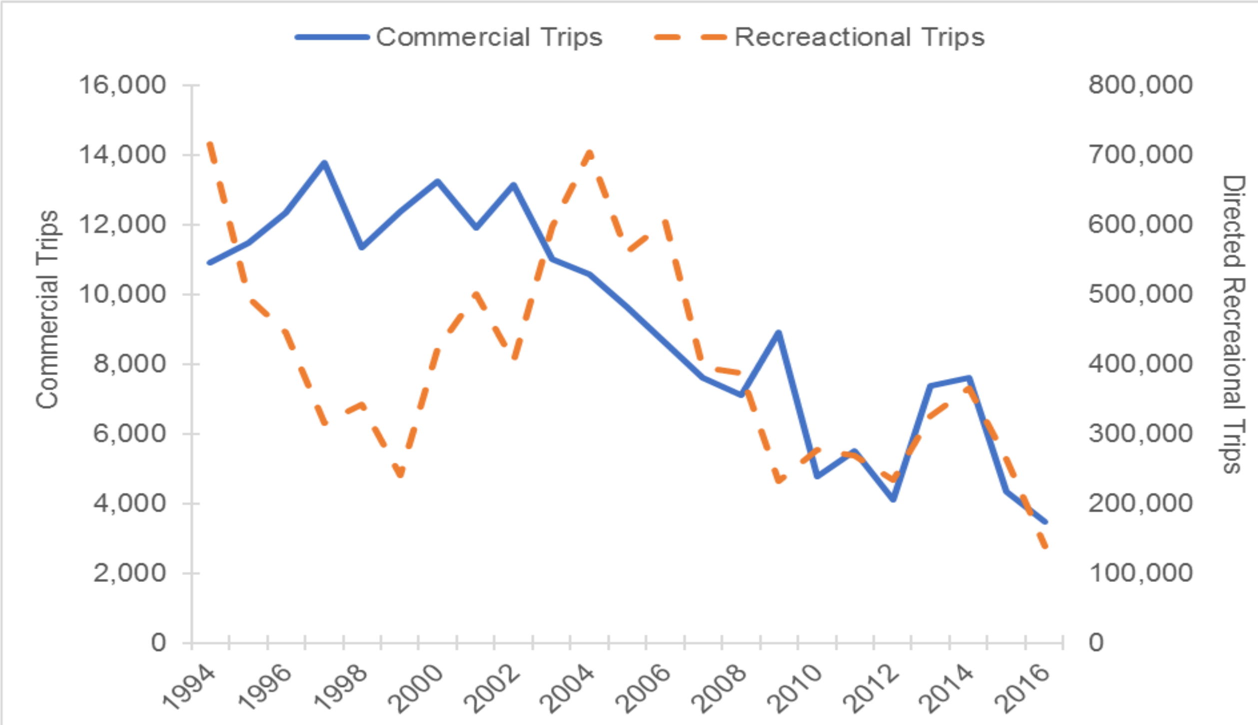

Figure 3.4. Number of trips reporting commercial landings of Spot and the number of directed recreational Spot trips, 1994–2016. (Source: MRIP) NOTE: Directed recreational trips are defined as trips where the angler specified Spot as the target of the trip or where Spot was harvested.

Table 3.4. Mean, minimum, and maximum lengths (total length, millimeters) of Spot sampled from the commercial and recreational fisheries of North Carolina, 2007–2016. (Source: NCDMF)

	Commercial				Recreational			
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2007	301	147	494	13,261	230	144	299	1,243
2008	294	174	495	13,274	213	128	311	1,344
2009	289	192	486	19,217	216	126	274	682
2010	288	151	452	20,239	209	147	306	1,096
2011	297	162	422	15,033	209	149	283	1,534
2012	287	188	454	10,508	200	141	298	611
2013	284	172	437	8,538	207	115	293	484
2014	267	113	423	10,946	210	121	258	344
2015	277	137	394	9,168	207	154	302	214
2016	275	187	385	6,492	200	160	263	107

Addendum I to the Omnibus Amendment for Spot established the TLA to evaluate trends in the Spot fishery in years between stock assessments (ASMFC 2014a). Annually, harvest and abundance indices are analyzed; if established thresholds for both indices are exceeded for two consecutive years, management actions are triggered. The extent of management action is determined based on whether a 30% or 60% threshold has been exceeded.

As mentioned previously, the 2017 Spot stock assessment was not endorsed for management use by a panel of independent fisheries scientists, though they did agree that immediate management actions were not necessary and that the TLA should continue to be used to monitor the stock (ASMFC 2017a). The panel noted that the models generally suggested spawning stock biomass was increasing and if new information suggests the stock could be declining, a new assessment should be expedited. The conclusions of the panel were ultimately supported by the South Atlantic Board at its August 2017 meeting (ASMFC 2017e). The main cause of uncertainty in both the Spot and Atlantic Croaker assessments was the disagreement in harvest trends and abundance trends. Spot abundance, as indicated by fisheries independent surveys, indicates increasing abundance; whereas, harvest from directed commercial and recreational fisheries has generally been declining. This trend has also been observed in the annual TLA (ASMFC 2017b).

Though the assessment did not pass peer review and will not be used for management, there are elements of the data, particularly commercial and recreational removals and dead discards from shrimp trawls, that can still be informative. The following is a description of trends in removals and independent indices from the 2017 assessment review. From 1989–2014, total annual coastwide removals (landings and discards) ranged from 4,637 to 57,287 metric tons (41 to 1,324 million fish) and have been relatively stable since 1997 (ASMFC 2017a). The stability in removals coincides with initial BRD requirements for North Carolina shrimp trawl fisheries initiated in 1992. North Carolina's BRD requirement was adopted before the device became federally required in 1997 and 1998 (50 CFR 622). After the peak year in 1991, coastwide removals were 12,785 metric tons (254 million fish). Shrimp trawl discards accounted for most of the removals.

3.3 Atlantic Croaker

Atlantic Croaker generally mature by age two, with males maturing at 7.25 inches and females maturing at 7.5 inches total length (ASMFC 2010b). Results of a stock assessment completed in 2010 indicated that Atlantic Croaker was not experiencing overfishing. Overfished status could not be determined in the 2010 ASMFC stock assessment due to uncertainty in the biomass estimates as a result of uncertainty in the shrimp trawl bycatch estimates at that time. The ASMFC lists the status of Atlantic Croaker as unknown due to the lack of an approved stock assessment, but management action has not been triggered based on the TLA through 2016 (ASMFC 2017c).

A coastwide stock assessment for Atlantic Croaker was completed and presented to the ASMFC South Atlantic State/Federal Fisheries Management Board in May 2017 (ASMFC 2017f). This 2017 assessment was not endorsed for management use by a panel of independent fisheries scientists (ASMFC 2017d). The current stock status of Atlantic Croaker could not be determined because the assessment results were sensitive to certain modeling assumptions, particularly those regarding fishery and survey gear selectivity. The panel did agree that immediate management actions were not necessary because base model and all sensitivity runs evaluated suggested the spawning stock biomass was increasing; therefore, recent removals are likely sustainable (i.e., unlikely to result in further depletion of Atlantic Croaker).

Coastwide commercial landings of Atlantic Croaker have fluctuated since 1971, but have been generally declining since the early 2000s (ASMFC 2017c). Commercial landings of Atlantic Croaker in North Carolina have followed a similar trend (Table 3.5; Figure 3.5). The decline in landings can, in part, be linked to declining effort, mostly from the traditionally high-volume flynet fishery (Figure 3.6). In 1997, 304 flynet trips landed Atlantic Croaker in North Carolina accounting for 6.9 million pounds. From 2011 through 2016, only 84 flynet trips have landed Atlantic Croaker in North Carolina accounting for a total of 2.1 million pounds over the six-year period. The decrease in effort in recent years has been attributed to shoaling at Oregon Inlet, making it difficult for flynet boats to transit. Overall, commercial landings have been declining. Coastwide recreational landings of Atlantic Croaker have fluctuated since 1981, but have generally declined since the mid-2000s (ASMFC 2017c). While recreational harvest of Atlantic Croaker in North Carolina has been declining over time, harvest since 2007 has been relatively steady, fluctuating between 99,298 pounds and 241,993 pounds (Table 3.5; Figure 3.5). Since 1995, the number of Atlantic Croaker harvested has remained relatively steady, while the number of recreational discards has been increasing since the mid-2000s. From 1994–2016, commercial and recreational trips for Atlantic Croaker have followed similar declining trends (Figure 3.6).

Unlike Spot, where the commercial fishery typically lands larger fish than the recreational fishery, the average size of Atlantic Croaker in the recreational fishery are larger than those caught commercially (Table 3.6). From 2007–2016, the average size of Atlantic Croaker caught in the recreational fishery ranged from 201 mm (7.9 inches) to 244 mm (9.6 inches) while the average size of fish landed in the commercial fishery ranged from 202 mm (8.0 inches) to 213 mm (8.4 inches).

Table 3.5. Recreational harvest (number of fish and weight) and releases (number of fish) and commercial harvest (weight in pounds) of Atlantic Croaker from North Carolina, 2007–2016. (Source: NCTTP; MRIP)

	Commercial	Recreational					
		Number of fish				Weight (pounds)	
Year	Landings (pounds)	Released	PSE	Harvested	PSE	Harvested	PSE
2007	7,271,162	1,608,120	12.7	461,162	17.6	131,185	18.8
2008	5,791,766	1,419,019	12.1	317,940	15.7	132,731	17.1
2009	6,135,437	1,912,670	11.0	368,990	16.7	131,742	16.5
2010	7,312,159	1,598,139	8.9	478,156	12.4	241,993	12.4
2011	5,054,186	1,798,230	10.7	246,676	12.9	99,298	13.2
2012	3,106,616	1,255,216	8.7	288,813	11.5	105,530	11.9
2013	1,927,938	1,984,701	9.8	411,882	14.6	141,880	13.6
2014	2,629,908	2,713,787	11.7	541,657	13.3	227,949	14.6
2015	1,819,070	2,477,625	10.4	471,869	12.3	190,808	13
2016	2,092,135	2,147,160	14.6	368,203	19.7	141,571	21.7

The percent standard error (PSE) represents the standard error of the harvest estimate as a percentage.

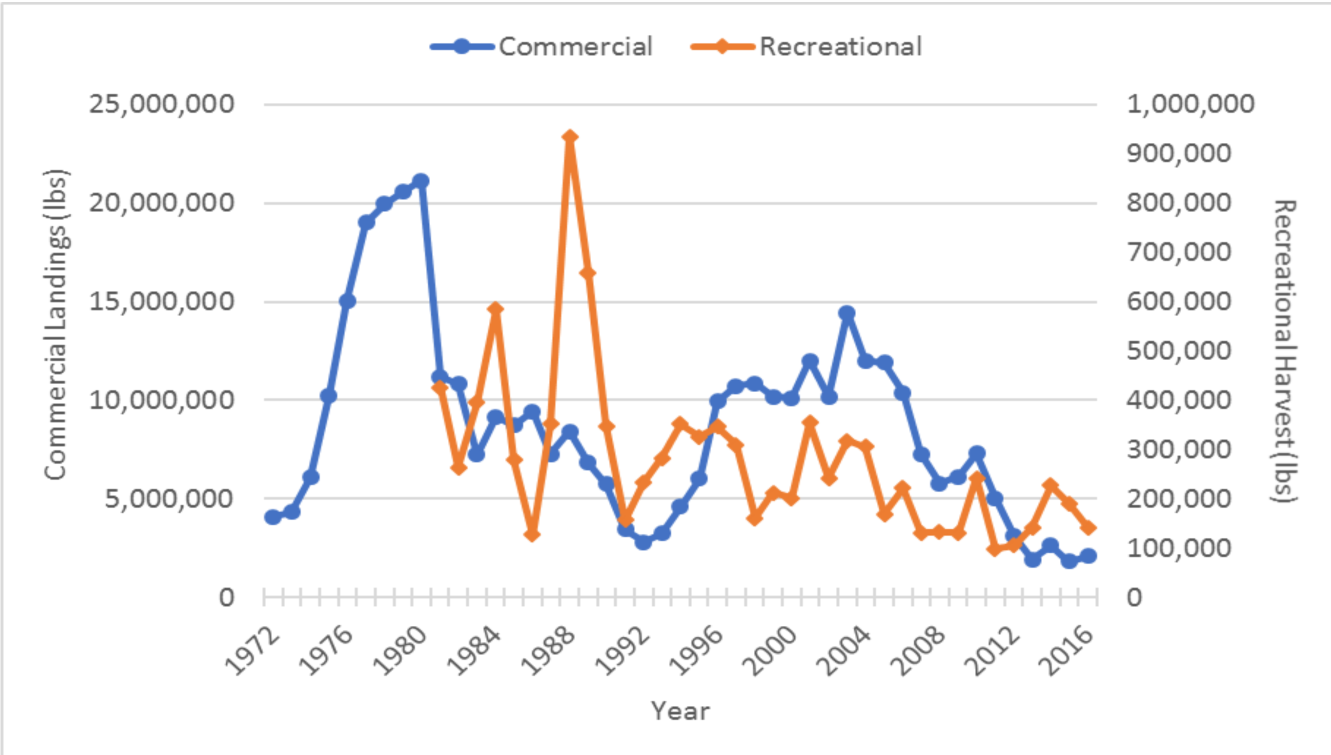

Figure 3.5. Annual commercial and recreational landings (pounds) of Atlantic Croaker in North Carolina, 1972–2016. (Source: NCTTP; MRIP)

Table 3.6. Mean, minimum, and maximum lengths (total length, millimeters) of Atlantic Croaker sampled from the commercial and recreational fisheries of North Carolina, 2007–2016. (Source: NCDMF)

	Commercial				Recreational			
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2007	207	152	306	12,445	201	103	348	113
2008	209	105	337	9,384	244	141	392	188
2009	208	111	298	8,546	224	145	402	210
2010	209	155	294	7,047	248	157	427	330
2011	211	116	334	8,432	239	148	363	255
2012	206	165	300	4,278	233	124	358	230
2013	213	119	339	4,626	229	151	392	267
2014	208	161	334	6,412	236	105	357	215
2015	208	162	324	4,476	237	147	352	142
2016	202	125	325	1,541	235	135	319	219

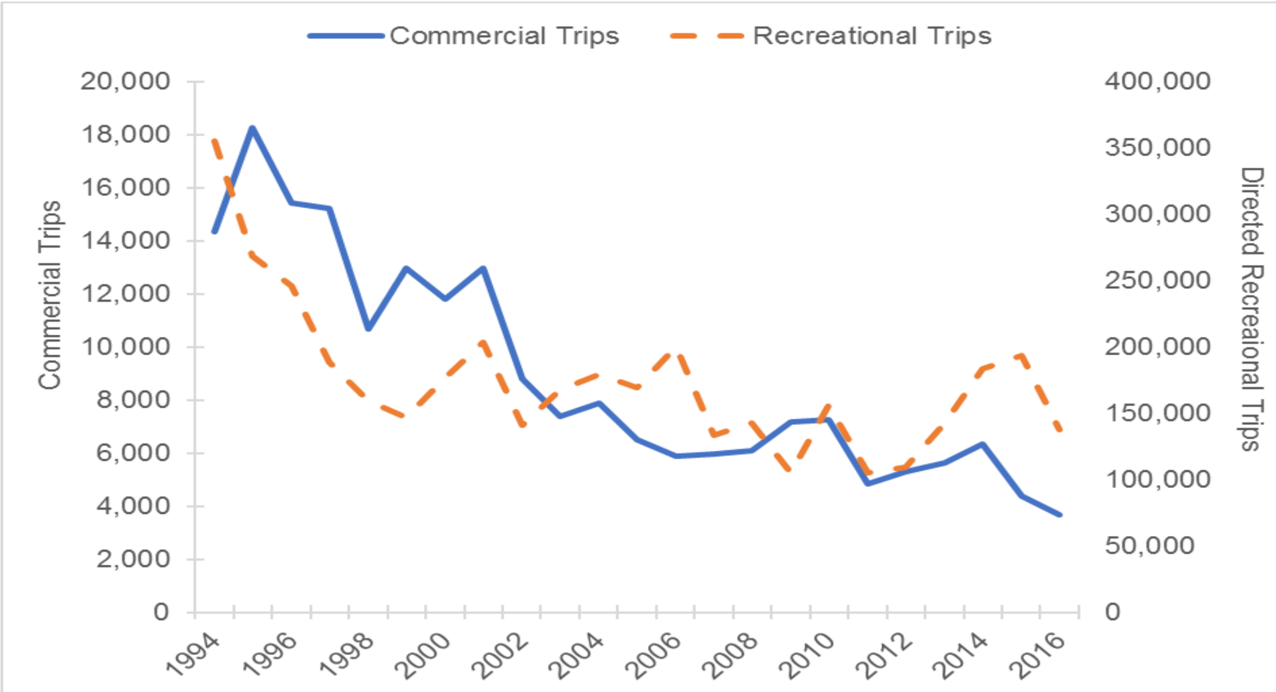

Figure 3.6. Number of trips reporting commercial landings of Atlantic Croaker and the number of directed recreational Atlantic Croaker trips, 1994–2016. (Source: MRIP) NOTE: Directed recreational trips are defined as trips where the angler specified Atlantic Croaker as the target of the trip or where Atlantic Croaker was harvested.

Exhibit B to the Petition raises concern over the decline of the commercial and recreational fisheries for Atlantic Croaker in the South Atlantic (NCWF 2016a). A northward shift of the Atlantic Croaker population that has been occurring since at least the 1970s may help partially explain the decline in landings from the Southeast (Hare and Able 2007; Nye et al. 2009), with some models predicting the center of the Atlantic Croaker population to shift northward by 50–100 km (Hare et al. 2010).

Addendum II to Amendment I to the Interstate FMP for Atlantic Croaker established the TLA to monitor trends in the Atlantic Croaker fishery in years between stock assessments (ASMFC 2014b). Annually, harvest and adult abundance indices are analyzed. If both indices exceed established thresholds for three consecutive years, management actions are triggered. The extent of management action is determined based on whether a 30% or 60% threshold has been exceeded.

The TLA for Atlantic Croaker has recently been updated with data through 2016 (ASMFC 2017c). The harvest index was above the 30% threshold in 2013–2016. While the negative trend in the harvest index is due in part to declining recreational landings, the decline is largely the result of significant declines in commercial landings. From 1997 through 2010, the harvest index indicated a largely positive trend, and the harvest index did not begin to approach the 30% threshold until 2011. The adult abundance index (age-1+) was not above the 30% threshold from 2011–2016, and there was no portion red in 2015 and 2016. Since 2004, the proportion red in the index has been low, only exceeding the 30% threshold in 2008 indicating high abundance of adult Atlantic Croaker. The juvenile abundance index (age-0) was not above the 30% threshold in 2015 or 2016. High variability in the juvenile index in comparison to the adult index is likely the result of variability in recruitment rather than population trends. Management triggers have not been tripped because the indices in both population characteristics (harvest and abundance) were not above the 30% threshold for the 2014–2016 time period.

As mentioned previously, the 2017 Atlantic Croaker stock assessment was not endorsed for management use by a panel of independent fisheries scientists, though they did agree that immediate management actions were not necessary and that the TLA should continue to be used to monitor the stock (ASMFC 2017d). The panel also stated, “despite uncertainty in the assessment model results and an inability to confidently determine stock status, trends in landings and indices do not indicate immediate cause for concern, and therefore do not call for a subsequent new stock assessment in the short-term.”

The conclusions of the panel were ultimately supported by the South Atlantic Board at its May 2017 meeting (ASMFC 2017f). The main cause of uncertainty in both the Spot and Atlantic Croaker assessments was the disagreement in harvest trends and abundance trends. Atlantic Croaker abundance, as indicated by fisheries independent surveys, indicates increasing abundance; whereas, harvest from directed commercial and recreational fisheries has generally been declining. This trend has also been observed in the annual TLA. Though the assessment did not pass peer review and will not be used for management, elements of the data, particularly commercial and recreational removals and dead discards from shrimp trawls, can still be informative. The following is a description of coastwide trends in removals from the 2017 assessment. From 1989–2014, total annual coastwide removals (landings and discards) ranged from 101,132 to 519,449 metric tons and have been relatively stable ranging from 125,00 to 225,000 metric tons since the peak in 1991 (ASMFC 2017d). The stability in removals coincides with initial BRD requirements for North Carolina shrimp trawl fisheries initiated in 1992. North Carolina’s BRD requirement was adopted before the device became federally required in 1997 and 1998 (50 CFR 622). Coastwide discards in the shrimp trawl fishery ranged from 82,040 to 513,801 metric tons. Shrimp trawl discards account for most of the removals (ranging from 81–99%).

3.4 Weakfish

Weakfish are currently managed under Addendum IV to Amendment 4 of the ASMFC Weakfish FMP and requires all the Atlantic states to implement a one fish per person bag limit, a 100-pound commercial bycatch trip limit, and a 100-fish undersized trip limit allowance for the trawl fishery (ASMFC 2009b). The Weakfish Technical Committee (TC) noted that there is no long-term stable equilibrium population of Weakfish due to time varying natural mortality, so they recommended managing the stock based off *Z*-based (total mortality) targets and thresholds of 20% and 30% (ASMFC 2016a). Because the total mortality of the stock in the terminal year of the assessment (2014) was below the *Z* threshold, the TC recommended and the board approved no new management measures at this time.

Commercial landings of Weakfish peaked in 1980 at 20,343,952 pounds (Figure 3.7). Landings have since steadily dropped and reached their lowest point in 2011 (65,897 pounds; Table 3.7). Recent years have shown little increase, due to low abundance and commercial harvest restrictions. Total commercial landings for 2016 were 79,640 pounds. The ocean sink net fishery and estuarine gill net fishery dominate the catches of Weakfish, accounting for 93% of the overall commercial catch. The pound net fishery and the historically dominant long-haul seine fishery account for about 5% of the remaining commercial harvest with various gears including trawls, crab pots, and rod-n-reels making up the rest. Addendum IV to Amendment 4 to the Weakfish FMP reduced commercial harvest to 100 pounds per trip, achieving an estimated reduction of 61% from the 2005–2008 harvest levels (ASMFC 2009b).

Recreational harvest has been variable since 1989 with a peak in 1987 at 710,009 pounds (Figure 3.7). Harvest since 2009 has been considerably low due to the implementation of a one-fish bag limit in

November 2009 as part of the harvest reductions from Addendum IV, which was estimated to reduce recreational harvest by 53% for North Carolina (ASMFC 2009b). Average harvest since 2010 is 34,375 pounds and has varied from a high of 46,081 pounds in 2012 to a low of 17,621 pounds in 2011 (Table 3.7). Recreational harvest in 2016 was 34,860 pounds, near the time series average for the period of 2010–2016 (Table 3.7). A total of seven recreational citations were issued for Weakfish in 2016, 3.5 times higher than in 2015. Commercial and recreational trips for Weakfish have been declining over time even though recreational trips were high from 2004–2006 (Figure 3.8).

Minimum and average lengths of fish harvested in the commercial fishery have remained consistent over the last 10 years (Table 3.8). As with Atlantic Croaker, mean lengths of Weakfish sampled from the recreational fishery are larger than the average lengths from the commercial fishery (Table 3.8). Minimum and maximum lengths of Weakfish have varied over time with no trend.

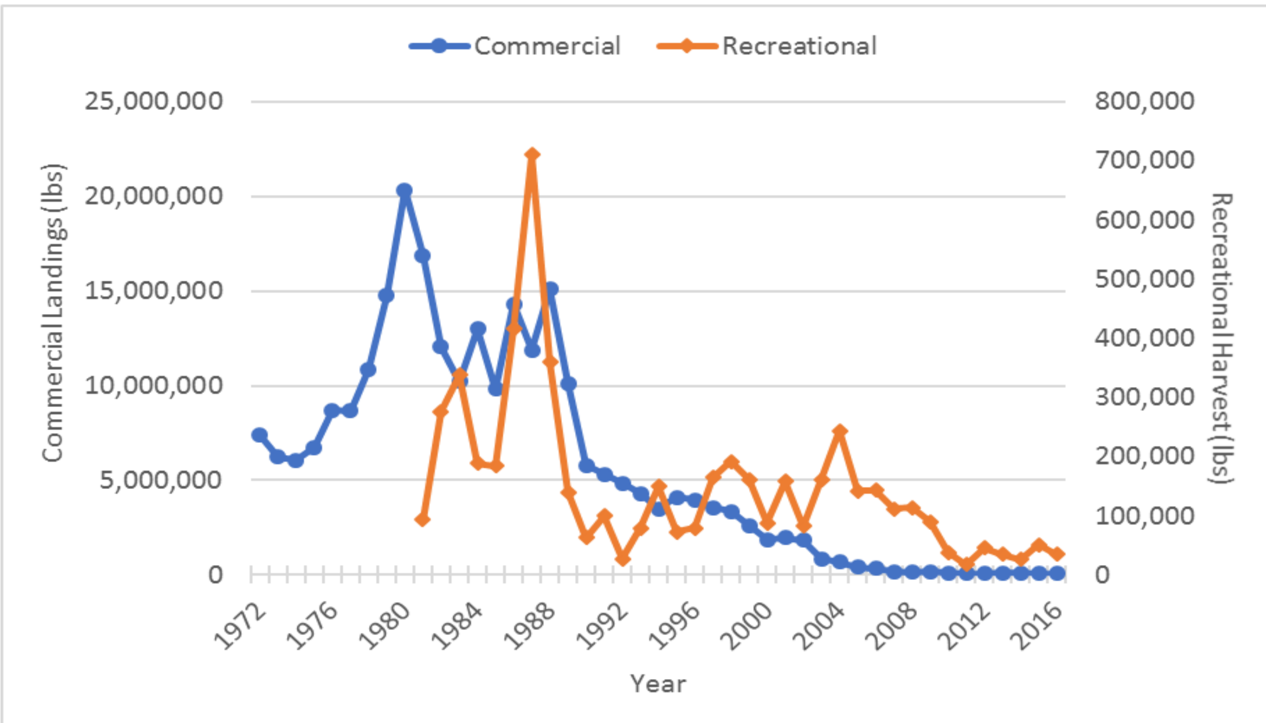

Figure 3.7. Annual commercial and recreational landings (pounds) of Atlantic Croaker in North Carolina, 1972–2016. (Source: NCTTP; MRIP)

Table 3.7. Recreational harvest (number of fish released and weight) and releases (number of fish) and commercial harvest (weight in pounds) of Weakfish from North Carolina, 2007–2016. (Source: NCTTP; MRIP)

	Commercial	Recreational					
		Number of fish				Weight (pounds)	
Year	Landings (pounds)	Released	PSE	Harvested	PSE	Harvested	PSE
2007	175,589	226,601	25.4	94,398	19.8	111,754	22.3
2008	162,516	195,776	28.4	108,389	24.5	114,192	27.4
2009	163,146	220,121	37.3	68,553	24.9	89,652	34.6
2010	106,328	225,246	27.3	41,598	15.0	38,721	15.4
2011	65,897	111,574	27.7	13,464	24.8	17,621	25.0
2012	91,383	173,843	18.5	40,299	17.4	46,081	22.6
2013	120,188	111,524	20.1	33,851	28.1	34,731	26.6
2014	105,115	281,335	21.4	26,308	17.6	25,957	17.7
2015	80,235	520,782	29.8	39,842	24.6	50,903	26.2
2016	79,640	423,482	33.7	33,585	21.9	34,860	21.0

The percent standard error (PSE) represents the standard error of the harvest estimate as a percentage.

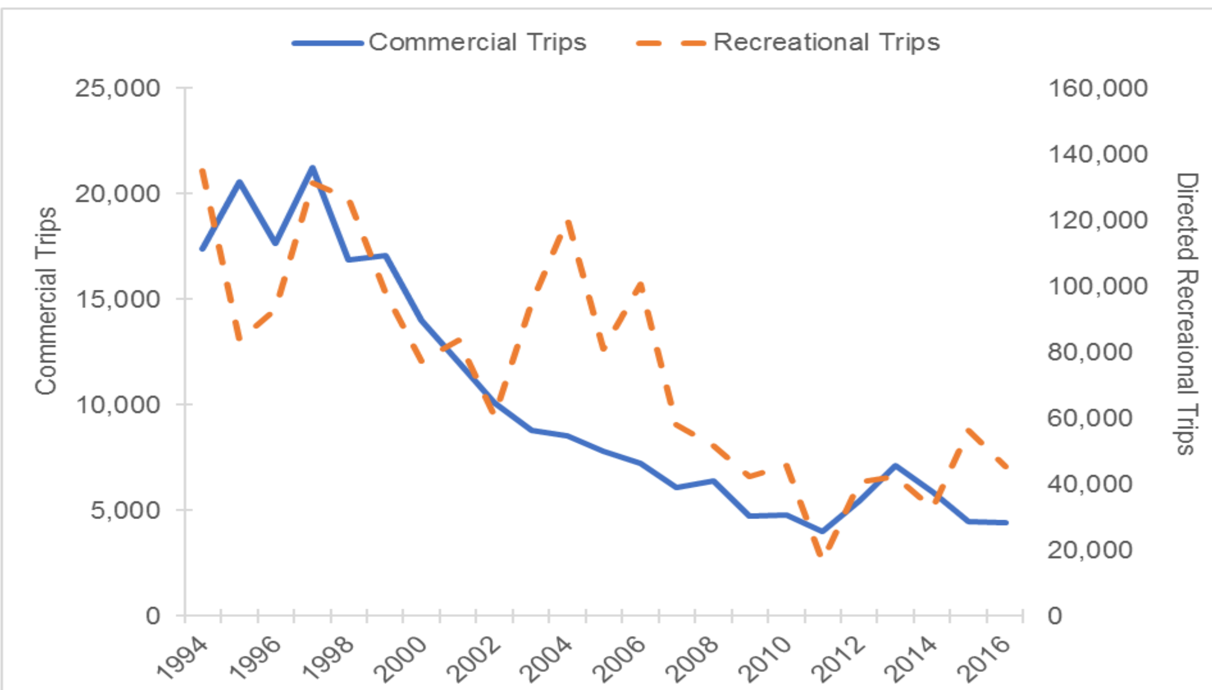

Figure 3.8. Number of trips reporting commercial landings of Weakfish and the number of directed recreational Weakfish trips, 1994–2016. (Source: NCTTP; MRIP) NOTE: Directed recreational trips are defined as trips where the angler specified Weakfish as the target of the trip or where Weakfish was harvested.

Table 3.8. Mean, minimum, and maximum lengths (total length, millimeters) of Weakfish sampled from the commercial and recreational fisheries of North Carolina, 2007–2016. (Source: NCDMF)

	Commercial				Recreational			
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2007	324	121	662	4,569	369	267	525	76
2008	322	127	668	3,185	355	297	519	145
2009	333	160	857	2,631	383	247	555	132
2010	322	130	880	2,074	345	235	440	96
2011	333	97	637	1,701	375	294	780	41
2012	350	127	591	2,623	367	259	529	81
2013	360	202	718	3,323	356	192	580	74
2014	358	127	620	3,322	352	277	515	71
2015	356	137	704	2,371	373	311	482	34
2016	359	220	600	2,588	353	261	457	76

Exhibit E of the Petition uses Weakfish as an example of a collapsed fishery due to overfishing and loss of spawning potential, but also states the scientific evidence to validate this point is lacking (NCWF 2016a). There is no doubt that fishing mortality contributed to the decline of Weakfish stocks in the Mid-Atlantic, but it remains unclear if the relative contribution of dead discards from the shrimp trawl fishery are affecting the recovery of the stock. The most recent ASMFC stock assessment reviewed numerous juvenile and adult abundance indices and noted that the stock-recruit relationship for Weakfish was weak because young-of-year indices did not show the same decline in abundance as the adult indices (ASMFC 2016a).

Exhibit B makes the argument for growth overfishing of Weakfish based on the truncated age structure seen in the recreational harvest of the species and implies that this is due to high mortality of age-0 and age-1 fish from bycatch in the shrimp trawl fishery (NCWF 2016a). The observed decline in harvest of fish age-1 and older in the recreational fishery is more likely due to increased natural mortality on these fish rather than failed recruitment to the fishery (ASMFC 2016b; Figure 3.9). The stock assessment noted that Weakfish recruitment trends throughout the Atlantic Coast did not show the same declining trend as adult abundance (ASMFC 2016a; Figures 3.10 and 3.11), suggesting that the observed decline in adults is not impacting, at least not substantially, recruitment of Weakfish; that is, the mortality on the age-0 fish (recruits) at current levels is independent of the adult stock size. The recent (2016) peer reviewed ASMFC assessment of the Weakfish stock concluded that the stock is depleted, but overfishing is not occurring (ASMFC 2016a). The stock has experienced some dramatic declines over the previous decades, largely attributed to overfishing and increasing natural mortality. The recent emergence of a Weakfish bottleneck at age 0 is thought to be largely due to enhanced predation by Striped Bass and Spiny Dogfish, rather than a surge in unreported landings and discards. However, empirical evidence for the increase in natural mortality due to predation is inconclusive and further work on this topic is needed.

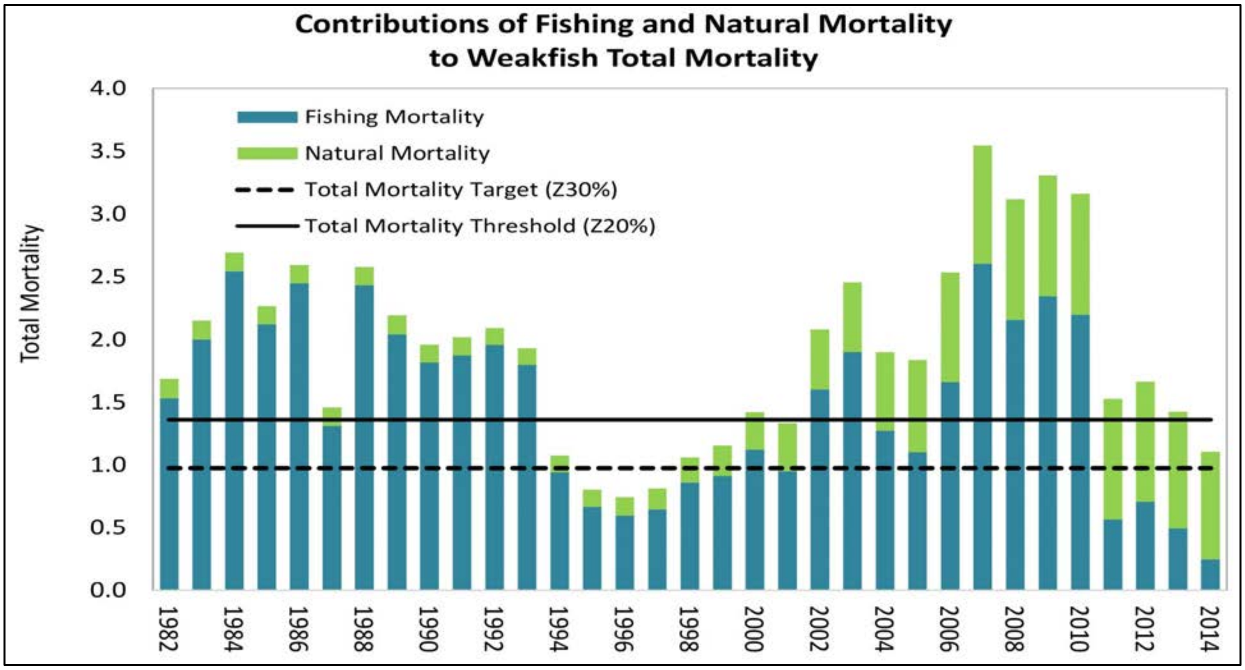

Figure 3.9. Fishing (F) and natural (M) mortality estimated from the 2016 Weakfish stock assessment, by year, 1982 – 2014. Total mortality (*Z*) overfishing target of 30% (dashed line) and threshold of 20% (solid line). (Source: ASMFC 2016b)

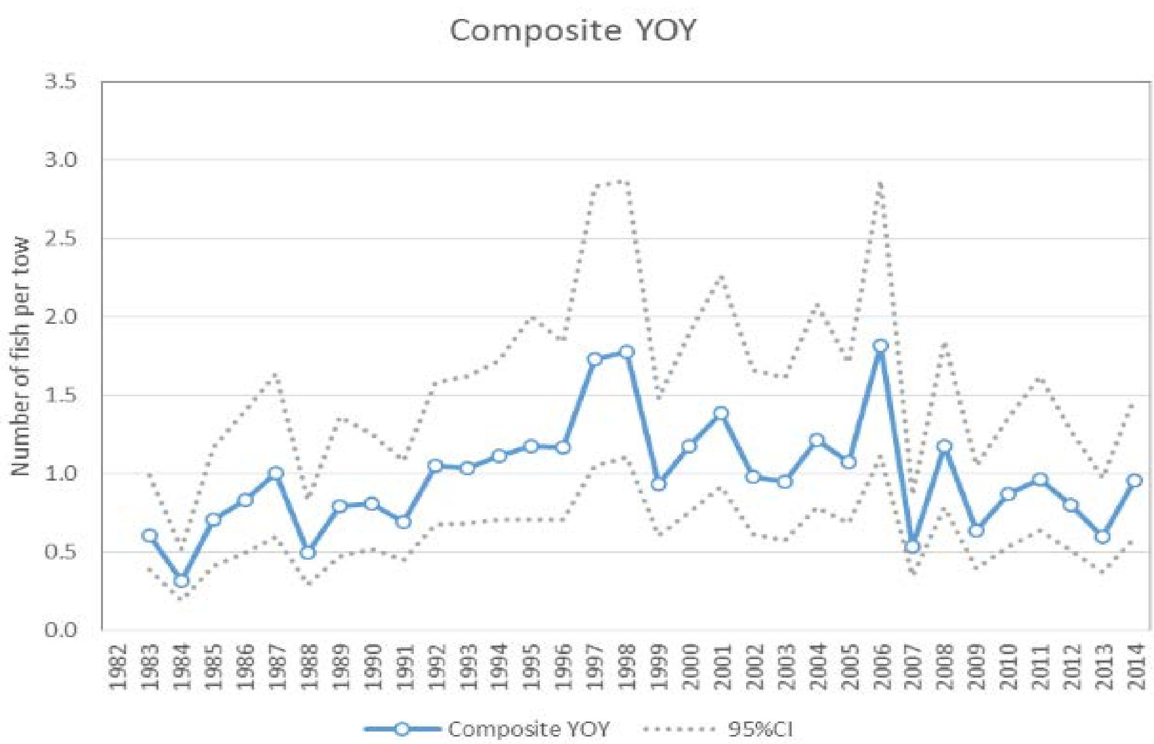

Figure 3.10. Composite of Atlantic States young-of-year index with 95% confidence intervals, 1993–2014. (Source: ASMFC 2016a)

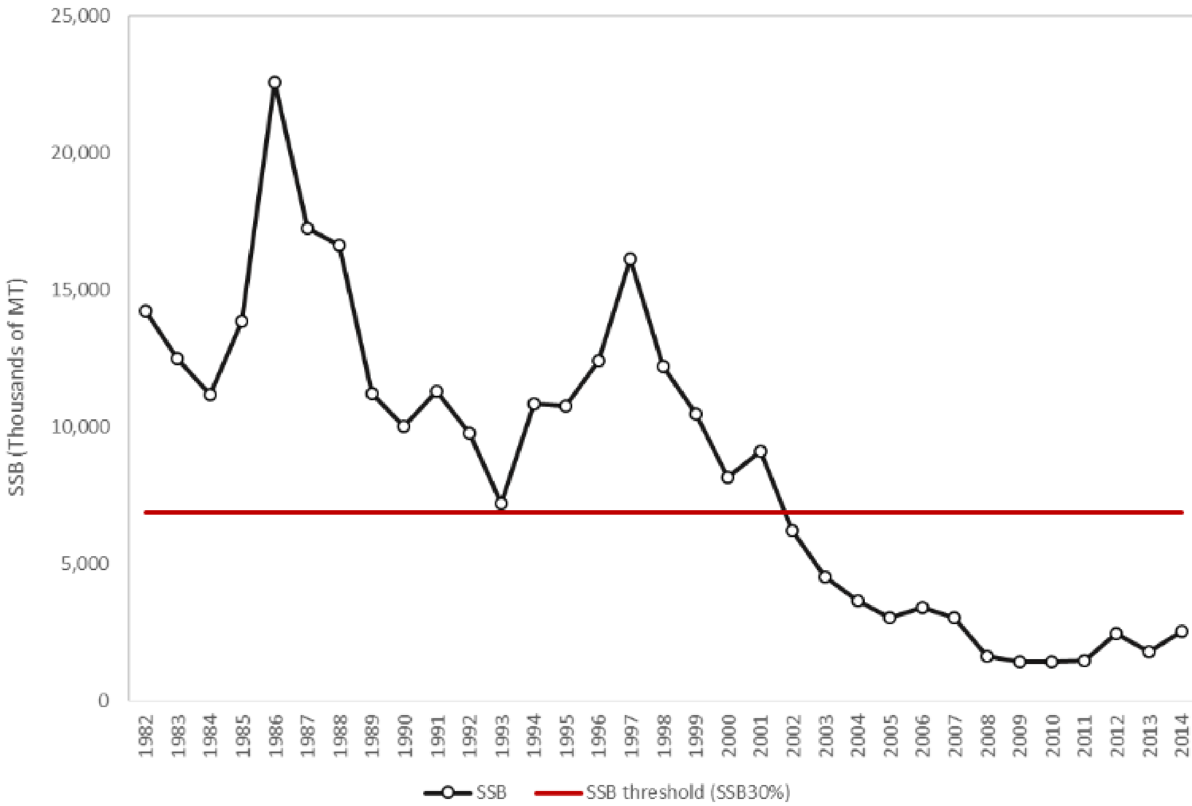

Figure 3.11. Spawning stock biomass (SSB) and the SSB threshold of 30% un-fished stock estimated from the 2016 Weakfish stock assessment. (Source: ASMFC 2016a)

3.5 Bycatch Management

NCDMF and NOAA Fisheries (formerly known as NMFS) have conducted bycatch reduction studies to develop methods and management options to reduce bycatch since the early 1980s. These studies have investigated the use of minimum tailbag mesh sizes, BRDs, and TEDs as a means of reducing finfish bycatch. See section 6.3.7 of the 2015 Shrimp FMP Amendment 1 for a full description of these studies as well as the various management strategies used to reduce bycatch in North Carolina (NCDMF 2015a). The below sections describe bycatch data available for shrimp, Spot, and Atlantic Croaker. The recent stock assessment for Weakfish did not evaluate the impact of bycatch on the resource (ASMFC 2016a).

3.5.1 <u>Shrimp</u>

In 1992, North Carolina became the first state to require a BRD in shrimp trawls and did so prior to implementation of federal BRD regulations. The 2015 N.C. Shrimp FMP Amendment 1 adopted the requirement of either a T-90 panel/square mesh tailbag or other applications of square mesh panels (e.g., skylight panel), reduced bar spacing in a TED, or another federal or state certified BRD, in addition to existing TED and BRD requirements in all skimmer and otter trawls. This was accomplished by proclamation in 2015 (SH-2-2015) and implemented the requirement of a second BRD, but allows flexibility for fishermen to select from a wide variety of state and federally-certified BRDs appropriate for the fishing situation. This also made North Carolina the first state to require two BRDs in shrimp trawls. Based on characterization data and anecdotal reports from fishermen, most have selected the reduced bar spaced TED or a second fisheye. Based on anecdotal information from fishermen and NCDMF observations, this second BRD appears to be having noticeable positive effects on bycatch reduction (K. Brown, NCDMF, personal communication). However, other factors may be contributing to this reduction in bycatch, including higher concentrations of shrimp.

In 2011, the North Carolina General Assembly made several changes to the Administrative Procedure Act (G.S. 150B) via Session Law 2011-398, the Regulatory Reform Act of 2011. One of these changes was to add a new section entitled "Limitation on Certain Environmental Rules" (G.S. 150B-19.3). This statute prohibits an agency from adopting "a rule for the protection of the environment or natural resources that imposes a more restrictive standard, limitation, or requirement than those imposed by federal law or rule, if a federal law or rule pertaining to the same subject matter has been adopted" with only narrow exceptions provided. The MFC is specifically named in the statute as such an agency. In the Federal Code of Regulations, 50 CFR 622.207 specifically requires the use of a single BRD on a shrimp trawler in the South Atlantic Exclusive Economic Zone (3–200 miles from shore) for each net that is rigged for fishing, with only narrow exceptions provided. Currently, the requirement in North Carolina for fishermen to use a second BRD is implemented by existing proclamation authority via MFC rule 15A NCAC 03J .0104, Trawl Nets. The MFC was not required to adopt a rule to implement this management strategy from the Shrimp FMP Amendment 1. The addition of a second BRD in rule as a result of the Petitioned rules would not impact the current level of bycatch since this requirement has already been implemented by proclamation.

In 2015, in accordance with Amendment 1 to the Shrimp FMP, a Shrimp Bycatch Reduction Industry Work Group was convened, comprised of fishermen, net manufacturers, gear specialists, and scientists from NCDMF, NOAA Fisheries, and N.C. Sea Grant. The group was tasked to develop different gear configurations to reduce bycatch to the extent practicable, with a 40% target reduction. During 2015–2017, a series of gear comparisons were made using modified shrimp trawls in Pamlico Sound and the Atlantic Ocean to determine methods of reducing bycatch, while maintaining acceptable shrimp harvest (Brown et al. 2017, 2018). Twelve experimental otter trawl configurations were tested against a control net consisting of a federally-certified TED with 4-inch bar spacing, one state fisheye BRD, and a 1 ½-inch stretch mesh tail bag (current industry standard). Paired t-tests and a randomization test were used to determine whether the catches between the control and experimental nets were significantly different for each catch category (shrimp and bycatch species). The randomization test does not require the data to be normally distributed and does not require tows to be dropped from the analysis.

Four of the 12 gears tested met or exceeded the 40% target reduction in finfish bycatch while minimizing shrimp loss (Tables 3.9 and 3.10). Tows made with a 4-inch TED, double federal fisheyes, and 1 3/4-inch tailbag significantly reduced finfish bycatch from 54.0% (randomization test) to 57.2% (t-test) and had the greatest reduction in finfish bycatch of all the gear combinations tested by the work group. Tows made with a 3-inch TED, double federal fisheyes, and 1 3/4-inch tailbag gears yielded the second highest reduction of the gear combinations tested, reducing finfish bycatch by 44.9% (t-test and randomization test). Finfish bycatch reductions were slightly lower in the fall for the gear combination of one state fisheye, the Virgil Potter BRD, and 1 3/4-inch tailbag. Finfish bycatch reductions ranged from 43.2% (t-test) to 44.3% (randomization test). T-test results indicated the mean weight of shrimp was significantly reduced by 5.5% for this gear combination. The double federal fisheye, 4-inch TED and 1 7/8-inch tailbag gear combination was found to significantly reduce finfish bycatch by 40.8% based on the t-test results. Randomization test results also found that finfish bycatch was reduced by 40.6% for this gear. It is important to note the reductions in bycatch achieved by the industry work group testing are in addition to the 30% reduction in finfish mandated by the federal BRD certification process; therefore, gear combinations that met the MFC’s 40% finfish bycatch reduction target achieved nearly twice the federal requirement for reducing bycatch. For a detailed description of the sampling methodology, gear parameters, and full data analysis, see Brown et al. (2017, 2018).

At its May 2018 business meeting, the MFC voted to require fishermen to use one of four gear combinations tested by the workgroup that achieved at least 40% finfish bycatch. The new gear configurations will be required in all shrimp trawls, except skimmer trawls, used in inside waters where greater than 90-foot headrope length is allowed (Pamlico Sound and portions of Core Sound, Pamlico River and Neuse River) and will be effective July 1, 2019. The commission also voted to continue the shrimp industry workgroup and explore funding options for more studies, to survey fishermen to determine what bycatch reduction devices the shrimp trawl industry currently uses, and to begin development of Amendment 2 to the Shrimp Fishery Management Plan. The information paper titled “Shrimp Fishery Management Plan (FMP) Amendment 1: Consideration of Gear Modifications to Reduce Bycatch in the North Carolina Shrimp Trawl Fishery” will serve as a Revision to Amendment 1 to the North Carolina Shrimp Fishery Management Plan and will document the management strategy changes and rationale. All other management strategies contained in Amendment 1 will remain in place until another Revision, Supplement, or Amendment to the N.C. Shrimp FMP is adopted.

The amount of finfish bycatch reduced from these new required gear configurations represents all finfish species and may not have equal effects on the species addressed by the Petition. The regulations to be implemented in July 2019 will reduce bycatch independently from the proposed rules and may affect the baseline landings and harvest numbers of shrimp as well as those species that are typically caught as bycatch such as Atlantic Croaker, Spot, and Weakfish. The extent of the effect will be dependent upon compliance to the new regulations and the difference between an individual fisherman’s current gear and the new gear requirements.

Table 3.9. Results from the paired t-test of the four experimental gears tested that met or exceeded the MFC 40% target reduction in finfish bycatch. Mean weight of catch data reported in kg. Values in bold indicate significant p-values (alpha = 0.05). (Source: Brown et al. 2017, 2018)

Season / Waterbody	Vessel size (ft)	Gear	Tailbag (in)	TED (in)	Species group	N	Control Mean	Exp. Mean	T-test % Change	T-test p-value
Summer / Pamlico Sd.	88	Double federal fisheye	1 7/8	4	Finfish	25	90.0	53.3	-40.8	**< 0.001**
					Shrimp	25	61.3	61.9	1.0	0.778
Summer / Pamlico Sd.	75	Double federal fisheye	1 3/4	4	Finfish	6	201.5	86.3	-57.2	**0.001**
					Shrimp	6	23.0	20.2	-12.1	0.215
					Invert.	6	7.2	6.1	-15.7	0.081
					Shark	6	1.8	2.6	45.8	0.509
Summer / Pamlico Sd.	75	Double federal fisheye	1 3/4	3	Finfish	30	115.4	63.6	-44.9	**< 0.001**
					Shrimp	30	27.0	25.7	-4.9	0.435
					Invert.	30	2.1	1.8	-13.3	0.418
					Shark	27	1.8	1.4	-18.6	0.404
Fall / Pamlico Sd.	68	Single state fisheye, Virgil Potter BRD	1 3/4	4	Finfish	20	189.0	107	-43.2	**< 0.001**
					Shrimp	20	33.1	31.3	-5.5	0.055
					Invert.	25	0.0	0.0	n/a	n/a
					Shark	25	0.0	0.1	n/a	n/a

*See Brown et al. (2017, 2018) for the results of gear combinations that did not meet the target reduction.

Table 3.10. Results from the randomization test of the four experimental gears tested that met or exceeded the MFC 40% target reduction in finfish bycatch. Mean weight of catch data reported in kg. Values in bold indicate significant p-values (alpha = 0.05). (Source: Brown et al. 2017, 2018)

Season / Waterbody	Vessel size (ft)	Gear	Tailbag (in)	TED (in)	Species group	N	Control Mean	Exp. Mean	T-test % Change	T-test p-value
Summer / Pamlico Sd.	88	Double federal fisheye	1 7/8	4	Finfish	32	88.3	52.9	-40.1	< **0.001**
					Shrimp	32	60.6	61.9	2.2	0.862
Summer / Pamlico Sd.	75	Double federal fisheye	1 3/4	4	Finfish	23	164.5	75.6	-54	< **0.001**
					Shrimp	23	28.1	23.6	-16.2	0.28
					Invert.	23	5.4	5.1	-4.9	0.833
					Shark	23	2.1	2.5	18.8	0.573
Summer / Pamlico Sd.	75	Double federal fisheye	1 3/4	3	Finfish	30	115.4	63.6	-44.9	**0.007**
					Shrimp	30	27.0	25.7	-4.9	0.706
					Invert.	30	2.1	1.8	-13.3	0.601
					Shark	30	1.6	1.3	-18.6	0.568
Fall / Pamlico Sd.	68	Single state fisheye, Virgil Potter BRD	1 3/4	4	Finfish	25	172.3	96.1	-44.3	**0.001**
					Shrimp	25	31.3	29.5	-5.8	0.691
					Invert.	25	0.0	0.0	n/a	n/a
					Shark	25	0.0	0.0	n/a	n/a

*See Brown et al. (2017, 2018) for the results of gear combinations that did not meet the target reduction.

3.5.2 Spot

In North Carolina, Spot discards from shrimp trawls ranged from 945 million fish in 1991 to 6.1 million fish in 1997 (Figure 3.12; J. Kipp, ASMFC, personal communication). Discards have declined significantly since 1991 (both inshore and offshore), with a few small peaks throughout the time period and a slight increasing trend since 2012 (Figure 3.12). Generally, shrimp trawl effort in North Carolina has been declining since at least the mid-1990s (ASMFC 2017a). Methods to estimate discards of Spot from the South Atlantic shrimp trawl fishery were similar to those used by Walter and Isley (2014) in a peer approved SEDAR for estimating King Mackerel bycatch in the shrimp trawl fishery (J. Kipp, ASMFC, personal communication).

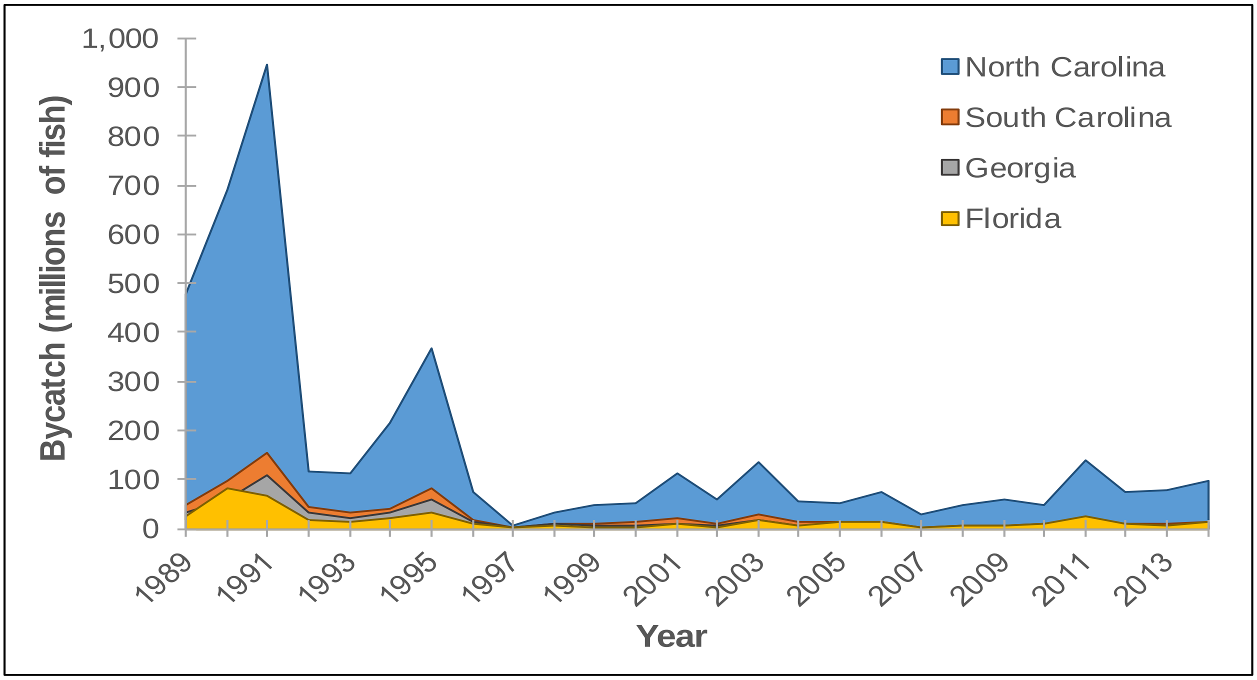

Figure 3.12. Annual estimates of Spot bycatch in the south Atlantic shrimp trawl fishery by state, 1989–2014. (Source: J. Kipp, ASMFC, personal communication)

3.5.3 Atlantic Croaker

In North Carolina, Atlantic Croaker discards from shrimp trawls ranged from 2.8 billion fish in 1991 to 195 million fish in 2005 (Figure 3.13; J. Kipp, ASMFC, personal communication). Discards have declined significantly since 1991 (both inshore and offshore), but have increased slightly since 2009 (Figure 3.13; ASMFC 2017d). Generally, shrimp trawl effort in North Carolina has been declining since at least the mid-1990s (NCDMF 2015a). Methods to estimate discards of Atlantic Croaker from the South Atlantic shrimp trawl fishery were similar to those used by Walter and Isley (2014) in a peer approved SEDAR for estimating King Mackerel bycatch in the shrimp trawl fishery (J. Kipp, ASMFC, personal communication).

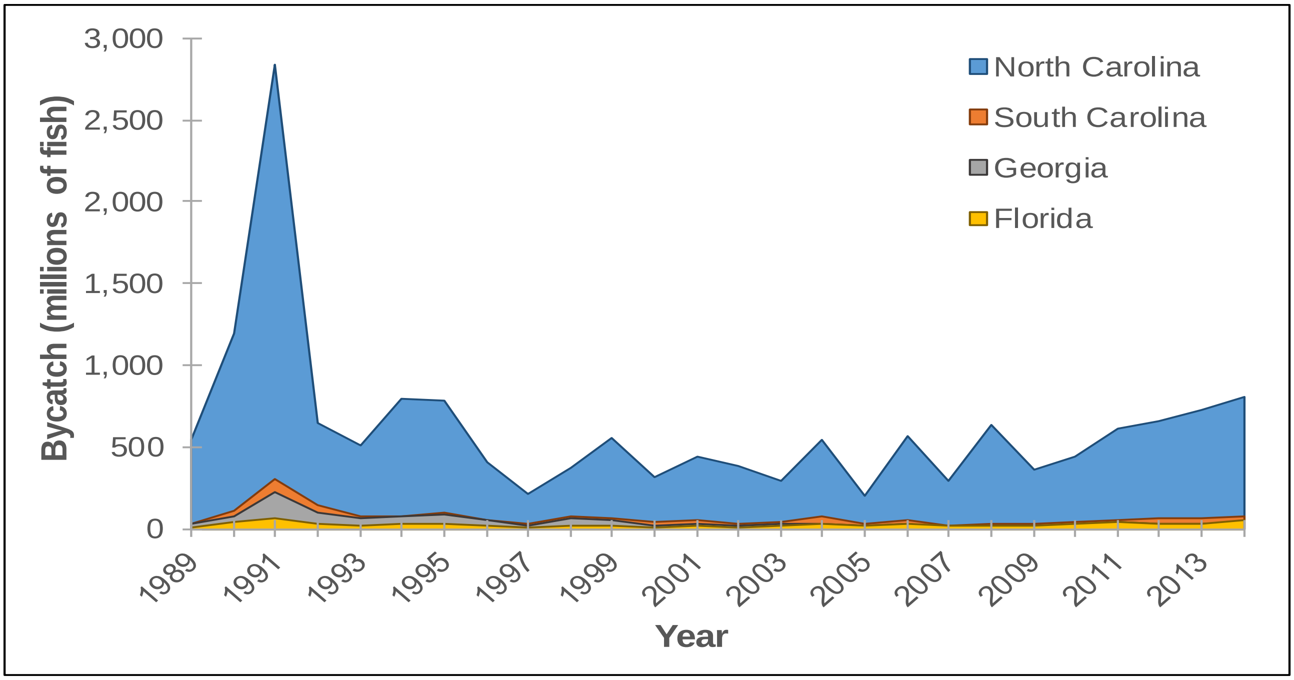

Figure 3.13. Annual estimates of Atlantic Croaker bycatch in the south Atlantic shrimp trawl fishery by state, 1989–2014. (Source: J. Kipp, ASMFC, personal communication)

3.6 Commercial Value

The U.S. exports the majority of its domestic catch, and then imports seafood to satisfy domestic demand. Stronger demand and more restricted supply make prices from exporting more profitable for U.S. fishing operators than selling domestic products (Newsome 2014). U.S. exports of edible fishery products of domestic origin in 2015 were 1,378,364 tons valued at $5.2 billion, a decrease of 113,114 tons (7.6%) and $134.9 million (2.5%) from 2014 (NOAA 2015). The volume of shrimp imported in 2015 was 585,826 tons, an increase of 18,153 tons (3.2%), from the quantity imported in 2014. Shrimp imports were valued at $5.4 billion, a decrease of $1.2 billion (18.6%) from 2014. Shrimp imports accounted for 29% of the value of total edible imports.

In 2013, the North Carolina Rural Economic Development Center conducted interview surveys of North Carolina fishermen and fish house operators (NCREDC 2013). They found that one of the main underlying issues in the supply chain is that many independent fish houses only have ice and refrigeration units for freshly caught seafood. They note that the shelf life of unfrozen seafood is generally less than a week, based on certain post-harvest handling practices. Product must be moved quickly into distribution before it spoils, and this results in fishermen and fish house owners carrying exclusively North Carolina seafood to sell even when demand is low and supplies are high.

One way to look at the effect a business, industry, or event has on a specified area is through economic impact modeling. Typically, an economic impact model examines the effect of an event on the economy through measuring changes in business revenue, business profits, personal wages, and jobs. The total industry output is the compilation of direct impacts, indirect impacts, and induced impacts generated in the economy as a result of the industry. Direct impacts include all direct effects the organization has on the region due to the organization's production operations. These include direct employment, business spending, and employee spending. Indirect impacts include the impact of local industries buying goods and services from other local industries. This spending from indirect impacts works its way backward through the supply chain until all the money is spent outside of the local economy. The induced impact is the response by an economy to an initial change (direct and indirect) that occurs through re-spending of income received by a component of the value-added impacts. In other words, higher incomes from direct and indirect effects induce further spending back into the local economy. "Sales refer to the gross value of all sales by regional businesses affected by an activity, such as commercial fishing. It includes both the direct sales of fish landed and sales made between businesses and households resulting from the original sale. Income includes personal income (wages and salaries) and proprietors' income (income from self-employment). Value-added is the contribution made to the gross domestic product in a region. Employment is specified on the basis of full-time and part-time jobs supported directly or indirectly by the sales of seafood or purchases of other goods and services related to commercial fishing. The first three types of measures are calculated in terms of dollars, whereas employment impacts are measured in terms of numbers of jobs. The United States seafood industry is defined here as the commercial fishing sector, seafood processors and dealers, importers, and seafood retailers" (NOAA 2017b).

The economic impact estimates presented below represent those of commercial seafood harvesters, dealers, wholesalers, and retailers in North Carolina and are calculated via the NCDMF commercial fishing economic impact model as updated in July 2017. These estimates are a product of IMPLAN economic impact modeling software customized with data from NCDMF and economic multipliers originating from the NOAA Fisheries Commercial Fishing and Seafood Industry Input/Output Model (NOAA 2015; IMPLAN 2013). Commercial landings data from the NCTTP are used as the primary input, as well as data from North Carolina commercial fishermen and seafood dealers collected through surveys that have been carried out by the NCDMF Fisheries Economics Program (Crosson 2007a, 2007b, 2009, 2010a; Hadley and Crosson 2010; Hadley and Wiegand 2014, Stemle and Wiegand 2017). Economic impact estimates for the commercial harvesting and seafood dealer sectors are derived from NCDMF data, while estimates for seafood wholesalers and retailers originate from multipliers found within the NOAA Fisheries model.

Total economic impact from commercial fishing has been on the rise in the past few years, although appears to be leveling off (Table 3.11; Figure 3.14). Income impacts have also been increasing in a similar trend to total economic impacts. While commercial participants have been declining as overall ex-vessel values rise, the number of job impacts has been increasing since a decline in 2011 (Table 3.11). Overall, North Carolina's percent contribution to the total economic impact of commercial fishing in the U.S. is relatively small. The economic impacts from commercial harvesters, seafood processors and dealers, importers, wholesalers and distributers, and retail contribute to less than 2% to the total jobs, sales, income, and value added to the entire U.S. (Table 3.12; NOAA 2015). The U.S. relies heavily on imported seafood to meet consumption demands. When imports are removed from the economic impacts, total jobs decrease by 70%, sales decrease by 178%, income is reduced by 109%, and total value added is reduced by 125%. North Carolina shows similar dependence on imported seafood when imports are removed from the economic impacts. Jobs are decreased by 71%, sales by 210%, income by 109%, and value added by 135% (Table 3.12).

Table 3.11. Economic Impacts of commercial fishing in North Carolina, all species. (Source: NCDMF Economics Program)

				Economic Impacts		
Year	Commercial Participants[1]	Pounds[1]	Ex-Vessel Value[1]	Jobs[2,3]	Income Impacts (thousands of dollars)[3]	Total Economic Impacts (thousands of dollars)[3,4]
2007	3,742	68,847,979	$82,284,625	7,508	$133,211	$320,728
2008	3,665	71,200,227	$86,809,853	7,597	$140,417	$338,662
2009	3,757	68,963,523	$77,196,361	7,022	$122,757	$297,558
2010	3,598	72,001,861	$79,865,263	7,094	$127,316	$307,322
2011	3,244	67,502,014	$71,184,083	6,373	$114,216	$275,867
2012	3,170	56,690,935	$72,571,121	6,405	$116,154	$281,369
2013	3,152	50,197,517	$79,105,058	6,795	$127,136	$303,982
2014	3,173	61,965,232	$94,105,047	7,360	$147,190	$351,513
2015	3,134	65,954,924	$94,284,106	7,728	$163,153	$389,173
2016	2,973	59,939,039	$94,049,856	7,410	$166,066	$388,325

[1]As reported by the NCDMF Trip Ticket Program
[2]Represents both full-time and part-time jobs
[3]Economic impacts calculated using the NCDMF commercial fishing economic impact model and IMPLAN economic impact modeling software. Economic impact estimates are for the state economy of North Carolina
[4]Represents sales impacts

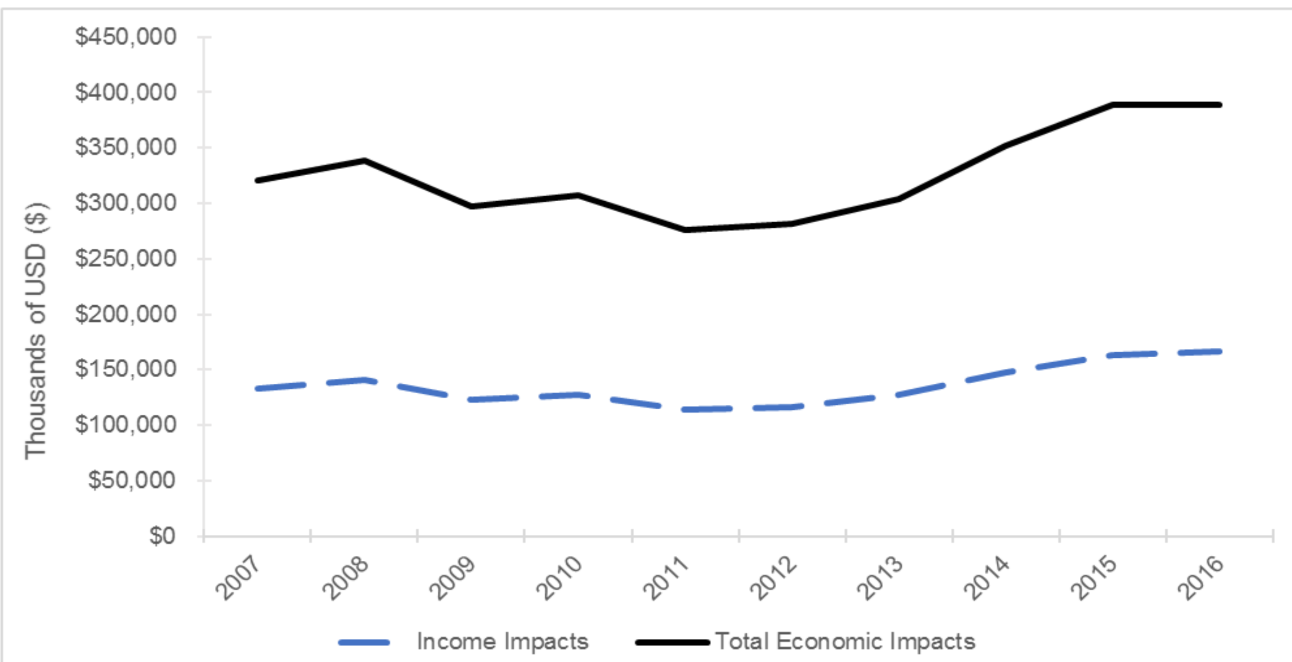

Figure 3.14. Total economic impact and income impacts of commercial fishing in North Carolina, 2007–2016. (Source: NCDMF Economics Program)

Table 3.12. Economic impacts of the commercial seafood industry (thousands of dollars) for the United States and North Carolina, 2015. (Source: NOAA 2017b).

	With Imports				No Imports			
All of U.S.	# Jobs	Sales	Income	Value Added	# Jobs	Sales	Income	Value Added
Total Impacts	1,179,848	144,194,119	39,743,521	60,565,501	695,794	51,905,330	18,997,595	26,958,135
Commercial Harvesters	164,047	13,894,494	4,617,433	7,190,601	164,047	13,894,494	4,617,433	7,190,601
Seafood Processors & Dealers	200,919	30,922,511	9,758,943	13,566,022	52,972	8,152,699	2,572,939	3,576,672
Importers	188,385	58,271,127	9,339,060	17,763,591	0	0	0	0
Seafood Wholesalers and Dist.	53,548	8,166,237	2,683,482	3,839,697	24,666	3,761,719	1,236,127	1,768,729
Retail	572,949	32,939,750	13,344,602	18,205,590	454,109	26,096,417	10,571,096	14,422,133

	With Imports				No Imports			
North Carolina	# Jobs	Sales	Income	Value Added	# Jobs	Sales	Income	Value Added
Total Impacts	10,439	1,026,699	286,269	427,301	6,120	331,175	137,194	181,715
Commercial Harvesters	2,586	160,383	65,212	88,618	2,586	160,383	65,212	88,618
Seafood Processors & Dealers	1,214	90,790	35,300	45,615	484	36,215	14,081	18,195
Importers	1,739	537,913	86,211	163,979	0	0	0	0
Seafood Wholesalers and Dist.	499	60,283	21,142	27,906	145	17,522	6,145	8,111
Retail	4,401	177,330	78,405	101,184	2,905	117,055	51,756	66,791

Note that these categories are not additive. Numbers are presented in thousands of dollars.

Shrimp are the second most valuable commercial fishery in North Carolina, typically making up 16% to 22% of the overall commercial landings value (Table 3.13). On average, the contribution of the shrimp fishery (i.e., shrimp landed in shrimp trawls or skimmer trawls) to the total commercial landings in North Carolina increases by 1% every five years, even though total shrimp landings have remained fairly constant over the last 36 years (Table 3.13; Figure 3.15–3.16). Currently, shrimp is the second most landed species by volume in North Carolina. Landings of shrimp from shrimp trawls and skimmer trawls in estuarine and state ocean waters (areas affected by the Petitioned rules) make up about 98% of the total shrimp landings for North Carolina. Landings of shrimp fluctuate from year to year due to a variety of environmental factors (Figure 3.17). Shrimp ex-vessel values have decreased since the 1990s, but shrimp price does not follow a typical supply-price relationship. There are years when shrimp landings are high and price remains high, as well as years of low landings while price remains steady from year to year (Figure 3.17). This could be due to the fact that domestic shrimp face market competition with foreign shrimp that are imported in high volumes at low prices. The U.S. does have anti-dumping measures in place on foreign shrimp, but imported shrimp continue to be regarded as one of the largest challenges to the U.S. shrimping industry (Crosson 2010b; Newsome 2014).

Compared to shrimp, the commercial fishery for Spot in North Carolina accounts for only 1.5% of the total commercial pounds landed and 1% of the total value of the commercial industry (Table 3.13). In recent years, the value of Spot as a percentage of the entire commercial sector has dropped to less than 1%. Spot landings have been dropping on average around 700,000 pounds every five years and the fishery's overall value is declining on average by $75,000 every five years (Table 3.13; Figures 3.15 and 3.16). Spot landings have been declining dramatically since 2006, but ex-vessel price have been rising during the same period (Figure 3.18). When supply is restricted, there is typically an increase in overall price.

Atlantic Croaker is one of the most landed commercial species in North Carolina. On average, it has been the fourth largest fishery in terms of total landings from 1978–2015 and eighth in total value to the industry. Croaker landings have been near or even greater than shrimp landings in some years; however, since 2007, there has been a sharp decline in overall landings. Atlantic Croaker made up a large proportion of the landings between 2003 and 2012, but in recent years has dropped to levels typical of the 1980s and 1990s (Table 3.13; Figure 3.15). ASMFC has reported that landings of Atlantic Croaker typically exhibit a cyclical pattern in abundance that could explain the flux in North Carolina landings (ASMFC 2017c). In recent years, 2013–2015, Atlantic Croaker has been fifth in total pounds landed and 13th in total ex-vessel value. On average, the Atlantic Croaker industry's contribution to the total landings declines by less than 1% every five years, while the value of the fishery has been declining on average about 1% every five years (Table 3.13; Figures 3.15 and 3.16). Like Spot, ex-vessel price for Atlantic Croaker has been increasing as a result of reduced supply (Figure 3.19).

In the late 1970s and 1980s, Weakfish were landed in quantities similar to Atlantic Croaker and shrimp (Table 3.13; Figure 3.15). However, in recent years, landings of Weakfish have declined drastically, now only representing less than half a percent of the total commercial landings and value of North Carolina. As such, ex-vessel price has sharply increased from less than $1.00 a pound to an all-time recent high of $1.52 per pound (Figure 3.20).

The current decline in landings of Spot, Atlantic Croaker, and Weakfish since 2012 and the rising ex-vessel price indicates that the demand for these species has not diminished despite the recent supply constraints (Figures 3.18–3.20).

Table 3.13. Average landings and nominal ex-vessel value of Atlantic Croaker, shrimp, Spot, and Weakfish compared to total North Carolina landings by five-year period, 1978–2016. (Source: NCTTP)

	Species	Avg. Landings	Avg. Value	% of Total Commercial Landings	% of Total Commercial Value	Avg. $/Lb.
2013–2016	Croaker, Atlantic	2,117,262	$1,849,858	3.56%	2.07%	$0.87
	Shrimp	7,958,314	$17,604,567	13.37%	19.68%	$2.21
	Spot	536,961	$498,717	0.90%	0.56%	$0.93
	Weakfish	76,417	$99,583	0.13%	0.11%	$1.30
2008–2012	Croaker, Atlantic	5,480,033	$2,970,980	8.15%	3.83%	$0.54
	Shrimp	6,411,860	$12,533,156	9.53%	16.17%	$1.95
	Spot	748,389	$526,914	1.11%	0.68%	$0.70
	Weakfish	117,854	$120,206	0.18%	0.16%	$1.02
2003–2007	Croaker, Atlantic	11,198,641	$3,227,401	11.55%	4.20%	$0.29
	Shrimp	5,735,916	$10,371,565	5.92%	13.50%	$1.81
	Spot	1,663,773	$898,813	1.72%	1.17%	$0.54
	Weakfish	498,946	$367,752	0.51%	0.48%	$0.74
1998–2002	Croaker, Atlantic	10,676,122	$3,174,007	6.80%	3.23%	$0.30
	Shrimp	7,839,513	$17,726,260	4.99%	18.02%	$2.26
	Spot	2,553,375	$1,077,145	1.63%	1.09%	$0.42
	Weakfish	2,325,821	$1,253,518	1.48%	1.27%	$0.54
1993–1997	Croaker, Atlantic	6,915,638	$2,440,672	3.61%	2.54%	$0.35
	Shrimp	6,996,290	$16,893,732	3.65%	17.61%	$2.41
	Spot	2,706,849	$936,678	1.41%	0.98%	$0.35
	Weakfish	3,890,226	$2,099,681	2.03%	2.19%	$0.54
1988–1992	Croaker, Atlantic	5,452,317	$2,482,277	3.03%	3.57%	$0.46
	Shrimp	8,212,408	$15,476,592	4.56%	22.29%	$1.88
	Spot	3,132,727	$724,288	1.74%	1.04%	$0.23
	Weakfish	8,236,196	$3,516,865	4.58%	5.06%	$0.43
1983–1987	Croaker, Atlantic	8,369,781	$2,972,103	3.78%	4.82%	$0.36
	Shrimp	6,675,076	$13,444,848	3.02%	21.81%	$2.01
	Spot	3,327,658	$758,937	1.50%	1.23%	$0.23
	Weakfish	11,848,339	$4,183,519	5.36%	6.79%	$0.35
1978–1982	Croaker, Atlantic	16,736,151	$4,054,060	4.68%	7.01%	$0.24
	Shrimp	5,462,016	$10,500,886	1.53%	18.16%	$1.92
	Spot	5,542,446	$1,090,899	1.55%	1.89%	$0.20
	Weakfish	14,979,648	$3,863,241	4.19%	6.68%	$0.26

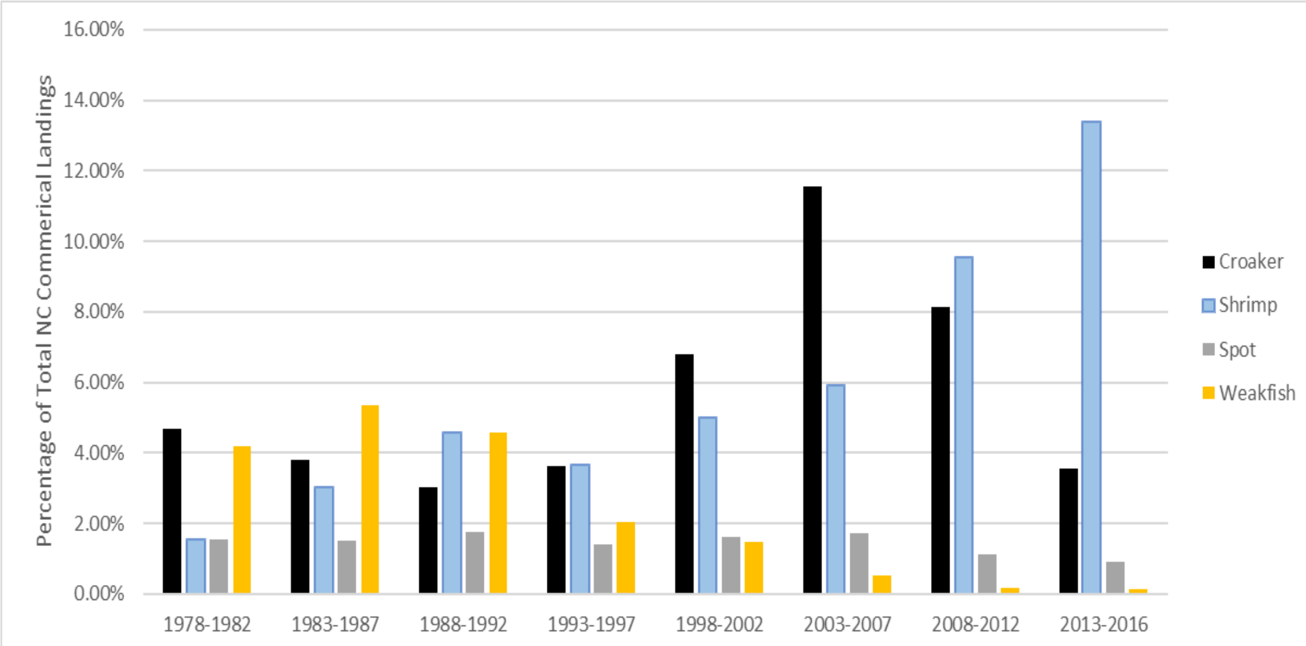

Figure 3.15. Percentage of North Carolina's total commercial landings by species and five-year period for Atlantic Croaker, shrimp, Spot, and Weakfish, 1978–2016. (Source: NCTTP)

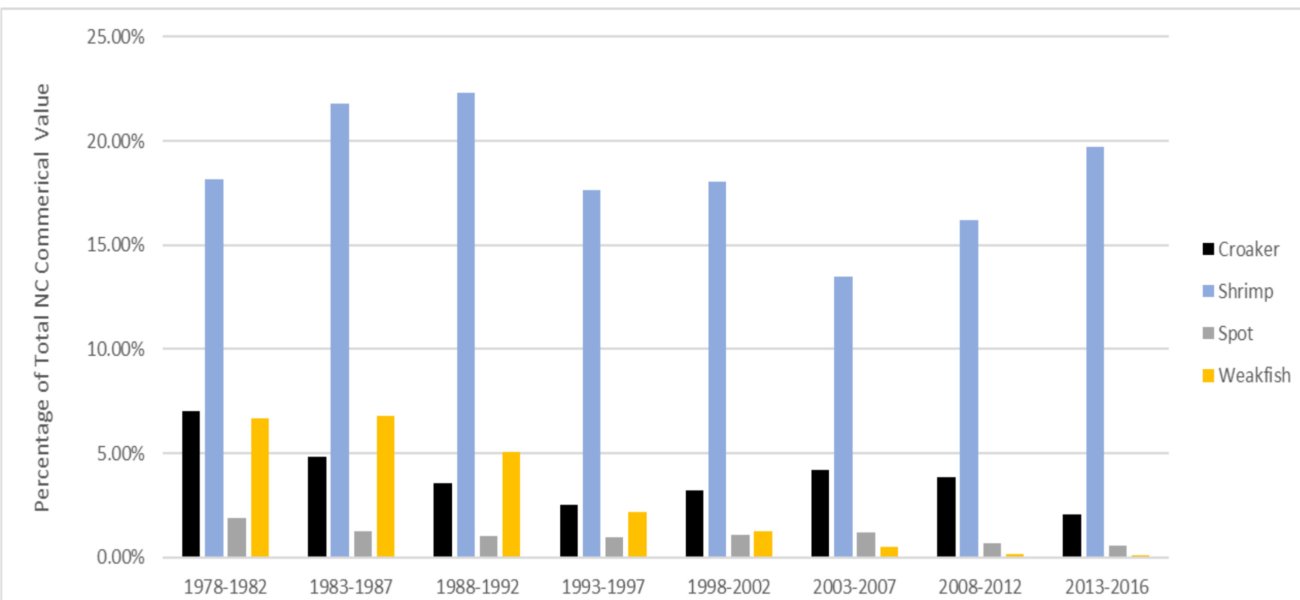

Figure 3.16. Percentage of North Carolina's total commercial ex-vessel value by species and five-year period for Atlantic Croaker, shrimp, Spot, and Weakfish, 1978–2016. (Source: NCTTP)

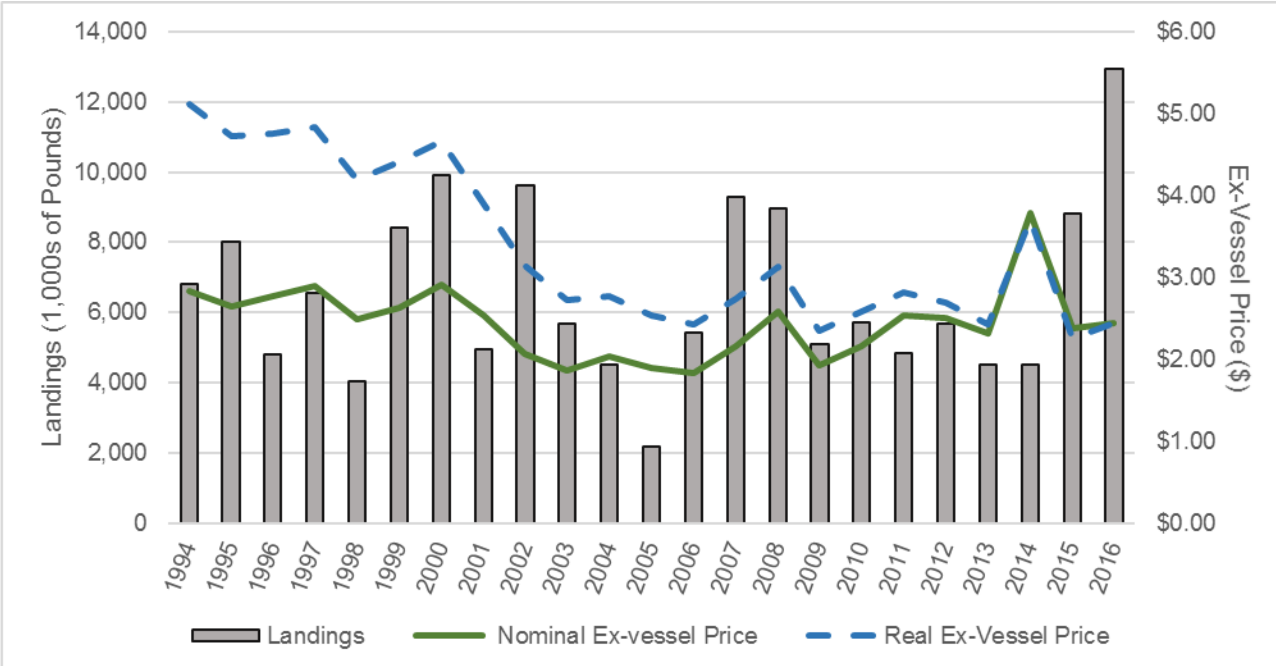

Figure 3.17. Commercial landings and ex-vessel prices (real and nominal) of shrimp in estuarine and state ocean waters for North Carolina from shrimp and skimmer trawls, 1994–2016. (Source: NCTTP; Bureau of Labor Statistics 2017) NOTE: Nominal prices represent the original price in its current year and real price refers to those which have been adjusted for inflation and are represented in 2016 dollar values.

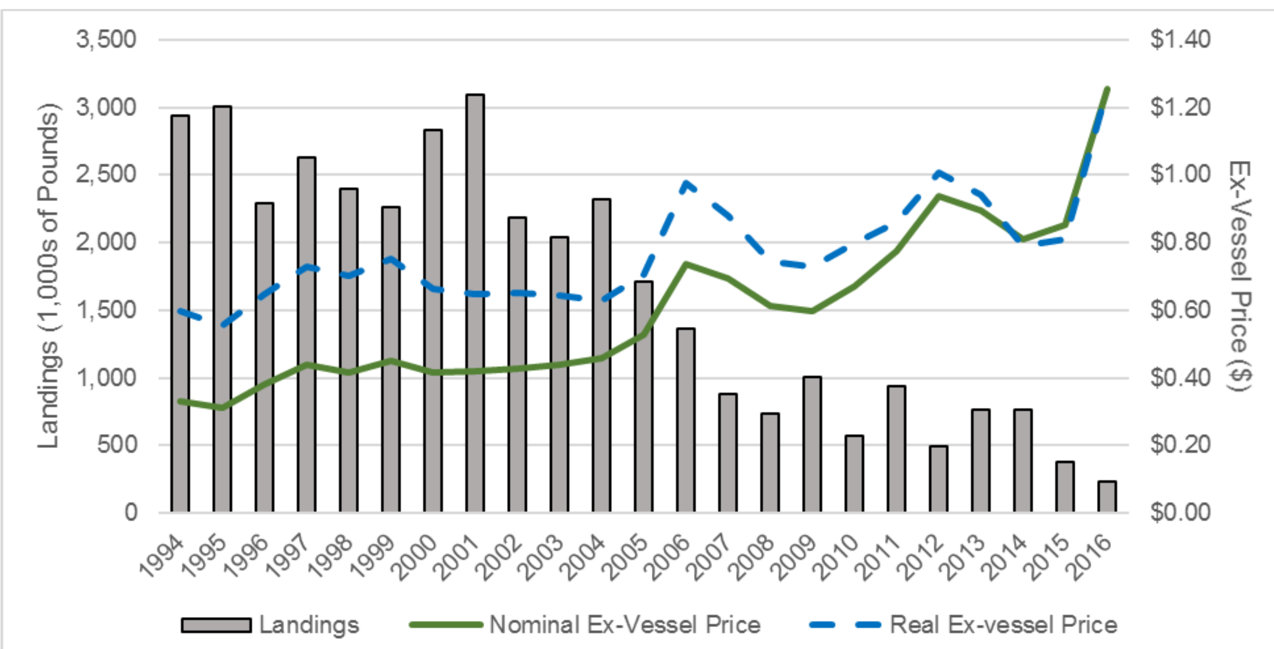

Figure 3.18. Spot landings and ex-vessel prices (real and nominal) for North Carolina, 1994–2016. (Source: NCTTP; Bureau of Labor Statistics 2017) NOTE: Nominal prices represent the original price in its current year and real price refers to those which have been adjusted for inflation and are represented in 2016 dollar values.

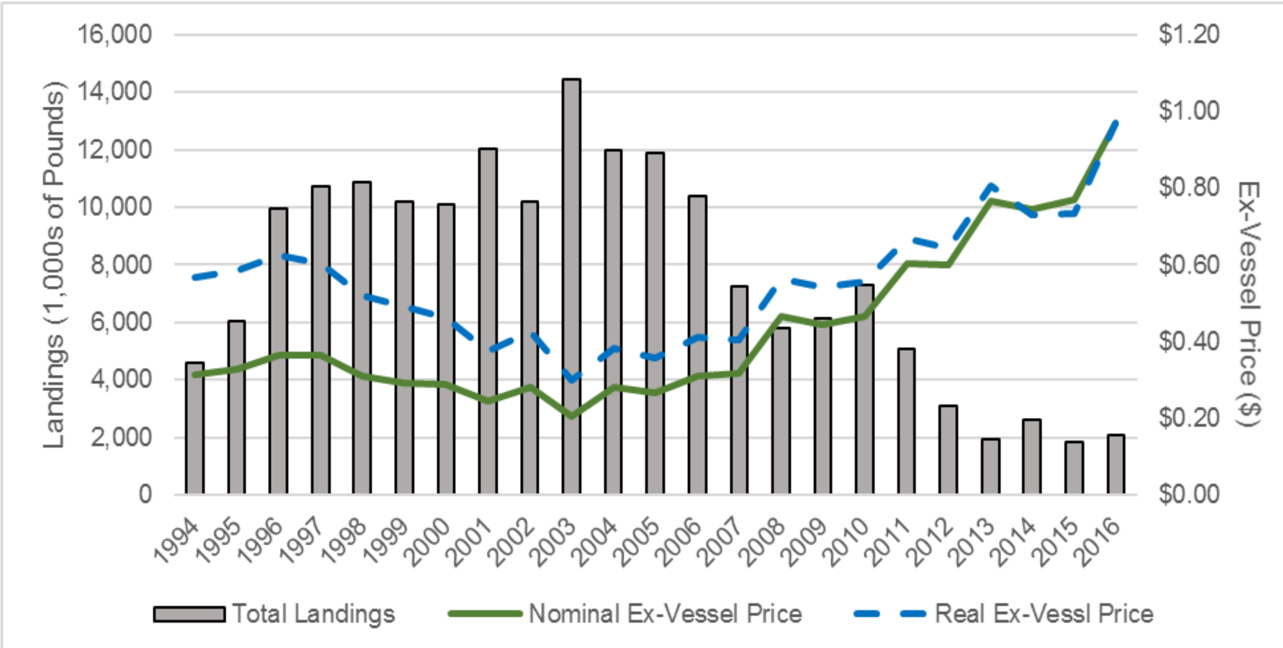

Figure 3.19. Atlantic Croaker commercial landings and ex-vessel prices (real and nominal) for North Carolina, 1994–2016. (Source: NCTTP; Bureau of Labor Statistics 2017) NOTE: Nominal prices represent the original value in its current year and real price refers to those which have been adjusted for inflation and are represented in 2016 dollar values.

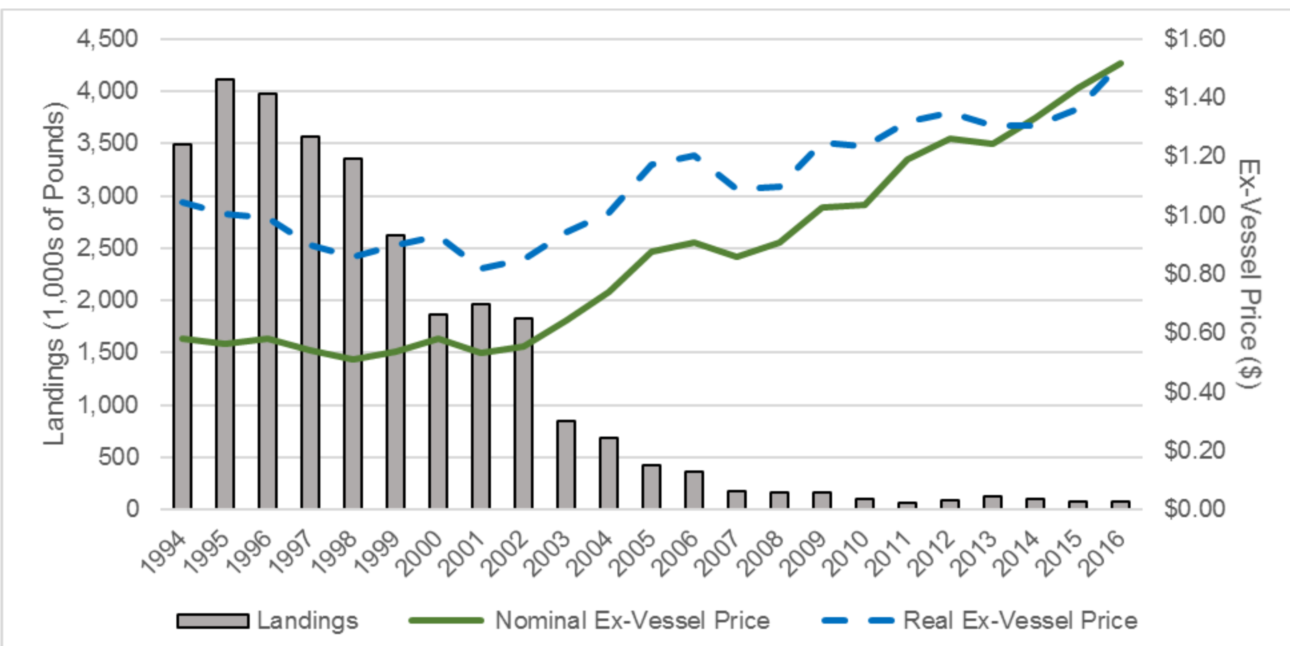

Figure 3.20. Weakfish commercial landings and ex-vessel prices (real and nominal) for North Carolina, 1994–2016. (Source: NCTTP; Bureau of Labor Statistics 2017) NOTE: Nominal prices represent the original price in its current year and real price refers to those which have been adjusted for inflation and are represented in 2016 dollar values.

3.7 Recreational Value

Generally, federal and state agencies have mandatory reporting requirements in commercial fishing for catch and sale of seafood products. This provides managers with data to make informed decisions regarding catch limits, seasonal restrictions, and other harvest rules to ensure the sustainability of a fishery. However, there are very few (if any) mandatory reporting requirements for recreational fishermen. Furthermore, even fewer voluntary data collection programs exist for economic information on recreational angling. Therefore, far less information is available to measure the economic impact of recreational fishing on the national economy. Most impacts for recreational fishing come from the production, sales, and consumption of durable goods related to recreational fishing. These goods typically include things such as tackle, ice, bait, fishing equipment, and other purchases required to go recreational fishing. The value of many of these items that are also necessary for commercial fishing are not commonly estimated. Other factors that add value to the recreational fishery that cannot be monetized include the non-market value of the fishing itself, as a form of recreation, and the worth of the fish to the fisherman for consumption or as a trophy ("bragging rights").

Since 1994, NOAA Fisheries (formerly known as NMFS) has collected annual economic and human dimension data from recreational anglers using the MRFSS sampling frame, until 2006, when the program was redesigned and became the MRIP. This program is the primary entity collecting recreational catch, effort, and socioeconomic data for marine species in the U.S. MRIP also conducts nationwide expenditure add-on surveys of anglers every three to five years. Survey results are used to assess how marine recreational fishing contributes to the economies of coastal communities and to the nation's economy.

The economic activity associated with the North Carolina coastal recreational fishing industry is calculated via the NCDMF coastal recreational fishing economic impact model as updated in July 2017. The economic impact estimates presented for coastal recreational fishing represent the economic activity generated by both trip expenditures and durable goods expenditures. These estimates are a product of economic data originating from the NOAA Fisheries coastal recreational fishing economic impact estimates for durable goods expenditures and IMPLAN economic impact modeling software input with data from NCDMF for trip expenditures (Gentner and Steinback 2008; Lovell et al. 2013). To calculate recreational fishing trip expenditures, the NCDMF coastal recreational fishing economic impact model uses effort data by area and by mode (i.e., shore, for-hire, private/rental vessel, and man-made) that are derived from the MRIP. These data are combined with angler trip expenditure data collected from North Carolina recreational anglers during surveys that have been carried out by the NCDMF Fisheries Economics Program and N.C. Sea Grant to provide estimated total coastal recreational fishing trip expenditures (Dumas et al. 2009; Crosson 2010b; Hadley 2012).

As with the commercial economic impacts, "[s]ales refer to the gross value of all sales by regional businesses affected by an activity, such as recreational fishing. It includes both the direct sales of durable recreational fishing goods and sales made between businesses and households resulting from the original sale. Income includes personal income (wages and salaries) and proprietors' income (income from self-employment). Value-added is the contribution made to the gross domestic product in a region" (NOAA 2017b). "Employment is specified on the basis of full-time and part-time jobs supported directly or indirectly" by the sales of durable goods related to recreational fishing (NOAA 2017b).

Below is a table of the estimated impacts of recreational fishing on the North Carolina economy from the NCDMF recreational impact model (Table 3.14). It contains total estimated participants, durable good expenditures, sales and income impacts, and estimated job impacts. The number of recreational participants for 2016 rose above the 10-year average (1.7 million anglers) to 1.88 million anglers (Table

3.14). Total durable goods expenditures in 2016 was also above the 10-year average ($1.55 billion) at $1.74 billion. In 2016, job impacts were at a recent low of 15,069 estimated jobs supported by the industry, falling by 1,300 jobs from the 10-year average. Income impacts have remained fairly constant over the last 10 years, averaging approximately $603 million (Table 3.14; Figure 3.21). Total economic impacts are on a slight downturn with recent years falling below the 10-year average of $1.75 billion. Recreational fishing is a vital part of the coastal economy in North Carolina and affects many facets of the state economy as a whole.

Table 3.14. Economic impacts of coastal recreational fishing in North Carolina. (Source: NCDMF Economics Program)

			Economic Impacts		
Year	Recreational Participants[1]	Estimated Expenditures (thousands of dollars)[2]	Jobs[3,4]	Income Impacts (thousands of dollars)[4]	Total Economic Impacts (thousands of dollars)[4]
2007	1,908,162	$1,575,233	18,248	$640,208	$1,798,433
2008	1,969,675	$1,556,843	18,029	$631,103	$2,016,206
2009	1,680,781	$1,195,326	13,699	$487,256	$1,543,353
2010	1,914,029	$1,343,080	14,948	$540,245	$1,711,079
2011	1,499,041	$1,505,438	16,398	$602,563	$1,911,811
2012	1,661,474	$1,810,385	18,304	$692,901	$1,870,460
2013	1,404,600	$1,531,847	16,356	$600,664	$1,741,763
2014	1,655,544	$1,525,307	16,050	$592,779	$1,732,482
2015	1,547,964	$1,754,483	16,624	$664,672	$1,658,302
2016	1,888,821	$1,747,730	15,069	$621,019	$1,575,947

[1]Participant estimates as reported by the NOAA Fisheries MRIP
[2]Estimated expenditures includes both durable good expenditures and fishing trip expenditures.
[3]Includes full time and part time jobs
[4]Economic impacts calculated using the NCDMF coastal recreational fishing economic impact model and IMPLAN economic impact modeling software. Economic impact estimates are for the state economy of North Carolina.

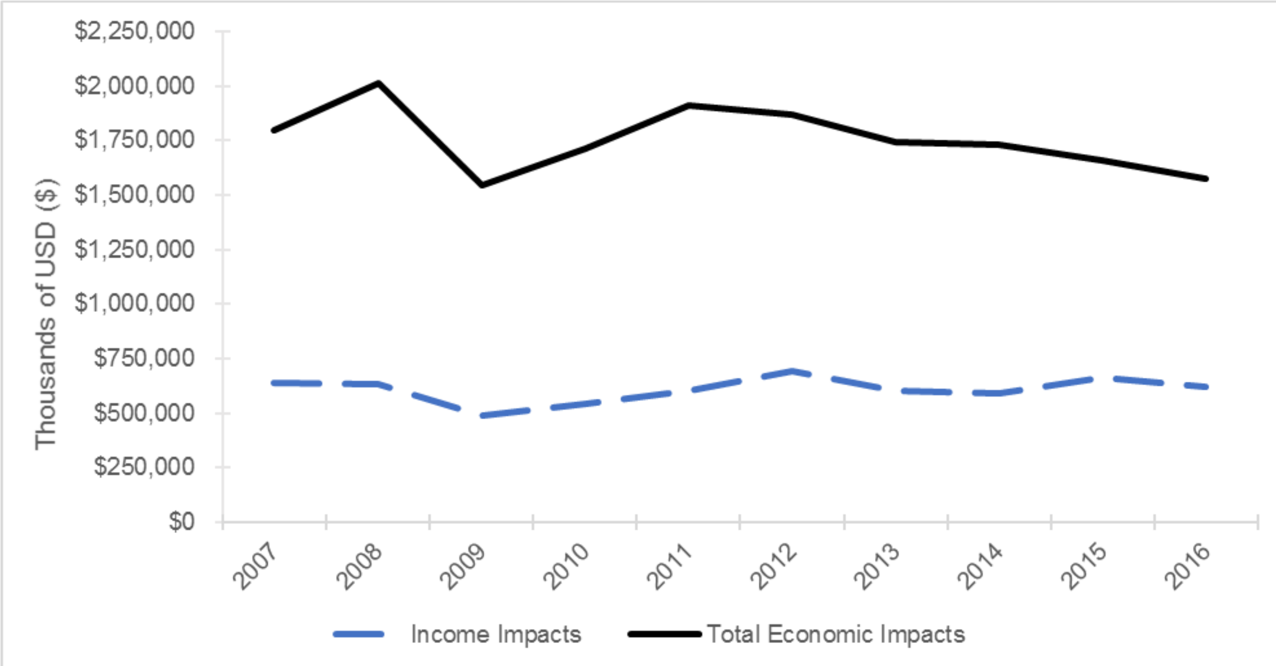

Figure 3.21. Total economic impact and income impacts of coastal recreational fishing in North Carolina, 2007–2016. (Source: NCDMF Economics Program)

Below are two tables from the most recent edition of Fisheries Economics of the United States (FEUS) published by the NOAA Fisheries Office of Science and Technology office, also showing economic impact estimates from recreational fishing for North Carolina in 2015 (NOAA 2017b). Similar impacts were presented above from the NCDMF impact model, but the NCDMF model shows the total across all modes (Table 3.14). The FEUS tables break these impacts down by fishing mode: for-hire, private boats, and shore trips (Tables 3.15 and 3.16). Table 3.15 shows both the durable good expenditures and trip related expenditures made by anglers in the state of North Carolina for 2015. These data are used to estimate the economic impact of marine recreational fishing to the state's economy via a regional input-output model. The input-output model used in these reports generates four different metrics, referred to as "impacts", for assessing the overall economic impacts of expenditures on marine recreational fishing. Table. 3.16 shows the results of that input-output model for North Carolina in 2015. While the estimate of total sales and income impacts produced by FEUS is less than the NCDMF model, the NOAA Fisheries impacts are presented in this document to show the range of impact estimates that are generated from different survey data and model methodologies.

Table 3.15. Angler trip and durable goods expenditures (thousands of dollars) in North Carolina, 2015. (Source: NOAA 2017b).

Fishing Mode	Trip Expenditures	Equipment	Durable Goods Expenditures
		Fishing Tackle	$226,458
For-Hire	$43,624	Other Equipment	$91,681
Private Boat	$136,986	Boat Expenses	$607,243
Shore	$208,215	Vehicle Expenses	$55,538
Total Trip Expenditures	$388,825	Second Home Expenses	$21,973
		Total Durable Expenditures	$1,002,893
Total State Trip and Durable Goods Expenditures			**$1,391,718**

Table 3.16. Economic impact of the recreational fishery (thousands of dollars) in North Carolina, 2015. (Source: NOAA 2017b)

		#Jobs	Sales	Income	Value Added
Trip Impacts by Fishing Mode	For-Hire	623	$72,896	$26,480	$38,956
	Private Boat	1,369	$131,781	$46,301	$74,109
	Shore	2,973	$268,806	$94,946	$154,912
Total Durable Expenditures		9,198	$976,818	$392,131	$602,739
Total State Economic Impacts		**14,163**	**$1,450,301**	**$559,858**	**$870,716**

4 IMPACT ON ENVIRONMENT

The Petition proposes designating all coastal fishing waters (estuarine and state ocean) that are currently not designated as primary, secondary, or special secondary nursery areas as a new classification of SSNA (special secondary nursery area). New gear and effort limits would be applied to the new nursery areas to reduce the overall amount of trawling and afford these areas additional habitat and water quality protection and bycatch reduction of juvenile species. The Petitioner states that reducing bycatch levels of lower trophic level prey species (e.g., Spot, Atlantic Croaker) will benefit higher trophic level species that are "more" economically valuable (e.g., Spotted Seatrout, Red Drum, flounder), and enhance the overall ecosystem services provided by a balanced trophic structure (NCWF 2016a).

These new nursery area designations would require a large enforcement effort (see section 9.1) to ensure rules are being adhered to and would likely result in a displacement of effort to less restrictive waters (i.e., previously designated SSNAs). Indirect impacts to surrounding environments due to displaced effort from the designation of new SSNAs are discussed below in section 4.1. Benefits to the ecosystem, including potential improvements in habitat and water quality conditions are discussed in section 4.2.

4.1 Displacement of Effort

Proposed changes to 15A NCAC 03N .0105 by the Petition provide an exception for existing SSNAs, which have less restrictive harvest regulations than areas that would be newly designated as SSNAs by the Petitioned rules (i.e., Pamlico Sound, Core Sound, and the ocean 0–3 miles). The Petitioned rules divide SSNAs into two subparagraphs (Table 4.1; NCWF 2016a). The first (subparagraph (b)) is the current list of SSNAs, which are nursery area habitat where later juvenile development takes place and are designated to protect larger juvenile species that have moved down from the primary nursery areas. These areas are required to be closed to shrimp and crab trawling between May and August and are opened to trawling once migration of these juvenile and sub-adult fish has occurred. Once these areas are opened, based on sampling by NCDMF after Aug. 15, fishermen are able to trawl day and night, five days a week with unlimited tow times. Proposed subparagraph (c), additional areas designated by the Petition, describes new SSNAs, which are not subject to this May–August closure. These proposed SSNAs encompass a much larger area with a broader range of habitat types that include the ocean waters out to three miles and whose ecological functions are different compared to the SSNAs already in existence. The existing SSNAs have less restrictions and are typically located in upstream, small, shallow, and brackish water areas. The designation of the new SSNAs may result in increased bottom disturbance in the existing shallow nursery areas from increased trawl fishing effort by fishermen avoiding the additional restrictions in the proposed SSNAs.

Table 4.1. Comparison of restrictions of trawling between existing designated SSNAs and the proposed SSNAs per 15A NCAC 03N .0105.

Existing SSNAs (closed May–Aug)	**Proposed SSNA**
1.3% of Coastal Waters	94.5% of Coastal Waters
Daytime and night trawling	Daytime trawling only
Five days a week	Three/Four days a week (estuarine/ocean)
Unlimited tow times	45-minute tow times

4.2 Benefits

Potential benefits from the Petitioned rules include habitat improvements in estuarine and state ocean waters to a variety of habitat types, including soft bottom, water column, oyster reefs, and SAV. Improvement in these habitats as a result of the Petitioned rules would be extremely difficult to quantify without a baseline measurement of how "good" the habitat in the areas affected by the proposed rules is now. That baseline is currently unavailable, as data do not exist for the whole area defined by the Petition to be designated as SSNAs. Any overall improvement to the habitats in those areas and in North Carolina as a whole is contingent on compliance with the proposed rules and how the fishermen respond. There is a large amount of uncertainty about whether fishermen would intensify effort during the times they are allowed to fish to recoup potential losses or move to other areas that are less restrictive, causing potential increased effort in those waterbodies. This section discusses the types of improvements that may occur due to better habitat and water quality over time, but with so many uncertainties, the magnitude of change from the proposed rules is unknown and the impact on habitat is unquantifiable at this time.

4.2.1 <u>Habitat Improvements</u>

If an area of soft bottom habitat that had been heavily trawled on a consistent basis, was no longer subject to trawling, it is possible that habitat conditions would improve relative to the baseline trend, holding all other factors constant. Improvements could include:

- More diverse, abundant, and productive benthic community, that in turn benefits small and demersal finfish;
- Lower predation on invertebrates and small fish due to increased microstructure that could lead to greater abundance of fishery species due to increased prey availability; and
- Increased water clarity and productivity in the water.

If oyster reefs and SAV had been impacted indirectly by trawling-related turbidity and sedimentation, an increase in SAV acreage and/or density, and an increase in growth rates, recruitment, and reef structure might occur relative to the baseline trend, holding all other factors constant. Positive changes to SAV and oysters could take many years. A study to look at before and after the Petitioned rules would go into effect would be needed to evaluate, if and when, any changes occur (see section 10 and Appendix 4).

The severity of impact to soft bottom habitat from trawling depends on the frequency a specific area is trawled and the size of the trawl doors. This information has not been quantified on a site-specific level in North Carolina. The management changes in the Petition would not eliminate trawling, but would reduce days and times available. Without knowing how much or where trawling would be reduced, there is a large degree of uncertainty regarding expected benefits. A potential way to evaluate improvements to habitat is through ecosystem services enhancement discussed in section 4.2.2.

Implementation of the Petition would designate 65,128 acres of estuarine waters and 86,174 acres of ocean waters that are currently managed for shrimping as a new type of SSNA (Table 2.1). Under the Petitioned rules, shrimp trawling activity would not be prohibited, but is estimated to potentially be limited to approximately 22% of the year for estuarine trawling and 29% of the year for ocean trawling, compared to the current level of about 75% (NCDMF 2017). Three NCDMF documents summarized the effects of trawling on habitat and water quality in estuarine and ocean waters (NCDMF 1999; NCDMF 2014; NCDEQ 2016). Based on references in those documents, habitat impacts to soft bottom and the water column from trawling potentially include:

- Reduced abundance, diversity, and productivity of the benthic community;

- A shift in benthic invertebrate species composition to those that are more resilient to frequent disturbance;
- Reduced structural complexity on the bottom (e.g., sand ripples, troughs, biotic structure like worm tubes, sponges, algae, shell);
- Change in sediment composition to finer and more easily suspended material;
- Temporary resuspension of sediment and nutrients into the water column;
- Reduced productivity of benthic microalgae on the sediment surface, since light availability would be more limited where bottom sediments were resuspended;
- Clogged gills of filter feeding fish and invertebrates due to increased turbidity in the water column; and
- Siltation onto nearby oyster reefs and SAV from redeposited sediment, which would negatively impact oyster filtration, oyster recruitment, and SAV growth.

Because shrimp trawling activity is estimated to be greatly reduced under the Petitioned rules, the corresponding habitat impacts from trawling would likely be mitigated.

However, studies conducted in North Carolina estuaries have shown no or minimal negative impacts to soft bottom or water column habitat or benthic productivity (NCDMF 2014). For example, Cahoon et al. (2002) and Corbett et al. (2004) studied the effects of trawling in the Pamlico River and some tributaries on productivity in the sediment and water column, respectively. In comparing trawled and un-trawled areas, both found a short-term increase in suspended sediment, and no significant difference in benthic microalgae. Change to nematodes, an important food source for shrimp and juvenile fish, was inconsistent and no significant difference in the macrofauna was evident. Trawling increased nutrient concentrations in the water column, but they were not statistically significant and persisted less than one day. Deehr et al. (2014) examined differences in productivity between Core Sound (trawled) and adjacent bays (Nelson, Jarrett, and Thoroughfare bays). The bays are designated SSNAs, but can be opened after Aug. 15, and usually have been. This scenario is similar to the Petitioned scenario, since the Petition would designate all undesignated waters as SSNAs, which are not closed to trawling, but opened conditionally by proclamation. Results of the Deehr et al. (2014) study found the open areas of Core Sound had significantly lower abundance of nematodes, but significantly higher abundance of total macroinvertebrates (e.g., deposit feeding polychaetes) and crabs compared to that found in the bays that were open less frequently. One likely reason for lack of significant negative impacts in North Carolina estuaries from trawling is because they are relatively shallow, dynamic, and frequently subject to disturbance from currents and wind. Consequently, effects of trawling are similar to the natural conditions.

4.2.2 <u>Ecosystem Services Enhancement</u>

Ecosystem services are defined as benefits people obtain from ecosystem functions, often expressed in monetary terms. These may include water quality cleansing (reduces cost that would otherwise be needed for wastewater treatment – e.g., oyster reefs), food production (habitats that improve survival of juvenile fish, and thus produce more food at no cost to people – e.g., SAV), and erosion control (habitats that buffer wave energy and protect shoreline development naturally instead of having to construct a costly bulkhead – e.g., wetlands; Costanza et al. 2008).

1. Effect of reduced trawling to ecosystem services of soft bottom:
   Ecosystem services of soft bottom include 1) subtidal bottom acts as a storage reservoir of nutrients, bacteria, and chemicals where they can become inactive, and thus enhance water quality conditions; 2) subtidal and intertidal soft bottom provide food (benthic microalgae) for small invertebrates, thereby increasing productivity of benthic fishery species such as

shrimp and red drum; 3) intertidal shorelines, shoals, and beaches provide erosion control for shoreline properties; and 4) shorelines and beaches enhance the coastal economy by providing areas for beach goers to recreate. The latter two services are not affected by trawling activity. Studies are lacking regarding the economic value of soft bottom habitat for ecosystem services and fishery production.

2. Effect of reduced trawling to ecosystem services of water column:
   Potential negative effects from trawling to the water column include temporarily elevated nutrients and toxins that are biologically available, and elevated turbidity, which can impact phytoplankton production and possibly redeposit it on SAV or oyster reefs. A healthy water column is necessary to support swimming, aquatic life, fishery production, and recreational and commercial fishing. In 2013, the estimated economic impact of commercial fisheries was $305 million and recreational fisheries was $1.7 billion (NCDMF unpublished data). Coastal tourism is highly dependent on having waters open to swimming. In 2017, coastal tourism expenditures (within the 20 coastal counties) were estimated at $11 billion (Harrison et al. 2017). While it has not been quantified how much of these values decline with somewhat lower water quality, some portion of the total amount could potentially decline, depending on the magnitude of reduced water quality.

3. Effect of reduced trawling to ecosystem services of subtidal oyster reefs:
   Ecosystem services provided by subtidal oyster reefs include 1) enhancing water quality through filtration or trapping of nutrients, sediment and toxins; 2) enhancing survival of many species by providing predator protection, increasing fishery production; and 3) providing erosion control for shoreline properties. This last function is not affected by trawling activity. Ecosystem services of oyster reefs were estimated at $2,200–$40,200/acre/year, excluding fishery values (Grabowski et al. 2012). The increased value to recreational fishing due to reef restoration was estimated at $640,000/year. These values are for increases in oyster acreage. It is uncertain if reductions in trawling would improve conditions for oyster reefs to the extent that growth and survival would substantially increase.

4. Effect of reduced trawling to ecosystem services of SAV:
   Ecosystem services provided by SAV include 1) erosion control due to trapping and binding sediment; 2) water quality improvements and climate regulation by absorbing nutrients and carbon dioxide and releasing oxygen into the water column; and 3) food production by enhancing survival of many species by providing predator protection and increasing fishery production. Ecosystem services of SAV were estimated at $7,700/acre/year (Costanza et al. 1997). These values are for increases in SAV acreage that may result from reduced trawling. It is uncertain if reductions in trawling would improve conditions for SAV to the extent that growth and survival would substantially increase.

5 IMPACT ON FISH STOCKS

The Petitioner states that mortality due to bycatch from shrimp trawls is contributing to the decline of fish stocks in North Carolina, especially for species such as Spot, Atlantic Croaker, and Weakfish (NCWF 2016a). The idea behind this statement is that these species are being caught before they are able to spawn and contribute to the population. The Petition proposes to implement new gear and effort limits to the new special secondary nursery areas to reduce the overall amount of trawling and afford these areas additional habitat protection and reduced bycatch of juvenile species. The Petition also proposes to establish minimum size limits for Spot and Atlantic Croaker to increase biomass (weight of the stock) and abundance (numbers of fish) by reducing mortality.

Increasing juvenile recruitment into the adult population is a goal of most FMPs in hopes of increasing stock abundance, but there are more threats to juvenile fish than just fishing mortality, whether caused by directed or indirect methods (bycatch). Natural mortality was discussed in section 2.1.1 and the other causes of mortality outside of fishing, such as environmental factors were discussed in sections 2.1.3–2.1.5. This section focuses on the effect of the proposed rules on biomass and abundance of finfish species, including impacts and benefits to fish stocks utilizing estuarine and state waters. Impacts and benefits of the proposed rules on the industry are discussed in section 6.

Fishing mortality can be reduced through management strategies such as area and season closures, trip limits, and size limits, as well as by reducing indirect fishing mortality such as bycatch (see section 5.1). Reducing fishing mortality can typically have positive effects on fish stock abundance (see section 5.1.4.1 and 5.1.4.2), but in cases where the natural mortality of the stock is larger than the fishing mortality, a reduction in fishing may not result in increased abundance (see section 5.1.4.3). Potential benefits to the stock from habitat improvements is summarized in section 5.2. Minimum size limits as a management tool can have positive benefits on stock abundance if appropriate size limits based on the species life history and fishery characteristics are taken into account (see section 5.3). If regulations implemented are stringent enough to negatively affect the profitability of a fishery, fishermen may shift effort to other species. This displacement of effort may have positive impacts to the species under restriction, but could have an adverse effect on the abundance of any new target species if this new effort is high enough (see section 5.4).

Fishing mortality will likely be reduced from an overall reduction in total fishing effort due to the Petitioned rules; however, the magnitude of the expected effect is unknown. This is due in part to several factors that make quantifying impacts or benefits difficult. Among these are factors that can be both positive and potentially negative for fish stock abundance. Positive factors include additional non-fishing days due to weather impacts and reduced effort in regulated fisheries due to displacement of effort to other fisheries. Potentially negative factors include recoupment of effort by fishermen on allowed fishing days, noncompliance with proposed rules, and increased effort in fisheries not directly affected by the Petitioned rules. For example, a shrimp trawl fisherman may shift effort to a more profitable species if the proposed rules make trawling less desirable, which in turn could result in a decline in biomass of the other species.

Management scenarios may also include methods to reduce indirect fishing mortality resulting from bycatch in gears not targeting the species caught and the mortality of fish that are discarded. The mortality level of species harvested as bycatch is dependent on several factors including gear, marketability, handling practices of fishermen, culling time, and heartiness of the species caught. For these reasons, in addition to the unknown magnitude of the effect on fishing mortality, the magnitude of the reduction on bycatch in the shrimp trawl fishery from of the proposed rules is also unknown.

5.1 Stock Responses to Changes in Mortality

In order to determine the status of fish stocks, various types of models are used. Scientific modeling is the generation of a physical, conceptual, or mathematical representation of a real phenomenon that is difficult to observe directly (Rogers 2011). Models may explain and predict the behavior of real systems; however, models are at best only approximations of the systems that they represent. Striving to fully understand the system in question requires multiple models with each representing a part of the system. When necessary, incomplete information from the best available models (grounded in the best available data) is employed to make decisions that balance competing conservation goals.

Fisheries management modeling is evolving from a single species approach to the entire ecosystem addressing a broader perspective of ecosystem considerations. An ecosystem is defined as "an ecological community together with its environment, considered as a unit" (adapted from Tansley 1935; Link 2002). Ecosystems are complex and cover many processes at many levels of the biological hierarchy. Single species approaches generally do not consider species interactions, allocation of biomass, changes in ecosystem structure or function, biodiversity, non-fishing ecosystem services, protected or rare species, non-target species, ecosystem effects of discarding unwanted bycatch, or gear impacts on habitat. Ecosystem approaches generally do not consider demographic parameters, density-dependent effects, stock recruitment relationships, genetic diversity, economic tradeoffs, or standards, reference points, and performance statistics (Link 2002). In theory, ecosystem-based fisheries management (EBFM) is a holistic strategy for dealing with the complexities of diverse ecosystems; its strength lies in the ability to simultaneously explore the trade-offs among social, cultural, economic, and environmental factors that may influence an ecosystem, and to find optimal solutions for all stakeholders (Link et al. 2002). The ability to quantify the relative strength of "the complex interconnections that exist among many species, habitat types, and human activities" in an ecosystem threatened by various pressures, both natural and anthropogenic, is the theory, but has not yet been realized in the management arena. There is the inherent difficulty of ever fully determining, especially to the point of predictability, the complex dynamics of ecosystems.

This shortcoming in the reliable predictability of model outcomes confounds simple projections of what may happen with fish stocks, such as the extent of any improvements in biomass and abundance of Spot and Atlantic Croaker that may be caused by a combination of management strategies like those noted in the Petition. Weakfish (see section 5.1.4.3) is a good example of where unaccounted changes in mortality factors (see section 2.1) nullified the expected recovery from a significant mandated reduction in harvest based on a stock assessment model. Without advances in EBFM and a corresponding improvement in the best available data for model inputs, the model predictions of a system's response to management action are debatable (Schwart 2002). The accuracy needed from model outputs may depend on the way in which the model output will be used, as well as who is impacted. Decision making often is adapted to the perceived complexity of the model. For example, the TLA referenced in sections 3.2 and 3.3 for Spot and Atlantic Croaker has not triggered management action despite declining trends in a number of the traffic light metrics and given where the management trigger levels were set (30% and 60%). The external peer review panel for both species also indicated while the TLA generally suggested spawning stock biomass was increasing, if new information suggests the stock could be declining, a new stock assessment to produce estimates of population size and fishing mortality should be expedited (ASMFC 2017b, 2017c).

Stock assessment models are necessarily a simplification of reality. This simplification does not mean the models cannot be complex and many are, in fact, highly complex, requiring considerable data and knowledge of biological parameters. It is important to evaluate the sensitivity of model results to our assumptions regarding the model parameters, as changing assumptions may impact stock status and recommended management strategies. Sensitivity analysis is an important tool for evaluating the robustness of results and is a routine part of conducting a stock assessment.

Stock assessment models may assist in evaluating the relative impact of natural and fishing mortality on stock status, taking into account the population dynamics of the species. Nesslage and Dumas (2017) provided model projections for Atlantic Croaker and Weakfish. Projection models were tailored to each species to explore the potential biological response of the population from alternative fishing mortality scenarios and the resulting economic impacts, based on completed stock assessments available at the time of the report.

This section focuses on how the stock size of Atlantic Croaker and Weakfish could respond to varying fishing and natural mortality. These models help answer questions like, “If bycatch was reduced by a certain amount, how much will the fish stock change?” The various changes in fishing or natural mortality being assessed are programmed directly into the model and do not reflect a response to a particular management action. It is important to note that the size of the change in fishing and natural mortality attributable to the proposed rules is unknown. Therefore, it is not possible to model the associated change in the stock. There is no association between any regulatory intervention and the stock projections described below; they represent various “what-if” scenarios. Although not reflective of the proposed rules, these stock projections can be used to understand the direction, timing, and relative magnitude of the effect of reducing fishing or natural mortality, as well as how much change would be needed to achieve a desired stock status. Such “what if” models can inform professional judgements about the probability of a specific management intervention delivering the required effect size. Economic impact projection data is discussed in section 6.4.4.

5.1.1 Spot

The coastwide stock assessment of Spot was not yet completed at the time Nesslage and Dumas (2017) completed their report; therefore, their report did not perform projections of the Spot stock. Due to the similarities in life histories between Spot and Atlantic Croaker, Spot may respond to natural and fishing mortality changes in a similar way to Atlantic Croaker.

5.1.2 Atlantic Croaker

At the time of the Nesslage and Dumas (2017) report, the 2010 ASMFC stock assessment of Atlantic Croaker was the most recent coastwide stock assessment available (ASMFC 2010b). Nesslage and Dumas (2017) considered stock projections based on the assessment model used in the 2010 assessment. They projected the stock forward 40 years under eight different combinations (scenarios) of fishing mortality and shrimp trawl bycatch. In Scenario 1, the stock was projected forward assuming stock conditions equivalent to those in 2008. In Scenarios 2 through 5, the stock was projected assuming reductions in fishing mortality equally across all fleets and that removals of age-0 fish in the shrimp trawl bycatch were the same as the levels estimated for 2008. Projected SSB increased with decreasing fishing mortality in those scenarios. In Scenario 6, fishing mortality for all fleets was assumed equal to the 2008 value and the magnitude of the age-0 removals in the shrimp trawl bycatch was assumed to double. In that scenario, predicted SSB increased in the first three years of the stock projection and then decreased to the estimated SSB target (SSB at maximum sustainable yield), where it stabilized throughout the rest of the projected time series. This result comes from assumptions made in the model about the population dynamics of the species that predict a rebound followed by a stabilization in stock size. Scenarios 7 and 8 also assumed fishing mortality for all fleets was equal to the 2008 value; however, it was assumed that no removals in the shrimp trawl bycatch occurred starting in 2017. In those scenarios, SSB was projected to stabilize at a value higher than that projected for Scenario 6. All scenarios projected the stock would equal or exceed the SSB target in the long term and so would suggest sustainable stock levels for each of the proposed scenarios.

It is important to note that the 2010 ASMFC stock assessment model on which stock projections by Nesslage and Dumas (2017) were based was considered acceptable for management by the external peer review panel, but the estimates of biomass were not approved due to the high uncertainty associated with the shrimp trawl bycatch estimates (ASMFC 2010b). For this reason, any projections of biomass based on that model would likely also be deemed unacceptable. The reviewers of the 2017 ASMFC Atlantic Croaker stock assessment endorsed the new shrimp trawl bycatch estimates, but did not consider the assessment model acceptable for management due to the model's sensitivity to certain assumptions, particularly those regarding fishery and survey gear selectivity (ASMFC 2017). Despite the inability to estimate stock status in the 2017 ASMFC stock assessment, the peer review panel agreed that recent removals were likely sustainable and no immediate management action was needed. The reviewers of the 2010 ASMFC stock assessment did not comment on management, but did believe that it was unlikely that the stock was in trouble (ASMFC 2010b).

In their report, Nesslage and Dumas (2017) noted the high degree of uncertainty regarding how the stock might respond to reductions in fishing and bycatch mortality. Their results indicate that a reduction in either fishing or bycatch mortality could have a benefit on the stock, suggesting a possible benefit to the Atlantic Croaker stock due to the Petitioned rules. They also noted that if age-0 removals in the shrimp trawl bycatch are two or more times higher than the 2008 estimate, the stock risks dropping below sustainable levels. The estimates of shrimp trawl bycatch from the 2017 stock assessment were, on average, 7.5 times higher (in terms of weight) than those referenced by Nesslage and Dumas (2017) from the 2010 stock assessment. The completion of a stock assessment seven years later (ASMFC 2017d) using estimates of shrimp trawl bycatch much higher than those estimated in the 2010 stock assessment showed the stock did not respond as projected by Nesslage and Dumas (2017); however, shrimp trawl bycatch was calculated differently in the more recent assessment and the type of model used was different, so results are not directly comparable.

5.1.3 <u>Weakfish</u>

Nesslage and Dumas (2017) applied stock projections for Weakfish to the model used in the 2016 coastwide stock assessment conducted by the ASMFC (ASMFC 2016a). The analysis projected the stock forward 30 years under nine different scenarios of commercial and recreational fishing mortality, natural mortality, and the stock-recruitment relationship. Scenarios that considered reductions in fishing mortality assumed that fishing mortality for the commercial and recreational fisheries were reduced by equal amounts. The results of the stock projections suggest that natural mortality rates need to reduce substantially for SSB to increase, assuming current fishing mortality rates do not increase. Weakfish SSB has been seriously compromised by high natural mortality rates in recent years (ASMFC 2016a). Reductions in fishing mortality alone (Scenarios 1 and 2) are not predicted to result in sustainable levels of SSB within at least the next 30 years. Reductions in natural mortality (Scenarios 3–9) do show positive impacts to the stock over time, but the low levels of natural mortality used in the stock projections do not accurately represent the current level for the stock. It is unclear why the natural mortality of weakfish is currently at a high level (e.g., water quality, predation, environmental impacts), so it is not possible at this time to determine if the proposed rules would result in a reduction in natural mortality for this species.

Scenarios used by Nesslage and Dumas (2017) are not comparable to the reductions in fishing proposed by the Petition due to use of natural mortality estimates that do not currently exist in nature. The size of the reductions in fishing and natural mortality created by the proposed rules is unknown.

5.1.4 Existing Species Examples

All fish, of every species, will experience a mortality event that removes them from the population. There are two types of mortality that act on any fish stock. The first type is fishing mortality where death is caused by removal of fish through use of fishing gears. The second type is natural mortality where death is caused by things other than fishing such as predation, cannibalism, competition, disease, and pollution. Natural mortality is difficult to quantify due to unmeasurable environmental factors, while identification of fishing mortality events can be identified through fisheries monitoring (Pauly 1980). As mentioned previously, reducing fishing mortality is the most common approach used by managers in an attempt to improve fish stocks that are experiencing a decline in abundance or are heading toward that result in the near future. If fishing mortality is very high and a fish stock is in poor condition then regulations are developed to reduce fishing mortality by adjusting things such as quotas, size limits, bag limits, seasons, and fishing gear. Striped Bass (*Morone saxatilis*) and Summer Flounder (*Paralichthys dentatus*) are examples that exhibit how reducing fishing mortality can both serve to rebuild and sustain a fish stock that has been experiencing overfishing. On the other hand, Weakfish serves as an example of how a reduction in fishing mortality did not benefit the stock as expected. For more information about natural mortality and fishing mortality, see section 2.

5.1.4.1 Atlantic Ocean Striped Bass

Atlantic Ocean Striped Bass is a good example of a stock for which strict harvest regulations along with improvements in habitat and water quality restored the stock to sustainable levels. Striped Bass have long been the focus of fisheries from North Carolina to New England and were integral in the development of numerous coastal communities since the 1600s. Attempts at regulations were made by states during the 1940s when size limits were imposed. Minimum size limits ranged from 16 inches for many coastal states to 10 inches in some southern states. By the 1970s, it became increasingly evident that stronger regulations would be needed to maintain stocks at a sustainable level. Recruitment in the Chesapeake Bay stock had reached an all-time low, as determined by a juvenile survey conducted by the Maryland Department of Natural Resources since 1954. In response to the decline, the ASMFC developed a FMP in 1981 to increase restrictions in commercial and recreational fisheries. Two amendments were passed in 1984 recommending management measures to reduce fishing mortality. To strengthen the regulations, a federal law was passed in late 1984, which mandated that coastwide regulations already implemented would be adhered to by the Atlantic states between North Carolina and Maine.

Amendment 3 to the FMP called for size regulations to protect the 1982-year class, which was the first modest size cohort since the previous decade. The objective was to increase size limits to allow at least 95% of the females in the 1982 cohort to spawn at least once. This required an increase in the size limit as the cohort grew, which equaled a 36-inch minimum size limit by 1990. However, estuaries have traditionally been considered producer areas and smaller size limits were permitted in these producer areas than elsewhere along the coast. This was allowed because the migration of fish out of the producer areas after spawning reduces the availability of the larger females in these areas. However, several states, beginning with Maryland in 1985, opted for a more conservative approach and imposed a complete moratorium on Striped Bass landings.

Consequently, the management plan was amended for the fourth time to allow state fisheries to reopen their fisheries in 1990 under a target fishing mortality of 0.25, which was half the 1990 F_{MSY}[2] estimate of 0.5. Amendment 4 to the FMP allowed an increase in the target F once the SSB was restored to levels estimated during the late 1960s and early 1970s. The dual size limit concept was maintained with a 28-

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[2] F_{MSY} is defined as [t]he fishing mortality rate that will result in the stock biomass producing the maximum greatest yield over time, or weight of harvest within a year" (ASMFC 2009a).

inch minimum size limit in coastal jurisdictions and 18 inches in producer areas. A recreational trip limit and commercial season was implemented to reduce the harvest to 20% of that in the historic period of 1972-1979. Amendment 4 and its four addenda aimed to rebuild the resource, rather than maximize yield. Based on the results of a model simulation of the increase in SSB, Striped Bass was declared restored by the ASMFC in 1995. The model, known as the SSB model, was a life history model resulting in a relative index of SSB (Rugolo et al. 1994). When the time series of SSB crossed the level comparable to the 1960-1972 average, the stock reached the criteria for a restored stock.

Under Amendment 5 (adopted in 1995), target F was increased to 0.31, midway between the initial F (0.25) and F_{MSY}, which was revised to equal 0.40. Regulations were developed to allow 70% of the historic harvest (based on the historic period of 1972-1979) and achieve the target F, although states could submit proposals for alternative regulations that were conservation equivalent. Amendment 5 retained the limit of two fish per day at 28 inches minimum size limit in coastal waters, but allowed two fish per day at 20 inches in producer areas. States could adjust the minimum size, if the size change was compensated with a change in season length, bag limits, commercial quota, or a combination of changes. However, no size limit could be less than 18 inches (NEFSC 2013).

Currently Atlantic Striped Bass are managed under Amendment 6 and its addenda. In response to the results of the various stock assessments conducted on Striped Bass over the last three decades, there have been several instances when regulations were put in place to reduce fishing mortality, which in most cases had the intended effect of reducing F to below the desired target. The reductions in F allowed the SSB to increase to an adequate level to produce successful year classes, and from 1993 through 2004, the stock experienced nearly a decade of above average recruitment (i.e., the number of age-1 fish entering the stock each year; a measure of spawning success). However, this period of above average recruitment was immediately followed by a nine-year period (from 2005 through 2013) in which the stock experienced below average recruitment, including one of the lowest years of recruitment on record with the 2013 cohort. This period of low recruitment occurred when the total SSB of the stock was estimated to be at its highest levels during the entire stock assessment time series (1982–2015) (ASMFC 2015). It is therefore important to recognize that for estuarine dependent species that rely on the rivers and/or estuaries for spawning and/or subsequent larval development, environmental conditions during the critical periods of egg development and larval settlement can be the most important factor in determining annual spawning success. There absolutely must be a minimum level of SSB at which managers do not want a stock's biomass to fall below, but even at high levels of SSB other factors can influence spawning success. This example shows that a variety of factors over several decades resulted in successful improvement in the stock, but cannot be used as an indication that the Petitioned rules would have the same effect for Atlantic Croaker, Spot, and Weakfish.

5.1.4.2 Summer Flounder

Summer Flounder are one of the most important commercial and recreational fisheries along the Atlantic Coast. They range from Massachusetts to North Carolina. Commercially, the primary gear used to harvest Summer Flounder is the ocean trawl fishery. Trawling for Summer Flounder has been ongoing since 1880. Commercial and recreational landings peaked in 1979 and 1983, respectively. By 1990, commercial and recreational landings declined far below peak periods. The 1991 stock assessment determined that the Summer Flounder stock was overfished and overfishing was occurring. According to the stock assessment, the fishing mortality rate for Summer Flounder on the spawning stock (fish at least age-2 or greater) was F=1.1, which was nearly five times the fishing mortality threshold (F_{max}=0.23). The stock assessment recommended reducing fishing mortality rates to rebuild the SSB and age structure of Summer Flounder (Terceiro 2002).

In 1992, Amendment 2 to the Summer Flounder Fishery Management Plan was drafted and implemented by the ASMFC and MAFMC. Amendment 2 enacted stringent harvest controls to curtail fishing mortality. These included annual commercial quotas, minimum mesh sizes and other gear specifications, seasons, recreational harvest limits, and recreational size and bag limits. Although in 1999, Summer Flounder were still considered overfished and overfishing was occurring, the stock had improved dramatically with fishing mortality reduced to the lowest levels since the 1960s and SSB being the highest since the 1970s. Also, the age structure for mature fish in the population that had been truncated was now expanding far beyond what was observed in the early 1990s (Terceiro 2002).

Continued restrictions and rebuilding resulted in the Summer Flounder population being considered not overfished and not overfishing when a new stock assessment was conducted in 2011. Fishing mortality was F=0.216 with a threshold of F_{max} =0.31 in 2010 (Terceiro 2011). Not long after, the Summer Flounder stock was declared rebuilt (Terceiro 2018). A few years later, the 2016 stock assessment update found that the Summer Flounder population was not overfished, but overfishing was once again occurring with an F=0.390 and a fishing mortality threshold (F_{max} =0.309; Terceiro 2018). Managers continue to evaluate and adjust target and threshold biological reference points to sustain the Summer Flounder stock and fishery (Terceiro 2011).

5.1.4.3 Weakfish

Reducing fishing mortality through stringent harvest restrictions does not guarantee that the stock will respond in a positive way. There are a variety of factors that can cause stock decline other than mortality due to fishing and Weakfish provides a good example of this. Under Amendment 3 to the ASMFC Interstate FMP for Weakfish, measures were adopted to reach and maintain a target fishing mortality rate of F=0.5 (34% annual harvest rate and spawning potential ratio (SPR) of 20%) and to restore the age structure to the average of 1979–1994 (ASMFC 1996). In 1994, the exploitation rate was estimated at 76% with a rate of F=1.88, and the maximum spawning potential was only 3%. States could use conservation equivalency to accomplish the reductions necessary to meet Amendment 3 goals. North Carolina opted to maintain a 12-inch commercial minimum size limit for all fisheries, except for the estuarine pound net and long haul seine fisheries (seasonal 10-inch size limit). For the recreational fishery, a 12-inch total length minimum recreational size limit with a 4-fish per day creel limit was implemented. For all measures combined (including trawl and gill net mesh restrictions), a 32% reduction in Weakfish exploitation was needed during the April through March ASMFC-designated fishing season. Evaluation guidelines for states were included as Appendix 2 in Amendment 3 (O'Reilly 1996). For the 1994/1995 timeframe and using the methods in the evaluation guidelines, the closure to flynets south of Cape Hatteras, based on the 1990–1992 fishing years, was computed as a 42% reduction in F, exceeding the reduction required to achieve the required reduction in exploitation. The 2015 Information Update to the N.C. FMP for Interjurisdictional Fisheries, Appendix B, contains a summary of subsequent management actions for North Carolina Weakfish up to 2015 (NCDMF 2015b).

The main Weakfish fishing grounds for the flynet fishery were south of Cape Hatteras. These fishing grounds were documented in the early 1930s by Pearson (1932). The flynet closure was premised on the quantity of small Weakfish caught by the fishery in that area. Fish less than 12 inches comprised 95% of the catch south of the Cape, compared to 74% north of the Cape for the years 1990–1992. Also 82% of the harvest on average were caught south of the Cape during the same time span (NCDMF 1994).

While management measures implemented (initiated 1994) through Amendments 3 and 4 resulted in an initial (1994–1998) positive response to rebuilding the overfished stocks of Weakfish along the Atlantic Coast, the 2006 stock assessment indicated that SSB declined rapidly after 1999 and was at the lowest level in the time series (ASMFC 1996, 2002, 2006). The decline in biomass was reflected in landings along the Atlantic Coast, which were at historic lows. While the 2006 stock assessment was not upheld by a peer review panel, the Weakfish Management Board accepted five conclusions (supported by significant evidence) for management use: 1) the stock is declining; 2) total mortality is increasing; 3) there is not much evidence of overfishing; 4) something other than fishing mortality is causing the decline in the stock; and 5) there is a strong chance that regulating the fishery will not reverse stock decline (ASMFC 2006).

The latest assessment completed in 2016 employed a new spatially-structured forward projecting statistical catch-at-age model with time-varying natural mortality (ASMFC 2016a). This model accounts for varying population spatial distribution and changing natural mortality through time. After review of the assessment results, the Weakfish TC recommended an SSB threshold (*Z* based) of 15.2 million pounds that is equivalent to 30% of the projected SSB under average natural mortality and no fishing ($SSB_{30\%}$). The model indicated natural mortality has been increasing since the mid-1990s, from approximately 0.16 at the beginning of the time-series to an average of 0.93 from 2007–2014. The assessment proposed a total mortality target of 0.93 and threshold of 1.36. Total mortality in 2014 was 1.11, which is above the target but below the threshold, indicating that total mortality is still high but within acceptable limits. Results of the assessment show that the Weakfish stock is depleted and has been for the past 13 years, but overfishing is not occurring. Declining trends are seen along the Atlantic Coast. Even though fishing mortality has been at low levels in recent years, the Weakfish population has been experiencing very high levels of total mortality, which has prevented the stock from recovering. Because the total mortality of the stock in the terminal year of the assessment (2014) was below the *Z* threshold, the board did not take any new management measures. Other states along the Atlantic coast (that do not have an inshore shrimp fishery) are also experiencing declines in landings. Due to the coastwide nature of the stock and current compliance with conservative management measures, the Petitioned rules would not likely have an effect on the Weakfish population.

5.2 Stock Responses to Changes in Habitat Quality

As mentioned in section 4.2, habitat protections and reduced natural mortality on a fish stock can lead to increases in abundance. Improving habitats such as soft bottom could result in increased diversity in the benthic community that may benefit small demersal fish as well as invertebrates by providing increased microstructure that provides more protection from predators. Increased water quality can have impacts all the way up the food chain from benthic microalgae (food for small invertebrates) to benthic fishery species such as shrimp and red drum. However, the extent of the proposed rules' effect on water quality is unknown.

Improvements to oyster reefs and SAV can enhance water quality and increase the survival of species that use these habitats to protect themselves from predators. As mentioned previously, it is uncertain if reductions in trawling from the Petitioned rules would improve conditions to the extent that growth and survival of these habitats would substantially increase.

Another unknown is estimating the decrease in natural mortality due to increases in the quality of these habitats. Natural mortality is tied to the life history of a species. If better habitat led to a longer life span, then the natural mortality of the species could decrease. If habitats associated to a particular life stage (e.g., nursery areas) improved, then it is possible that natural mortality associated with that life stage (e.g., juveniles) could decrease. It is unclear what effect the Petitioned rules would ultimately have on a stock's abundance or its life history.

5.3 Minimum Size Limits

Minimum size limits as a management tool to improve stock abundance can be beneficial if size limits based on the life history of the target species are appropriately evaluated. Appropriate size limits can allow fish to spawn at least once, contributing to the overall population, before being removed from the population due to mortality. This section focuses on how minimum size limits could impact fish stock abundance. Impacts to commercial and recreational fisheries from minimum size limits on direct and indirect landings of Spot and Atlantic Croaker are discussed in more detail in sections 6.1.6 and 6.2.2, respectively.

Length at maturity is used in fisheries management to set minimum size limits and to estimate what portion of the population may be able to reproduce before recruiting to the fishery. Minimum length at maturity, length at 50% maturity, and length at 100% maturity are metrics commonly used in stock assessments. Minimum size at maturity for male Spot ranges from 10.9–17.5 centimeters (4.3–6.9 inches), average length at maturity ranges from 18–27 centimeters (7.0–10.6 inches), and minimum length at 100% maturity ranges from 22–27 centimeters (8.7–10.6 inches; ASMFC 2010a). Minimum size at maturity for female Spot ranges from 12–17 centimeters (4.7–6.7 inches), average size at maturity ranges from 18–29 centimeters (7.0–11.4 inches), and minimum length at 100% maturity ranges from 26-33 centimeters (10.2–13.0 inches; ASMFC 2010a). Based on the ranges discussed above for female Spot, instituting an 8-inch minimum size limit would likely have little effect on allowing a majority of female Spot to reach spawning size. Based on biological data collected by NCDMF from 2004–2017, Spot greater than or equal to 8 inches are 77% female and 23% male (Table 5.1); therefore, instituting the size limit proposed in the Petition would shift harvest to primarily females, which would have unknown consequences on the stock.

Utilizing data collected from North Carolina commercial fisheries for Atlantic Croaker, minimum length at maturity for males was 18 centimeters (7.0 inches), length at 50% maturity was 22.4 centimeters (8.8 inches), and minimum length at 100% maturity was 25 centimeters (9.8 inches). Minimum length at maturity for females was 11 centimeters (4.3 inches), length at 50% maturity was 19.3 centimeters (7.6 inches), and minimum length at 100% maturity was 29 centimeters (11.4 inches). Utilizing the North Carolina commercial fisheries dataset, the 2010 ASMFC assessment found 66.7% of male Atlantic Croaker and 90.4% of female Atlantic Croaker were mature by age two (22–27 centimeters) (ASMFC 2010b). Based on length at maturity estimates, instituting a 10-inch minimum size limit for Atlantic Croaker in North Carolina would be adequate to allow 50% of females to reach spawning size (7.6 inches), but would not be adequate to allow 100% of females to reach minimum spawning size (11.4 inches). Based on biological data collected by NCDMF from 2004-2017, Atlantic Croaker greater than or equal to 10 inches are 73% female and 27% male (Table 5.1); therefore, as mentioned above for Spot, instituting the size limit proposed in the Petition would shift harvest to primarily females, which would have unknown consequences on the stock.

Table 5.1. Percentage of Spot and Atlantic Croaker by sex based on size (inches), 2004–2017. (Source: NCDMF)

Spot			Atlantic Croaker		
Size (inches)	% Male	% Female	Size (inches)	% Male	% Female
<8	31.57	68.43	<10	28.66	71.34
≥8	23.36	76.64	≥10	26.66	73.34

The minimum size limits that would be implemented by the Petitioned rules, although not a complete moratorium, would have a drastic impact on commercial landings and recreational harvest. Data has shown that a large percentage of the marketable commercial catch of Spot and Atlantic Croaker from shrimp trawls is below the Petition-requested size limits for these species (see section 6.1.6). Under the proposed rules, these fish would have to be discarded. For commercial gears targeting these species, portions of the current landings would also be under the proposed minimum size limits, resulting in a 46% (Spot) and 14% (Atlantic Croaker) loss in value to those fisheries, in which, ultimately, fishermen may choose to not continue to target these species, given the already low ex-vessel prices they command (section 6.2.2.1). Again, this portion of the catch would have to be discarded. Recreational harvest (i.e., kept fish) that would be below the proposed minimum size limits may be between 34% and 67% for Spot and between 72% and 84% for Atlantic Croaker (see section 6.2.2.2). Fishermen who target these species would be required to discard any catch below the size limit. Catch and release fishermen would not be directly affected by the rule change; however, fishermen that keep their catch may choose to target other species since they would have to discard a large portion of their catch.

Discarded fish experience varying levels of mortality after being discarded (e.g., potential injuries from gear, handling of the fish while out of the water). It is estimated that up to 67% of species discarded from shrimp trawls will likely die after being discarded (NCDMF 2015a). Spot had the greatest mortality rates of the commonly discarded species caught as bycatch in shrimp trawls. Atlantic Croaker showed increased mortality after release when subjected to more time out of the water. The extent of the discard mortality from recreational hook and line fishing is currently unknown for Spot and Atlantic Croaker. Discard mortality adds to the total mortality on a species. The magnitude of increase on total mortality due to additional discards that would come from the Petitioned rules is unknown; however, increased mortality would have negative effects on stock abundance.

5.4 Displacement of Effort

The Petitioned rules present a probability that fishermen who normally participate in either the shrimp trawl, Spot, or Atlantic Croaker fisheries will exit the fishery completely, or shift their efforts into another commercial fishery. This often happens when increased regulations make a fishery unprofitable for fishermen (Conrad 2010; Tidd et al. 2011). As discussed in the previous section, this may be largely true for the commercial Spot fishery, which could potentially see a 46% loss in value, and recreational Atlantic Croaker, which could see as much as an 84% reduction due to the minimum size limits proposed in the Petition. Reduction in effort due to displacement may benefit the originally targeted species by reducing fishing mortality on those stocks, but an increase in effort on other potentially more profitable species would cause increased levels of fishing mortality on these species in both the commercial and recreational fisheries. Over time, this increased fishing mortality could lead to lower biomass and abundance for these stocks. Currently, the magnitude of any effort shift due to the Petitioned rules is unknown and without proper economic performance indicators for the fisheries affected by these rules, it is not possible to model probabilities of how many fishermen would exit or shift to other fisheries. Shifts in effort, if any, would not be able to be determined until several years after the Petitioned rules would be in place.

6 IMPACT ON INDUSTRY

The Petitioned rules would greatly affect the shrimp trawl fishery, as well as other trawl fisheries throughout the state. Both commercial and recreational fishing industries would be affected, but the Petitioned rules would impact the commercial fishing industry more severely. For a complete picture of the impacts of the Petition on the fishing industry, each management measure proposed is discussed in detail for two fishery categories: shrimp (section 6.1) and other (section 6.2), which includes the recreational fishery. Benefits to the industry due to the Petitioned rules is also discussed. Additionally, there would likely be impacts throughout the supply chain, but data are not available to evaluate the scope or magnitude of these impacts. Estimates presented in the section below are based on the best available data and may not reflect the actual amounts that would result from the Petitioned rules.

6.1 Shrimp Fishery

The shrimp fishery is the second largest and second most valuable fishery in North Carolina. The combination of management strategies proposed by the Petitioner, including setting the season based on a count size, decreasing headrope length in both the ocean (where there is no headrope length maximum) and the internal coastal waters, and limiting the number of days in combination with limits on time of day and length of tow, has the potential to significantly reduce the commercial shrimping industry effort, resulting in losses to the industry. Shrimp are considered an annual crop and are highly influenced by the environment; therefore, shrimp abundance and recruitment to the fishery can be highly variable and differ by species (i.e., brown, pink, and white) and location, making it difficult to estimate total reductions in landings and bycatch from reduced effort.

Currently, fishermen can shrimp trawl approximately 74% of the year in internal coastal waters with the existing weekend trawl closures in place (9 p.m. Friday through 5 p.m. Sunday). If restricted to fishing three days in internal coastal waters (example: Wednesday–Friday), trawling would be limited to approximately 45% of the year (see section 6.1.1). Since weekend fishing is allowed in the ocean, a four-day reduction would limit fishing to approximately 57% of the year. By incorporating nighttime restrictions along with limited tow times, the amount of allowable trawling time in both the ocean and internal coastal waters is further reduced (see sections 6.1.2 and 6.1.5). Unfavorable weather, tides, and moon phases can lead to additional losses in days fished. While this is true now, potential losses due to these conditions could be magnified under the Petitioned rules when the conditions occur during the shorter windows of allowed fishing.

Given the high variability in the timing and abundance of the three species that make up North Carolina's shrimp fishery, it is difficult to accurately predict when the count size would open the season. The Petitioner suggests that based on count sizes in the Pamlico Sound, the fishery would open sometime after mid-May. Recognizing that effort is low from January to May, this still potentially reduces the shrimping season by approximately 42% (see section 6.1.3).

Restricting total headrope length from 220 feet to 110 feet in the ocean would cut the maximum allowable headrope length by 50% (see section 6.1.4). Restricting maximum total headrope length from 220 feet to 90 feet in internal coastal waters would reduce maximum allowable headrope length by 59%. It should be noted that not all vessels fish the maximum headrope sizes. While it is not possible to estimate what the magnitude of the reduction in fishing effort would be if the proposed rules are implemented, overall effort would be reduced due to a loss of fishing power.

The Petitioned rules center around reducing harvest time in the shrimp fishery, which may affect the amount of shrimp available to consumers and limits the catch of other marketable species on those fishing trips through minimum size limits (see section 6.1.6).

Shortening the harvest period could lead to surplus quantities of shrimp getting to the dealers and processors at the same time, depressing the price fishermen can earn on their catch. The North Carolina Rural Economic Development Center found that North Carolina fish houses often have their shrimpers bringing catch to the market simultaneously, causing ex-vessel prices to be suppressed (NCREDC 2013). Ex-vessel value is based on the estimated average price paid to the fishermen by the dealer for each species and market grade. Typically, these fish houses then need to move the supply of shrimp to wholesalers as soon as possible, resulting in sale to economy food processors at low or near break-even prices, devaluing the front end of the supply chain. Current seafood market trends show a growing demand for seafood in countries like the U.S. due to ease of overseas aquaculture production and importation. Capture fisheries, on the other hand, peaked in the 1980s and are predicted to shrink as demand grows for aquaculture products (Kite-Powell et al. 2013).

When harvest is heavily restricted in an open access fishery (not limited entry), derby fishing can occur. Derby fishing is defined as racing to harvest as much as possible before the fishery closes (NOAA 2006). This activity has been seen in many open access fisheries around the U.S., with an upper bound on total harvest (i.e., total allowable catch or TAC) such as the Alaskan Salmon fishery, Gulf of Alaska Halibut and Sable fishery, and the New England groundfish fishery. Homans and Wilen (1997) found that if a fishery was under an open access TAC, fishermen were incentivized to participate in derby-style fishing. This caused seasons to inadvertently become shorter because the TAC was met soon after the season opened. From the early 1970s to 1990, Halibut seasons in Alaska fell from 150 days to just two or three days as a result of derby fishing (NRC 1999). In addition to shortened seasons, fishermen often overcapitalize their vessels when in these situations, meaning they increase gear and fishing power to catch as much as possible; thereby, increasing the cost of each trip hoping for high returns from increased harvest. Derby fishing also creates user conflicts as many fishermen are competing for fishing grounds before the harvest is gone, thus increasing the propensity for vessel accidents or disputes between fishermen and fishing sectors (i.e., commercial vs. recreational). It has been often observed that the pulse of fishing from derbies results in landings reaching dealers and processers in large quantities at the same time. Dealers are then required to freeze the catch to be sold throughout the year, or sell their large supply for sub-optimal prices to off-load excesses. This decreases the ex-vessel value paid to fishermen and the overall value of the fishery itself. Although the proposed rules would not implement an upper bound on total catch, if fishermen perceive the proposed reductions in available fishing time and limitations on total effort as significantly limiting their total catch potential, it is possible that the rules could create an incentive for a similar behavioral response.

It is impossible to predict the number of shrimping vessels that would exit the fishery due to the Petitioned rules. Economic literature tells us that fishermen will generally exit the fishery when the marginal cost of effort exceeds marginal revenue (Conrad 2010; Tidd et al. 2011). Very little is known about the costs and structure of shrimping enterprises in North Carolina. In order to determine the exit point most shrimpers would face, the equilibrium point of where cost and revenue functions intersect would need to be known. Determining an equilibrium, or break-even point, is further confounded by the diversity of shrimping vessel configurations. Shrimping vessels vary greatly in net length, mesh size, number of rigs towed, overall vessel size, and engine displacement. This results in significant variability in yield-effort estimates and cost structures for operation. However, some generalizations can be made. Smaller vessels typically land smaller quantities of shrimp, have smaller gear configurations, and employ less crew members (see section 6.3.1, Table 6.18). The Petitioned rules are less likely to affect smaller shrimping vessels because average headrope length is already under the proposed limit of 90 feet. Large vessels, on the other hand, are at a greater risk for exiting the fishery. Owners of large vessels typically have more capital invested in their shrimping vessels, a higher debt to equity ratio, and typically exceed the total proposed headrope length of the Petitioned rules. Larger trawlers are also highly specialized vessels, whose only purpose is typically shrimping. If shrimping is no longer a viable option because of the regulatory changes proposed, it is doubtful these larger vessels could be repurposed for other fisheries. Whether individual shrimping vessels would be able to sustain profitability under the proposed management measures is unknown.

There are potential benefits to the shrimp industry. While the industry may experience a loss of overall fishermen employed, industry consolidation and reduced effort may yield greater positive net revenues for the remaining shrimpers. Harvest restrictions may prove fruitful if the total biomass of shrimp increases over time and effort is simultaneously reduced.

There are a multitude of data needs and analyses needed to determine the factors other than fish stock abundance affecting industry trends. Trends in overall operational costs over the last few decades, ex-vessel prices, and employment costs would need to be examined, along with import and export data, supply chain factors, and consumer purchases. This is an extremely broad topic that would require a large amount of time, research, and analysis. NCDMF does not currently have the resources to perform such analyses. Each proposed rule is discussed in more detail below and the value of each impact is calculated using the data available.

6.1.1 Limiting Days per Week

The proposed rules designate millions of acres of coastal and joint waters as new SSNAs that would restrict harvest. Currently, shrimpers can freely choose when to go fishing in these waters except in areas already restricted (i.e., those designated as PNAs, SNAs, existing SSNAs, and shrimp trawl net prohibited areas; see Table 2.1). Holding all other factors constant, reducing the number of days in a week to fish would reduce shrimp trawling effort (i.e., fewer trips); however, it may be difficult to quantify associated reductions in bycatch. It is possible that recoupment may occur (e.g., increased number of tows during open periods resulting in a minimal reduction of bycatch). It is unknown if fishermen are currently maximizing effort during periods when the shrimp are available. Therefore, the extent of the effort reduction and the associated costs and benefits are uncertain. Commercial landings are reported on trip tickets, which only collect self-reported dates of when the trip started (vessel left the dock) and when they returned to offload. Specific fishing days and times are not currently collected, so an estimate of when effort is maximized is not possible with the data available. More specific data on fishing times would be needed.

The Petitioner correctly points out that it has been observed that the best catches of shrimp are usually immediately after the existing weekend closure. The literature cited by both the Petitioner and the Shrimp FMP Amendment 1 state there is as much as twice as many pounds of shrimp caught early in the five-day trawling week than later in the week (Johnson 2006). This suggests that time restrictions could improve the efficiency of the shrimp fishery. However, reducing allowable days to three per week does not take into account days lost to weather, unfavorable tides, and moon phases, when less options could remain in a week for fishermen to decide when to go fishing. Johnson (2006) further notes that the efficiency of the fishery may be improved by increasing the number of breaks in the week, either by having two one-day closures during the week rather than one two-day closure, or by reducing the number of total days during the week for which trawling is allowed. These potential benefits may be offset, to an unknown extent, by concentrated recoupment of effort and the potential for depressed ex-vessel prices mentioned previously.

It is also unclear how the proposed rules limiting days of the week would affect vessels that are out for multiple days at a time, which is a common practice for large trawlers. If the allowed fishing days are not consecutive, these trawlers may not be allowed to conduct multi-day trips, which would cut into overall profitability of the trip and would complicate enforcement.

The Petition document does not address which days of the week to close and the Petitioner stated in their comments they did not intend to recommend specific days for closure and that decision is best left to the Fisheries Director. The Petitioned rules as written limit trawling effort in estuarine waters to no more than three days per week. If days of the week are eliminated based on average participation (Thursday, Friday, Wednesday, Tuesday; weekdays with the most fishermen ranked from highest to lowest number of fishermen participating) then, with other conditions remaining the same, the maximum potential loss would be an average of 7,612 trips and a total of $10,757,771 in revenue from the shrimp fishery annually (253 participants; Table 6.1). At a minimum (Tuesday, Monday, Saturday, Sunday; weekdays with least fishermen ranked from highest to lowest number of fishermen participating), it would result in a potential average loss of 3,107 trips and $2,466,074 in revenue annually (146 participants). This is only an approximation based on the average daily value of shrimping trips from the NCTTP. Dates used to derive landings by weekday represent the unload/off load date at the dealer and may not reflect actual fishing days. The NCTTP does not record fishing date or time spent fishing. Actual losses may be greater or less depending on how effort is redirected into the new available fishing days, and/or exits from the fishery.

The Petitioned rules as written limit trawling efforts in state ocean waters to no more than four days per week. If days of the week are eliminated based on average participation (Monday, Thursday, Friday; weekdays with the most fishermen ranked from highest to lowest number of fishermen participating) then, with other conditions remaining the same, the maximum potential loss would be an average of 1,463 total trips and a total of $1,419,681 in revenue annually (77 participants; Table 6.1). At a minimum (Tuesday, Saturday, Sunday; weekdays with the least fishermen ranked from highest to lowest number of fishermen participating), it would result in a potential average loss of 1,086 total trips and $1,007,044 in revenue annually (63 participants). This is only an approximation based on the average daily value of shrimping trips from the NCTTP. Dates used to derive landings by weekday represent the unload/off load date at the dealer and may not reflect actual fishing days. The NCTTP does not record fishing date or time spent fishing. Actual losses may be greater or less depending on how effort is redirected into the new available fishing days, and/or exits from the fishery.

Shrimp trawlers also land other species of finfish and shellfish as non-targeted catch that can be legally sold rather than discarded. Table 6.2 shows an average weekday catch by shrimp otter trawlers of non-shrimp species and the value of those non-shrimp catches. Applying the same logic as before in restricting the days of the week based on average participation (number of fishermen), and using shrimping effort as the determinate since shrimp are the target species of those trips, the loss in revenue for non-target species can be estimated.

For estuarine waters, with other conditions remaining the same, eliminating Thursday, Friday, Wednesday, and Tuesday would result in a potential additional loss of an average of $48,589 in revenue annually from non-shrimp species in the shrimp trawl fishery (25 participants; 1,323 trips; Table 6.2). Eliminating Tuesday, Monday, Saturday, Sunday would result in a potential additional loss of an average of $73,405 in revenue annually (32 participants; 2,094 trips). This is only an approximation based on the average daily value of shrimping trips from the NCTTP. Dates used to derive landings by weekday represent the unload/off load date at the dealer and may not reflect actual fishing days. The NCTTP does not record fishing date or time spent fishing. Actual losses may be greater or less depending on how effort is redirected into the new available fishing days, and/or exits from the fishery.

For state ocean waters, with other conditions remaining the same, eliminating Monday, Thursday, Friday would result in a potential additional loss of an average of $37,399 in revenue annually from non-shrimp species in the shrimp trawl fishery (19 participants; 975 trips; Table 6.2). Eliminating Tuesday, Saturday, Sunday would result in a potential additional loss of an average of $28,876 in revenue annually (17 participants; 881 trips). This is only an approximation based on the average daily value of shrimping trips from the NCTTP. Dates used to derive landings by weekday represent the unload/off load date at the dealer and may not reflect actual fishing days. The NCTTP does not record fishing date or time spent fishing. Actual losses may be greater or less depending on how effort is redirected into the new available fishing days, and/or exits from the fishery.

There is a current weekend closure for shrimp trawling in internal coastal waters (non-ocean waters) that has been in place since 1991 (15A NCAC 03L .0102). The Petitioner did not address how the proposed rules limiting the number of allowable trawling days would interact with this current restriction.

A Weekend Trawling for Live Shrimp Permit was established as part of the 2015 Shrimp FMP Amendment 1, allowing permit holders to shrimp for live bait in areas open to the harvest of shrimp with trawls from Friday at 9 p.m. until Saturday at 12 p.m. (noon). Permit holders must report the location of all activities prior to each weekend use of the permit and are only allowed one gallon of dead shrimp per trip. Additional gear restrictions require the use of trawls with no more than a 40-foot combined headrope length and require the use of live tanks with aerators and/or circulating water (50-gallon minimum). While bycatch does occur in this fishery, overall bycatch and at-net mortality is generally low due to short tow times and culling times associated with smaller trawls operating in this fishery. The Petition does not address how reducing the number of days of the week would interact with rules that were established to implement this permit.

Reducing the number of days in the week that trawling is allowed would not only directly impact the live bait shrimp fishery, but would also impact bait users such as recreational fishermen and dealers. The Weekend Trawling for Live Shrimp Permit was established at the request of the MFC Southern Regional AC and was developed to meet the needs of the state’s growing live bait market. Live shrimp are a popular bait for many recreational hook and line fishermen, especially anglers targeting Spotted Seatrout in the fall. Prior to the development of the permit, many live bait dealers would sell out of shrimp before the weekend due to limited tank capacity to hold large volumes of live shrimp. Restricting the number of days in the week that trawling is allowed would further limit the supply of live bait shrimp and hinder the growth of the live bait market. The overall value of the fishery has increased over time and its value is higher than food shrimp (NCDMF 2015a). The value of live shrimp sold by the dozen can be as high as $27 per pound. Reducing the number of days that trawling is allowed could further drive up the price per pound of live shrimp for recreational fishermen; however, this could result in higher profits for bait fishery participants. The average value of the bait shrimping fishery for 2007-2016 was $47,897 per year with an average price per pound of $26.11. Regardless of which days of the week would be closed, the availability of live shrimp and the revenue generated from its sale would be negatively and positively impacted by additional closure days, the magnitude of which is unknown as this time.

Table 6.1. Average weekday landings of shrimp from shrimp trawls and skimmer trawls, 2007–2016. (Source: NCTTP)

	Avg. Landings per Trip (lb)	Avg. Ex-Vessel Price ($)	Avg. Number of Trips	Avg. Number of Participants	Avg. Daily Value
Estuarine					
Sunday	169	$1.61	235	59	$63,809
Monday	268	$1.52	1,058	200	$429,952
Tuesday	318	$1.83	1,377	231	$802,358
Wednesday	480	$2.23	1,728	252	$1,847,068
Thursday	667	$2.26	2,043	265	$3,076,013
Friday	860	$2.37	2,464	263	$5,032,333
Saturday	1,136	$2.36	436	94	$1,169,955
State Ocean					
Sunday	376	$1.81	254	50	$173,310
Monday	489	$1.99	478	78	$465,580
Tuesday	539	$1.96	464	75	$490,286
Wednesday	442	$1.95	467	76	$402,270
Thursday	480	$1.94	490	76	$457,471
Friday	529	$2.01	519	78	$551,831
Saturday	473	$1.97	368	64	$343,448

Table 6.2. Average weekday landings and value of non-shrimp species caught with otter trawls, 2007–2016. (Source: NCTTP)

	Avg. Landings per Trip (lb)	Avg. Ex-Vessel Price ($)	Avg. Number of Trips	Avg. Number of Participants	Avg. Daily Value
Estuarine					
Sunday	27	$1.01	1,080	42	$29,609.70
Monday	36	$0.88	263	28	$8,338.25
Tuesday	24	$0.84	196	17	$3,999.51
Wednesday	27	$0.88	33	7	$790.07
Thursday	33	$1.14	692	43	$26,023.03
Friday	44	$1.00	402	34	$17,776.29
Saturday	59	$0.95	555	39	$31,458.19
State Ocean					
Sunday	30	$0.88	333	19	$8,613.01
Monday	43	$0.97	335	20	$13,884.18
Tuesday	41	$0.97	232	15	$9,243.87
Wednesday	37	$1.00	187	12	$6,861.18
Thursday	33	$0.96	319	18	$9,914.18
Friday	44	$0.97	321	20	$13,600.91
Saturday	34	$1.01	317	18	$11,018.83

6.1.2 <u>Nighttime Restrictions</u>

Life histories of the three primary shrimp species harvested in North Carolina determine nighttime or daytime shrimping. Brown and pink shrimp stay burrowed during the day and are more active at night while white shrimp tend to be found more in the water column and can be caught during both day and night (NCDMF 2015a). Ingraham (2003), which is cited by the Petitioner, looked at nighttime versus daytime trawling only off the coast of Brunswick County. They found that the catch of shrimp (*Penaeus spp*.) did not vary significantly between day and night, but catch rates of shrimp were generally higher during the day. They also observed that catch rates of Southern Flounder, Spot, Atlantic Croaker, and Southern Kingfish were significantly higher during night trawling. It should also be noted that this is one study in one geographic area, and may not be representative of the fishery across the state. Currently, there are other areas in the state where nighttime trawling is not allowed. In New River, nighttime trawl restrictions from 9 p.m. through 5 a.m. from Aug. 16 through Nov. 30 were put in place due to user conflicts and are also in place in the ocean off Brunswick County (15A NCAC 03J .0208(b); 15A NCAC 03J .0202(8)).

According to data retrieved from the Astronomical Applications Department of the U.S. Naval Observatory, there are 8,760 hours in a year, and approximately 4,446 hours of daylight in 2017 (AAD 2017). Currently, shrimp trawlers have 6,455 hours available to harvest under current regulations, or about 75% of the time in a year. As mentioned in section 6.1.1, the Petitioned rules seek to limit shrimp trawling efforts to only three days a week for estuarine waters, and four days for state ocean waters. In addition to these weekdays restrictions, the Petitioned rules seek to limit trawling to daylight hours only. A reduction to three days a week reduces the available time for estuarine harvest to 59% of the year, and 45% for state ocean harvest. The available harvest time is further reduced by constraining harvest to daylight hours only. Estuarine trawling would then be limited to 22% of the year, and ocean-going vessels would be limited to 29%. It should be noted that calculating an increased impact to the industry in addition to the reductions from weekday closures presented in section 6.1.1 would be inaccurate, as those estimates likely include reductions from nighttime restrictions as well. When determining weekday reductions, estimates were calculated using unload dates from the Trip Ticket Program since time of fishing was not available. For example, a trip that fished for two days and landed (unloaded) on Wednesday likely included both day and night harvest from that 48-hour trip, so including additional impacts from nighttime trawling on top of weekday restrictions may inadvertently multiply the reduction. The reductions using only weekday closures do not include additional nighttime restrictions on open fishing days, but also do not account for recoupment of effort.

Estimating accurate economic losses to the shrimp fishery from nighttime restrictions is extremely difficult to project. Trip tickets only record total trip duration, defined as the date from when the vessel left the dock to the date when the vessel landed their catch at the seafood dealer. Data elements such as fishing time, tow times, or time of the day when fishing began and ended are not required to be recorded on trip tickets. As a result, the NCDMF does not know what percentage of trips occur exclusively at night, nor how long each trip takes on average. Without this information, it is very difficult to project the loss in shrimp harvest, as the NCDMF does not have a measure for landings per hour. Even though the available time for shrimp trawling would be reduced, economic literature would suggest that a large increase in effort and pressure during available times for trawling would be expected, as fishermen often respond to season and time restrictions by overcapitalizing vessels to increase fishing pressure and recoup lost effort (Conrad 2010; Pfeiffer and Gratz 2016).

The extent that effort is maximized during specific times of the day is unknown. Commercial landings are reported on trip tickets, which only collect self-reported dates of when the trip started (vessel left the dock) and when they returned to offload. Specific fishing times are not currently collected. There are mixed reports from dialogue between commercial fishermen and NCDMF staff about their preferences for night or daytime trawling, but without a survey of the fleet, it would be difficult to extrapolate to the entire population with any confidence.

6.1.3 Opening Shrimp Season based on Shrimp Count Size

The Petitioner states that opening the fishery when the shrimp count size reaches 60 shrimp per pound (heads-on) would reduce concerns that "shrimp are too small or that bycatch is too high" when the fishery becomes more active in the Pamlico Sound in mid-May (NCWF 2016a). Shrimping effort in Pamlico Sound does not increase until larger quantities of marketable shrimp are available in the sound. Under existing regulations, shrimpers can freely choose when to go fishing in coastal and joint fishing waters except in areas already restricted (i.e., those designated as PNAs, SNAs, existing SSNAs, and shrimp trawl net prohibited areas; see Table 2.1).

Analysis of NCTTP landings data indicates that a 60-count opening target size for Pamlico Sound may not provide a predictable outcome in delaying the opening of shrimp season. Landings (by count size) in Pamlico Sound indicate that the shrimping season may not be greatly affected in the sound if a proposed 60-count opening target size is established and no consideration of shrimp species is accounted for. Brown shrimp would most likely drive the opening date based on shrimp count size because that species is the first shrimp to enter North Carolina estuaries each year.

While setting species-specific target sizes may or may not delay the opening of the shrimping season, the brown shrimp fishery in the southern portion of the state would likely be delayed, as well as the spring shrimp fishery in the Atlantic Ocean. Roughly 90% or greater of all shrimp (i.e., brown, white, pink) harvested in Pamlico Sound are 60-count size or larger (e.g., 56/60 count, 51/55 count, 46/50 count; Table 6.3). Furthermore, only a minimal delay in the opening date would occur if the proposed measures were to include species-specific openings. By May, 52% of all brown shrimp landed in Pamlico Sound from 1994–2015 were 56/60 count or larger, and by June, 95% were 56/60 count or larger (Table 6.4; NCDMF 2017). The same count size of white shrimp landed ranged from a low of 87% in June to a high of 100% in January (Table 6.5). By April, 95% of the pink shrimp landed from Pamlico Sound were 56/60 count or larger (Table 6.6).

NCTTP data only show what was landed and not what may have been discarded due to size. Different culling practices between fishing operations may result in different sizes of discarded shrimp, whereas some vessels typically discard smaller shrimp while others prefer to sell it for bait or keep for consumers who prefer smaller, cheaper shrimp. Independent sampling would be the best way to determine opening based on shrimp count size. The NCDMF conducts a fisheries-independent survey in the waters of Pamlico Sound, and the lower Neuse and Pamlico rivers during the middle two weeks of June and September each year. One objective of the survey is to monitor the distribution, relative size abundance, and size composition of fish, shrimp, and crabs. Sampling is of a stratified random design where 54 stations are randomly selected from strata based on depth and location. Double rigged 30-ft demersal mongoose trawls (9.1-m headrope, 1.0-m by 0.6 m doors, 2.2-cm bar mesh body, 1.9-cm bar mesh cod end, and a 100-mesh tailbag extension) are deployed from the 44-ft fiberglass hulled R/V *Carolina Coast* and towed during daylight hours for a duration of 20 minutes at 2.5 knots. This survey or the use of the R/V *Carolina Coast* may be a means to sample for opening on a 60-count shrimp size. See section 9.2 for a discussion of impacts to the state from monitoring for opening the season based on shrimp count size.

Shrimp count size estimates are based on a combination of conversions used by the NCTTP and length frequencies from marked and released shrimp from the 1960s (McCoy 1968; Appendix 2). Analysis of sizes of brown shrimp from the June Pamlico Sound Survey for the last five years (2012 through 2016), show approximately 57% of brown shrimp caught were 95 mm or more (61/65 count heads-on and larger; Figure 6.1). Additionally, historical data from the Juvenile Shrimp Sampling (Program 510) taken from 1972 through 2010 (when sampling ended in the Pamlico Sound) during May, June, and July in Pamlico Sound bays and tributaries show that in May 3% of brown shrimp were 95 mm or more (Figure 6.2). This increases through June and July to approximately 64% and 85% of brown shrimp being 95 mm or more, respectively. If brown shrimp count sizes are used to determine an opening, it is possible that the shrimping season could open in June, dependent on environmental conditions. This would potentially have an effect on shrimp fisheries in the southern part of the state where shrimping effort increases in May. Brown shrimp would most likely drive the opening date based on shrimp count size because that species is the first shrimp to enter North Carolina estuaries each year.

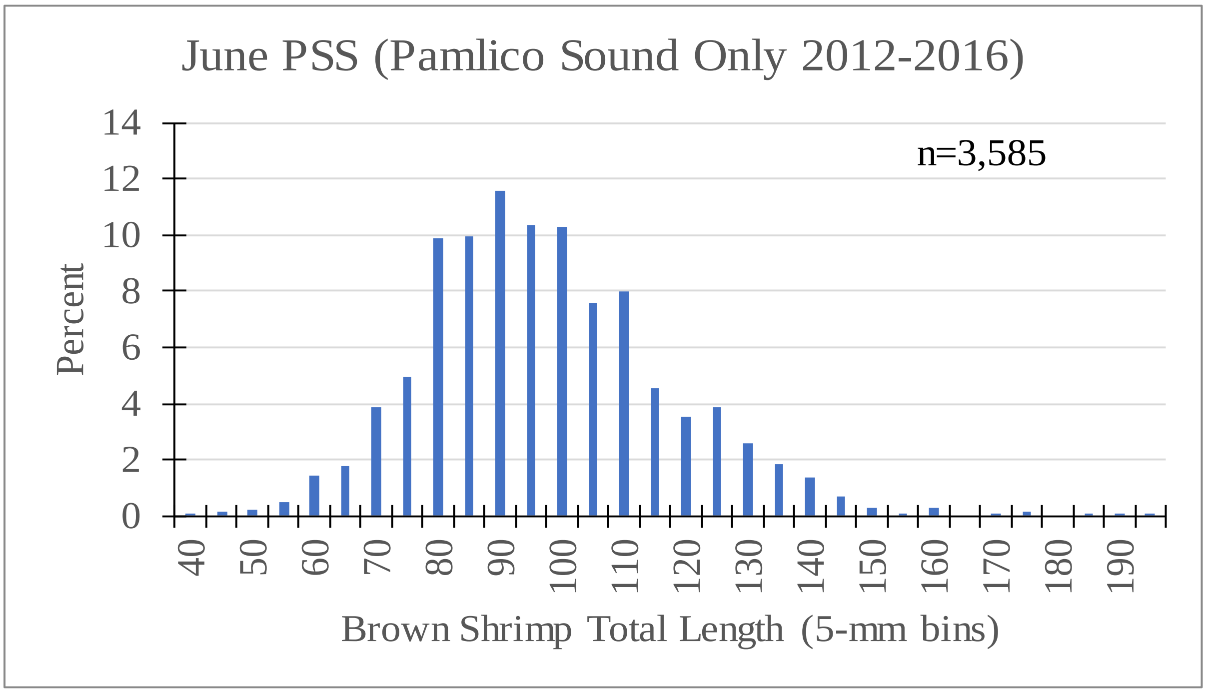

Figure 6.1. Percent brown shrimp lengths from the June Pamlico Sound Survey (Program 195) from 2012–2016. (Source: NCDMF)

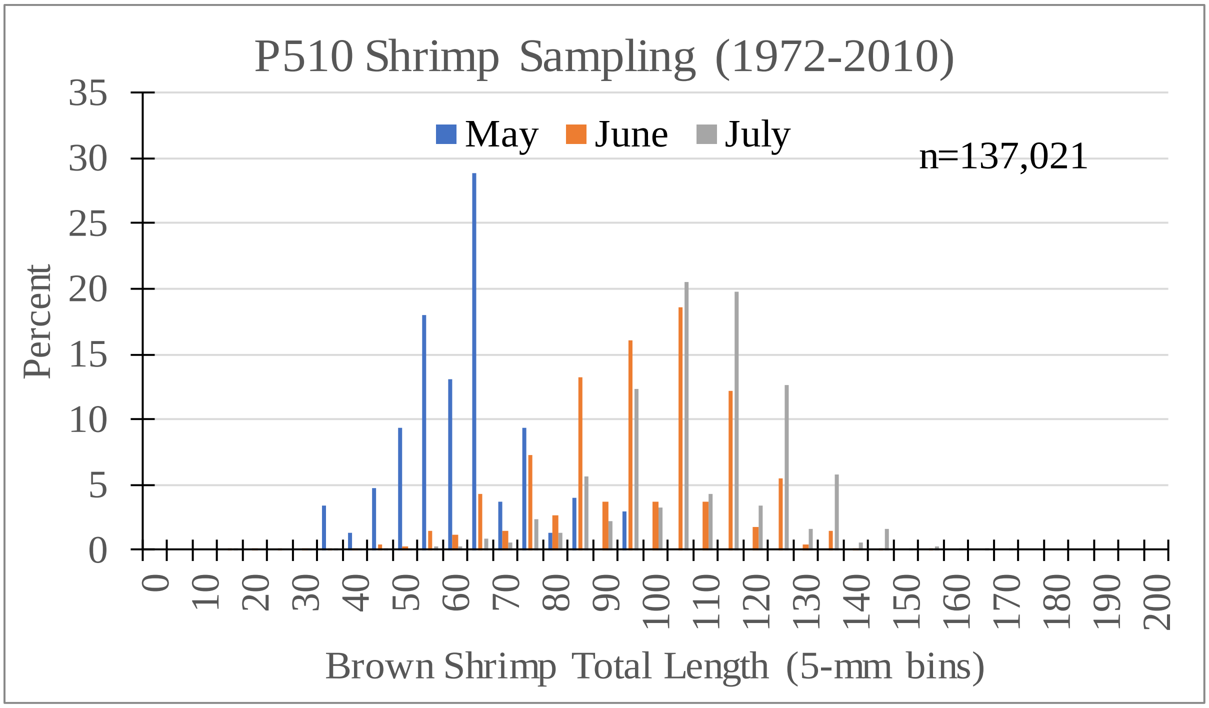

Figure 6.2. Percent brown shrimp lengths from Juvenile Shrimp Sampling (Program 510) of Pamlico Sound bays and tributaries from 1972–2010. (Source: NCDMF)

Table 6.3. Monthly shrimp* (all three species combined) landings and trips by size for Pamlico Sound, 1994–2015 (Source: NCDMF 2017). *Does not include live/bait shrimp (number/dozen).

All Species	Month																									
	1		2		3		4		5		6		7		8		9		10		11		12		Total	
Size	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%
0/15	16,988	35.2	854	8.5	89	4.4	648	1.9	13,321	3.2	77,458	3.3	3,061,672	11.1	7,158,976	30.5	3,245,806	28.4	4,750,376	40.8	2,369,011	49.2	212,549	48.2	20,907,749	25.4
16/20	5,175	10.7	2,307	23.1	774	38.5	1,064	3.2	58,519	14.2	262,518	11.2	7,461,671	27.1	8,260,325	35.1	2,599,565	22.8	2,310,767	19.8	690,220	14.3	63,389	14.4	21,716,294	26.4
21/25	17,099	35.4	6,311	63.1	295	14.7	2,717	8.1	79,202	19.2	484,069	20.6	8,217,683	29.8	3,944,475	16.8	2,145,877	18.8	1,777,708	15.3	638,042	13.2	95,751	21.7	17,409,230	21.2
26/30	1,395	2.9	78	0.8	1	<0.1	5,113	15.2	93,225	22.6	545,250	23.2	4,973,122	18.1	1,688,741	7.2	912,582	8.0	437,025	3.8	128,741	2.7	8,920	2.0	8,794,194	10.7
31/35	4,416	9.1	275	2.8	162	8.1	6,492	19.3	64,546	15.7	278,068	11.8	1,258,997	4.6	491,852	2.1	742,568	6.5	924,798	7.9	436,873	9.1	28,081	6.4	4,237,127	5.2
36/40	1,756	3.6	51	0.5			6,469	19.3	41,528	10.1	340,845	14.5	1,275,412	4.6	591,198	2.5	761,373	6.7	705,102	6.1	292,851	6.1	15,925	3.6	4,032,509	4.9
41/45	816	1.7			438	21.8	3,237	9.6	7,540	1.8	93,762	4.0	119,993	0.4	176,394	0.8	345,036	3.0	287,006	2.5	140,381	2.9	6,258	1.4	1,180,860	1.4
46/50	5	<0.1			33	1.6	3,666	10.9	9,599	2.3	88,529	3.8	170,885	0.6	86,795	0.4	132,489	1.2	106,013	0.9	18,425	0.4	1,380	0.3	617,820	0.8
51/55							797	2.4	339	0.1	12,358	0.5	13,076	<0.1	15,993	0.1	20,287	0.2	9,503	0.1	1,638	<0.1	134	<0.1	74,124	0.1
56/60							232	0.7	2,488	0.6	21,076	0.9	20,519	0.1	23,663	0.1	30,238	0.3	11,221	0.1	2,516	0.1	263	0.1	112,216	0.1
60/70									1,959	0.5	14,156	0.6	7,371	<0.1	10,507	<0.1	20,571	0.2	4,783	<0.1	1,813	<0.1	339	0.1	61,498	0.1
70/80											1,950	0.1	2,845	<0.1	3,697	<0.1	6,433	0.1	881	<0.1	596	<0.1	94	<0.1	16,496	<0.1
80+									11	0.0	1,463	0.1	9,045	<0.1	6,562	<0.1	7,214	0.1	7,199	0.1	93	<0.1	16	<0.1	31,603	<0.1
MIXED	672	1.4	126	1.3	220	10.9	3,135	9.3	39,402	9.6	125,804	5.4	958,718	3.5	1,044,876	4.4	453,753	4.0	315,390	2.7	95,468	2.0	7,762	1.8	3,045,327	3.7
Total	48,321	0.1	10,002	<0.1	2,013	<0.1	33,570	<0.1	411,679	0.5	2,347,306	2.9	27,551,008	33.5	23,504,052	28.6	11,423,791	13.9	11,647,772	14.2	4,816,669	5.9	440,861	0.5	82,237,044	
Size ≥ 56/60	47,649	98.6	9,877	98.7	1,792	89.0	30,435	90.7	370,307	90.0	2,203,933	93.9	26,573,030	96.5	22,438,411	95.5	10,935,820	95.7	11,319,519	97.2	4,718,699	98.0	432,651	98.1	79,082,121	96.2
Size ≥ 60/70	47,649	98.6	9,877	98.7	1,792	89.0	30,435	90.7	372,266	90.4	2,218,089	94.5	26,580,400	96.5	22,448,917	95.5	10,956,391	95.9	11,324,301	97.2	4,720,512	98.0	432,990	98.2	79,143,619	70.8

Table 6.4. Monthly brown shrimp* landings and trips by size for Pamlico Sound, 1994–2015 (Source: NCDMF 2017). *Does not include live/bait shrimp (number/dozen).

Brown Shrimp	Month																									
	1		2		3		4		5		6		7		8		9		10		11		12		Total	
Size	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%
0/15										0.0	23,275	2.3	2,739,682	11.8	5,890,906	31.9	1,645,421	34.9	562,875	44.0	79,625	49.4	6,263	53.7	10,948,047	22.4
16/20									3,123	16.3	72,436	7.1	6,682,595	28.8	6,875,050	37.2	1,275,097	27.0	304,779	23.8	27,125	16.8	1,633	14.0	15,241,837	31.2
21/25					273	100.0					181,267	17.9	6,688,592	28.9	2,750,898	14.9	643,822	13.7	114,587	9.0	19,264	11.9	1,230	10.6	10,399,932	21.3
26/30									1,884	9.9	249,333	24.6	4,417,103	19.1	1,490,067	8.1	458,996	9.7	115,842	9.1	14,251	8.8	1,079	9.3	6,748,554	13.8
31/35									981	5.1	120,196	11.9	739,386	3.2	154,944	0.8	68,404	1.5	21,526	1.7	11,136	6.9			1,116,573	2.3
36/40									1,143	6.0	207,876	20.5	943,251	4.1	377,932	2.0	305,316	6.5	68,554	5.4	7,498	4.7	804	6.9	1,912,374	3.9
41/45									66	0.3	37,928	3.7	64,304	0.3	82,750	0.4	50,056	1.1	10,907	0.9	251	0.2			246,262	0.5
46/50									1,510	7.9	43,399	4.3	127,043	0.5	45,143	0.2	28,397	0.6	10,518	0.8	904	0.6			256,914	0.5
51/55											5,454	0.5	8,650	<0.1	5,384	<0.1	3,104	0.1	1,296	0.1	40	<0.1			23,928	<0.1
56/60									1,136	5.9	9,949	1.0	14,531	0.1	7,591	<0.1	4,281	0.1	845	0.1	48	<0.1			38,381	0.1
60/70											6,418	0.6	4,050	<0.1	2,173	<0.1	6,339	0.1	148	<0.1					19,127	<0.1
70/80											4	<0.1	1,058	<0.1	283	<0.1	528	<0.1	41	<0.1	14	<0.1			1,928	<0.1
80+											4	<0.1	7,934	<0.1	5,329	<0.1	1,019	<0.1	544	<0.1					14,830	<0.1
MIXED									9,271	48.5	56,438	5.6	730,718	3.2	800,570	4.3	225,791	4.8	66,349	5.2	1,067	0.7	650	5.6	1,890,854	3.9
Total					273	<0.1			19,114	<0.1	1,013,976	2.1	23,168,896	47.4	18,489,018	37.8	4,716,571	9.7	1,278,811	2.6	161,224	0.3	11,658	<0.1	48,859,542	
Size ≥ 56/60					273	100.0			9,843	51.5	951,112	93.8	22,425,137	96.8	17,680,664	95.6	4,482,894	95.0	1,211,728	94.8	160,143	99.3	11,008	94.4	46,932,803	96.1
Size ≥ 60/70					273	100.0			9,843	51.5	957,530	94.4	22,429,187	96.8	17,682,836	95.6	4,489,233	95.2	1,211,876	94.8	160,143	99.3	11,008	94.4	46,951,930	96.1

Table 6.5. Monthly white shrimp* landings and trips by size for Pamlico Sound, 1994–2015 (Source: NCDMF 2017). *Does not include live/bait shrimp (number/dozen).

White Shrimp	Month																									
	1		2		3		4		5		6		7		8		9		10		11		12		Total	
Size	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%
0/15	15,493	43.4	131	98.7			103	20.1	209	100.0	10,208	65.9	7,062	22.4	36,455	16.1	669,981	21.3	3,136,115	44.5	1,826,022	55.7	170,825	53.8	5,872,604	41.7
16/20	4,615	12.9									777	5.0	507	1.6	40,555	17.9	727,041	23.1	1,550,635	22.0	537,116	16.4	45,635	14.4	2,906,881	20.6
21/25	9,096	25.5					390	76.0			1,510	9.8	6,001	19.0	40,614	18.0	834,828	26.6	1,115,585	15.8	411,283	12.5	56,168	17.7	2,475,474	17.6
26/30	1,303	3.6			1	5.3	20	3.9			858	5.5	1,727	5.5	14,079	6.2	198,856	6.3	188,949	2.7	63,109	1.9	3,801	1.2	472,703	3.4
31/35	3,006	8.4									70	0.5	7,607	24.1	45,024	19.9	366,092	11.6	541,674	7.7	241,024	7.3	22,772	7.2	1,227,269	8.7
36/40	1,325	3.7									89	0.6	4,347	13.8	14,438	6.4	98,561	3.1	197,914	2.8	59,825	1.8	8,583	2.7	385,081	2.7
41/45	816	2.3											1,657	5.2	8,434	3.7	111,561	3.5	116,931	1.7	70,053	2.1	4,566	1.4	314,018	2.2
46/50													112	0.4	4,952	2.2	17,300	0.6	23,771	0.3	7,567	0.2	667	0.2	54,369	0.4
51/55															294	0.1	3,326	0.1	1,612	<0.1	572	<0.1	114	<0.1	5,918	<0.1
56/60													845	2.7	2,886	1.3	5,618	0.2	3,430	<0.1	1,355	<0.1	80	<0.1	14,214	0.1
60/70															62	<0.1	1,859	0.1	800	<0.1	1,208	<0.1	224	0.1	4,152	<0.1
70/80															786	0.3		<0.1	121	<0.1	459	<0.1	52	<0.1	1,418	<0.1
80+															29	<0.1	1,568	0.0	2,489	<0.1	37	<0.1	10	<0.1	4,133	<0.1
MIXED	78	0.2	2	1.3	18	94.7					1,971	12.7	1,725	5.5	17,384	7.7	105,983	3.4	165,732	2.4	60,187	1.8	4,315	1.4	357,395	2.5
Total	35,734	0.3	133	0.0	19	0.0	513	0.0	209	0.0	15,483	0.1	31,590	0.2	225,992	1.6	3,142,573	22.3	7,045,758	50.0	3,279,817	23.3	317,812	2.3	14,095,631	
Size ≥ 56/60	35,656	99.8	131	98.7	1	5.3	513	100.0	209	100.0	13,512	87.3	29,865	94.5	207,731	91.9	3,033,163	96.5	6,876,617	97.6	3,217,925	98.1	313,211	98.6	13,728,533	97.4
Size ≥ 60/70	35,656	99.8	131	98.7	1	5.3	513	100.0	209	100.0	13,512	87.3	29,865	94.5	207,793	91.9	3,035,021	96.6	6,877,417	97.6	3,219,133	98.1	313,435	98.6	13,732,685	97.4

Table 6.6. Monthly pink shrimp landings and trips by size for Pamlico Sound, 1994–2015 (Source: NCDMF 2017).

Pink Shrimp	Month																									
	1		2		3		4		5		6		7		8		9		10		11		12		Total	
Size	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%
0/15									5,892	2.5	40,620	5.2	218	0.1	534	3.8	776	9.4	11,498	20.8	645	4.7			60,182	4.2
16/20							1,053	6.2	51,243	21.4	174,945	22.2	46,985	14.9	3,846	27.3	491	6.0	9,990	18.0	100	0.7			288,654	19.9
21/25							2,327	13.8	65,151	27.2	212,865	27.1	69,881	22.2	5,201	37.0	197	2.4	11,115	20.1	200	1.5			366,936	25.3
26/30	22	10.8					3,375	20.0	56,525	23.6	189,408	24.1	120,233	38.2	818	5.8	985	12.0	8,483	15.3	2,404	17.4			382,253	26.4
31/35			36	87.8			4,387	26.0	22,803	9.5	44,564	5.7	33,184	10.6	2,415	17.2	3,285	39.9	3,717	6.7	9,520	69.1			123,911	8.5
36/40							2,486	14.7	18,578	7.7	62,810	8.0	24,823	7.9	496	3.5	1,000	12.1	7,877	14.2	300	2.2	414	100.0	118,784	8.2
41/45					123	67.6	1,290	7.6	3,296	1.4	11,436	1.5	887	0.3	436	3.1	970	11.8	1,723	3.1	583	4.2			20,745	1.4
46/50					33	18.1	1,038	6.2	3,390	1.4	22,282	2.8	3,152	1.0	22	0.2	52	0.6	261	0.5					30,230	2.1
51/55							488	2.9	274	0.1	1,597	0.2	339	0.1		0.0	400	4.9	615	1.1					3,713	0.3
56/60							232	1.4	384	0.2	5,476	0.7	169	0.1	295	2.1	80	1.0	60	0.1					6,696	0.5
60/70											697	0.1	224	0.1					65	0.1	14	0.1			1,000	0.1
70/80													6	0.0											6	<0.1
80+																										<0.1
MIXED	181	89.2	5	12.2	26	14.3	202	1.2	12,373	5.2	19,934	2.5	14,267	4.5							18	0.1			47,006	3.2
Total	203	<0.1	41	<0.1	182	<0.1	16,878	1.2	239,909	16.5	786,634	54.2	314,368	21.7	14,064	1.0	8,236	0.6	55,405	3.8	13,784	1.0	414	<0.1	1,450,117	
Size ≥ 56/60	22	10.8	36	87.8	156	85.7	16,676	98.8	227,536	94.8	766,003	97.4	299,871	95.4	14,064	100.0	8,236	100.0	55,340	99.9	13,752	99.8	414	100.0	1,402,105	96.7
Size ≥ 60/70	22	10.8	36	87.8	156	85.7	16,676	98.8	227,536	94.8	766,700	97.5	300,095	95.5	14,064	100.0	8,236	100.0	55,405	100.0	13,766	99.9	414	100.0	1,403,105	96.8

Environmental conditions also play a role in size and number of shrimp, affecting each species differently. Once post-larval shrimp enter the estuaries, growth is highly dependent on salinities and temperature (NCDMF 2015a). For example, a warm winter, along with a dry year may have a positive impact on shrimp count size and growth while a cold winter during a wet year may result in fewer and smaller shrimp. Extreme weather conditions that result from hurricanes can also have an impact.

Current rules do not restrict shrimping effort in any waters except in PNAs, SNAs, existing SSNAs, and shrimp trawl net prohibited areas, leaving a large amount of water open to shrimping (See Table 2.1). Restricting shrimping effort in these remaining waters and enacting a closure until shrimp count size reaches 60 shrimp per pound in Pamlico Sound could also result in "grand openings," where a large number of vessels operate in an area following a closure. Reductions in bycatch may then be offset by recoupment from the increased effort once an area is opened. Previous fishing seasons observed by NCDMF have shown that delayed openings in the existing SSNAs in waterbodies such as New River and Stump Sound have resulted in a large number of vessels in a small area trying to recoup harvest and effort once the areas are opened.

As proposed, the Petitioner recommends that all areas open once Pamlico Sound shrimp are 60-count size heads-on (NCWF 2016a). They proposed the use of Pamlico Sound as a "proxy" for other areas to determine coastwide opening of the shrimp season because the majority of effort occurs in Pamlico Sound. Under the Petition, NCDMF would be required to develop new sampling protocols that would likely involve significant effort by the NCDMF to sample shrimp in Pamlico Sound (see section 9.2). The Shrimp FMP Amendment 1 provides guidance on count sizes for opening shrimping in different areas, especially in the southern and central coast.

6.1.4 Reduction in Headrope Length

The Petitioner interprets Brown (2015) to say that otter trawl headrope length has increased over time and states that in 2012, the average maximum headrope length was 94 feet and in 2015, this length increased to 134 feet (NCWF 2016a). Therefore, the Petitioned rules propose a 90-foot maximum headrope length in estuarine waters and a 110-foot maximum in ocean waters. However, it should be noted that observer coverage during this time was less than 2% of the commercial shrimp otter trawl fishery (fishing days) for 2015 and may not provide a true representation of the fishery.

The Shrimp FMP Amendment 1 examined headrope lengths for the years 2010 and 2011 by area, using data from the CFVR gear survey, and found that average total headrope length in Pamlico Sound was 128 feet and 117 feet, respectively (Table 6.7). In the mouths of the Neuse, Pamlico, and Bay rivers, the average total headrope length was 55 feet in 2010 and 52 feet in 2011. Total headrope lengths in Carteret County waterbodies averaged 47 and 46 feet during those same years. South of Carteret County, vessels with average total headrope lengths measuring 40 feet or less made up the majority of the fleet in both years, in the ocean, vessels using total headrope lengths less than 120 feet accounted for 44% of the fleet in 2010 and 46% in 2011. Average total headrope length for skimmer trawlers was less than 50 feet in the Pamlico Sound, as well as other parts of the state. Based on these data, the larger double-barrel and four-barrel shrimp trawlers would be the most affected by the proposed 90-foot headrope length. These vessels typically fish in Pamlico Sound (164–189 vessels over 90 feet of headrope) and the Atlantic Ocean (70–93 vessels over 90 feet of headrope; Table 6.7). Data from the CFVR gear survey has its limitations and should be used with the understanding that it was the best data available at the time. Limitations from this survey include the fact that answers to the survey reflect the fisherman's predominant gear and does not capture variations in the use of different sizes and number of nets or rigs. In addition, only one predominant waterbody can be captured on some trip ticket forms, limiting the geographic scope of the survey results as compared to trip ticket landings and does not capture the variety of waterbodies in which these fishermen operate. A more comprehensive gear survey is needed to better characterize the fishery, specifically in regards to headrope length.

North Carolina’s headrope regulations were put in place following the 2006 Shrimp FMP as a means to allocate the resource fairly among vessels of all sizes, reduce bycatch, and to limit the effects of trawling in the prescribed areas. Greater headrope length and the use of multiple smaller nets (“double-barrel” and “four-barrel” rigs) allow trawlers to sweep a larger total area per gallon of fuel, resulting in increased CPUE and efficiency (Watson 1984). Currently, there are no data that show that larger headrope lengths yield more bycatch per unit effort. The type and amount of bycatch from a single tow is hard to predict as some tows result in very low bycatch and others have greater levels of bycatch. Reducing headrope length would reduce the total area fished, but since there is not a one to one relationship between harvest and bycatch, neither the magnitude of the bycatch reduction nor the impact on the harvest of target species can be determined. Restricting the total headrope length of otter trawls would essentially restrict the total number of rigs, as well as vessel size in most parts of the state (Table 6.7). It is also important to note that the fishing power, efficiency, and selectivity of the gear rely on more than just the length of the headrope. Currently, it is unlawful to use shrimp trawls that have a combined headrope greater than 90 feet in internal coastal waters (non-ocean) except Pamlico Sound and in the mouths of the Pamlico and Neuse rivers. Through the Shrimp FMP Amendment 1, the areas of Pamlico Sound and the mouths of the Pamlico and Neuse rivers have a maximum headrope length of 220 feet. This became effective on Jan. 1, 2017 and was implemented to cap the fishing capacity of the fleet. In both South Carolina and Georgia, maximum headrope length is also 220 feet. The Atlantic Ocean of North Carolina has no headrope limits.

Decreasing the overall headrope would decrease the overall landings per tow. This would increase the number of haul backs needed to capture the same volume of shrimp with longer headrope lengths. This may result in decreased efficiency and higher operating cost for the fishery. If the efficiency of the gear is reduced due to smaller headropes, some shrimpers may pull more tows and/or longer than normal tows, so total area fished could potentially increase as well as effort. Some may exit the fishery completely, causing effort and intensity to be reduced. Because the Petitioned rules affect multiple aspects of the shrimp fishery in addition to headrope length, it is impossible to predict how fishermen would respond to the proposed rules in order to recoup potential losses or if operating costs started to exceed their profits. Operating costs may also be on the rise with increasing fuel costs and gear costs due to inflation. Additionally, the NCDMF does not have complete or representative data on operational costs per trip in the shrimp fishery, so it would be extremely difficult, if not impossible, to monetize the effect of the proposed rules on gear efficiency and operational costs. To determine the average expenditures for each trip and vessel, additional data would need to be collected. See section 6.3.2 for more on operational expenses.

A benefit of reduced headrope length could be shorter culling times due to the drop in overall landings per tow, which may potentially decrease the discard mortality of species not kept for sale. Reduced landings per tow also reduces the weight or volume of catch in the tailbag of the trawl, which also has an effect on discard mortality, along with species composition of the catch and the size of discarded fish. It is difficult to estimate what percent of discarded fish die once they return to the water due to delayed mortality (mortality happening after the fisherman has lost sight of the released fish) and predation.

Table 6.7. North Carolina vessel and shrimp trawl configuration by area and year, 2010–2011. (Source: NCDMF 2017)

Year	Trawl Type	Area Fished	Total Shrimp lb	Trips #	Average Shrimp (lb/trip)	Vessels #	Vessel Length Average ft	Vessel Length Mode ft	Total Headrope Length Average ft	Total Headrope Length Mode ft	Single Rig #	Single Rig %	Double-Barrel Rig #	Double-Barrel Rig %	Four-Barrel Rig #	Four-Barrel Rig %
2010	Otter	Pamlico Sound	3,837,201	1,656	2,317	220	53	36	128	180	31	14%	71	32%	118	54%
2011	Otter	Pamlico Sound	3,633,502	1,502	2,419	201	49	36	117	70	37	18%	71	35%	93	46%
2010	Otter	Neuse, Pamlico, Bay Rivers	114,871	377	305	58	31	20	55	80	22	38%	33	57%	3	5%
2011	Otter	Neuse, Pamlico, Bay Rivers	104,743	446	235	49	30	19	52	30	21	43%	25	51%	3	6%
2010	Otter	Bogue/Core/ Newport/North River	110,046	553	199	67	29	22	47	15	30	45%	35	52%	2	3%
2011	Otter	Bogue/Core/ Newport/North River	34,584	166	208	43	28	21	46	15	21	49%	22	51%	0	0%
2010	Otter	Southern	216,110	1,394	155	103	22	17	38	35	92	89%	7	7%	4	4%
2011	Otter	Southern	114,799	945	121	65	23	19	39	30	55	85%	9	14%	1	2%
2010	Otter	Ocean	1,253,754	1,623	772	116	51	55	120	160	23	20%	38	33%	55	47%
2011	Otter	Ocean	1,091,810	1,333	819	92	51	55	120	200	22	24%	26	28%	44	48%
2010	Skimmer	Pamlico Sound	*	*	*	2	24		20		0	0%	2	100%	0	0%
2011	Skimmer	Pamlico Sound	699	4	175	4	34	34	46		0	0%	4	100%	0	0%
2010	Skimmer	Neuse, Pamlico, Bay Rivers	14,771	73	202	7	28	25	27	28	0	0%	7	100%	0	0%
2011	Skimmer	Neuse, Pamlico, Bay Rivers	17,191	73	235	4	22		21		0	0%	4	100%	0	0%
2010	Skimmer	Bogue/Core/ Newport/North River	132,458	607	218	37	28	25	29	20	0	0%	37	100%	0	0%
2011	Skimmer	Bogue/Core/ Newport/North River	14,470	94	154	12	29	28	32	24	0	0%	12	100%	0	0%
2010	Skimmer	Southern	137,408	439	313	26	30	17	40	48	0	0%	26	100%	0	0%
2011	Skimmer	Southern	23,215	156	149	17	33	38	42	48	0	0%	17	100%	0	0%

***** Confidential, 3 or less participants, vessels, or dealers

† It is unlawful to take shrimp with trawls which have a combined headrope of greater than 90 feet in internal coastal waters except:

(1) Pamlico Sound;

(2) Pamlico River downstream of a line from a point 35° 18.5882'N – 76° 28.9625'W at Pamlico Point; running northerly to a point 35° 22.3741'N - 6°28.6905'W at Willow Point;

(3) Neuse River northeast of a line from a point 34° 58.2000'N – 76° 40.5167'W at Winthrop Point on the eastern shore of the entrance to Adam's Creek running northerly to a point 35° 01.0744' N – 76°42.1550' W at Windmill Point at the entrance of Greens Creek at Oriental.

6.1.5 Limiting Tow Times

The Petitioned rules establish 45-minute tow times for all trawl nets in estuarine and state ocean waters. This would greatly impact the shrimp trawl fishery as well as the other trawl fisheries operating in the state, as no tow time limits are currently required. Other trawl fisheries operating in estuarine waters that would be affected by the proposed tow time limits include clam trawling, crab trawling, peeler trawling, and the skimmer trawl fishery that targets both shrimp and non-shrimp species. Other trawl fisheries operating in state ocean waters include flounder trawling and flynets. The potential impact to the shrimp trawl fishery is discussed below. Due to a lack of data on the tow times used by fishermen in other trawl fisheries, the impacts from the Petitioned rules to these fisheries are unknown.

Similar to statements regarding headrope length, the Petitioner interprets Brown (2015) to say that tow times have increased over time. The Petition states that in 2012, average tow times were 100 minutes in Pamlico Sound and in 2015, tow times increased to an average of 181 minutes (NCWF 2016a). It must again be considered that these times are from observer data collected from less than 2% of the fishery and may not indicate trends in the fishery overall.

Reduced tow times were also considered as a potential management measure in the Shrimp FMP Amendment 1 in 2015. Reduced tow times would likely reduce bycatch mortality by reducing contact time with the fishing gear, culling time, and exposure on the deck, since total catch per tow would be reduced. However, fish aggregations as well as shrimp aggregations are not uniformly distributed, thus the magnitude of reductions in catch per unit of effort is unknown. Johnson (2006) found that tow duration patterns were inconsistent. Short tow times sometimes produced less bycatch and sometimes they produced more bycatch. Decreasing tow times means increasing the time gear is out of the water (increased number of haul backs), which may decrease effort, but some recoupment with additional tows would likely occur. Finally, increased frequency of gear deployment and haul back may result in a greater chance of fouling the gear, as well as increased risks of crew injury from doors and winches. This management option was removed by the Shrimp FMP AC from the overall option list during the development of Amendment 1.

As mentioned in section 6.1.4 with regards to a reduction in headrope length, a decrease in tow time may decrease the overall landings per tow. This would likely increase the number of haul backs needed to capture the same volume of shrimp during a tow where the time was not restricted to 45 minutes as put forth in the Petitioned rules. This could result in decreased efficiency and higher operating cost. However, there are not specific data available on operational cost per trip in the shrimp fishery. It is hard to determine what the losses would be in terms of efficiency or how operational cost would rise. To determine the average expenditures for each trip and vessel, additional data would need to be collected.

Enforcement of a tow time is extremely difficult without either constant Marine Patrol oversight for the entire duration of a tow or implementation of a costly vessel monitoring system. A NCDMF Marine Patrol officer must be able to observe when the trawl doors go into the water and observe when the doors are out of the water, as well as determine how long the tow lasts. It is challenging for one officer to observe more than one vessel at a time, so it is a labor-intensive process and one where the vessels outnumber the officers. See section 9.1 for enforcement concerns regarding tow time restrictions.

As written, the Petition’s proposal to implement shrimp trawl tow time limits would be very difficult to enforce. Even if a marine patrol officer is in close proximity to a shrimp trawl while it is in the middle of a tow, it is difficult for the officer to see if the trawl doors come completely out of the water, which determines the stopping point of the time limit. The proposed rule may also need a requirement to empty the contents of the net at the end of the tow in order to clearly distinguish a single tow event.

Tow times in the ocean were enforced from 1996 through 2005 under a now-expired Incidental Take Permit (ITP) from NMFS issued to the NCDMF to allow trawlers from Browns Inlet to Rich’s Inlet to operate without turtle excluder devices due to the presence of grass (brown algae). This involved constant monitoring and numerous observers and was difficult to enforce. Proclamations issued to regulate that permit (such as SH-15-2001) established a tow time definition and required the nets to be emptied in-between tows, which were critically important details to the feasibility of the restrictions. The requirement to empty nets between tows allowed officers to determine the length of the tow and, in this case, gave any endangered turtles that had interacted with the trawl a better chance of survival.

Another component of the enforcement concern about shrimp trawl tow times is the lack of a definition of a start and stop for skimmer trawls. This would be needed to enable monitoring by NCDMF Marine Patrol officers. Unlike otter trawls, skimmer trawls do not have doors and the trawl frames remain in the water at all times. These issues, as well as responding to the anticipated bystander complaints regarding operation of legal tow times, would likely impact the ability of officers to enforce other fishery regulations.

6.1.6 Minimum Size Limits

Minimum size limits implemented as part of the Petitioned rules would result in increased discards as well as a loss of revenue from the sale of Spot and Atlantic Croaker incidentally caught in the shrimp trawl fishery. Using length data from commercial shrimp trawl characterization studies conducted in the estuarine and ocean waters of North Carolina, approximately 99% to 100% of Spot caught would be discarded as the result of an 8-inch minimum size limit (total length; TL). The majority of Spot measured in the estuarine otter trawl fishery ranged from 2 to 7 inches TL and 3 to 5 inches TL in the skimmer trawl fishery (Brown 2010, 2015, 2017). The majority of Spot measured in the ocean otter trawl fishery ranged from 3 to 8 inches TL; however, 8-inch Spot were only recorded from ocean otter trawls by Brown (2017) in the fall of one study period and this size made about 10% of the total Spot sampled during that study (Brown 2009, 2015, 2017).

In the estuarine and ocean shrimp trawl fisheries, it is estimated that approximately 100% of Atlantic Croaker caught and previously sold would be discarded as the result of a 10-inch minimum size limit (TL). The majority of Atlantic Croaker measured in the estuarine otter trawl fishery ranged from 3 to 7 inches TL and 4 to 6 inches TL in the skimmer trawl fishery (Brown 2010, 2015, 2017). In the ocean otter trawl fishery, the majority of Atlantic Croaker measured ranged from 5 to 8 inches TL (Brown 2009, 2015, 2017). See Brown (2009, 2010, 2015, 2017) for a full description of the species composition and length frequencies of key species.

NCDMF Trip Ticket data indicate the annual ex-vessel value of Spot caught as bycatch in the estuarine shrimp trawl fishery over the last 10 years has ranged from $734 to $14,276 (Table 6.8). The average landings of Spot caught in the estuarine shrimp trawl fishery was 9,476 pounds annually from 2007 to 2016. In state ocean waters (0–3 miles), ex-vessel value of Spot caught as bycatch in the shrimp trawl fishery ranged from $1,384 to $10,382 per year with average landings of 6,353 pounds annually from 2007 to 2016. The annual ex-vessel value of Atlantic Croaker caught as bycatch in the estuarine shrimp trawl fishery, for the same time period, has ranged from $61 to $3,983 (Table 6.9). The average landings of Atlantic Croaker caught in the estuarine shrimp trawl fishery was 910 pounds annually from 2007 to 2016. In state ocean waters (0–3 miles) from 2007 to 2016, Atlantic Croaker landed annually are valued from $19 to $1,780. The average landings of Atlantic Croaker caught in the ocean fishery was 363 pounds annually from 2007 to 2016.

Currently, no data are available to establish the opportunity costs of culling undersized fish. While tow time is recorded for characterization studies conducted in North Carolina waters (Brown 2009, 2010, 2015, 2017), culling time is not. Longer tow times are not always indicative of longer culling times. The amount of bycatch in a trip can be skewed, with many tows having some bycatch and fewer tows with high bycatch (Johnson 2006; NCDMF 2015a). Thus, culling times can be highly variable due to spatial and temporal differences in fishing effort and the distribution of finfish. Additionally, the species makeup and volume of the catch often dictate culling times as well as the size and efficiency of the crew.

Table 6.8. Annual landings and total value of Spot from shrimp trawls in estuarine and state ocean waters (0–3 miles) in North Carolina, 2007–2016. (Source: NCTTP)

Year	Waterbody	Pounds Landed	Nominal Value	Waterbody	Pounds Landed	Nominal Value
2007	Estuarine	13,609	$9,475	State Ocean	8,004	$5,596
2008	Estuarine	15,452	$9,333	State Ocean	5,797	$3,588
2009	Estuarine	24,341	$14,276	State Ocean	12,170	$7,301
2010	Estuarine	1,089	$734	State Ocean	3,320	$2,225
2011	Estuarine	1,081	$798	State Ocean	1,807	$1,384
2012	Estuarine	3,203	$2,970	State Ocean	3,727	$3,521
2013	Estuarine	15,213	$13,599	State Ocean	9,711	$8,718
2014	Estuarine	16,094	$12,749	State Ocean	8,470	$6,857
2015	Estuarine	1,822	$1,530	State Ocean	2,309	$1,990
2016	Estuarine	2,852	$3,578	State Ocean	8,214	$10,382

Table 6.9. Annual landings and total value of Atlantic Croaker from shrimp trawls in estuarine and state ocean waters (0–3 miles) in North Carolina, 2007–2016. (Source: NCTTP)

Year	Waterbody	Pounds Landed	Nominal Value	Waterbody	Pounds Landed	Nominal Value
2007	Estuarine	161	$61	State Ocean	47	$19
2008	Estuarine	265	$113	State Ocean	241	$124
2009	Estuarine	485	$220	State Ocean	119	$56
2010	Estuarine	341	$139	State Ocean	184	$70
2011	Estuarine	91	$57	State Ocean	77	$57
2012	Estuarine	164	$92	State Ocean	249	$150
2013	Estuarine	368	$281	State Ocean	749	$692
2014	Estuarine	6,787	$3,983	State Ocean	296	$231
2015	Estuarine	179	$141	State Ocean	76	$45
2016	Estuarine	263	$303	State Ocean	1,596	$1,780

6.2 Other Fisheries Including Recreational (excluding Shrimp)

The North Carolina shrimp fishery would be the most affected by the Petitioned rules, but as proposed, those rules impact all trawling in estuarine and state ocean waters and are not specific to just shrimp trawling. Other trawl fisheries that would be impacted include blue crabs, hard clams, and finfish such as flounder. The proposed minimum size limits on Spot and Atlantic Croaker would increase culling time in the trawl fisheries as discussed above, but most notably, would reduce the commercial and recreational harvest in the directed Spot and Atlantic Croaker fisheries.

6.2.1 <u>Limiting Days Per Week</u>

As written, the Petitioned rules would not allow trawling for anything other than crabs or shrimp, effectively eliminating clam trawling (kicking) in the mechanical clam harvest areas in estuarine waters over public bottom and flounder trawling in state ocean waters. Clam harvest can occur over private leased bottom with the proper permit and would not be affected by the Petitioned rules. From 2007–2016, data from the NCTTP show that clam trawling over public bottom accounted for an estimated annual average of 220 directed trips with 15 vessels participating in this fishery. These participants harvested an average of 8,773 pounds of clams with an estimated value of $59,328 annually. The peeler crab trawl fishery is exclusively a nighttime fishery, and under the Petitioned rules, the fishery would also be eliminated. This would result in an average loss of 1,806 pounds of peeler crabs and 23 directed fishing trips whose landings are valued at $5,136 annually. Flounder trawling in state ocean waters had five participants total from 2012–2016 that took an average of five trips each year, accounting for an average of 11,418 pounds of seafood valued at $21,173 annually.

For other trawl fisheries subject to the same weekday closures as shrimp trawling, projected losses to those fisheries can be estimated by mirroring closures in the same fashion as those done for shrimp trawling in section 6.1.1. Other trawl fisheries operating in estuarine waters include clam trawling, crab trawling, peeler trawling, and the skimmer trawl fishery that targets non-shrimp species. Other trawl fisheries operating in state ocean waters include flounder trawling and flynets.

For estuarine waters, with other conditions remaining the same, the restriction of the most active days for shrimp trawling based on participant counts (Thursday, Friday, Wednesday, and Tuesday; weekdays with most fishermen ranked from highest to lowest number of fishermen participating) would result in a potential average annual loss for the clam trawl fishery of 238 total trips and $3,529 dollars in revenue (12 participants; Table 6.10). Potential loss in the crab trawl fishery would be an average of 565 total trips and $885,837 in total revenue (13 participants). Potential loss in the peeler trawl fishery would be an average of 16 trips and $1,597 in total revenue each year (3 participants). Skimmer trawls targeting non-shrimp species would expect a potential annual loss on average of 59 trips and $2,636 in total revenue (3 participants). Restricting the days of the week to the least active days for shrimp trawling based on participant counts (Tuesday, Monday, Saturday, Sunday; weekdays with least fishermen ranked from highest to lowest number of fishermen) would result in a potential loss for the clam trawl fishery of an average of 226 total trips and $3,313 dollars in revenue annually (17 participants). Potential loss in the crab trawling fishery would be on average 306 total trips and $458,897 in total revenue each year (8 participants). Peeler trawling could potentially lose on average 17 trips and $923 in total revenue annually (2 participants) and skimmer trawls landing non-shrimp species would expect a potential average loss of 44 trips and $1,277 in total revenue per year (3 participants). This is only an approximation based on the average daily value of shrimping trips from the NCTTP. Dates used to derive landings by weekday represent the unload/off load date at the dealer and may not reflect actual fishing days. The NCTTP does not record the fishing date or time spent fishing. Actual losses may be greater or less depending on how effort is redirected into the new available fishing days, and/or exits from the fishery.

For state ocean waters, with other conditions remaining the same, eliminating Monday, Thursday, and Friday (most active shrimp trawling weekdays ranked from highest to lowest number of fishermen participating), the potential loss for flounder trawling would be an average of 22 trips and a total of $48,531 in revenue each year (2 participants; Table 6.11). The flynet fishery would have losses of an average of 28 trips and a total of $194,062 in revenue annually (3 participants). Eliminating Tuesday, Saturday, and Sunday (least active weekdays for shrimp trawling ranked from highest to lowest number of fishermen participating), the potential loss to the flounder trawl fishery would be an average of 14 trips and $28,139 in total revenue each year (2 participants). The flynet fishery would lose an average of 17 trips and $120,264 in total revenue annually (2 participants). Dates used to derive landings by weekday represent the unload/off load date at the dealer and may not reflect actual fishing days. The NCTTP does not record the fishing date or time spent fishing. Again, actual losses may be greater or less depending on how effort is redirected into the new available fishing days, and/or exits from the fishery.

Table 6.10. Average landings per trip, ex-vessel value, and number of participants and number of trips using clam, crab, peeler, and skimmer trawls in estuarine waters by weekday, 2007–2016. (Source: NCTTP)

	Avg. lb per Trip	Avg. Ex-Vessel Price	Avg. Number of Participants	Avg. Number of Trips	Average Value
Clam Trawl Kicking[1]					
Sunday	-	-	-	-	-
Monday	55	$0.26	18	119	$1,707.63
Tuesday	54	$0.28	16	107	$1,606.12
Wednesday	52	$0.23	16	99	$1,171.84
Thursday	61	$0.54	8	17	$558.33
Friday	58	$0.22	7	15	$193.33
Saturday	-	-	-	-	-
Crab Trawl					
Sunday	503	$2.10	1	5	$5,060
Monday	404	$2.27	12	129	$118,324
Tuesday	672	$2.52	14	159	$270,048
Wednesday	524	$2.70	12	136	$192,372
Thursday	424	$2.82	13	140	$168,176
Friday	674	$2.92	12	130	$255,242
Saturday	449	$11.38	3	13	$65,464
Peeler Trawl[2]					
Sunday	78	$0.73	2	6	$367
Monday	67	$0.79	2	5	$257
Tuesday	81	$0.71	2	5	$278
Wednesday	77	$2.06	2	6	$970
Thursday	81	$0.76	2	4	$228
Friday	41	$1.87	1	2	$121
Saturday	26	$0.92	< 1	1	$21
Skimmer Trawl					
Sunday	26	$0.95	1	3	$70
Monday	28	$0.90	5	21	$531
Tuesday	39	$0.97	4	14	$535
Wednesday	69	$1.14	3	11	$882
Thursday	37	$0.95	3	16	$575
Friday	36	$1.02	4	17	$644
Saturday	33	$0.72	2	6	$142

[1] Clam Trawling is prohibited over public bottom on the weekend.
[2] Peeler trawls were separated from traditional crab trawls in 2010.

Table 6.11. Average landings per trip, ex-vessel value, and number of participants and number of trips using flounder trawls and flynets in state ocean waters by weekday, 2007–2016. (Source: NCTTP)

	Avg. lb per Trip	Avg. Ex-Vessel Price	Avg. Number of Participants	Avg. Number of Trips	Average Value
Flounder Trawl					
Sunday	1,002	$2.64	1	2	$4,759
Monday	1,221	$1.57	3	10	$18,195
Tuesday	1,380	$1.86	2	6	$15,921
Wednesday	954	$1.78	2	11	$18,648
Thursday	1,409	$1.96	3	8	$20,726
Friday	952	$1.91	2	5	$9,610
Saturday	779	$1.54	2	6	$7,458
Flynet					
Sunday	5,477	$2.09	1	2	$26,373
Monday	3,112	$1.79	3	9	$47,435
Tuesday	2,681	$1.73	3	9	$42,141
Wednesday	3,774	$1.47	3	9	$49,371
Thursday	4,786	$1.82	4	12	$100,781
Friday	4,998	$1.22	2	8	$45,847
Saturday	7,165	$1.36	2	5	$51,749

6.2.2 Minimum Size Limits

6.2.2.1 Commercial Reductions

Percent reductions in commercial harvest value of Spot based on an 8-inch minimum size limit and Atlantic Croaker based on a 10-inch minimum size limit in North Carolina waters were estimated using data from the NCTTP for years 2007–2016, combined with expanded length frequencies for Spot and Atlantic Croaker by market grade from the NCDMF fish house sampling. Fish house sampling data were available by year and gear and once combined with the trip ticket data, reductions could be evaluated by area (i.e., estuarine, state ocean, and federal ocean waters). The estimated reductions for Spot vary by market grade ranging from 0.19% in the large market grade to 67% in the small market grade (Table 6.12). Most Spot landed commercially in North Carolina are in the Mixed market grade, which saw a 35.6% reduction. Across all market grades, Spot is estimated to have an average loss of $135,767 per year (Table 6.13). In 2016, the Spot fishery was valued at approximately $295,019 resulting in an overall 46% loss of value to the fishery.

As with Spot, reductions for Atlantic Croaker varied widely by market grade. Jumbo croaker had no estimated reductions, but x-small croaker would all be under the proposed size limit; therefore, a 100% loss would occur in that market grade (Table 6.14). Atlantic Croaker is estimated to have an average loss of $311,247 per year across all market grades and areas (Table 6.15). In 2016, the Atlantic Croaker fishery was valued at approximately $2,216,106; therefore, the imposed 10-inch size limit would roughly result in an overall 14% loss of value to the fishery.

6.2.2.2 Recreational Reductions

Percent reductions in recreational harvest of Spot based on an 8-inch minimum size limit and Atlantic Croaker based on a 10-inch minimum size limit in North Carolina waters were estimated using data collected by MRIP. Harvest and the percentage of fish at length were examined from 2011-2016 to estimate percent reduction. In 2012, 2013, and 2016, the modal length of Spot in the recreational harvest was 7 inches (Figure 6.3). In 2011, 2014, and 2015, the modal length of Spot in the recreational harvest was 8 inches. Recreational harvest of Spot in North Carolina would have been reduced by 34–67% from 2011–2016 if an 8-inch total length size limit were applied to those harvest numbers, holding all else equal (Table 6.16).

In 2012–2014 and 2016, the modal length of Atlantic Croaker in the recreational harvest was 8 inches (Figure 6.4). In 2011 and 2015, the modal length of Atlantic Croaker in the recreational harvest was 9 inches. Recreational harvest of Atlantic Croaker in North Carolina would have been reduced by 72–84% from 2011–2016 if a 10-inch total length size limit were applied to those harvest numbers, holding all else equal (Table 6.17).

Table 6.12. Estimated reductions in total commercial landings of Spot due to 8-inch minimum size limit by market grade and gear. (Source: NCDMF)

	Market Grade			
Fishery	Large	Medium	Mixed	Small
Estuarine Gill Net	0.19%	25.28%	16.98%	57.00%
Long Haul	0.19%	3.65%	45.41%	67.34%
Ocean Gill Net	0.19%	45.44%	12.40%	77.68%
Ocean Trawl	0.19%	24.79%	35.48%	67.34%
Pound Net	0.19%	24.79%	67.94%	67.34%
Overall Average	**0.19%**	**24.79%**	**35.64%**	**67.34%**

Table 6.13. Estimated average ex-vessel value loss from reductions in Spot landings due to 8-inch minimum size limit by market grade and area. (Source: NCTTP)

	Market Grade			
Area	Large	Medium	Mixed	Small
Estuarine	-$2.91	-$503.98	-$107,996.15	-$641.63
State Ocean	-$2.64	-$1,003.48	-$23,959.61	-$895.91
Federal Ocean	-$0.11	-$56.47	-$591.59	-$112.63
Total	**-$5.66**	**-$1,563.94**	**-$132,547.35**	**-$1,650.17**

Table 6.14. Estimated reduction in total commercial landings of Atlantic Croaker due to 10-inch minimum size limit by market grade and gear. (Source: NCDMF)

	Market Grade					
Fishery	Jumbo	Large	Medium	Mixed	Small	X-small
Estuarine Gill Net	0%	0.12%	20.10%	46.39%	66.59%	100%
Long Haul	0%	0.03%	19.77%	59.07%	83.91%	100%
Ocean Gill Net	0%	0.02%	2.46%	52.59%	87.83%	100%
Ocean Trawl	0%	8.37%	5.53%	8.14%	56.88%	100%
Pound Net	0%	11.54%	13.77%	99.20%	66.44%	100%
Overall Average	**0%**	**4.02%**	**12.33%**	**53.08%**	**72.33%**	**100%**

Table 6.15. Estimated average ex-vessel value loss from reductions in Atlantic Croaker landings due to 10-inch minimum size limit by market grade and area. (Source: NCTTP)

	Market Grade					
Area	Jumbo	Large	Medium	Mixed	Small	X-Small
Estuarine	$0.00	-$32.99	-$4,072.40	-$3,249.88	-$8,126.49	-$29.57
State Ocean	$0.00	-$413.48	-$7,498.87	$39,690.07	-$14,039.42	-$923.54
Federal Ocean	$0.00	-$10,425.69	-$55,719.52	-$41,748.73	-$112,128.76	-$13,147.78
Total	**$0.00**	**-$10,872.16**	**-$67,290.78**	**-$84,688.68**	**-$134,294.67**	**-$14,100.88**

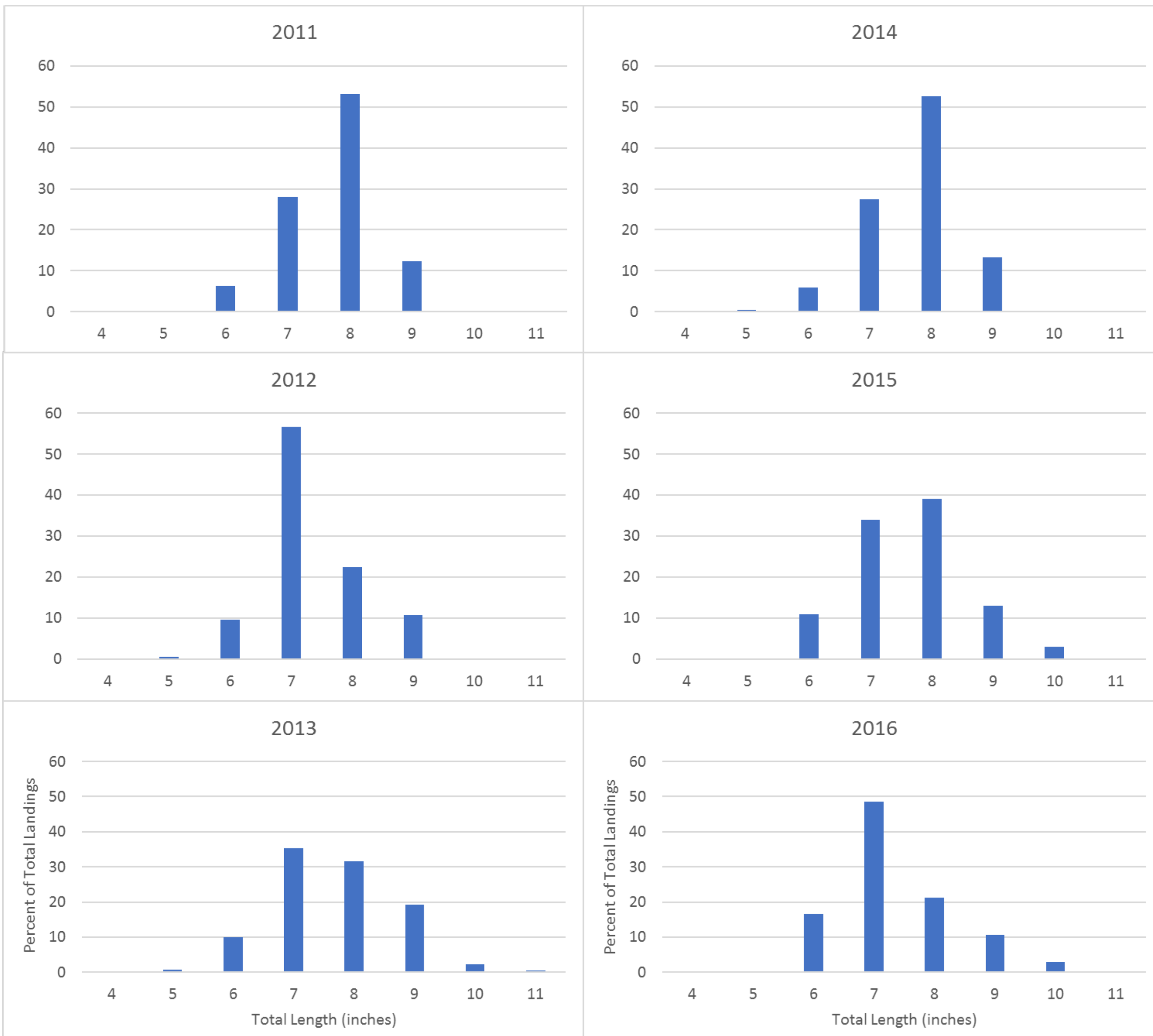

Figure 6.3. Percentage of total Spot landings by length bin (TL) in inches. (Source: NCDMF)

Table 6.16. Estimated reduction in the number of Spot caught recreationally based on an 8-inch minimum size limit. (Source: NCDMF)

	Spot			
Year	Total # of Fish	# of Fish < 8 in.	# of fish ≥ 8 in.	% Reduction
2011	1,206,744	416,002	790,742	34
2012	784,272	523,599	260,672	67
2013	1,464,592	679,067	785,525	46
2014	2,109,790	718,097	1,391,693	34
2015	1,081,083	484,973	596,110	45
2016	513,320	335,094	178,226	65

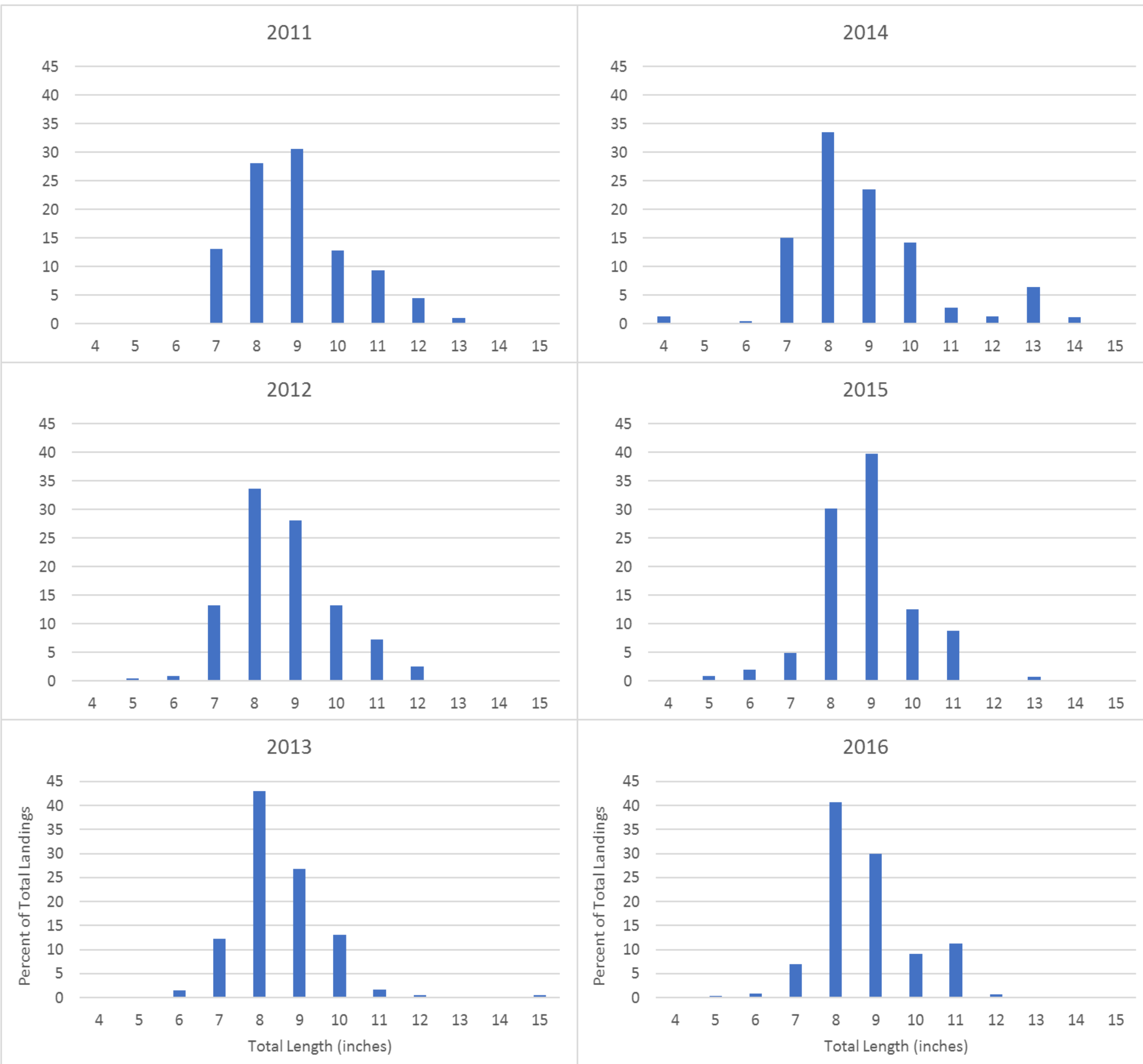

Figure 6.4. Percentage of total Atlantic Croaker landings by length bin (TL) in inches. (Source: NCDMF)

Table 6.17. Estimated reduction in the number of Atlantic Croaker caught recreationally based on a 10-inch minimum size limit. (Source: NCDMF)

	Atlantic Croaker			
Year	Total # of Fish	# of Fish < 10 in.	# of Fish ≥ 10 in.	% Reduction
2011	246,415	177,990	68,425	72
2012	286,309	219,454	66,855	77
2013	411,633	345,656	65,977	84
2014	538,879	398,554	140,325	74
2015	458,338	356,050	102,289	78
2016	363,315	286,719	76,596	79

6.3 Additional Impacts

6.3.1 Disproportionate Impacts by Vessel Size

As mentioned in section 6.1.4, the Petitioned rules have a potential to impact vessels of different size classes disproportionately. Larger vessels on average command greater ex-vessel prices and have overall larger total trip values and landings. Estuarine vessels have more dramatic increases in trip values than their ocean-going counterparts. Average values per trip rise, on average, 48% per size class for estuarine vessels, while only 7% for ocean going vessels (Table 6.18). Landings exhibit a similar distinction between estuarine and ocean vessels. Estuarine vessels land on average 45% more, moving up size classes; however, ocean vessels only increase by 9% per size class. This suggests that ocean vessels are more tightly grouped together in fishing power regardless of vessel length. Both estuarine and ocean vessels take less trips as vessel size increases, due to the ability to land more shrimp per trip. Larger vessels also have more total headrope lengths and an increase in number of rigs; however, the largest ocean-going vessels (80’+) have one less rig on average than the next smallest size class (60–79’). Both estuarine and ocean vessels typically land larger grades of shrimp as their vessel size increases. While most of these observations would be considered easily inferable, it is important to demonstrate that larger vessels are likely to be affected more by the Petitioned rules than smaller vessels, and would most likely bear the majority of losses.

6.3.2 Operational Expenses

North Carolina does not mandate the collection of operational business expenditure data for any specific commercial fishery. NOAA Fisheries requires mandatory reporting of operational expenses for federal shrimpers in the Gulf of Mexico, but the program is voluntary in the South Atlantic, the region under which North Carolina is managed. Federal ocean going shrimping vessels are typically larger and generally different than the smaller estuarine shrimp vessels operating in North Carolina, so their operating costs would be different. Without adequate information about vessels participating in the shrimp fishery in North Carolina waters, it is not possible to determine average operational expenses such as accounting costs, docking fees, insurance payments, and other forms of overhead for the entire fleet. Whether the Petitioned rules would affect overhead could only be determined from observing operational expenses before and after the proposed rules would be in effect.

Evaluating “economic returns” and “returns on equity” of the shrimp fleet should provide some insight on the economic performance of commercial fishermen operating in this fishery. An average economic return is calculated by dividing net operating revenue by the value of vessel assets. Economic return quantifies the vessel's productivity from a societal perspective. In contrast, the return on equity is the primary concern of the individual vessel owner. The return on equity is calculated by dividing the profit by the equity currently invested by the owner in the vessel.

After reviewing the available survey data from past economic studies conducted by NCDMF characterizing commercial fishing in North Carolina, there were a total of 150 surveys that captured information from shrimp trawlers over the 11 years when these studies took place. Many of these surveys have blank or missing costs fields, making it difficult to get an accurate assessment of average operational expenditures of shrimp trawlers. These data need to be updated to include the most recent surveys conducted 2017; however, there would likely not be enough data to make a statistically valid extrapolation to the whole shrimping fleet. In addition, returns on equity is not possible to calculate given the NCDMF does not collect total loan balances, only estimated monthly payments, in surveys. This is something to consider for future survey/data collection work.

Table 6.18. Average trip characteristics for vessels using shrimp trawls by vessel length and area. (Source: NCTTP)

	Vessel Length (ft)				
Otter Trawl Averages	0–19	20–39	40–59	60–79	80+
Estuarine					
Ex-Vessel Price	$1.44	$1.65	$2.12	$3.06	$3.26
Trip Value	$206	$408	$1,045	$2,428	$3,243
Pounds Landed	132	231	526	1,171	1,565
Trips	678	2,166	1,471	2,158	610
Number of Vessels	33	52	13	15	4
Total Headrope Length	33	58	99	152	173
Rig Count	1	2	3	4	4
Days at Sea	0	3	2	4	5
Shrimp Grade	36/40	31/35	21/25	21/25	21/25
Crew Size	1	2	2	3	4
Vessel Horsepower	69	231	349	447	579
State Ocean					
Ex-Vessel Price	$1.64	$2.04	$1.76	$2.04	$2.65
Trip Value	$836	$361	$676	$2,103	$3,919
Pounds Landed	375	168	315	909	1,680
Trips	41	834	1,143	735	148
Number of Vessels	4	13	8	11	3
Total Headrope Length	40	56	92	132	148
Rig Count	1	1	3	4	3
Days at Sea	0	0	0	2	6
Shrimp Grade	26/30	26/30	26/30	21/25	21/25
Crew Size	2	2	2	3	3
Vessel Horsepower	88	192	344	493	444

6.3.3 **Fishing Behavior**

Commercial fishing is one of the most dangerous professions in the country, with an annual average fatality rate of more than 30 times the U.S. average (Pfeiffer and Gratz 2016). Despite voluntary and regulatory fishing safety initiatives, the fatality rate has decreased only marginally and substantially less so when compared to other forms of employment in the U.S.

The competitive nature of commercial fishing often results in fishermen being assumed to have risk-prone preferences and engaging in behavior such as fishing in poor weather, capital stuffing (i.e., overcapitalizing by investing more to increase fishing power), and neglecting maintenance of their gear and vessels (Pfeiffer and Gratz 2016). Bockstael and Opaluch (1983) was one of the first widely cited works to have used a random utility model to model uncertainty and risk preferences into the behavioral choices of fishermen. They examined species, location, and gear choice of New England ground fishermen and found that fishermen are responsive to trip alternatives that would land a higher catch and result in more revenue and would forgo some trips with a higher payout for trips that would yield a more constant catch and a steadier stream of revenue, even if it meant less profit. They determined fishermen would rather have constant returns, than a boom or bust with potentially larger revenue yields.

The study by Pfeiffer and Gratz (2016) shows an example that seasonal limitations and open access quotas often lead to derby fishing and fishermen needing to take higher risk in order to land the same volume of catch to make ends meet. Their example of a catch share program being implemented in a large U.S. fishery shows that giving fishermen the opportunity to fish year-round, without restriction reduces the overall risk fishermen take, for example, making the decision to take a trip in adverse weather conditions. After catch shares were implemented in an economically important U.S. West Coast fishery, a fisherman's probability of taking a fishing trip in high wind conditions decreased by 82% compared with only 31% in the former open access fishery with seasonal restrictions.

Historically, many fisheries have been managed as open access, and fishery management has often restricted the length of fishing seasons to mitigate the depletion of a fishery resource (Pfeiffer and Gratz 2016). Seasonal closures of fisheries often "tends to create a perverse incentive to increase fishing power to catch the maximum amount of fish in the shortest amount of time" (Pfeiffer and Gratz 2016). Seasonal restrictions incentivize derby fishing, capital stuffing of vessel gear, and furthermore, fishermen have the incentive to participate in around-the-clock fishing in all weather conditions, overload their vessels, and ignore maintenance problems to maximize catch.

Policy changes affecting health and safety risk are often captured in economic studies as the value of mortality risk reduction, which is defined as how much people are willing to pay for small reductions in their probability of dying from adverse conditions. Calculating a direct cost as a result of increased risk taken by fishermen if the Petitioned rules become effective is not possible to quantify at this time due to the inability to estimate the change in mortality risk.

Another risky behavior resulting from increased regulations not discussed above is fishing outside of the regulations. The amount of fishing occurring outside of the regulations cannot be quantified without collecting information from Marine Patrol for several years after the rules would go into effect, to assess if there has been an increase in violations and a quantifiable impact on the industry. An analysis of violations may not provide a true estimate of increased risky behavior because it is only an estimate of individuals that were caught fishing outside of the regulations. It is impossible to predict how many fishermen would not comply with the proposed rules or how many of those would be found in violation; therefore, the impact of the proposed rules on the profitability of the industry cannot be fully assessed.

Some of the proposed rules (i.e., limiting headrope and tow times) could also cause increased wear and tear on fishing gear and vessel engines. Trying to determine if the proposed rules caused an additional cost to affected fishermen via gear and engine repair or replacement would not be possible until years after the rules were implemented. North Carolina does not currently survey fishermen for information on gear dexterity; however, it is anecdotal knowledge that trawl nets typically last about three years (K. Brown, NCDMF, personal communication). How tow times and trawling speed would affect the gear and engines remain in question. A survey of gear manufacturers and fishermen would be needed to gather information on refitting costs.

Regulations imposed by fishery managers such as harvest quotas and moratoriums, among others, have resulted in harvest practices where fishermen harvest as much of one species as possible while the season is open, commonly referred to as derby fishing (NCREDC 2013). This harvest practice leads to an oversupply of product, resulting in lower profit margins for fishermen and seafood dealers. Smaller independently owned seafood dealerships typically have only ice and refrigeration to store their own products, which provide a shelf life of less than a week. Consequently, seafood must be moved quickly to avoid spoiling, which can cause low prices and revenues for both fishermen and dealers when supply exceeds demand.

6.3.4 <u>Displacement of Effort</u>

As mentioned in section 4.1, proposed changes to 15A NCAC 03N .0105 provide an exception for existing SSNAs, which have less restrictive harvest regulations than areas that would be newly designated as SSNAs by the Petitioned rules, possibly resulting in a displacement of effort from the newly proposed SSNAs to the currently designated SSNAs.

The Petitioned rules divide SSNAs into two subparagraphs (Table 4.1). Subparagraph (b) is the current list of SSNAs and makes up approximately 37,000 acres. These areas are required to be closed to shrimp and crab trawling between May and August and make up 1.3% of all coastal and joint waters (including the ocean 0 to 3 miles; Table 2.1). Once these areas are opened based on sampling, fishermen are able to trawl day and night, five days a week with unlimited tow times after Aug. 15. The proposed subparagraph (c) describes new SSNAs that include 2.8 million acres of coastal and joint waters not already designated as a nursery area (94.5%; Table 2.1) and would not be subject to the May–August closure. The proposed SSNAs place more restrictions on trawling in a much larger area compared to those SSNAs already in rule.

The existing SSNA rule, 15A NCAC 03N .0105, places less restrictions in a smaller defined area, which may create an increase in trawl fishing effort by fishermen who want to avoid the additional restrictions in the proposed SSNAs. This displacement of fishermen from a large area to smaller areas may result in more user conflicts by concentrating more vessels in the currently defined SSNAs. This may also add to small vessel/large vessel conflict by enabling small vessels to catch shrimp in these smaller, less restricted areas, while larger vessels may only be able to fish in the larger proposed SSNAs.

6.3.5 <u>Exits from Commercial Fishing</u>

It is impossible to predict the number of participants that would exit commercial fishing due to losses in trawl fisheries affected by the Petitioned rules, as many fishermen in North Carolina participate in multiple fisheries throughout the year. Fishermen rarely specialize in any one species or gear, instead switching among gears, areas, and target species throughout the course of a year. This practice in known as “annual round” (Griffith 1996; Johnson and Orbach 1996). This flexible coping strategy accommodates changes or variations in species abundance, environmental conditions, and management regulations (Griffith 1996). Johnson and Orbach (1996) defined the network of relationships among fisheries in the different areas within North Carolina. Even though fishermen participate in multiple fisheries, shrimp trawling was identified as a top five gear in several areas of the state. The shrimp trawl was the central nodal gear in the Carteret and Southern area networks and ranked third in the Pamlico area behind crab pots and flounder gill nets. In discussing the current Friday night shrimp closure, fishermen revealed it required them to be more regimented in their fishing behavior, negating aspects of their flexibility strategy (Griffith 1996). As mentioned in section 6.1, large trawlers are highly specialized and it is doubtful that these vessels could be repurposed for other fisheries.

Studies in the 1970s and 1980s revealed that shrimp fishermen engage in a variety of both land and water based activities. Fishing activities required moving from one target species to another as opportunities prevailed, even though shrimping involved most of the effort throughout the year (Maiolo 2004). Shrimp fishermen continue to engage in a variety of capture activities throughout the year and, like most of North Carolina's commercial fishermen, they tend to diversify the species they target, gears they use, and waterbodies they fish (NCDMF 2015a). Shrimp constituted an average of 59% of their fishing income.

6.4 Benefits

The Petitioner expects "to see increases in the availability of fishes for harvest under the proposed rules" and says "[a]ll recreational fisheries will benefit if fish stocks currently in depleted or declining status rebound as a result of the proposed rule[s] (NCWF 2016a, p. 14–15)." There is a lack of literature that specifically discusses the benefits expected from implementing rules similar to those proposed in a similar ecological and economic context. Benefits to the fishing industries in the form of increased stock abundance is difficult to evaluate without data both before and after the proposed rules would be implemented. In addition, without an estimate of the effect size of the proposed rules, it is not possible to directly quantify the potential benefits.

Benefits to the industry are dependent on how fish stocks respond to reduced fishing mortality from the Petitioned rules, compliance with new regulations, and displacement of effort in other fisheries. If effort in the primary fisheries affected by the Petitioned rules is displaced into other fisheries, the long-term effects of increased fishing mortality on those fisheries could eventually result in decreased stock abundance, which would result in additional regulations and losses to the industry. There are additional factors that confound how successful the proposed rules would be at increasing stock abundance over time and make quantifying benefits to the industry difficult. These include lost fishing days due to weather in addition to the proposed weekday restrictions defined in the Petitioned rules, as well as any recoupment of effort by fishermen on allowed fishing days and other factors that could offset the intended benefits.

To evaluate the benefits of the proposed rules on the fishing industry, increased CPUE in the shrimp fishery and potential economic impacts due to increased abundance were evaluated for the commercial fishing industry. For the recreational fishing industry, improvements to recreational fishing and associated economic benefits were assessed. Stock projections and their associated economic impact projections were developed by Nesslage and Dumas (2017) for Atlantic Croaker and Weakfish. The stock projections were discussed previously in section 5.1. The economic impact projections are discussed in section 6.4.4. Projections for shrimp and Spot were not available. These projections were not modeling the effect of the proposed rules, but present examples of how the economic impact of commercial and recreational fisheries could potentially respond to changes in stock status.

6.4.1 <u>Recreational Fishing Improvements</u>

Of the 5.4 million recreational fishing trips taken in 2016, 792,883 of those were directed trips for Spot, Atlantic Croaker, or Weakfish (Source: MRIP). This constitutes about 15% of the total recreational fishing trips in North Carolina. These trips were either inshore private vessel trips (57%), inshore trips on man-made structures (piers) (18%), or beach fishing trips (25%). Generally, these three species are not fished for recreationally in waters greater than three miles offshore, nor are they the directed target of any charter/headboat paid fishing trip.

To assess if any improvements would occur in recreational fishing due to the Petitioned rules, data on the number of recreational trips, licenses sold, and surveyed expenditure information before and after the rules were implemented would be needed, and the change in the quality of recreational opportunities would need to be evaluated. It is unclear, and likely impossible to predict, how many years would need to pass after the Petitioned rules would be implemented before improvements could be detected or the magnitude of any impact could be determined on expenditures, sales, income, jobs, or participant satisfaction. Even with such data, it may not be possible to determine whether any improvements would be caused by the proposed rules or other factors.

6.4.2 Increases in Catch per Unit Effort

The Petitioner states that "the amount of effort in the shrimp trawl fishery may *increase* catch per unit effort, making the shrimp trawl fishery more efficient" (SELC 2017a). For CPUE to increase, one of two conditions must be met. The first condition is that the catch (numerator) must increase and this assumes that effort stays the same or decreases. Alternatively, the effort (denominator) must decrease and this assumes that catch stays the same or increases. For catch to increase, there must be an increase in the fishable shrimp biomass, assuming catchability (the proportion of the stock caught by one unit of effort) remains constant. A decrease in effort (assuming constant or increasing catch) would also increase CPUE for shrimp, but would require a reliable measure of effort to detect. The NCDMF does not currently require fishermen to report detailed effort information. Instead, effort is measured using generic "trips". The problem with using these trips to measure effort is that all trips are not equivalent. That is, one trip may consist of a single two-hour tow while another trip may consist of multiple tows of varying haul times. This lack of consistency makes it impossible to reliably quantify effort or to provide a reliable measure of CPUE. Additionally, the NCDMF does not require reporting of trips where no catch was made. These no-catch trips are important to the calculation of CPUE and the lack of this information adds further difficulty in measuring CPUE for the shrimp trawl fishery.

Decreasing the number of shrimping vessels may not increase the efficiency of the fleet at harvesting shrimp as suggested by the Petitioner (SELC 2017a). The implementation of a limited entry fishery for shrimp in the Gulf of Mexico in December 2002, as part of Amendment 13 to the Gulf of Mexico Shrimp FMP, showed that increased profitability did not occur due to less competition for the resource. Amendment 13 established a 10-year moratorium on the issuance of commercial shrimp vessel permits, capping the number of vessels in the federal fishery. The number of vessels and the fishing power of the vessels was increasing, but the level of landings had been stable, resulting in each participant becoming less efficient and therefore less profitable (GMFMC 2015a). This moratorium was implemented due to the excess capacity in the fishery and the expected result was fewer vessels harvesting the available shrimp resources at a more profitable level. Following the implementation of the moratorium, increased CPUE values were observed for a temporary time-period stemming from an overall reduction in effort and fleet size. However, substantial increases in CPUE were not seen after 2007. Overall, after implementation of the moratorium, acute increases to prices and gross revenue were observed because of decreased landings, such as in 2013 and 2014; however, long-term increases in profitability for permit holders have not been realized (GMFMC 2015b).

Improved efficiency alone does not ensure higher profits. Nearly 10 years later, vessels, on average, were still operating at a loss due to extreme economic conditions at the time, showing negative returns on equity and economic returns (Liese and Stemle 2014, 2017). Several factors may have led to the overall struggle of the financial performance of the Gulf of Mexico shrimping fleet. The year 2007 brought about an overall financial recession for the United States as well as record high fuel prices. In 2010, the Deepwater Horizon oil spill took place and had a profound effect on the economics of the Gulf shrimp fishery. Many vessels relied on damage claims and oil clean up jobs as a primary source of income after the spill (GMFMC 2015a). However, the main issue continues to be that variable non-labor costs, such as fuel costs that can account for 50% of all related operating costs, continue to dictate profitability of the industry. Overall net revenue cannot seem to overcome the expense of operating a shrimping vessel in the Gulf of Mexico.

6.4.3 Fishery Impacts from Harvest Restrictions and Closures

The question of whether certain types of commercial fishing practices and gears are detrimental to the abundance of species that interact with those gears is a common issue facing fisheries managers. Two situations in South Carolina and Florida are referenced as examples of management actions of a large magnitude. Reviewing other states' responses to these issues is informative to managers, helping them to identify the potential intended and unintended consequences of management interventions. But due to differences in the ecology, fishery economics, and regulatory implementation between locales, it is important to be cautious about generalizing outcomes to North Carolina.

In 1986 and 1987, South Carolina had an experimental closure and subsequent study of shrimp trawling in its sounds and bays. South Carolina's allowance of shrimp trawlers in sounds had been the subject of much debate for the better part of 30 years prior to the study. Some commercial fishermen wanted the sounds closed to allow shrimp to grow to a larger size, while fishermen on smaller vessels wanted the sounds open. Recreational finfish fishermen and environmentalists became involved in the conflict and asked for permanent closure of the sounds and bays to protect important sportfish and forage species. It was argued that the sounds were important spawning areas for sportfish and that many of these sportfish, particularly Spotted Seatrout and Red Drum, were caught in large numbers by commercial trawlers. The initial response of South Carolina's Marine Resources Center was that "the past policy of opening the sounds and bays had probably not increased or decreased the overall physical or economic yield of shrimp" (Whitaker et al. 1989). However, at the urging of several stakeholder groups, including environmentalists as well as commercial and recreational fishermen, three sounds and one bay were closed to commercial trawling in 1986 and 1987. The South Carolina Marine Resources Division (SCMRD) stressed that "a two-year closure would probably be much too short to properly assess the impact of the closing..." and it "may not be possible to definitely determine the usefulness of the closure".

The SCMRD assessed the closure through a fall trawl survey and a shrimp tagging program. After the evaluation was completed, no evidence was found to link trawling in these areas with long term decreases in the populations of finfish species collected during the evaluation (Whitaker et al. 1989). At the time of this evaluation, Spot and Atlantic Croaker stocks were believed to be of sufficient biomass for a viable population. The authors state that "had trawling in the sounds been significantly detrimental to whiting, Spot and croaker stocks, we would have expected a dramatic increase in our catch rates in 1987 after an absence of trawling for over 21 months" (Whitaker et al. 1989). It was concluded by the authors that commercial shrimp trawling did not have a negative effect on shrimp and fish stocks in South Carolina sounds and estuaries and they recommended that economic and social factors be the primary guidance used in future management plans for species within South Carolina's sounds.

A second example of a state's implementation of a largely impactful harvest restriction was Amendment Three to the Florida Constitution. This colloquially became known as the "net ban". In November of 1994, approximately 2.8 million residents of Florida voted to enact Amendment 3, Article X, Section 16 to the Florida Constitution, which made it unlawful to use entanglement nets such as gill nets and trammel nets in Florida state territorial waters (Adams et al. 2000). Other nets such as seines, cast nets, and trawls were still permitted, provided they did not exceed 500 square feet.

The origin of the net ban has its roots in the early 1990s. In 1991, the Florida Marine Research Institute delivered a preliminary stock assessment to the Florida Wildlife Commission, indicating that the Striped Mullet stock was in bad condition (Anderson 2002). It was proposed that the fishery be closed for several days during the annual roe harvest. This proposal was met with significant opposition by commercial fishermen and effectively stalled in the state legislature. Because of the perceived ineffectiveness of Florida's Marine Fisheries Commission, a petition was started by the recreational industry to gather signatures to allow a statewide vote to limit commercial netting within state waters. The Florida Conservation Association and several other groups launched a large media campaign to raise awareness and successfully gathered enough signatures to put the measure on the legislative ballot in November of 1994. The amendment passed with 71% of the total vote and went into effect in July 1995.

The impacts of banning entanglement nets in Florida state waters was researched in subsequent years following the implementation of the amendment (Shivlani et al. 1998; Adams et al. 2000; Anderson 2002). The net ban had an impact on several user groups, including commercial fishermen, wholesalers, retailers, anglers, marine supply dealers, and consumers. Typical expectations were that commercial landings would decline, but the price of the species most affected by the ban would increase (Adams et al. 2000). Twenty-two species were identified to be most impacted by the net ban. For those species, the average annual ex-vessel value declined by 38% from $21 million to $13 million in the three years following the ban (1996–1998). Trips declined by 56% and commercial license sales declined by 15%. Numbers of wholesalers and dealers statewide were affected very little, but impacts may have been greater on a more local basis. Striped Mullet, the initial driving factor of the ban, experienced a 60% decline in landings, an increase of 26% in price, but had an overall value decline of 49%. As expected, trips targeting species commonly caught with inshore nets decreased trips as did overall value due to lower total landings while ex-vessel prices increased. Recreational landings of the same species evaluated for commercial trends discussed above declined by 27% between 1996 and 1998, even though recreational license sales increased by 3%. The decrease in recreational catch may have been due to other more stringent regulations that were placed on some of these species during that same period.

Adams et al. (2000) found that the stock health of fish historically targeted with entangling nets was variable after the net ban, with some stocks showing improvement (e.g., Spanish Mackerel), some remaining at stable levels (e.g., Spotted Seatrout), and others are exhibiting trends that make it unclear if the net ban affected these species or not (e.g., Bluefish, Pompano). It was also reported that for some species, improvements in stock condition were already being noticed before the net ban went into place (e.g., Striped Mullet). "Overfishing still occurs for some of these species, reportedly due to increases in recreational and commercial harvests since the net ban" (Adams et al. 2000).

Changes to fishermen's family income structure were also observed. The number that identified themselves as a full-time commercial fisherman declined by 20% three years following the net ban, and working time on the water dropped from 62 hours per week to 38 (Adams et al. 2000). Total income from commercial fishing was reduced from 80% to 55%. Approximately 1,500 fishermen were identified as having to modify their gear use, or exit the industry completely because of the net ban. To help mitigate the burden, the state of Florida developed several assistance programs including a net buyback program, unemployment compensation, job retraining, and assistance through the Florida Cooperative Extension Service. In total, 82% of fishermen participated in the net buyback program, 26% collected unemployment benefits, 16% collected food stamps, and 16% of fishermen also participated in job re-training efforts such as aquaculture training.

Recreational angling was observed to improve following the net ban. Spanish Mackerel and Spotted Seatrout were stocks that benefitted from banning entanglement nets and anglers surveyed in the years following expressed satisfaction with increased catches following the net ban (Adams et al. 2000; Anderson 2002).

There are differing perspectives on whether the net ban was successful overall. Commercial fishermen experienced economic hardships in the first years following the ban and several redirected their fishing effort into other already fully-exploited fisheries, thus potentially resulting in overfishing of other fisheries

(Shivlani et al. 1998). However, overall the ban was seen by many recreational anglers and conservationists as a victory for recreational use of the resource (Anderson 2002). Again, due to differences in the ecology, fishery economics, and regulatory implementation between locales, it is important to be cautious about generalizing outcomes to North Carolina. North Carolina's management of its fisheries is governed under the 1997 FRA, which addresses the need for balanced management between commercial and recreational interests (S.L. 1997-400; G.S. 113-181; 113-182.1, 143B-289.52).

6.4.4 Economic Impact Projections

Nesslage and Dumas (2017) estimated stock abundance and the economic impacts for commercial and recreational fishing by species over a 30-year projection period (i.e., 2017 to 2046). Several scenarios analyzed varying levels of commercial and recreational fishing mortality to see how abundance and economic impacts changed over time. Species analyzed that are affected by the Petitioned rules include Atlantic Croaker and Weakfish. See section 5.1 for information on how stock abundance responded to each model scenario. It is important to note that the size of the change in fishing and natural mortality attributable to the proposed rules is unknown. Therefore, it is not possible to model the associated change in the fish stocks and the economic impacts to fishing industries. There is no association between any regulatory intervention and the projections described below; they represent various "what-if" scenarios.

Currently, it is not possible to recreate the producer and consumer surplus numbers or the economic impact results presented by Nesslage and Dumas (2017) because the stock projection-harvest relationship from year to year was not provided in the report. However, the overall trend in the results presented by the authors show how economic impacts in each fishing sector could potentially change if mortality (both fishing and natural mortality) on the species was to change. While evaluating these economic projections, it was determined that the data and assumptions used to predict the value of the commercial fishery were too general and could have artificially inflated the input into the projection models. The economic estimates generated by Nesslage and Dumas (2017) for Atlantic Croaker and Weakfish will not be presented due to uncertainty in the data, but the overall trend in the projections showed that as fishing mortality decreased, economic impacts for both commercial and recreational fisheries also decreased, which translates to economic losses for these fishing sectors. This result was expected since a reduction in fishing mortality equated to a decrease in the total amount of fishing in each sector. The effects of shrimp trawl bycatch were examined for Atlantic Croaker and projections with no bycatch resulted in positive effects on commercial and recreational fishing values, but would take about 30 years for any noticeable improvement.

Projections using lower levels of natural mortality than is currently estimated for Weakfish resulted in economic gains for both commercial and recreational fisheries. As mentioned in section 3.4 for Weakfish, high levels of natural mortality are currently the driving factor limiting stock improvement, so projections using biologically unrealistic levels of natural mortality do not appropriately characterize current stock conditions. Economic gains resulting from scenarios removing bycatch from the fishery or decreasing natural mortality are attributed to increased stock abundance. Results from Nesslage and Dumas (2017) are not comparable to the Petitioned rules. The various changes in fishing or natural mortality being assessed are programmed directly into the model and do not reflect a response to a particular management action and in the case of Weakfish, use estimates of natural mortality that do not currently exist in nature. From these results, an economic estimate of cost or benefit cannot be determined because the magnitude of change that would result from implementation of the Petitioned rules is unknown. It is unclear if potential benefits would outweigh the impacts and based on the projections evaluated by Nesslage and Dumas (2017), a drastic change would be needed to see a substantial benefit. See Appendix 3 for a detailed review of the economic projections evaluated for Atlantic Croaker and Weakfish.

7 IMPACT ON CONSUMERS

The Petitioned rules that would affect shrimp harvest, as well as Spot and Atlantic Croaker size limits may have a negative impact on the availability of local seafood to consumers in the state of North Carolina if the proposed rules result in a substantive decrease in the total effort, and total harvest, of the commercial industry. While the overall availability of seafood may not be impacted due to the overwhelming availability of cheaper imported seafood, consumers may be more deterred to purchase seafood if they prefer local-caught seafood. Unfortunately, data on retail sales of local versus imported seafood are not readily available for this fiscal analysis to determine any price premium for local seafood or estimate the lost value to consumers if the supply of local seafood declines. Studies on consumer preferences for local or fresh seafood mentioned below, while not representative of the North Carolina population as a whole, do indicate that consumers prefer seafood that is wild caught, and more so from a sustainable source.

Carteret Catch, a program whose mission is to sustain the livelihood and heritage of the Carteret County fishing industry through public marketing and education, surveyed the public at the North Carolina Seafood Festival in 2005. They found that over 90% of respondents would choose local seafood over imports (Nash and Andreatta 2011). The results from this survey also showed that 90% of the people who completed the survey expected the seafood served in local restaurants to be harvested locally. Another survey completed in 2006 by the University of North Carolina at Greensboro (UNC-G) found similar results and also reported that 83% of respondents were willing to pay more for locally caught seafood at restaurants versus imports. A survey in 2007 by the University of North Carolina at Chapel Hill determined that the vast majority (95%) of respondents would buy local seafood if available. In addition to the superior quality and freshness of local seafood, a 2010 survey by UNC-G found that 84% of buyers want to buy local seafood due to perceived health superiority and to support local fishermen.

A study conducted in Oregon by Fonner and Sylvia (2015) analyzed preferences for four classes of seafood information labels including safety, quality, local, and ecolabels with regards to crab and salmon. A portion of their study sample strongly preferred products with the local labels. Results showed 19% (crab) and 16% (salmon) of their survey respondents preferred the local label over other labels, and consumers were willing to pay an average of $1.91 (crab) and $3.15 (salmon) more for products that bore a local label. Adding additional labels to a product did not affect the preference for the local label, suggesting that local labels have the potential to add value to seafood, even in the presence of other classes of information labels.

While the overall literature on price premiums for local seafood, labeled or otherwise, is limited, research suggests consumers have a preference towards seafood harvested from local waterbodies. Therefore, a decrease in the overall supply of local seafood to North Carolina suppliers and retailers might negatively affect business revenues. Consumer demand may decrease for seafood products overall, if the supply of local seafood is decreased. Likewise, imported seafood may not command as high a market price as locally sourced seafood.

After further investigation, the NCDMF is not aware of additional market and product-specific quantitative data to evaluate the impact of the Petitioned rules on consumers.

8 IMPACT ON LOCAL GOVERNMENT AND LOCAL COMMUNITIES

The Petitioned rules would certainly impact the fishing industry, but would also stand to impact the local government and municipalities where these industries operate. Several of North Carolina's coastal counties have historically been home to various fishing communities. These counties traditionally have a workforce that has a large prevalence of employment based around commercial fishing, whether from harvesting, manufacturing, or through supply chain industries and as a result, these "fishing communities" stand to be disproportionally affected by the Petitioned rules. In *North Carolina Fisheries Association, Inc. v. Daley*, 27 F. Supp. 2d 650 (E.D. Va. 1998), a summary judgment was awarded to the North Carolina Fisheries Association on the issue of a summer flounder fishing quota for 1997. It was ruled that the decision to issue the quota by the U.S. Secretary of Commerce accompanied by an economic impact analysis that did not include an in-depth explanation of the possible ramifications to small fishing communities was arbitrary and capricious and the quota was dismissed that year. The Court ruled that the failure to consider the effect on small fishing communities in the economic analysis was inconsistent with regulatory requirements of the Small Business Reform Act of 1996 and National Standard 8 of the Magnuson-Stevens Fishery Conservation and Management Act.

North Carolina has 20 coastal counties that all support commercial fishing enterprises. Combined, these counties make up 10% of the total population in the state. However, each one of these counties represents 2% or less of the entire North Carolina population and has an average unemployment rate of 5.83%. Several communities dependent on commercial fishing can exist within each county, especially with regards to shrimping. Ten of these 20 counties have substantial shrimp landings over the past five years. Carteret County employs, on average, 132 commercial shrimp fishermen each year and five other counties (Pamlico, Hyde, Onslow, Dare, and Brunswick) employ, on average, between 44 and 61 commercial shrimpers per year (Table 8.1). In addition to fishermen that harvest shrimp, Carteret and Brunswick counties have over 30 seafood dealers that sell shrimp, annually. Examples of two coastal counties that support commercial fishing enterprises follow.

Hyde County is a primary example of an area that is dependent on its small fishing communities such as Engelhard for labor and economic production. It also serves to highlight that small fishing communities are still economically important to the state's economy and must be given consideration when adopting new rules or rule changes. Hyde County is the second smallest county in North Carolina in terms of total population (5,621; Table 8.1; NCDOC 2018). Of the coastal counties, it has the highest rate of unemployment at 10.38% for 2016. This small county is responsible for the largest amount of shrimp landings and value in North Carolina. Over the last five years, Hyde County averaged 1.9 million pounds of shrimp, worth approximately $4.2 million each year. Engelhard, a town in Hyde County with a population of 445 (based on 2010 census; NCDOC 2018) makes up only 8% of the county's total population, but lands 77% of the total pounds of shrimp within the county; revenue from shrimping accounts for 78% of the total county revenue as well. There are on average 61 fishermen with landings of shrimp in Hyde County each year, which represents only 1% of the county's total population, but contributes a significant amount to the county's economy.

It was reported in the 1997 court ruling mentioned above that manufacturing jobs related to commercial fishing made up 82% of the total manufacturing jobs in Pamlico County. In 2016, Pamlico County had 169 total manufacturing jobs (NCDOC 2018). Pamlico County averages 1.4 million pounds of shrimp each year worth $3.1 million (Table 8.1). The town of Oriental (Pamlico County) is one of the top five cities with respect to total commercial shrimp landings and value for North Carolina and makes up 68% of the total shrimp landings in the county. On average, over the past five years (2012–2016), Oriental had 967,603 pounds of shrimp per year worth approximately $2.1 million annually.

The Petitioned rules have the potential to drastically alter the labor force, municipal tax revenue, unemployment rates, and social service costs in small fishing communities such as those mentioned above. Some counties would be able to mitigate losses to the commercial shrimping industry better than others, but the potential impacts to those that are heavily dependent on shrimping are evident. Losses to the commercial shrimping industry would disproportionally affect smaller counties with smaller labor forces that have traditionally relied on commercial shrimping. This may lead to increased reliance on social service programs.

Tourism and durable good purchases related to recreational fishing is also a large source of seasonal income for many coastal counties in North Carolina. This tourism supports charter and guide fishing operations, as well as tackle shops, and local stores and hotels. A potential benefit of the proposed rules might be increased angler tourism to these counties if recreational fishing is perceived to improve after reduction in trawling effort in subsequent years following implementation of the Petitioned rules. Whether the benefits would off-set the losses to these coastal communities from decreased commercial fishing operations can only be observed in hindsight.

Table 8.1. Employment for 2016 and average commercial landings and value of shrimp by coastal county, 2012–2016. (Source: NCTTP; NCDOC 2018) NOTE: Only coastal counties that reported shrimp over the last five years to the NCTTP were included.

County	2016 Population	2016 Employment	2016 Unemployment	2016 Unemployment Rate	Avg. Value	Avg. Pounds Landed	Avg. # of Dealers	Avg. # of Fishermen
Hyde	5,621	1,936	201	10.38%	$4,201,338	1,904,880	6	61
Carteret	69,881	30,100	1,637	5.44%	$3,162,682	1,569,274	39	132
Pamlico	13,336	5,118	286	5.59%	$3,147,354	1,417,391	11	60
Dare	36,387	18,716	1,353	7.23%	$2,086,453	916,767	15	44
Onslow	193,914	60,231	3498	5.81%	$1,495,925	689,632	16	52
Brunswick	127,750	46,600	3,158	6.78%	$889,886	406,270	30	48
New Hanover	223,608	111,212	5,464	4.91%	$138,061	77,545	16	16
Pender	59,459	25,278	1,409	5.57%	$126,294	74,986	11	19
Beaufort	47,610	19,267	1,162	6.03%	$116,030	57,241	3	10
Craven	103,737	39,659	2,198	5.54%	$21,699	11,907	6	10

***Currituck, Tyrrell, and Washington had shrimp landings each year, but were minimal.

9 IMPACT ON STATE AGENCY

The NCDMF's mission is to ensure sustainable marine and estuarine fisheries and habitats for the benefit and health of the people of North Carolina. The agency enforces statutes and rules governing fishing in coastal waters; monitors the supply of fish and their health; protects public health of shellfish consumers and recreational bathers; monitors and protects fisheries habitats, including rehabilitation of shellfish habitat; and encourages public responsibility through information, technical assistance, and education.

The Petitioned rules would impact the NCDMF in a number of ways. Current staff would have to shift from normal job duties to ensure rules are enforced and sampling efforts would need to increase to determine when the shrimp fishery would be allowed to open. It is unknown if additional enforcement officers would be needed due to the uncertainty around the behavioral choices of fishermen responding to the Petitioned rules. There is the potential for increased workload for NCDMF Marine Patrol to enforce the proposed rules that could be more than what current staff could do with all other job duties continuing. Trawl restrictions in other fisheries as a result of the Petitioned rules would also cause staff to amend all FMPs of affected fisheries. The amendment of a FMP takes about two years and there is already a process in place to implement management measures for fisheries. The FMP process is prescribed under the FRA and set forth in G.S. 113-182.1. The majority of the rules proposed in the Petition were suggested as potential management options in Amendment 1 to the Shrimp FMP (adopted in 2015), but were not selected as the MFC's preferred management strategies adopted via Amendment 1. There is also a large impact on other existing rules and fisheries.

Diverting resources away from existing programs and activities to implement and enforce the proposed rules would be detrimental to the effectiveness of those programs and activities. The foregone societal benefits associated with the reallocation of resources is not addressed in this analysis.

9.1 Enforcement

There are three main enforcement concerns related to the Petitioned rules. The first pertains to having two different sets of restrictions for the category of "special secondary nursery areas." The second pertains to enforcing shrimp trawl tow times. The third concern is about patrolling multiple openings and closings across the state each week, resulting from reducing the number of days in a week for trawling and limiting trawling to daylight hours only. Additional concerns include the need for increased NCDMF Marine Patrol enforcement due to the potential elimination of certain fisheries, displacing other enforcement efforts.

The first enforcement concern is due to the 12 existing SSNAs (that would be exempted from the new requirements) adjoining a proposed new SSNA that would be subject to the more restrictive harvest practices. This could cause an increase in user conflicts. Patrolling these transition zones across the state could be time-consuming and displace other enforcement efforts, but to an unknown extent.

As mentioned in section 6.1.5, enforcement of tow times is extremely difficult without constant oversight by NCDMF Marine Patrol for the duration of the tow. Other concerns about the implementation of the proposed tow restrictions stem from how the Petitioned rules are currently written. The Petitioned rules would not require the net and trawl doors to be removed from the water between tows. Without that, it is not possible to determine the actual tow time, resulting in a regulation that is not enforceable. Skimmer trawls and other trawls without doors operate with their trawl frame in the water at all times, so enforcement of tow times in these gears would be problematic even with a requirement to remove the trawl doors from the water between tows.

Sections 6.1.1 and 6.2.1 describe the impacts from limiting the fishing days per week available for trawl fishermen. The Petition document does not address which days of the week to close and the Petitioner stated in their comments they did not intend to recommend specific days for closure and that decision is best left to the Fisheries Director. The Petitioned rules as written limit trawling effort in estuarine waters to no more than three days per week; there are currently five days per week available for fishing. The Petitioned rules as written limit trawling efforts in state ocean waters to no more than four days per week; there are currently seven days per week available for fishing. Additionally, section 6.1.2 describes the impacts from nighttime restrictions. The Petitioned rules seek to limit trawling to daylight hours only. The combination of these restrictions on fishing days and time of day for fishing would result in multiple openings and closings across the state each week. Whether consecutive days are selected to allow trawling or alternate days, when coupled with nighttime restrictions, the continuous openings and closings cannot be avoided. As a result, there may be a significant increase in the amount of time an officer spends patrolling closure days and times for the shrimp trawl and other trawl fisheries. Instead of patrolling for a lack of fishing during the single closure period for shrimp trawls currently in estuarine waters (Friday night to Sunday night), enforcement officers would have to patrol daily closure times in both estuarine and state ocean waters for multiple trawl fisheries to ensure a lack of fishing activity (compliance) during closures.

Currently, the NCDMF Marine Patrol has officers working in three distinct law enforcement districts along the coast. In addition to checking commercial and recreational fishermen, officers patrol waterways, piers, and beaches in coastal areas. They also inspect seafood houses, vehicles transporting seafood, and restaurants across the state to ensure compliance with fisheries rules. In addition to the inspections listed above, the NCDMF Marine Patrol have mandatory patrol responsibilities that must be fulfilled before trying to enforce the additional widespread restrictions proposed in the Petition. The U.S. Food and Drug Administration (FDA) requires North Carolina to patrol a certain number of hours in polluted waters each year. This is a primary function for the NCDMF Marine Patrol to ensure the health and welfare of consumers of North Carolina shellfish. In 2016, each NCDMF Marine Patrol officer spent, on average, 171 hours per year patrolling polluted areas to ensure fishermen are not harvesting shellfish from polluted waters, which would be dangerous and, in some cases, deadly to consumers who could ingest polluted shellfish. The Marine Patrol also assists the observer program with gill net observations to ensure that the NCDMF meets the observer coverage as required by its current federal ITPs. Failure to follow the requirements of the ITPs through lack of sufficient observer coverage could cause the estuarine gill net fishery to close completely.

The estimated total number of hours that would be spent by existing NCDMF Marine Patrol each year (12 months) to enforce the Petitioned rules is approximately 52,000 hours (Table 9.1). This is a total of 50 officers each working 20 hours per week during each week of the year. This is based on time needed to check gear requirements and net sizes, proper licensure, size and creel limits, monitor tow time limits, closure lines, closure days, user conflicts, and the transit time to patrol a vast geographical area, especially in larger water bodies like Pamlico Sound. Additionally, when an officer encounters a potential violation (regardless of the type of offense), there is significant time spent to process the violation, displacing effort on additional patrols. Processing a violation can include identifying who is on board the vessel, plotting the location on a chart for court, escorting the vessel to the dock, offloading the catch, securing three bids to sell the catch to the highest bidder, and processing criminal charges brought against the captain and/or crew, to include potential arrest. At an average salary plus benefits of $32.26 per hour, the opportunity costs for NCDMF Marine Patrol as a result of the Petitioned rules would be $1,677,520 per year.

Table 9.1. Number of hours estimated to be spent by existing NCDMF Marine Patrol officers to enforce Petitioned rules by district. (Source: NCDMF)

District	Number of Officers	Hours per Week	Total Hours per Week
1	19	20	380
2	15	20	300
3	16	20	320
All	50	20	1,000

Existing NCDMF Marine Patrol would have to balance any new responsibilities from the Petitioned rules with existing responsibilities. The opportunity costs presented quantify the value of the hours used by Marine Patrol to perform typical job duties that would now be needed to enforce the proposed rules. They do not represent new costs to NCDMF. Additionally, it is important to understand the temporal nature of any patrol. For example, in the course of patrolling for fishing activities related to the Petitioned rules, if an officer encounters a fisherman harvesting shellfish in a polluted area, they would address the immediate violation and cease the former effort. This adds to the uncertainty in quantifying the impacts to enforcement from the Petitioned rules.

It is unknown if additional enforcement officers would be needed due to the uncertainty around the behavioral choices of fishermen responding to the Petitioned rules. There is the potential for increased workload for existing NCDMF Marine Patrol to enforce the proposed rules that could be more than what current staff could do with all other job duties continuing, but to an unknown extent. The Petitioned rules may require a significant amount of additional monitoring and enforcement on the part of the NCDMF Marine Patrol. Actual work hours would likely be more than 20 hours per week during more active fishing months, but on average, is estimated to be about 20 hours per week per officer year-round.

Additional officers could enable the Marine Patrol to continue ensuring that other fisheries have the necessary coverage to maintain compliance with fisheries rules and regulations. To maintain the aforementioned monitoring required by the FDA and patrol additional areas more frequently due to the Petitioned rules, more officers could be required. This could also hold true with the assistance Marine Patrol provides to the observer program to meet required ITP observer coverage. It is highly uncertain what the behavioral choices of fishermen responding to the Petitioned rules would be. Fishermen could potentially shift to other gears, shift to other fisheries, continue fishing regardless of changes in requirements and/or potential consequences of failing to comply with them, or exit fishing completely. Initially, as both officers and fishermen become accustomed to the requirements of the Petitioned rules, there would likely be a learning curve that would take more effort by all parties until there is familiarity with the new requirements. This learning curve would likely be more pronounced than for previous regulation changes due to the nature of the combination of management strategies that would be implemented by the Petitioned rules, as well as the size of the area that would be affected. Due to this high variability, the number of potential new officers cannot be quantified. Existing NCDMF Marine Patrol would have to continue to balance any new responsibilities from the Petitioned rules with existing responsibilities. This would change over time as fishermen would make choices about their level of continued participation.

Currently, NCDMF Marine Patrol has 50 officers in the field to enforce regulations. There is also one aviation pilot to conduct aerial monitoring and enforcement. In addition to more officers, the additional restrictions to shrimp harvesting could require additional pilots to supplement coverage by officers on the water. The estimated costs of hiring and equipping one new officer and one new pilot for enforcement are shown in Table 9.2. After the initial cost of $118,625 for vessels, the estimated annual costs for one additional officer total $83,234. After the initial cost of $488,500 for a plane, the estimated annual costs for one additional pilot total $109,444. These are average costs and supplies when NCDMF Marine Patrol needs to add an additional officer to the personnel. Base salary is included for an average NCDMF Marine Patrol officer, as well as fringe benefits. Operational costs are also included for outfitting officers with standard equipment including vessels, supplies, uniforms, and other essential items needed for a NCDMF Marine Patrol officer to carry out enforcement duties. Due to the diverse habitats in North Carolina, two different types of vessels (i.e., 23-foot Parker, 21-foot flat bottom vessel) per officer are needed to safely access small and large bodies of water. Smaller water bodies have shallow areas that can only be accessed by a flat bottom boat; whereas, large areas like Pamlico Sound and the ocean require a v-hulled vessel to navigate safely. Again, the number of potential new officers or pilots cannot by quantified.

Table 9.2. Estimated initial costs per additional NCDMF Marine Patrol officer and pilot. (Source: NCDMF)

Cost for additional officers	1 officer	1 pilot
Law enforcement officer salary	$ 39,611	$ 50,000
Fringe benefits (Social security, retirement, health insurance)	18,183	21,414
Supplies/equipment/uniforms, etc.	8,500	8,500
Vehicle rental/miles (2,000 miles/ month x $.46/mile + $35/month)	11,460	11,460
Vessel gas ($2.20 per gallon x 1900 gallons)	4,180	0
Plane fuel	0	7,770
Travel for training	1,300	1,300
Cessna Skylane 182 S/T plane[1]	0	488,500
Plane hangar rental	0	4,000
Plane insurance	0	5,000
23’ Parker SE model (includes: GPS, radar, radios, etc.)[1]	76,000	0
21’ flat bottom vessel (includes: GPS, radios, etc.)[1]	42,625	0
Total Initial Cost	**$ 201,859**	**$ 597,944**
Subsequent Annual Cost	**$83,234**	**$109,444**

[1] Not a recurring annual cost

9.2 Monitoring for Opening Season based on Shrimp Count Size

The NCDMF has many fishery independent sampling programs that use a variety of gears to monitor trends in the relative abundance of species, their habitat use, and to collect environmental information. These programs are conducted by division staff and do not involve the commercial or recreational harvest of fish. They are designed to sample species present in an area as well as species at different sizes and ages, are not dependent on the skill of the sampler, and can be repeated following a set protocol. The value of a sampling program increases with time because it allows biologists and stock assessment scientists to look at a species’ abundance over time. Fishery independent data allow managers to have a more complete picture to understand stock condition and to evaluate management measures and the likely causes of stock changes.

Fishery independent sampling by NCDMF through Program 510 (Juvenile Shrimp Sampling) is performed with small outboard boats to determine area openings or the need to close an area based on shrimp count size per the N.C. Shrimp FMP. The majority of this sampling occurs in SSNAs in the southern district. This sampling uses a 25-foot trawl with ¾-inch bar body and ¼-inch bar cod end. Trawls may be two-seamed, four-seamed, or tongue trawl based on the target species of shrimp. Tows are typically 10 minutes long, but can vary based on abundance of shrimp and fish and can be less than five minutes or up to 20 minutes. This sampling gear is different from commercial shrimp gear in that no BRDs or TEDs are used and although the body of the gear is legal size, the cod end is a smaller mesh than what is allowed by the public. This allows the NCDMF to retain smaller shrimp and fish, which provides a better “snapshot” of what is present in the area being sampled. Shrimp count size as well as the amount of bycatch are determinants for opening these areas. Unfortunately, this sampling program could not be used “as is” to determine shrimp count size in Pamlico Sound, as this program only operates in the southern district of the state. Even though there are existing sampling programs in the Pamlico Sound area, such as Program 120 (Estuarine Trawl Survey) and Program 195 (Pamlico Sound Survey), these programs are insufficient to determine when to open shrimp season based on shrimp count size due to their limited temporal and spatial coverage.

To adequately monitor Pamlico Sound for a 60-count shrimp size as proposed by the Petition, a new survey would need to be designed. Sampling in the Pamlico Sound may entail a similar monitoring strategy to Program 510, as described above, in the bays within Pamlico Sound using similar gear. Sampling trips would likely be one-day trips made on multiple days to ensure adequate coverage of bays selected to be sampled. These days may take up to 12 hours or more due to further distances to travel to each of the selected bays, as compared to the southern district. Costs of this sampling include salary of three new temporary technicians, equipment, and fuel. The estimated new cost of this sampling could range from $4,359.40 to $9,318.80 per year depending on gear replacement needs, the number of sampling trips, and estimated fuel costs and salaries from 2017 (Table 9.3). It is unknown if sampling in the bays of the sound would be sufficient due to the timing of growth and movement of shrimp into the open waters as they emigrate to the ocean or if sampling in the open waters of Pamlico Sound would be required. For example, by the time shrimp reach the 60-count size threshold, they may have already left the bays and moved into the sound.

Table 9.3. Estimated new annual sampling costs of Pamlico Sound 60-count size sampling in the bays of Pamlico Sound (based on costs for Program 510).

Item	Cost	Trip Length	Number of Trips	Total Cost
Technician II	$21.58/hour	12 hours	5–10	$1,294.80 – $2,589.60
Technician II	$21.58/hour	12 hours	5–10	$1,294.80 – $2,589.60
Technician II	$21.58/hour	12 hours	5–10	$1,294.80 – $2,589.60
Boat fuel	$45.00/day	1 day	5–10	$225.00 – $450.00
Truck fuel	$50.00/day	1 day	5–10	$250.00 – $500.00
25-ft 4-seam trawl net	$600.00			$600.00
Total				**$4,359.40 – $9,318.80**

If sampling in the open waters of Pamlico Sound is required, then sampling could be completed using the R/V *Carolina Coast,* a 44-foot fiberglass hulled research vessel. Trawl nets on the R/V *Carolina Coast* are double rigged 30-foot mongoose trawls with a 7/8-inch bar mesh body and a ¾-inch bar mesh cod ends. The type of data collected from this survey would need to be determined, including time of year, time of day, station locations, tow times, as well as environmental and species data. Consideration of shrimp species targets for the 60-count size criteria would also determine net needs for sampling aboard the R/V *Carolina Coast*. The need for this additional sampling is dependent on environmental conditions and the prevalence of shrimp, both of which cannot be predicted.

Sampling trips on the R/V *Carolina Coast* would be completed in three days with eight hours of sampling done each day. An estimated two to three trips would be needed for determining the opening of shrimp season based on 60-count size shrimp. Costs of sampling include salary of three new temporary technicians, as well as the existing vessel captain and deck hand, plus equipment and fuel. The estimated total cost of this sampling ranges from $8,792.52 to $12,495.50 depending on the number of sampling trips (Table 9.4). The estimated new sampling costs range from $6,302.28 to $8,760.14 per year (i.e., total cost minus existing staff costs for captain and deck hand). The estimated opportunity costs range from $2,490.24 to $3,735.36 (i.e., cost for existing captain and deck hand). These costs may be in addition to the costs described in Table 9.3 if both the bays and open waters of Pamlico Sound would need to be sampled.

Table 9.4. Estimated sampling costs (new and opportunity) using R/V *Carolina Coast* to determine the opening of shrimp season in Pamlico Sound based on 60-count size shrimp in the open waters of the sound. (Source: NCDMF)

Item	Cost	Trip Length	Number of Trips	Total Cost
Technician III	$27.83/hour	24 hours (3 x 8-hour)	2–3	$1,335.84 – $2,003.76
Technician II	$21.58/hour	24 hours (3 x 8-hour)	2–3	$1,035.84 – $1,553.76
Technician II	$21.58/hour	24 hours (3 x 8-hour)	2–3	$1,035.84 – $1,553.76
Boat Captain[1]	$31.18/hour	24 hours (3 x 8-hour)	2–3	$1,496.64 – $2,244.96
Deck Hand[1]	$20.70/hour	24 hours (3 x 8-hour)	2–3	$993.60 – $1,490.40
Truck fuel	$25.00/day	3 days	2–3	$150.00 – $225.00
Boat use	$200.00/day	3 days	2–3	$180.00 – $270.00
Food cost for crew	$189.50/day	3 days	2–3	$1,137.00 – $1,705.50
Galley supplies	$20.00/trip		2–3	$40.00 – $60.00
(2) 30-ft trawl net	$1,388.36			$1,388.36
Total new costs				$6,302.28 – $8,760.14
Total opportunity costs[1]				$2,490.24 – $3,735.36
Grand Total				**$8,792.52 – $12,495.50**

[1]Opportunity costs only

The total amount of sampling required to determine the opening of shrimp season based on shrimp count size in Pamlico Sound is unknown. It is unclear if both the bays of Pamlico Sound and the open waters would need to be sampled to adequately determine the opening of shrimp season based on shrimp count size. At a minimum, new sampling costs could be as low as $4,359.42. This cost reflects the low end of the range of annual sampling costs presented in Table 9.3. New sampling costs could be as high as $18,078.94 per year. This cost reflects the highest sampling costs from both Table 9.3 and 9.4 minus the opportunity costs from Table 9.4. Estimates presented are based on the best available data and may not reflect the actual amounts that would result from the Petitioned rules.

9.3 Impacts to Other Rules

One consideration about impacts to other rules is the unintended consequences of proposed changes to 15A NCAC 03N .0105(c), making it unlawful “to use trawl nets” instead of “to take shrimp with trawl nets” in the new SSNAs proposed by the Petition. Without this important distinction, numerous fisheries that use trawl nets would be impacted, resulting in amendments to the concomitant FMPs, rules, and proclamations. As written, the Petitioned rule would not allow trawling for anything other than crabs or shrimp, effectively eliminating clam trawling (kicking) in the mechanical clam harvest areas in estuarine waters and finfish trawling in state ocean waters. In its Jan. 26, 2017 letter to MFC Chairman Sammy Corbett, the Petitioner states it “did not intend to impact activity in other fisheries, including but not limited to the peeler trawling, clam kicking, finfish trawling, and live bait harvest fisheries” (NCWF 2017b, p. 3). This is evident by the proposed amendments in the Petition that would change 15A NCAC 03L .0103 to restrict headrope length and require the use of two BRDs only for taking shrimp with trawls, and not for other types of trawling activities.

Clam trawl harvest (kicking) currently occurs during the winter in specific areas that are open by proclamation, but this would be eliminated in areas where it is currently allowed under the proposed nursery area designations. The proposed rules would only allow shrimp or crab trawling. This would also be the case for finfish trawl fisheries. Finfish trawls such as flynets are allowed in state ocean waters north of Cape Hatteras, while flounder trawls are allowed in state ocean waters. Species targeted with trawls north of Cape Hatteras include Atlantic Croaker, Bluefish, Atlantic Menhaden, Summer Flounder, and Striped Bass. In addition, trawls targeting Striped Bass can only fish in state ocean waters since it is unlawful to fish for Striped Bass in federal waters. The Petitioned rules only allow shrimp or crab trawling in all areas not already designated as nursery areas today, so each of these fisheries would be eliminated.

The peeler trawl and crab trawl fisheries operate primarily at night, but this activity would be prohibited in areas where it is currently allowed under the proposed nursery area designations. As written, the proposed amendments to 15A NCAC 03N .0105 would subject any remaining effort in these two fisheries to the new requirements of no trawling at night, tow time limits, and trawling only three days per week in estuarine waters and four days per week in the state ocean waters. The harvest of crabs with trawls would also be contingent on opening the shrimp season, which (under the Petition) would require a shrimp count size of 60 shrimp per pound, heads-on, in the Pamlico Sound.

A second consideration about impacts to other rules is the potential effect on rules recently amended by the MFC to implement the Permit for Weekend Trawling for Live Shrimp, as authorized by the 2015 North Carolina Shrimp FMP Amendment 1. These rules became effective May 1, 2017 and included the following changes: amendments to 15A NCAC 03J .0104 (Trawl Nets) and 03L .0102 (Weekend Shrimping Prohibited) made exceptions to the weekend closure for trawling for live shrimp; and amendments to 15A NCAC 03O .0503 (Permit Conditions; Specific) constrained this exception to 12 p.m. (noon) on Saturday. The Petition does not address how the proposed rules would impact the rules that implemented the Permit for Weekend Trawling for Live Shrimp, other than stating the Petitioner did not intend to impact them. The Petitioned rules would require further amendments to be made to 15A NCAC 03J .0104, 03L .0102, and 03O .0503 to address the differences in the proposed requirements under the Petition and make conforming changes.

The impacts to other rules would result in the need to make conforming changes to affected FMPs, rules, and proclamations. It is highly unlikely that new staff would be funded to do this work. It is more probable that existing staff would be tasked with undertaking these changes. Some tasks, like amending proclamations, can be completed quickly as part of regular duties and would take minimal resources. Other tasks, like amending rules and FMPs to reflect the changes to management strategies resulting from the Petitioned rules, are more involved, require the participation of other entities (e.g., ACs, the NCDEQ, the Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources) and would take more resources to complete. There are potentially many FMPs that would need amending or development resulting from the Petitioned rules. This would displace other rulemaking and FMP activities underway per the MFC's annual FMP review schedule and annual rulemaking cycle. The extent to which this is true depends on the number of plans under review or development at the time the Petitioned rules would be adopted, and therefore, cannot be quantified at this time.

9.4 Revenue Loss Associated with License Sales

9.4.1 <u>Commercial Fishery</u>

The Petitioned rules have the potential to cause some commercial fishermen to exit the fishery due to regulations becoming too stringent to remain profitable in their respective fisheries. Fishermen exiting commercial fishing completely would result in the decrease of commercial fishing license sales, and therefore, operating revenue for the NCDMF. Sales transaction data were used from the NCDMF to determine a five-year average of revenue from the sale of commercial fishing licenses, the number of licenses sold, and revenue per license sold for fiscal years 2012–2016. Fiscal years (FY) run from July to June, so FY2016 includes July 1, 2015 to June 30, 2016. FY2017 was not included because the 2017 Trip Ticket data were not finalized at the time of this analysis. The commercial fishing licenses included in the analysis were Standard Commercial Fishing License (SCFL), Retired Standard Commercial Fishing License (RSCFL), Commercial Fishing Vessel Registration (CFVR), Fish Dealer Licenses, and Land or Sell Licenses. Transaction types included in the analysis were Add, Approve, Renew, and Transfer. Counting transfer transactions is important with regards to determining total revenue when a resident license is transferred to a non-resident. In this instance, during the transfer, the transferee pays the difference between the resident and non-resident fees for their state of residence. Counting these transferred licenses may have inflated the total number of licenses issued when compared to previous reports. From FY2012–2016, the commercial license sales for those five licenses had an average value of $2 million (Table 9.5). Sales of SCFLs and RSCFLs make up the majority of transactions per year and generate the most revenue. The NCDMF sells on average 16,239 of these commercial fishing licenses annually. SCFLs and RSCFLs comprise 44% of average annual license sales, while 51% of license sales are CFVRs, indicating that some commercial fishermen have more than one vessel they use for commercial fishing. The overall average price of any commercial fishing license transaction is $126. The prices of commercial fishing licenses have seen several changes during this period, which affect the averages shown in the tables below. In FY2015, the price of these licenses increased by 25% from FY2014. In FY2016, prices doubled from the price in FY2014.

Table 9.5. Average revenue, average number of licenses sold, and average revenue per license for the top 5 commercial fishing licenses issued by NCDMF by fiscal year, 2012–2016. (Source: NCDMF License Program; NCTTP)

License Type	Avg. License Revenue	Avg. Number of Licenses	Avg. Revenue per License
Commercial Fishing Vessel Registration	$363,681	8,273	$43.96
Fish Dealer License	$103,361	755	$136.87
Land or Sell License	$31,122	92	$339.02
Retired Standard Commercial Fishing License	$161,313	1,291	$124.99
Standard Commercial Fishing License	$1,388,787	5,829	$238.26
Grand Total	**$2,048,263**	**16,239**	**$126.13**

The Petitioned rules have the largest impact on commercial shrimpers. Therefore, commercial fishermen who would most likely exit commercial fishing due to the proposed rules would be commercial shrimpers, as their industry would be subject to multiple regulatory changes. To quantify potential losses in license revenue to NCDMF, license sales data were matched to trip ticket data for commercial shrimp landings to estimate average license sales and revenue for commercial shrimpers for a five-year period by fiscal year (2012-2016). On average, commercial shrimpers accounted for 8% of the total revenue from the five licenses mentioned above and 7% of the total licenses sold per year (Tables 9.5 and 9.6). It is important to note that fishermen can operate as their own dealer by purchasing a Fish Dealer License from NCDMF. It is not uncommon for a commercial shrimp fisherman to also have a dealer license to remove the middle man and sell their catch directly to the public. Anyone holding a Fish Dealer License must fill out trip tickets and report their landings to the NCDMF monthly.

Because it is unknown how large the effect of the Petitioned rules would be on the commercial fishing industry, the extent of potential losses in license revenue from commercial shrimp fishermen exiting commercial fishing completely cannot be determined. It is also impossible to predict how the General Assembly could change the cost of licenses in the future (increases or decreases).

Table 9.6. Average revenue, average number of licenses used, and average revenue per license for the top 5 commercial fishing licenses issued by NCDMF for fishermen with commercial landings of shrimp by fiscal year, 2012–2016. (Source: NCDMF License Program; NCTTP)

License Type	Avg. License Revenue	Avg. Number of Licenses	Avg. Revenue per License
Commercial Fishing Vessel Registration	$63,926.10	628	$101.83
Fish Dealer License	$8,362.10	71	$117.78
Land or Sell License	$80.00	0	$400.00
Retired Standard Commercial Fishing License	$6,097.00	47	$129.72
Standard Commercial Fishing License	$108,576.10	440	$246.99
Grand Total	**$187,041.30**	**1,186**	**$157.76**

9.4.2 Recreational Fishery

It is unclear if recreational license sales would be affected by the Petitioned rules. If stock abundance noticeably increases for species such as Spot and Atlantic Croaker, there is the potential for an increase in the number of recreational licenses. These species are not the highest priority to recreational fishermen visiting North Carolina; however, they are commonly caught. In 2016, Spot was ranked 10th in the number of recreational trips that caught this species. Atlantic Croaker was ranked 6th. For 2016, about 1.5% of recreational fishing trips in North Carolina targeted Spot. Only 0.46% of recreational trips in 2016 reported targeting Atlantic Croaker. Weakfish is considered a more prestigious species in North Carolina; however, only 0.23% of recreational trips in North Carolina targeted this species. It should be noted that about 50% of trips do not indicate a target species. For those fishermen that do target Spot and Atlantic Croaker, minimum size limits on these species could cause some fishermen to shift harvest effort to other species, but it would be unlikely that they exit recreational fishing completely.

10 ALTERNATIVES

In the North Carolina Administrative Procedure Act, G.S. 150B-19.1(f) requires if "the agency determines that a proposed rule will have a substantial economic impact as defined in G.S. 150B-21.4(b1), the agency shall consider at least two alternatives to the proposed rule. The alternatives may have been identified by the agency or by members of the public." G.S. 150B-21.4(b1) defines the term "substantial economic impact" to mean "an aggregate financial impact on all persons affected of at least one million dollars ($1,000,000) in a 12-month period."

As analyzed throughout this document and described in the Executive Summary, the proposed rules are expected to have a substantial economic impact. As such, alternatives to the proposed rules are included here.

The agency previously considered multiple management options for shrimp with a focus on bycatch reduction of non-target species in the 2015 Amendment 1 to the North Carolina Shrimp FMP. Within that effort, several options were developed and subsequently vetted by the public, ACs of the MFC, the NCDEQ secretary, the Joint Legislative Commission on Governmental Operations, and the MFC. Ultimately, the MFC selected its preferred management options for the FMP. The MFC gave its final approval of Amendment 1 and associated rules Feb. 19, 2015; implementing rules became effective May 1, 2015. The preferred management options did not include every option that was developed, vetted, and presented to the MFC. These options are alternatives to the Petition for reconsideration.

The North Carolina Shrimp FMP Amendment 1 was developed by the NCDMF with the assistance of the Shrimp FMP AC, as is required by G.S. 113-182.1(c). The committee was formed in January 2013 and met over a period of eight months to become familiar with the content of the FMP in general and the bycatch issue specifically and to review different bycatch management options. The NCDMF proposed a holistic approach to review the numerous options under consideration and directed the ACs to assess the different management options through a series of evaluation matrices. Each evaluation matrix listed management options along with an initial list of potential impacts discussed by the NCDMF Plan Development Team (PDT). Quantifying the potential biological gain to affected bycatch species populations was not possible with existing data; therefore, it was important for the committee to consider reasonable and practicable management strategies to reduce bycatch while balancing the economic and social value of the shrimp fishery. The AC was directed to the following two FMP objectives during its deliberations:

- Minimize waste and enhance economic value of the shrimp resource by promoting more effective harvesting practices.
- Minimize harvest of non-target species of finfish and crustaceans, and protected, threatened, and endangered species.

The committee assessed bycatch reduction, economic impacts, social impacts, and inter-fishery impacts for each management option for the shrimp fishery. The additional categories of enforcement and authority/administration were only assessed by the PDT. These evaluation matrices provided focused deliberations and provided a starting point for thorough and meaningful discussions in determining the best approaches for reducing bycatch in the shrimp trawl fishery. The committee was able to add options and remove options as well as change or rephrase the initial impacts as contemplated for each management option.

Twenty-nine different management options were brought forward to address eight different issues during monthly meetings from May through August 2013. Each of these issue papers is found in Section 12 of Amendment 1[3], including both sets (AC and PDT) of evaluation matrices. The committee voted to remove

[3] http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=24626903&name=DLFE-134540.pdf

four of those options from the evaluation process. After all options were evaluated, the members of the committee were sent an option selection package and asked to select what he or she considered to be the five best options to reduce bycatch. This enabled discussion to be focused on the best options and combinations of those options, and to discuss the details needed to develop management recommendations. The AC deliberated and recommended actions for the MFC to consider addressing bycatch in the shrimp fisheries. The NCDMF also assessed management options in a similar manner. Bycatch management recommendations for each issue from the Shrimp FMP AC and the NCDMF, and the preferred management strategy of the MFC are found in Section 12.10 of the FMP and are also found in Appendix 5 of this document. Recommendations contained in Amendment 1 of the Shrimp FMP that were not already implemented under the authority of Amendment 1 of the Shrimp FMP are alternatives to the proposed rules for reconsideration. Some of these alternatives would be more restrictive than measures already implemented by the amendment, while other alternatives would primarily address a different way of achieving what is already in place.

G.S. 150B-19.1(f) also allows “members of the public” to identify alternatives to proposed rules. Within the context of the statute, the Petitioner is a member of the public. Jan. 12, 2017, the Petitioner submitted a letter to the MFC to make two substantive modifications to the Petition (NCWF 2017a). The modifications were reflected in the Petitioned rules that were granted in full for rulemaking by the MFC Feb. 16, 2017.

The first modification was to the Petitioner’s original proposal to reduce headrope length on all shrimp trawls in North Carolina coastal fishing waters. The Petition initially proposed limiting maximum headrope length on all shrimp trawls operating in all coastal fishing waters to 90 feet under 15A NCAC 03L .0103 (NCWF 2016a). The requested modification was to establish a 110-foot headrope limit in the Atlantic Ocean (from 0 to 3 miles; NCWF 2017a). The Petitioner stated this change will allow commercial fishermen operating in coastal fishing waters in the Atlantic Ocean to continue to use gear that was recently modified to meet the current 220-foot limit on headrope length for all trawls in internal coastal fishing waters that went into effect on Jan. 1, 2017. An alternative would be proposed changes to the rule as originally submitted by the Petitioner, which would be more restrictive than the Petitioned rules granted in full by the MFC for rulemaking.

The second modification the Petitioner submitted was to its proposal regarding trawling activities in SSNAs under 15A NCAC 03N .0105 to allow for an additional day of shrimp trawling in coastal fishing waters in the Atlantic Ocean. The Petition initially proposed restricting trawling to a total of three days per week in all SSNAs (NCWF 2016a). The requested modification was to limit trawling in SSNAs in the Atlantic Ocean (from 0 to 3 miles) to four days per week (NCWF 2017a). This modification would change the number of days allowed to fish in the Atlantic Ocean to a total of four days per week. These restrictions on trawling exclude waters already designated as PNAs, SNAs, and all other SSNAs and would only apply to waters newly designated as SSNAs resulting from the Petition. An alternative would be proposed changes to the rule as originally submitted by the Petitioner, which would be more restrictive than the Petitioned rules granted in full by the MFC for rulemaking.

In addition to the above modifications, the Petitioner made a recommendation to the MFC in its Jan. 12, 2017 letter (NCWF 2017a). The original Petition proposed a size limit for Spot and Atlantic Croaker for all commercial and recreational fisheries in order to limit the harvest of juvenile fish of these species. Limits on mesh size in commercial fishing gear are often used to achieve the same result. Mesh selectivity studies evaluating the most appropriate mesh size to limit harvest of juvenile Spot and Atlantic Croaker are not available, so the Petition did not include a mesh size limit to complement the size limit contained in the proposed rules. The Petitioner recommended in its Jan. 12, 2017 letter that the MFC undertake a mesh selectivity study to evaluate the mesh size most effective at limiting the harvest of juvenile Spot and Atlantic Croaker. Upon completion, rules could be further amended in accordance with the results of the study to reflect the best available data. Depending on the availability of funding, a mesh selectivity study could be an alternative to the proposed rules for minimum size limits for Spot and Atlantic Croaker. This could help inform the determination if mesh size and/or minimum size limits are appropriate management measures for these species.

At the Aug. 16, 2017 MFC meeting in Raleigh, North Carolina, a member of the Southern Environmental Law Center (SELC) spoke on behalf of the NCWF and provided two alternatives to the Petitioned rules during the public comment period of the meeting (SELC 2017b). The two alternatives put forth were (1) *Status quo* and (2) a complete net ban in estuarine waters. It was also stated "the Petitioned rules should not be evaluated as the most restrictive option" and "would provide the public with reasonable alternatives against which to weigh the impact of the proposed rules". In a letter from the SELC on Sep. 18, 2017 inquiring about the status of the NCWF Petition for Rulemaking, the two alternatives mentioned at the August 2017 MFC meeting were restated (SELC 2017a). Although a complete net ban in estuarine waters illustrates the spectrum of management actions to address bycatch and habitat protection concerns, a complete net ban in estuarine waters is not recognized as an alternative to the Petitioned rules because it includes gears outside the scope of the Petition including gill nets, trammel nets, pound nets, seine nets, hoop nets, and any other kind of net used in a fishing operation. Under the status quo alternative, there are already mechanisms in place to manage state and interjurisdictional species through the FMP process (see section 1) per the requirements of the FRA (G.S. 113-182.1). The issue of bycatch in the shrimp trawl fishery was discussed in the 2015 North Carolina Shrimp FMP Amendment 1.

Additional information about an alternative to the proposed rules is found in Appendix 4, which explains the potential benefits of conducting a Before-After Control-Impact study. The information is appended to this document because it provides an alternative to the rulemaking process underway at this time that would be in lieu of the Petitioned rules. This study would include monitoring of sediment and water quality, as well as mapping the soft bottom habitat and looking for changes in oyster reef and SAV abundance, to determine what effects the Petitioned rules had on the environment in the newly proposed SSNAs. Because of the size of the area that would be affected by the proposed rules, the total time needed to document the current habitat under existing levels of trawling would occur over a period of 18 years and cost approximately $2.9 million dollars.

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APPENDIX 1 Proposed Rule Text (Source: NCWF 2016a)

TEXT OF PROPOSED RULES

The added text is denoted by underline and deleted text is denoted ~~by strike-through~~ below.

15A N.C. Admin. Code 3R .0105: Special Secondary Nursery Areas

The special secondary nursery areas referenced in 15A NCAC 3N .0105(b) are designated in the following coastal water areas:

(1) Roanoke Sound:

(a) Outer Shallowbag Bay--west of a line beginning on Baum Point at a point 35° 55.1461' N--75° 39.5618' W; running southeasterly to Ballast Point to a point 35° 54.6250' N--75° 38.8656' W; including the canal on the southeast shore of Shallowbag Bay; and
(b) Kitty Hawk Bay/Buzzard Bay--within the area designated by a line beginning at a point on the east shore of Collington Creek at a point 36° 2.4360' N--75° 42.3189' W; running westerly to a point 36° 2.6630' N--75° 41.4102' W; running along the shoreline to a point 36° 2.3264' N--75° 42.3889' W; running southwesterly to a point 36° 2.1483' N--75° 42.4329' W; running along the shoreline to a point 36° 1.6736' N--75° 42.5313' W; running southwesterly to a point 36° 1.5704' N--75° 42.5899' W; running along the shoreline to a point 36° 0.9162' N--75° 42.2035' W; running southeasterly to a point 36° 0.8253' N--75° 42.0886' W; running along the shoreline to a point 35° 59.9886' N--75° 41.7284' W; running southwesterly to a point 35° 59.9597' N--75° 41.7682' W; running along the shoreline to the mouth of Buzzard Bay to a point 35° 59.6480' N--75° 32.9906' W; running easterly to Mann Point to a point 35° 59.4171' N--75° 32.7361' W; running northerly along the shoreline to the point of beginning;

(2) In the Pamlico and Pungo rivers Area:

(a) Pungo Creek--west of a line beginning on Persimmon Tree Point at a point 35° 30.7633' N--76° 38.2831' W; running southwesterly to Windmill Point to a point 35° 31.1546' N--76° 37.7590' W;
(b) Scranton Creek--south and east of a line beginning on the west shore at a point 35° 30.6810' N--76° 28.3435' W; running easterly to the east shore to a point 35° 30.7075' N--76° 28.6766' W;
(c) Slade Creek--east of a line beginning on the west shore at a point 35° 27.8879' N--76° 32.9906' W; running southeasterly to the east shore to a point 35° 27.6510' N--76° 32.7361' W;
(d) South Creek--west of a line beginning on Hickory Point at a point 35° 21.7385' N-- 76° 41.5907' W; running southerly to Fork Point to a point 35° 20.7534' N--76° 41.7870' W; and
(e) Bond Creek/Muddy Creek--south of a line beginning on Fork Point 35° 20.7534' N-- 76° 41.7870' W; running southeasterly to Gum Point to a point 35° 20.5632' N--76° 41.4645' W;

(3) In the West Bay Area:

(a) West Thorofare Bay--south of a line beginning on the west shore at a point 34° 57.2199' N--76° 24.0947' W; running easterly to the east shore to a point 34° 57.4871' N--76° 23.0737' W;

(b) Long Bay-Ditch Bay--west of a line beginning on the north shore of Ditch Bay at a point 34° 57.9388' N--76° 27.0781' W; running southwesterly to the south shore of Ditch Bay to a point 34° 57.2120' N--76° 27.2185' W; then south of a line running southeasterly to the east shore of Long Bay to a point 34° 56.7633' N--76° 26.3927' W; and
(c) Turnagain Bay--south of a line beginning on the west shore at a point 34° 59.4065' N--76° 30.1906' W; running easterly to the east shore to a point 34° 59.5668' N--76° 29.3557' W;

(4) In the Core Sound Area:

(a) Cedar Island Bay--northwest of a line beginning near the gun club dock at a point 34° 58.7203' N--76° 15.9645' W; running northeasterly to the south shore to a point 34° 57.7690' N--76° 16.8781' W;
(b) Thorofare Bay-Barry Bay--northwest of a line beginning on Rumley Hammock at a point 34° 55.4853' N--76° 18.2487' W; running northeasterly to Hall Point to a point 34° 54.4227' N--76° 19.1908' W;
(c) Nelson Bay--northwest of a line beginning on the west shore of Nelson Bay at a point 34° 51.1353' N--76° 24.5866' W; running northeasterly to Drum Point to a point 34° 51.6417' N--76° 23.7620' W;
(d) Brett Bay--north of a line beginning on the west shore at a point 34° 49.4019' N--76° 26.0227' W; running easterly to Piney Point to a point 34° 49.5799' N--76° 25.0534' W; and
(e) Jarrett Bay--north of a line beginning on the west shore near Old Chimney at a point 34° 45.5743' N--76° 30.0076' W; running easterly to a point east of Davis Island 34° 45.8325' N--76° 28.7955' W;

(5) In the North River Area:

(a) North River--north of a line beginning on the west shore at a point 34° 46.0383' N-- 76° 37.0633' W; running easterly to a point on the east shore 34° 46.2667' N--76° 35.4933' W; and
(b) Ward Creek--east of a line beginning on the north shore at a point 34° 46.2667' N-- 76° 35.4933' W; running southerly to the south shore to a point 34° 45.4517' N--76° 35.1767' W;

(6) Newport River--west of a line beginning near Penn Point on the south shore at a point 34° 45.6960' N--76° 43.5180' W; running northeasterly to the north shore to a point 34° 46.8490' N--76° 43.3296' W;

(7) New River--all waters upstream of a line beginning on the north side of the N.C. Highway 172 Bridge at a point 34° 34.7680' N--77° 23.9940' W; running southerly to the south side of the bridge at a point 34° 34.6000' N--77° 23.9710' W;

(8) Chadwick Bay--all waters west of a line beginning on the northeast side of Chadwick Bay at a point 34° 32.5630' N--77° 21.6280' W; running southeasterly to a point near Marker “6” at 34° 32.4180' N--77° 21.6080' W; running westerly to Roses Point at a point 34° 32.2240' N--77° 22.2880' W; following the shoreline in Fullard Creek to a point 34° 32.0340' N--77° 22.7160' W; running northwesterly to a point 34° 32.2210' N--77° 22.8080' W; following the shoreline to the west point of Bump's Creek at a point 34° 32.3430' N--77° 22.4570' W; running northeasterly to the east shore to a point 34° 32.4400' N--77° 22.3830' W; following the shoreline of Chadwick Bay back to the point of origin;

(9) Intracoastal Waterway--all waters in the IWW maintained channel from a point near Marker “17” north of Alligator Bay 34° 30.7930' N--77° 23.1290' W; to a point near Marker “49” at Morris Landing at a point 34° 28.0820' N--77° 30.4710' W; and all waters in the IWW maintained channel and 100 feet on either side from Marker “49” to the N.C. Highway 50-210 Bridge at Surf City;

(10) Cape Fear River--all waters bounded by a line beginning on the south side of the Spoil Island at the intersection of the IWW and the Cape Fear River ship channel at a point 34° 1.5780' N--77° 56.0010' W; running easterly to the east shore of the Cape Fear River to a point 34° 1.7230' N--77° 55.1010' W; running southerly and bounded by the shoreline to the Ferry Slip at Federal Point at a point 33° 57.8080' N--77° 56.4120' W; running northerly to Bird Island to a point 33° 58.3870' N--77° 56.5780' W; running northerly along the west shoreline of Bird Island and the Cape Fear River spoil islands back to point of origin;

(11) Lockwood Folly River--all waters north of a line beginning on Howells Point at a point 33° 55.3680' N--78° 12.7930' W and running in a westerly direction along the IWW near IWW Marker “46” to a point 33° 55.3650' N--78° 13.8500' W; and

(12) Saucepan Creek--all waters north of a line beginning on the west shore at a point 33° 54.6290' N--78° 22.9170' W; running northeasterly to the east shore to a point 33° 54.6550' N--78° 22.8670' W.

(13) All Coastal Fishing Waters under the jurisdiction of the Marine Fisheries Commission, pursuant to N.C. Gen. Stat. § 113-132(a), not otherwise designated as primary, secondary, or special secondary nursery areas under .0103, .0104, or above, respectively.

15A N.C. Admin. Code 3L .0101: Shrimp Harvest Restrictions

(a) It is unlawful to take shrimp until the Fisheries Director, by proclamation, opens the season.

(b) The Fisheries Director may not open the season until the shrimp count reaches 60 shrimp per pound, heads on, in the Pamlico Sound.

~~(b)~~ (c) The Fisheries Director may, by proclamation, impose any or all of the following restrictions on the taking of shrimp:

(1) specify time;
(2) specify area;
(3) specify means and methods;

(4) specify season;
(5) specify size; and
(6) specify quantity.

15A N.C. Admin. Code 3L .0103: Prohibited Nets, Mesh Lengths and Areas

(a) It is unlawful to take shrimp with nets with mesh lengths less than the following:

(1) Trawl net--one and one-half inches;
(2) Fixed nets, channel nets, float nets, butterfly nets, and hand seines--one and one-fourth inches; and
(3) Cast net--no restriction.

(b) It is unlawful to take shrimp with a net constructed in such a manner as to contain an inner or outer liner of any mesh length. Net material used as chafing gear shall be no less than four inches mesh length, except that chafing gear with smaller mesh may be used only on the bottom one-half of the tailbag. Such chafing gear shall not be tied in a manner that forms an additional tailbag.

(c) ~~It is unlawful to take shrimp with trawls that have a combined headrope of greater than 90 feet in Internal Coastal Waters in the following areas:~~

~~(1) North of the 35| 46.3000' N latitude line;~~
~~(2) Core Sound south of a line beginning at a point 34| 59.7942' N--76| 14.6514' W on Camp Point; running easterly to a point 34| 58.7853' N--76| 9.8922' W on Core Banks; to the South Carolina State Line;~~
~~(3) Pamlico River upstream of a line from a point 35| 18.5882' N--76| 28.9625' W at Pamlico Point; running northerly to a point 35| 22.3741' N--76| 28.6905' W at Willow Point; and~~
~~(4) Neuse River southwest of a line from a point 34| 58.2000' N--76| 40.5167' W at Winthrop Point on the eastern shore of the entrance to Adams Creek; running northerly to a point 35| 1.0744' N--76| 42.1550' W at Windmill Point at the entrance of Greens Creek at Oriental.~~

~~(d)~~ (c) Effective January 1, 201~~7~~8 it is unlawful to take shrimp with trawls that have a combined headrope of greater than 90 feet in Coastal Fishing Waters. ~~220 feet in Internal Coastal Waters in the following areas:~~

~~(1) Pamlico Sound south of the 35| 46.3000' N latitude line and north of a line beginning at a point 34| 59.7942' N--76| 14.6514' W on Camp Point; running easterly to a point 34| 58.7853' N--76| 9.8922' W on Core Banks;~~
~~(2) Pamlico River downstream of a line from a point 35| 18.5882' N--76| 28.9625' W at Pamlico Point; running northerly to a point 35| 22.3741' N--76| 28.6905' W at Willow Point; and~~
~~(3) Neuse River northeast of a line from a point 34| 58.2000' N--76| 40.5167' W at Winthrop Point on the eastern shore of the entrance to Adams Creek; running northerly to a point 35| 1.0744' N--76| 42.1550' W at Windmill Point at the entrance of Greens Creek at Oriental.~~

~~(e)~~ (d) It is unlawful to use a shrimp trawl in the areas described in 15A NCAC 3R .0114.

~~(f)~~ (e) It is unlawful to use channel nets except as provided in 15A NCAC 3J .0106.

~~(g)~~ (f) It is unlawful to use shrimp pots except as provided in 15A NCAC 3J .0301.

~~(h)~~ (g) It is unlawful to use a shrimp trawl that does not conform with the federal rule requirements for Turtle Excluder Devices (TED) as specified in 50 CFR Part 222.102 Definitions, 50 CFR Part 223.205 (a) and Part 223.206 (d) Gear Requirements for Trawlers, and 50 CFR Part 223.207 Approved TEDs. These federal rules are incorporated by reference including subsequent amendments and editions. Copies of these rules are available via the Code of Federal Regulations posted on the Internet at http://www.gpoaccess.gov/cfr/index.html and at the Division of Marine Fisheries, P.O. Box 769, Morehead City, North Carolina 28557 at no cost.

~~(i)~~ (h) It is unlawful to use a shrimp trawl without two (2) authorized North Carolina Division of Marine Fisheries bycatch reduction devices properly installed and operational in the cod end of each net in Coastal Fishing Waters.

15A N.C. Admin. Code 3N .0105: Prohibited Gear, Secondary Nursery Areas

(a) It is unlawful to use trawl nets for any purpose in any of the permanent secondary nursery areas designated in 15A NCAC 3R .0104.

(b) It is unlawful to use trawl nets for any purpose in any of the special secondary nursery areas designated in 15A NCAC 3R .0105(1)-(12), except that the Fisheries Director, may, by proclamation, open any or all of the special secondary nursery areas listed in 15A NCAC 3R .0105(1)-(12), or any portion thereof, ~~listed in 15A NCAC 3R .0105~~ to shrimp or crab trawling from August 16 through May 14 subject to the provisions of 15A NCAC 3L .0100 and .0200.

(c) It is unlawful to use trawl nets for any purpose in any of the special secondary nursery areas designated in 15A NCAC 3R .0105(13), except that the Fisheries Director, may, by proclamation, open any special secondary nursery areas listed in 15A NCAC 3R .0105(13), or any portion thereof, to shrimp or crab trawling, subject to the provisions of 15A NCAC 3L. 0100 and .0200 and the restrictions described below:

(1) Trawling may only occur during shrimp season;
(2) Trawling is restricted to a total of three days per week;
(3) Trawling is prohibited between sunset and sunrise; and
(4) Tow time may not exceed 45 minutes. Tow time begins when the doors of the trawl enter the water and ends when the doors exit the water.

15A N.C. Admin. Code 3I .0101: Definitions

All definitions set out in G.S. 113, Subchapter IV and the following additional terms apply to this Chapter:

(1) Enforcement and management terms:

(a) Commercial Quota. Total quantity of fish allocated for harvest by commercial fishing operations.

(b) Educational Institution. A college, university, or community college accredited by an accrediting agency recognized by the U.S. Department of Education; an Environmental Education Center certified by the N.C. Department of Environment and Natural Resources Office of Environmental Education and Public Affairs; or a zoo or aquarium certified by the Association of Zoos and Aquariums.

(c) Internal Coastal Waters or Internal Waters. All Coastal Fishing Waters except the Atlantic Ocean.

(d) Length of finfish.

i. Curved fork length. A length determined by measuring along a line tracing the contour of the body from the tip of the upper jaw to the middle of the fork in the caudal (tail) fin.
ii. Fork length. A length determined by measuring along a straight line the distance from the tip of the snout with the mouth closed to the middle of the fork in the caudal (tail) fin, except that fork length for billfish is measured from the tip of the lower jaw to the middle of the fork of the caudal (tail) fin.
iii. Pectoral fin curved fork length. A length of a beheaded fish from the dorsal insertion of the pectoral fin to the fork of the tail measured along the contour of the body in a line that runs along the top of the pectoral fin and the top of the caudal keel.
iv. Total length. A length determined by measuring along a straight line the distance from the tip of the snout with the mouth closed to the tip of the compressed caudal (tail) fin.

(e) Recreational Possession Limit. Restrictions on size, quantity, season, time period, area, means, and methods where take or possession is for a recreational purpose.

(f) Recreational Quota. Total quantity of fish allocated for harvest for a recreational purpose.

(g) Regular Closed Oyster Season. March 31 through October 15, unless amended by the Fisheries Director through proclamation authority.

(h) Scientific Institution. One of the following entities:

(i) An educational institution as defined in this Item;

i. A state or federal agency charged with the management of marine or estuarine resources; or
ii. A professional organization or secondary school working under the direction of, or in compliance with mandates from, the entities listed in Subitems (h)(i) and (ii) of this Item.
iii. Seed Oyster Management Area. An open harvest area that, by reason of poor growth characteristics, predation rates, overcrowding or other factors, experiences poor utilization of oyster populations for direct harvest and sale to licensed dealers and is designated by the Marine Fisheries Commission as a source of seed for public and private oyster culture.

(2) Fishing Activities:

(a) Aquaculture operation. An operation that produces artificially propagated stocks of marine or estuarine resources or obtains such stocks from permitted sources for the purpose of rearing in a controlled environment. A controlled environment provides and maintains throughout the rearing process one or more of the following:

i. food;
ii. predator protection;
iii. salinity
iv. temperature controls; or
v. water circulating, utilizing technology not found in the natural environment.

(b) Attended. Being in a vessel, in the water or on the shore, and immediately available to work the gear and be within 100 yards of any gear in use by that person at all times. Attended does not include being in a building or structure.

(c) Blue Crab Shedding. The process whereby a blue crab emerges soft from its former hard exoskeleton. A shedding operation is any operation that holds peeler crabs in a controlled environment. A controlled environment provides and maintains throughout the shedding process one or more of the following:

i. food;
ii. predator protection;
iii. salinity;
iv. temperature controls; or
v. water circulation, utilizing technology not found in the natural environment. A shedding operation does not include transporting pink or red-line peeler crabs to a permitted shedding operation.

(d) Depuration. Purification or the removal of adulteration from live oysters, clams, or mussels by any natural or artificially controlled means.

(e) Long Haul Operations. Fishing a seine towed between two vessels.

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

(g) Possess. Any actual or constructive holding whether under claim of ownership or not.

(h) Recreational Purpose. A fishing activity that is not a commercial fishing operation as defined in G.S. 113-168.

(i) Shellfish marketing from leases and franchises. The harvest of oysters, clams, scallops, or mussels from privately held shellfish bottoms and lawful sale of those shellfish to the public at large or to a licensed shellfish dealer.

(j) Shellfish planting effort on leases and franchises. The process of obtaining authorized cultch materials, seed shellfish, and polluted shellfish stocks and the placement of those materials on privately held shellfish bottoms for increased shellfish production.

(k) Shellfish production on leases and franchises:

i. The culture of oysters, clams, scallops, or mussels on shellfish leases and franchises from a sublegal harvest size to a marketable size.
ii. The transplanting (relay) of oysters, clams, scallops, or mussels from areas closed due to pollution to shellfish leases and franchises in open waters and the natural cleansing of those shellfish.

(l) Swipe Net Operations. Fishing a seine towed by one vessel.

(m) Transport. Ship, carry, or cause to be carried or moved by public or private carrier by land, sea, or air.

(n) Use. Employ, set, operate, or permit to be operated or employed.

(3) Gear:

(a) Bunt Net. The last encircling net of a long haul or swipe net operation constructed of small mesh webbing. The bunt net is used to form a pen or pound from which the catch is dipped or bailed.

(b) Channel Net. A net used to take shrimp that is anchored or attached to the bottom at both ends or with one end anchored or attached to the bottom and the other end attached to a vessel.

(c) Commercial Fishing Equipment or Gear. All fishing equipment used in Coastal Fishing Waters except:

i. Cast nets;
ii. Collapsible crab traps, a trap used for taking crabs with the largest open dimension no larger than 18 inches and that by design is collapsed at all times when in the water, except when it is being retrieved from or lowered to the bottom;
iii. Dip nets or scoops having a handle not more than eight feet in length and a hoop or frame to which the net is attached not exceeding 60 inches along the perimeter;
iv. Gigs or other pointed implements that are propelled by hand, whether or not the implement remains in the hand;
v. Hand operated rakes no more than 12 inches wide and weighing no more than six pounds and hand operated tongs;
vi. Hook-and-line and bait-and-line equipment other than multiple-hook or multiple-bait trotline;
vii. Landing nets used to assist in taking fish when the initial and primary method of taking is by the use of hook and line;
viii. Minnow traps when no more than two are in use;
ix. Seines less than 30 feet in length;

x. Spears, Hawaiian slings, or similar devices that propel pointed implements by mechanical means, including elastic tubing or bands, pressurized gas, or similar means.

(d) Corkline. The support structure a net is attached to that is nearest to the water surface when in use. Corkline length is measured from the outer most mesh knot at one end of the corkline following along the line to the outer most mesh knot at the opposite end of the corkline.

(e) Dredge. A device towed by engine power consisting of a frame, tooth bar or smooth bar, and catchbag used in the harvest of oysters, clams, crabs, scallops, or conchs.

(f) Fixed or stationary net. A net anchored or staked to the bottom, or some structure attached to the bottom, at both ends of the net.

(g) Fyke Net. An entrapment net supported by a series of internal or external hoops or frames, with one or more lead or leaders that guide fish to the net mouth. The net has one or more internal funnel-shaped openings with tapered ends directed inward from the mouth, through which fish enter the enclosure. The portion of the net designed to hold or trap fish is completely enclosed in mesh or webbing, except for the openings for fish passage into or out of the net (funnel area).

(h) Gill Net. A net set vertically in the water to capture fish by entanglement of the gills in its mesh as a result of net design, construction, mesh length, webbing diameter, or method in which it is used.

(i) Headrope. The support structure for the mesh or webbing of a trawl that is nearest to the water surface when in use. Headrope length is measured from the outer most mesh knot at one end of the headrope following along the line to the outer most mesh knot at the opposite end of the headrope.

(j) Hoop Net. An entrapment net supported by a series of internal or external hoops or frames. The net has one or more internal funnel-shaped openings with tapered ends directed inward from the mouth, through which fish enter the enclosure. The portion of the net designed to hold or trap the fish is completely enclosed in mesh or webbing, except for the openings for fish passage into or out of the net (funnel area).

(k) Lead. A mesh or webbing structure consisting of nylon, monofilament, plastic, wire, or similar material set vertically in the water and held in place by stakes or anchors to guide fish into an enclosure. Lead length is measured from the outer most end of the lead along the top or bottom line, whichever is longer, to the opposite end of the lead.

(l) Mechanical methods for clamming. Dredges, hydraulic clam dredges, stick rakes, and other rakes when towed by engine power, patent tongs, kicking with propellers or deflector plates with or without trawls, and any other method that utilizes mechanical means to harvest clams.

(m) Mechanical methods for oystering. Dredges, patent tongs, stick rakes, and other rakes when towed by engine power, and any other method that utilizes mechanical means to harvest oysters.

(n) Mesh Length. The distance from the inside of one knot to the outside of the opposite knot, when the net is stretched hand-tight in a manner that closes the mesh opening.

(o) Pound Net Set. A fish trap consisting of a holding pen, one or more enclosures, lead or leaders, and stakes or anchors used to support the trap. The holding pen, enclosures, and lead(s) are not conical, nor are they supported by hoops or frames.

(p) Purse Gill Nets. Any gill net used to encircle fish when the net is closed by the use of a purse line through rings located along the top or bottom line or elsewhere on such net.

(q) Seine. A net set vertically in the water and pulled by hand or power to capture fish by encirclement and confining fish within itself or against another net, the shore or bank as a result of net design, construction, mesh length, webbing diameter, or method in which it is used.

(4) Fish habitat areas. The estuarine and marine areas that support juvenile and adult populations of fish species, as well as forage species utilized in the food chain. Fish habitats as used in this definition, are vital for portions of the entire life cycle, including the early growth and development of fish species. Fish habitats in all Coastal Fishing Waters, as determined through marine and estuarine survey sampling, include:

(a) Anadromous fish nursery areas. Those areas in the riverine and estuarine systems utilized by post-larval and later juvenile anadromous fish.

(b) Anadromous fish spawning areas. Those areas where evidence of spawning of anadromous fish has been documented in Division sampling records through direct observation of spawning, capture of running ripe females, or capture of eggs or early larvae.

(c) Coral:

i. Fire corals and hydrocorals (Class Hydrozoa);
ii. Stony corals and black corals (Class Anthozoa, Subclass Scleractinia); or
iii. Octocorals; Gorgonian corals (Class Anthozoa, Subclass Octocorallia), which include sea fans (Gorgonia sp.), sea whips (Leptogorgia sp. and Lophogorgia sp.), and sea pansies (Renilla sp.).

(d) Intertidal Oyster Bed. A formation, regardless of size or shape, formed of shell and live oysters of varying density.

(e) Live rock. Living marine organisms or an assemblage thereof attached to a hard substrate, excluding mollusk shells, but including dead coral or rock. Living marine organisms associated with hard bottoms, banks, reefs, and live rock include:

i. Coralline algae (Division Rhodophyta);
ii. Acetabularia sp., mermaid's fan and cups (Udotea sp.), watercress (Halimeda sp.), green feather, green grape algae (Caulerpa sp.) (Division Chlorophyta);
iii. Sargassum sp., Dictyopteris sp., Zonaria sp. (Division Phaeophyta);
iv. Sponges (Phylum Porifera);

v. Hard and soft corals, sea anemones (Phylum Cnidaria), including fire corals (Class Hydrozoa), and Gorgonians, whip corals, sea pansies, anemones, Solengastrea (Class Anthozoa);
vi. Bryozoans (Phylum Bryozoa);
vii. Tube worms (Phylum Annelida), fan worms (Sabellidae), feather duster and Christmas treeworms (Serpulidae), and sand castle worms (Sabellaridae);
viii. Mussel banks (Phylum Mollusca: Gastropoda); and
ix. Acorn barnacles (Arthropoda: Crustacea: Semibalanus sp.).

(f) Nursery areas. Areas that for reasons such as food, cover, bottom type, salinity, temperature, and other factors, young finfish and crustaceans spend the major portion of their initial growing season. Primary nursery areas are those areas in the estuarine system where initial post-larval development takes place. These are areas where populations are uniformly early juveniles. Secondary nursery areas are those areas in the ocean and estuarine system where later juvenile development takes place. Populations are composed of developing sub-adults of similar size that have migrated from an upstream primary nursery area to the secondary nursery area located in the middle portion of the estuarine system.

(g) Shellfish producing habitats. Historic or existing areas that shellfish, such as clams, oysters, scallops, mussels, and whelks use to reproduce and survive because of such favorable conditions as bottom type, salinity, currents, cover, and cultch. Included are those shellfish producing areas closed to shellfish harvest due to pollution.

(h) Strategic Habitat Areas. Locations of individual fish habitats or systems of habitats that provide exceptional habitat functions or that are particularly at risk due to imminent threats, vulnerability, or rarity.

(i) Submerged aquatic vegetation (SAV) habitat. Submerged lands that:

i. are vegetated with one or more species of submerged aquatic vegetation including bushy pondweed or southern naiad (Najas guadalupensis), coontail (Ceratophyllum demersum), eelgrass (Zostera marina), horned pondweed (Zannichellia palustris), naiads (Najas spp.), redhead grass (Potamogeton perfoliatus), sago pondweed (Stuckenia pectinata, formerly Potamogeton pectinatus), shoalgrass (Halodule wrightii), slender pondweed (Potamogeton pusillus), water stargrass (Heteranthera dubia), water starwort (Callitriche heterophylla), waterweeds (Elodea spp.), widgeongrass (Ruppia maritima), and wild celery (Vallisneria americana). These areas may be identified by the presence of above-ground leaves, below-ground rhizomes, or reproductive structures associated with one or more SAV species and include the sediment within these areas; or
ii. have been vegetated by one or more of the species identified in Sub-item (4)(i)(i) of this Rule within the past 10 annual growing seasons and that meet the average physical requirements of water depth (six feet or less), average light availability (secchi depth of one foot or more), and limited wave exposure that characterize the environment suitable for growth of SAV. The past presence of SAV may be demonstrated by aerial photography, SAV survey, map, or other documentation. An extension of the past 10 annual growing seasons criteria may be considered when average environmental conditions are altered by drought, rainfall, or storm force winds.

This habitat occurs in both subtidal and intertidal zones and may occur in isolated patches or cover extensive areas. In defining SAV habitat, the Marine Fisheries Commission recognizes the Aquatic Weed Control Act of 1991 (G.S. 113A-220 et. seq.) and does not intend the submerged aquatic vegetation definition, or this Rule or Rules 3K .0304 and .0404, to apply to or conflict with the non-development control activities authorized by that Act.

(5) Licenses, permits, leases and franchises, and record keeping:

(a) Assignment. Temporary transferal to another person of privileges under a license for which assignment is permitted. The person assigning the license delegates the privileges permitted under the license to be exercised by the assignee, but retains the power to revoke the assignment at any time, and is still the responsible party for the license.

(b) Designee. Any person who is under the direct control of the permittee or who is employed by or under contract to the permittee for the purposes authorized by the permit.

(c) For Hire Vessel. As defined by G.S. 113-174, when the vessel is fishing in state waters or when the vessel originates from or returns to a North Carolina port.

(d) Holder. A person who has been lawfully issued in his or her name a license, permit, franchise, lease, or assignment.

(e) Land:

i. For commercial fishing operations, when fish reach the shore or a structure connected to the shore.
ii. For purposes of trip tickets, when fish reach a licensed seafood dealer, or where the fisherman is the dealer, when fish reach the shore or a structure connected to the shore.
iii. For recreational fishing operations, when fish are retained in possession by the fisherman.

(f) Licensee. Any person holding a valid license from the Department to take or deal in marine fisheries resources.

(g) Logbook. Paper forms provided by the Division and electronic data files generated from software provided by the Division for the reporting of fisheries statistics by persons engaged in commercial or recreational fishing or for-hire operators.

(h) Master. Captain of a vessel or one who commands and has control, authority, or power over a vessel.

(i) New fish dealer. Any fish dealer making application for a fish dealer license who did not possess a valid dealer license for the previous license year in that name. For purposes of license issuance, adding new categories to an existing fish dealers license does not constitute a new dealer.

(j) Office of the Division. Physical locations of the Division conducting license and permit transactions in Wilmington, Washington, Morehead City, Roanoke Island, and Elizabeth City, North Carolina. Other businesses or entities designated by the Secretary to issue Recreational Commercial Gear Licenses or Coastal Recreational Fishing Licenses are not considered Offices of the Division.

(k) Responsible party. Person who coordinates, supervises, or otherwise directs operations of a business entity, such as a corporate officer or executive level supervisor of business operations, and the person responsible for use of the issued license in compliance with applicable statutes and rules.

(l) Tournament Organizer. The person who coordinates, supervises, or otherwise directs a recreational fishing tournament and is the holder of the Recreational Fishing Tournament License.

(m) Transaction. Act of doing business such that fish are sold, offered for sale, exchanged, bartered, distributed, or landed.

(n) Transfer. Permanent transferal to another person of privileges under a license for which transfer is permitted. The person transferring the license retains no rights or interest under the license transferred.

(o) Trip Ticket. Paper forms provided by the Division and electronic data files generated from software provided by the Division for the reporting of fisheries statistics by licensed fish dealers.

15A N.C. Administrative Code 3M .0522: Spot (new section)

It is unlawful to possess spot less than 8 inches in total length.

15A N.C. Administrative Code 3M .0523: Atlantic croaker (new section)

It is unlawful to possess Atlantic croaker less than 10 inches in total length.

APPENDIX 2 Shrimp Count Conversions based on Species and Lengths

Length (inches)	Length (modal, mm)	Length (mm)	Count (heads-off)	Count (heads-on) Brown and Pink[1]	Count (heads-on) White[2]
3	75	70–79	160+	99+	100+
3.38	85	80–89	136–140	85–90	90–95
3.75	95	90–99	96–100	61–65	61–65
4.13	105	100–109	66–70	41–45	41–45
4.5	115	110–119	51–55	31–35	31–35
5	125	120–129	41–45	26–30	26–30
5.25	135	130–139	31–35	16–20	21–25
5.75	145	140–149	26–30	16–20	16–20
6.13	155	150–159	21–25	0–15	0–15
6.5	165	160–169	16–20	0–15	0–15

[1]Heads-off conversion to heads-on conversion for brown shrimp is 1.61 and pink shrimp is 1.60 heads-off. Using the same count for both.
[2]Heads-off conversion to heads-on conversion for white shrimp is 1.54.

APPENDIX 3 Economic Impact Projections

Nesslage and Dumas (2017) estimated stock abundance and the economic impacts for commercial and recreational fishing by species over a 30-year projection period (i.e., 2017 to 2046). Several scenarios analyzed varying levels of commercial and recreational fishing mortality to see how abundance and economic impacts changed over time. Species analyzed that are affected by the Petitioned rules include Atlantic Croaker and Weakfish. See section 5.1 for information on how stock abundance responded to each model scenario.

Currently, it is not possible to recreate the producer and consumer surplus numbers or the economic impact results presented by Nesslage and Dumas (2017) because the stock projection-harvest relationship from year to year was not provided in the report. However, the overall trend in the results presented by the authors show how economic impacts in each fishing sector could potentially change if mortality (both fishing and natural mortality) on the species was to change.

A3.1 Atlantic Croaker

Producer surplus (i.e., revenue minus cost from landings) and economic impacts (i.e., sales, income, jobs) were estimated by Nesslage and Dumas (2017) using seven different scenarios presented alongside a status quo scenario that vary commercial fishing mortality, recreational fishing mortality, scrap/baitfish mortality, recreational discard mortality, shrimp trawl bycatch, natural mortality, and recruitment (Nesslage and Dumas 2017). It should be noted that the model used by the authors to produce stock projections for each scenario was the same stock assessment model used by ASMFC for the 2010 Atlantic Croaker stock assessment (ASMFC 2010b), where estimates of SSB were considered too uncertain to be used to determine stock status. This overall uncertainty largely stemmed from the high degree of uncertainty associated with the estimates of shrimp trawl bycatch.

Scenario 1 was status quo, assuming stock conditions were equivalent to those in 2008 (Nesslage and Dumas 2017). Scenarios 2–5 reduced commercial fishing mortality, recreational fishing mortality, scrap/baitfish mortality, and recreational discard mortality by 10%, 25%, 50%, and 100%, respectively while holding shrimp trawling bycatch at 2008 levels. Scenario 6 was status quo with all mortality parameters, but doubled the current amount of bycatch estimated. Scenario 7 and 8 kept commercial fishing mortality, recreational fishing mortality, scrap/baitfish mortality, and recreational discard mortality at current estimates, but Scenario 7 had no bycatch beyond 2017, with 2016 exhibiting normal bycatch estimates, and Scenario 8 has no bycatch beyond 2017, with 2016 having double the estimated bycatch estimates.

Data used in the economic impact models of Nesslage and Dumas (2017) for the 30-year projections are annual landings and value for Atlantic Croaker and appear to be from the NCDMF License and Statistics Section Annual Statistics Report. There are two issues with using this resolution of data. The economic projections were made from source data by species across all gear types combined. As noted in a more detailed review of the authors' analysis below, this can lead to issues when calculating true total value of the fishery and the model that generates the ex-vessel price relationship. Secondly, the source data also includes all waterbodies, while the analysis seems to be intended for estuarine waters only.

A3.1.1 Commercial Impacts

In Nesslage and Dumas (2017), the authors calculated average nominal dockside (ex-vessel) prices for Atlantic Croaker in North Carolina for each year 1994-2014 by dividing nominal dollar value of landings in North Carolina by pounds landed in North Carolina for each year. This may be an overly simplified way of specifying the average ex-vessel price for annual data coming from the NCTTP. Value data within the NCTTP are calculated by multiplying landings by an average ex-vessel price per market grade for each species. Therefore, if a market grade sold at a specific price (whether high or low) was the majority of the catch then the simple division of total value by total landings could primarily represent that market grade and not represent the actual average price across all market grades. In 2016, average prices for Atlantic Croaker by market grade ranged from $0.68/pound to $1.47/pound. A closer estimation of average price can be calculated by using data received from electronic trip tickets, when available, and then filling in missing prices per trip with the average annual price per market grade. Electronic data are available since 2004 and provide prices at the species and market grade level for each trip for some species such as Atlantic Croaker. This provides a value for the whole trip and facilitates a regression analysis at the trip level. Prices are missing on a large percentage of trip tickets because price is not a mandatory reporting requirement; therefore, average prices calculated using this method should still be considered an estimate, but are of a finer resolution than that used by Nesslage and Dumas.

In 2016, 99% of Atlantic Croaker landings came from ocean waters. If the economic impact analysis conducted by Nesslage and Dumas (2017) was intended to be limited to estuarine waters (sound and estuaries) then the data used might result in the analysis suffering from misspecification. This issue is raised due to the following statement describing operating behavior of fishermen only in sounds: “It is assumed that the operating costs of vessels landing croaker in North Carolina sounds are similar to the operating costs of average-length gill net / crab pot vessels operating in Albemarle and Pamlico sounds” (Nesslage and Dumas 2017).

Another assumption in the Nesslage and Dumas (2017) analysis with regards to Atlantic Croaker is that the number of vessels using gill net gear operating in 2014 was 1,340 vessels that took 26,228 trips; this may not be correct. These numbers represent statewide aggregations and include all ocean vessels and trips that recorded landings from anchored gill nets, regardless of species. In 2016, the number of gill net vessels landing Atlantic Croaker from estuarine waters was only 313 and the number of trips was only 1,845. Nesslage and Dumas (2017) assumed that captain and crew is equal to the number of participants, which is an incorrect assumption because the data used for participant count is equal to the number of licensed fishermen who recorded commercial landings. It is not an accurate reflection of the count for captain and crew. In 2016, only 309 participants recorded landings of Atlantic Croaker from gill nets in estuarine waters. The average crew size from these same estuarine trips was 1.3. Because the size of the vessel will determine the amount of crew, a closer measure of the total captain and crew count would be to multiply the average crew size by the number of vessels (1.3*313). This is equal to 407 people, but still less than half of the number used by Nesslage and Dumas (2017) in their analysis, which was 1,214 participants.

Nesslage and Dumas (2017) assumed the average size of a vessel used in the estuarine gill net fishery to be approximately 25 feet and the maximum carrying capacity of a vessel of that size is 2,500 pounds. This information is reported to originate from a personal communication with O’Neal’s Seafood Harvest, a large North Carolina dealer. In 2016, there were 305 vessels 25 feet or less and 12 vessels from 26 to 49 feet in length that reported landings of Atlantic Croaker from estuarine waters using gill nets. These vessels (from both size ranges) averaged about 10 pounds of Atlantic Croaker per trip. The maximum amount of Atlantic Croaker caught per trip from gill nets in estuarine waters was 358 pounds in vessels of 25 feet or less, and 265 pounds in vessels between 26 and 49 feet. This shows that Atlantic Croaker is not a commonly targeted fish for these gill net vessels and that no estuarine vessel would approach landing 2,500 pounds. Average annual Atlantic Croaker landings in 2016 of vessels that were 25 feet or less was 50 pounds and the maximum was 1,430 pounds. For vessels from 26 to 49 feet, the annual average landings of Atlantic Croaker was 114 pounds with the maximum amount of landings at 918 pounds.

Another major assumption by the authors is that if Atlantic Croakers landings increase, the economic model determines whether the existing number of vessels and trips can accommodate the increased landings. If landings exceed the capacity of the existing trips, then each existing vessel is assumed to increase its number of trips to 24.5 trips per vessel per year, the maximum annual average number of observed trips per vessel for 25'–35' gill net vessels over the period 1994–2014 (Nesslage and Dumas 2017). If increased landings do not exceed the capacity of the existing vessels and trips, then an increase in landings also increases ex-vessel value, producer surplus, and downstream economic impacts, but it does not increase upstream impacts, which depend on the number of vessels, trips, and crew, which do not change in this case. Again, it is doubtful that landings can reach the capacity stated previously by each vessel per trip.

The authors also assume, through Hadley and Crosson (2010), that 25.75% of finfish sold by North Carolina seafood dealers was sold to out-of-state buyers; therefore, they assumed 74.25% of Atlantic Croaker from North Carolina dealers is sold to in-state buyers (Nesslage and Dumas 2017). When calculating producer surplus and the economic impacts that commercial Atlantic Croaker harvest has on the North Carolina economy, Nesslage and Dumas (2017) excluded exports of Atlantic Croaker from their analysis. This assumption reduces the total value of economic impacts for Atlantic Croaker by a quarter for the 30-year projection period. Exported seafood still creates value for in-state dealers; however, the effects of seafood harvested in North Carolina and then exported are not traceable through the supply chain beyond the state’s dealers.

The authors assume that in multispecies fisheries, such as the Atlantic Croaker gill net fishery, a fishing trip is made and operating costs are incurred, even if no croaker are caught, because the (expected) revenues from landings of other species cover the variable costs of the trip (Nesslage and Dumas 2017). As a result, if Atlantic Croaker are caught, the authors assume trip revenues increase without an increase in trip operating costs. If croaker landings can be accommodated with no change in the number of vessels or vessel trips, then the ex-vessel revenue from Atlantic Croaker landings flows directly to producer surplus. If Atlantic Croaker landings decrease, they assume vessels remain in the fishery and the number of trips does not change because gill nets catch species other than Atlantic Croaker and other gear can be used on these same vessels to catch other target species (Nesslage and Dumas 2017). These assumptions may not reflect the actual behavior of gill net vessels depending on how much they rely on Atlantic Croaker to pay for their fishing trips. Directed Atlantic Croaker gill net trips usually land a majority of Atlantic Croaker with minimal marketable bycatch, which is inconsistent with the assumption above (NCDMF unpublished data, Program 434 Ocean Gill Net Fishery). Therefore, it may be incorrect to assume that on an Atlantic Croaker gill net trip, if no Atlantic Croaker are landed, that fishermen would be able to cover the variable cost of a trip. In fact, fishermen may incur costs they cannot recoup if no fish are caught during the trip.

As expected, reductions in fishing-related mortality (Scenarios 2–5) reduced the overall producer surplus and economic impacts associated with the commercial Atlantic Croaker fishery. Scenario 6 (shrimp trawl bycatch mortality was doubled, but all other fishing mortalities remained the same) also resulted in reductions to the overall producer surplus and economic impacts. Removing shrimp trawl bycatch completely (Scenario 7 and 8) resulted in increasing producer surplus and economic impacts over the 30-year period. These increases are related to expected increases in stock abundance. Scenario 1 was status quo. The scenarios examined by Nesslage and Dumas (2017) cannot be directly compared to the Petitioned rules, as many of these scenarios reduce commercial and recreational fishing (therefore, reducing fishing mortality) in equal amounts. Most of the Petitioned rules would greatly impact directed fishing mortality from commercial fishing, while directed recreational fishing mortality would remain unchanged except for the addition of size limits proposed for Spot and Atlantic Croaker; however, the proposed size limits would affect both commercial and recreational fisheries. The scenarios that removed shrimp trawl bycatch kept all other fishing mortality levels at status quo, which again is not comparable to the Petitioned rules. It is unclear whether potential benefits from the Petitioned rules would outweigh the costs over time to result in net positive results for North Carolina commercial fishing as a whole.

A3.1.2 Recreational Impacts

The economic analysis by Nesslage and Dumas (2017) estimates the consumer surplus (i.e., recreational value of catching a fish) of recreational anglers participating in the Atlantic Croaker recreational fishery and the economic impacts (i.e., sales, income, jobs) supported by the recreational fishing activity. Estimates of consumer surplus per Atlantic Croaker caught by recreational anglers along the U.S. Atlantic Coast were presented as an average across two data sources. Estimates for the value per fish were calculated through two methods in these sources, including travel cost estimation and a random utility model valuation. The economic impacts of the recreational Atlantic Croaker fishery were calculated for four fishing modes: 1) beach or bank, 2) man-made locations (e.g., pier, dock), 3) charter or headboats, and 4) privately-owned or rented vessels (Nesslage and Dumas 2017). This analysis assumed that bag limits remain fixed, so increased catch translates to an increase in the number of recreational trips. More information on how expenditures and impacts for the recreational fishery were calculated by the authors can be found in their report.

Except for Scenario 1 (Status quo), the scenarios varied commercial fishing mortality, recreational fishing mortality, natural mortality, scrap/bait mortality, and shrimp trawl bycatch. Similar to the commercial fishery for Atlantic Croaker, scenarios that reduced fishing mortality (Scenarios 2–5) resulted in losses to consumer surplus and economic impacts from recreational fishing, as did Scenario 6 (doubling shrimp trawl bycatch; Nesslage and Dumas 2017). Scenarios 7 and 8 that removed shrimp trawl bycatch completely resulted in increases in consumer surplus and economic impacts related to the recreational fishing industry. These increases are related to expected increases in stock abundance.

The projections showed that reducing shrimp trawl bycatch may have a greater effect on consumer surplus, economic impacts, and angler expenditures than if only fishing mortality is reduced. These results cannot be directly compared to the Petitioned rules as these scenarios reduce commercial and recreational fishing in equal amounts. As mentioned in the previous section, most of the Petitioned rules would greatly impact directed fishing mortality from commercial fishing, while directed recreational fishing mortality would remain unchanged except for the addition of size limits proposed for Spot and Atlantic Croaker; however, the proposed size limits would affect both commercial and recreational fisheries.

A3.2 Weakfish

Producer surplus (i.e., revenue minus cost from landings) and economic impacts (i.e., sales, income, jobs) were estimated by Nesslage and Dumas (2017) using eight different scenarios presented alongside a status quo scenario that vary commercial fishing mortality, recreational fishing mortality, natural mortality, and recruitment. Scenario 1 was status quo based on the 2014 Weakfish stock assessment completed by the ASMFC. Scenario 2 assumed a complete moratorium on Weakfish starting in 2017; therefore, fishing mortality, both commercial and recreational, would be zero. Scenario 3 assumed status quo for commercial and recreational fishing levels, but used a reduced estimate for natural morality. Scenarios 4–7 reduced commercial fishing mortality and recreational fishing mortality by 10%, 25%, 50%, and 100%, respectively while using the reduced estimate for natural mortality. Scenarios 8 and 9 used a low estimate of natural mortality equal to the natural mortality estimated prior to 1995; however, Scenario 8 used status quo for commercial and recreational fishing, while Scenario 9 used a 50% reduction in both fishing sectors.

Data used in the economic impact models of Nesslage and Dumas (2017) for the 30-year projections are annual landings and value for Weakfish and appear to be from the NCDMF License and Statistics Section Annual Statistics Report. There are two issues with using this resolution of data. The economic projections were made from source data by species across all gear types combined. As noted in a more detailed review of the authors' analysis below, this can lead to issues when calculating true total value of the fishery and the model that generates the ex-vessel price relationship. Secondly, the source data also includes all waterbodies, while the analysis seems to be intended for estuarine waters only.

A3.2.1 Commercial Impacts

As with Atlantic Croaker, the authors calculated average nominal dockside (ex-vessel) prices for Weakfish in North Carolina for each year 1994–2014 by dividing nominal dollar value landed by pounds landed for each year (Nesslage and Dumas 2017). As stated previously, this may be an overly simplified way of specifying the average ex-vessel price for annual data coming from the NCTTP. Value data within the NCTTP are calculated by multiplying landings by an average ex-vessel price per market grade for each species. Therefore, if a market grade sold at a specific price (whether high or low) was the majority of the catch then the simple division of total value by total landings could primarily represent that market grade and not represent the actual average price across all market grades. In 2016, average prices for Weakfish by market grade ranged from $1.17/pound to $1.96/pound. A closer estimation of average price can be calculated by using data received from electronic trip tickets, when available, and then filling in missing prices per trip with the average annual price per market grade. Electronic data are available since 2004 and provide prices at the species and market grade level for each trip for some species such as Atlantic Croaker. This provides a value for the whole trip and facilitates a regression analysis at the trip level. Prices are missing on a large percentage of trip tickets because price is not a mandatory reporting requirement; therefore, average prices calculated using this method should still be considered an estimate.

Although a larger proportion of the landings of Weakfish come from estuarine waters, Weakfish are commonly landed in ocean waters. In 2016, 54% of the landings were from estuarine waters. If the intention of the analysis performed by Nesslage and Dumas (2017) for economic impacts was intended to be limited to estuarine (sound and estuaries) waters, then the data used might result in the analysis suffering from misspecification, as the landings data used in the projections were statewide (which include ocean landings). This issue is raised due to the following statement describing operating behavior of fishermen only in sounds: "It is assumed that the operating costs of vessels landing Weakfish in North Carolina sounds are similar to the operating costs of average-length gill net / crab pot vessels operating in Albemarle and Pamlico sounds" (Nesslage and Dumas 2017).

The authors' assumption of the number of vessels using gill net gear operating in 2014 is not accurate with regards to Weakfish and is a large over-estimate of the fleet. In Nesslage and Dumas (2017), it is reported that 1,340 vessels took 26,228 trips using gill nets; however, these numbers represent statewide aggregations and include all ocean vessels and trips that recorded landings from anchored gill nets, regardless of species. In 2016, the number of gill net vessels landing Weakfish from estuarine waters was only 305 and the number of trips was only 2,458. The authors' analysis also assumes that the number of participants is equal to the captain and crew; however, the number of participants from the data source is the number of licensed fishermen who recorded commercial landings using gill nets. It is not an accurate reflection of the count for captain and crew. The authors assume that the number of participants would be constant through 2017 at 1,214. In 2016, only 291 participants had landings of Weakfish from gill nets in estuarine waters. The average crew size from those same trips was 1.4. Because the size of the vessel will determine the amount of crew, a closer measure of the total captain and crew count would be to multiply the average crew size by the number of vessels (1.4*305). This is equal to 427 people, but still less than half of the 1,214 participants used by Nesslage and Dumas (2017).

Another assumption made by the authors is that the size of the vessel used in the estuarine fishery is approximately 25 feet and that the maximum carrying capacity of a vessel of that size is 2,500 pounds. This information is reported to originate from a personal communication with O'Neal's Seafood Harvest, a large North Carolina dealer. In 2016, 291 vessels 25 feet or less and 27 vessels from 26 to 49 feet reported landings of Weakfish from estuarine waters using gill nets. Both vessel size ranges averaged about 14–16 pounds of Weakfish per trip. The maximum amount of Weakfish caught per trip from gill nets in estuarine waters was 152 pounds in vessels of 25 feet or less, and 100 pounds in vessels from 26 to 49 feet. This shows that Weakfish is not a commonly targeted fish for these gill net vessels, and that no estuarine vessel would approach landing 2,500 pounds. There are also trip limits currently set at 100 pounds, so for this analysis, the maximum carrying capacity should have been 100 pounds.

Another major assumption by the authors is that if Weakfish landings increase, the economic model determines whether the existing number of vessels and trips can accommodate the increased landings. If landings exceed the capacity of the existing trips, then each existing vessel is assumed to increase its number of trips to 24.5 trips per vessel per year, the maximum annual average number of observed trips per vessel for 25'–35' gill net vessels over the period 1994–2014 (Nesslage and Dumas 2017). If increased landings do not exceed the capacity of the existing vessels and trips, then an increase in landings also increases ex-vessel value, producer surplus, and downstream economic impacts, but it does not increase upstream impacts, which depend on the number of vessels, trips, and crew, which do not change in this case. Again, it is doubtful that landings can reach the capacity stated previously by each vessel per trip, especially given current harvest restrictions.

The authors also assume, through Hadley and Crosson (2010), that 25.75% of finfish sold by North Carolina seafood dealers was sold to out-of-state buyers; therefore, they assumed 74.25% of Weakfish from North Carolina dealers is sold to in-state buyers (Nesslage and Dumas 2017). When calculating producer surplus and the economic impacts that commercial Weakfish harvest has on the North Carolina economy, Nesslage and Dumas (2017) excluded exports of Weakfish from their analysis. This assumption reduces the total value of economic impacts for Weakfish by a quarter for the 30-year projection period. Exported seafood still creates value for in-state dealers; however, the effects of seafood harvested in North Carolina and then exported are not traceable through the supply chain beyond the state's dealers.

The authors also assume that in multispecies fisheries, such as the Weakfish gill net fishery, a fishing trip is made and operating costs are incurred, even if no Weakfish are caught, because the (expected) revenues from landings of other species cover the variable costs of the trip (Nesslage and Dumas 2017). As a result, if Weakfish are caught, trip revenues increase without an increase in trip operating costs. If Weakfish landings can be accommodated with no change in the number of vessels or vessel trips, then the ex-vessel revenue from Weakfish landings flows directly to producer surplus. This assumption makes sense because Weakfish is managed commercially as a bycatch fishery. If Weakfish landings decrease, it is assumed that vessels remain in the fishery and the number of trips does not change because gill nets catch species other than Weakfish and other gear can be used on the same vessels to catch other target species (Nesslage and Dumas 2017). These assumptions may not reflect the actual behavior of gill net vessels depending on how much they rely on Weakfish to pay for their fishing trips. In 2016, the ex-vessel price of Weakfish was between $1.16 and $1.96 per pound depending on market grade size, so even a small amount of catch can add a lot of value to a single fishing trip where Weakfish were harvested.

When looking at the data across the different model scenarios, Scenarios 2 and 7 removed all fishing mortality and thus, resulted in losses to producer surplus and economic impacts in the commercial fishing industry. Scenarios 3–6 progressively resulted in increases to producer surplus and economic impacts related to increases in stock abundance as fishing mortality decreased. Finally, Scenarios 8 and 9 assumed a 0.15 natural mortality rate (i.e., historically low rate occurring prior to 1995) and Scenario 9 also had a

50% reduction in all fishing mortality. Again, as a result of increased Weakfish stock abundance, these models resulted in a large positive impact to commercial fishing. Lowering the mortality rates means that more fish are surviving and available to the fishery. The natural mortality rate used in Scenarios 3–9 do not currently exist in nature; therefore, any positive impacts from these Scenarios cannot be expected under existing stock conditions. Scenario 1 was status quo.

The results from Nesslage and Dumas (2017) cannot be directly compared to the Petitioned rules as these scenarios reduce commercial and recreational fishing in equal amounts. The Petitioned rules affecting Weakfish focus on shrimp trawl bycatch reduction, which was not analyzed by Nesslage and Dumas (2017) specific to Weakfish and would only reduce commercial fishing levels. Recreational fishing effort would remain the same for Weakfish under the Petitioned rules. It is unclear whether potential benefits from the Petitioned rules would outweigh the costs over time to result in net positive results for the North Carolina commercial fishing industry.

A2.2.2 Recreational Impacts

The economic analysis performed by Nesslage and Dumas (2017) estimates the consumer surplus (i.e., recreational value of catching a fish) of recreational anglers participating in the Weakfish recreational fishery and the economic impacts (i.e., sales, income, jobs) supported by the recreational fishing activity. Estimates of consumer surplus per Weakfish caught by recreational anglers along the U.S. Atlantic Coast were presented as an average across two data sources through two methods in these sources, including travel cost estimation and a random utility model valuation. The economic impacts of the recreational Weakfish fishery were calculated for four fishing modes: 1) beach or bank, 2) man-made locations (e.g., pier, dock), 3) charter or headboats, and 4) privately-owned or rented vessels (Nesslage and Dumas 2017). This analysis assumed that bag limits remain fixed, so increased catch translates to an increase in the number of recreational trips. More information on how expenditures and impacts for the recreational fishery were calculated by the authors can be found in their report.

For the consumer surplus, angler expenditures, and economic impacts results, eight different scenarios were presented alongside a status quo scenario (Scenario 1) that varied commercial fishing mortality, recreational fishing mortality, natural mortality, and recruitment. Scenarios 2 and 7 removed all fishing mortality, consequently resulting in losses to consumer surplus and economic impacts in the recreational fishing industry. Scenarios 3–6 assumed average natural mortality conditions (but lower than current levels) and varied fishing mortality at levels from status quo to 50% for both commercial and recreational fisheries. Scenarios 3–6 had progressive increases in consumer surplus, angler expenditures, and economic impact values from an expected increase in stock abundance as fishing mortality decreased. The reduction in natural mortality assumed by the model likely played a bigger role than fishing mortality in the increase in stock abundance since scenarios without a reduction in natural mortality had little effect on stock size. Scenarios 8 and 9 assumed a 0.15 natural mortality rate (i.e., historically low rate occurring prior to 1995) and Scenario 9 also had a 50% reduction in all fishing mortality. These models resulted in large positive economic impacts to the recreational fishing industry. As mentioned with the commercial industry, the natural mortality rate used in Scenarios 3–9 do not currently exist in nature; therefore, any positive impacts from these scenarios cannot be expected under existing stock conditions.

These results cannot be directly compared to the Petitioned rules as the scenarios reduce commercial and recreational fishing in equal amounts. The Petitioned rules affecting Weakfish focus on shrimp trawl bycatch reduction, which was not analyzed by Nesslage and Dumas (2017) specific to Weakfish and would only reduce commercial fishing levels. Recreational fishing effort would remain the same for Weakfish under the Petitioned rules.

APPENDIX 4 Monitoring for Habitat Improvements

One goal of the Petitioned rules is an improvement of the habitat in the proposed SSNAs once trawling is reduced, which would be more utilized by fish species than current habitat existing in the estuaries and ocean off North Carolina. A BACI (Before-After; Control-Impact) monitoring design is the preferred method to evaluate human disturbances (e.g., reduced trawling effort) on ecological conditions. Without data in the same area before and after a treatment and at a control site, it would be difficult to determine if the observed water quality and soft bottom characteristics are due to less or no trawling, or due to other environmental or anthropogenic factors. Unfortunately, the NCDMF does not have before data on the relevant water quality and habitat conditions in Pamlico Sound. Also, all areas not previously designated as nursery areas would be affected, so there would be no control area. Sampling would have to be completed prior to implementation of the Petitioned rules and repeated after management changes were in place for at least one year.

Study Objectives

A study to determine habitat changes due to the Petitioned rules would have the following objectives.

1. Compare soft bottom topography before and after Petition implementation to determine if soft bottom microstructure changes.
2. Compare changes in soft bottom community (e.g., infauna, epifauna, benthic primary productivity) before and after Petition implementation to determine change in abundance or diversity of benthic fauna and flora.
3. Assess turbidity and nutrient conditions in the water column before and after Petition implementation to assess changes in water clarity and nutrient concentrations in the water column.
4. Compare changes in oyster reef and SAV habitat before and after Petition implementation.

Monitoring

Because the greatest impact from trawling would be in deeper waters less influenced by wind and where trawling is most concentrated, monitoring should focus in Pamlico Sound, the lower Pamlico and Neuse rivers, and Core Sound. Pamlico Sound is approximately 5,200 km^2. To make monitoring more logistically feasible, several sentinel sites should be selected within different Pamlico Sound Survey (Program 195) strata as well as Core Sound (Table A4.1; Figure A4.1). Trawling areas further south are smaller in area and would not be monitored. The weighting of sites per strata follows the area-based weighting ratio used in the Pamlico Sound Survey. The exact location of sites would be determined later. Size and number of sentinel sites may need to be adjusted for logistical reasons.

Table A4.1. Proposed sampling grids for monitoring in the Pamlico Sound system.

Strata	Dimensions of Sentinel Sites (km)	Area of Sentinel Sites (km^2)	Number of Sites
Pamlico Deep East	10x10	100	8
Pamlico Deep West	10x10	100	4
Pamlico Shallow East	10x10	100	2
Pamlico Shallow West	10x10	100	2
Pamlico River	10x10	100	2
Neuse River	10x10	100	2
Core Sound	10x10	100	2
Total Sampled			22

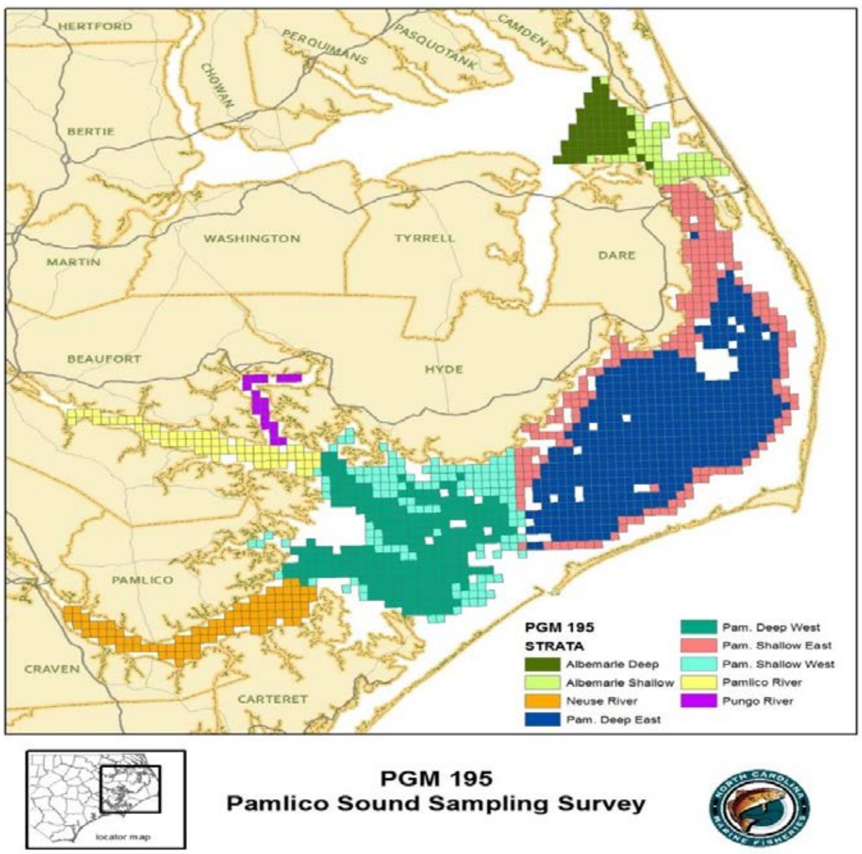

Figure A4.1. Location of strata used in the Pamlico Sound Survey.

Sediment and Water Quality Data

Within each of the 22 sampling grids (Table A4.1), approximately three random sediment cores would be collected quarterly. Sample collection could be done by temporary staff and an existing NCDMF vessel. Analysis would need to be completed by a contractor. Sediment and water quality sampling could be conducted during the same time periods as the mapping work described below. Cores would be used to quantify benthic microalgae, meiofauna, macrofauna, grain size, and possibly sedimentation rates. Random water samples would be analyzed for nutrient levels, chlorophyll a, turbidity, and total suspended sediments. Resources needed to collect and analyze water and sediment samples for two years include:

Option A

2 temporary Technician IIs - 2 year	$129,150
Funds to hire contractor for analysis	$190,000
Total	$319,150

Option B

Collection and analysis completed by contractor: $320,000–$380,000

Mapping Topography of Soft Bottom Habitat

The NCDMF Habitat and Enhancement Section can use existing side scan equipment (Edge Tech 6205 Dual Side Scan Sonar and Swath Bathymetry – 550 and 1600 kHz) and software (Sonar Wiz) to map bottom topography within each sampling grid two times (one time before the Petitioned rule changes would go into effect, and one after). The accuracy of the side scan is +/- 10 cm. Initial costs for a side scan sonar (including the hardware, vessel, computer, and insurance) add up to over $205,000, so purchase of a second unit is prohibitive. A pilot test should be conducted to determine if this accuracy will be satisfactory for detecting sediment profile changes. Mapping is estimated to take 5.5 hr/km^2. One grid in each of the six strata in Pamlico Sound and the Pamlico and Neuse rivers, as well as Core Sound should be selected to map before and after the management change would go in effect. Grids with relatively intense trawling activity should be selected. Seven grids that are 100 km^2 each (700 km^2) would take approximately 642 days, or 2.5 years, to map (estimating six hours/day of mapping). Since side scan would be done before and after the management change, this would need to be repeated after the management change would occur. Total mapping time needed for soft bottom habitat would be five years. In addition, side scan and bathymetry data would need to be post-processed, which is estimated to take 1–2 days for every day of field mapping. The biologist would be responsible for field planning and post-processing. Resources needed to map the seven sampling grids two times include:

2 temporary Technician IIs – 5 years	$322,876
1 temporary Biologist I – 5 years	$214,750
Total	$537,626

Changes to Oyster Reef and SAV Abundance

Effects of reduced trawling activity on oyster reefs and SAV could be assessed by mapping around the perimeter of the sounds before and after the management change occurs. Mapping of subtidal oyster reefs in Pamlico Sound could be done with the same side scan system described above, but not concurrently with the soft bottom mapping. The aerial limit of the mapping would need to be determined through GIS assessment, but could be restricted to the area where oyster reef habitat is generally distributed (Figure A4.2). Potential oyster habitat within the Pamlico Sound system that should be mapped is roughly 1,600 km^2. An area of that size would take approximately six years to complete. Total mapping time needed for oyster reefs and SAV would be 12 years. In addition to mapping, it would be valuable to monitor oyster size and density on a subset of sites, as well as sedimentation. This could possibly be integrated into existing oyster sanctuary monitoring. Resources needed include:

2 temporary Technician IIs – 6 years	$774,900
1 temporary Biologist I – 6 years	$515,400
Total	$1,290,300

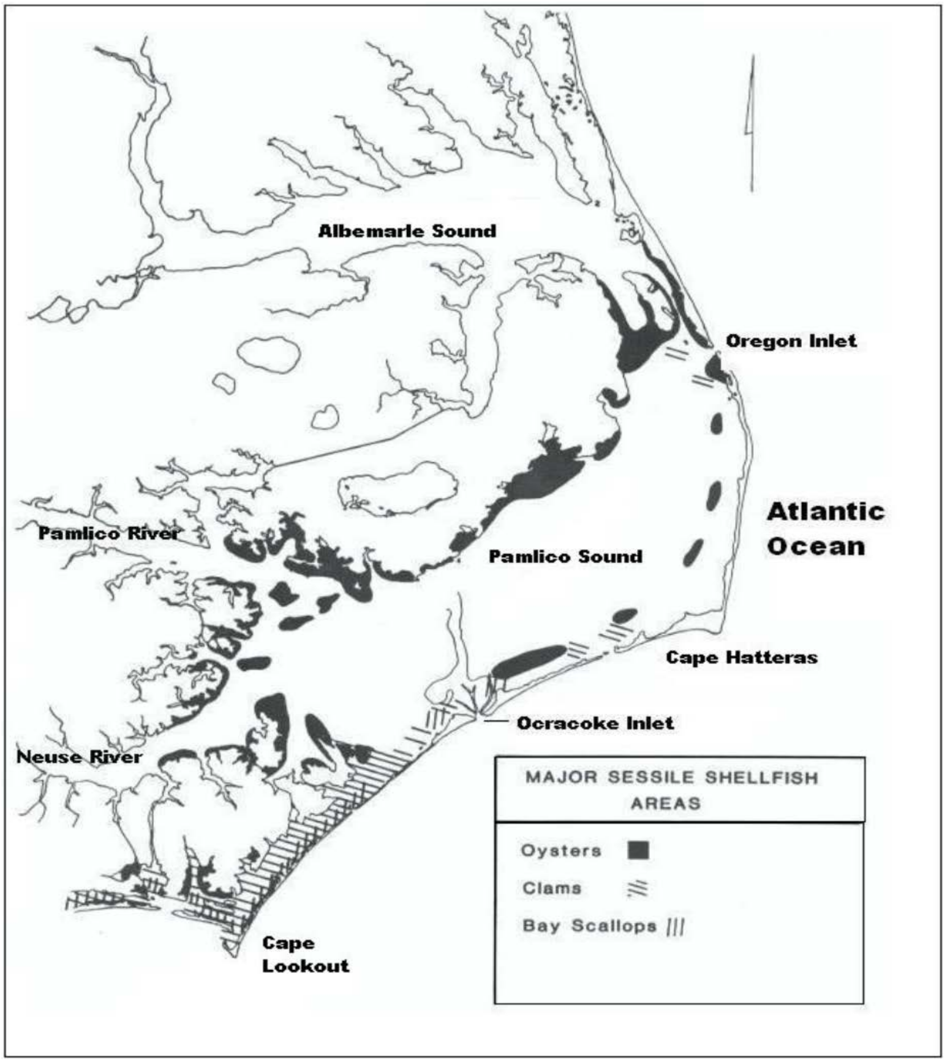

Figure A4.2. Location of area to map for SAV and oyster reefs based on the general distribution of eastern oysters, hard clams, and bay scallops in the Albemarle-Pamlico estuarine system (Epperly and Ross 1986).

Maps of SAV from aerial imagery in the Pamlico and Core sounds is available from 2013 (Figure A4.3). SAV maps in Pamlico and Neuse rivers from sonar data is available from 2016 and 2017 (Figure A4.3). New mapping data could be limited to post-Petition change and compared to these existing datasets. Aerial imagery and sonar data and delineation could be completed by a contractor. Based on previous work, a rough estimate for doing this one time would include the following costs:

Aerial imagery and digitized maps	$ 200,000
Sonar data and digitized maps	$ 130,000
Subtotal (one time)	$ 330,000
Total (two times; before and after)	$ 660,000

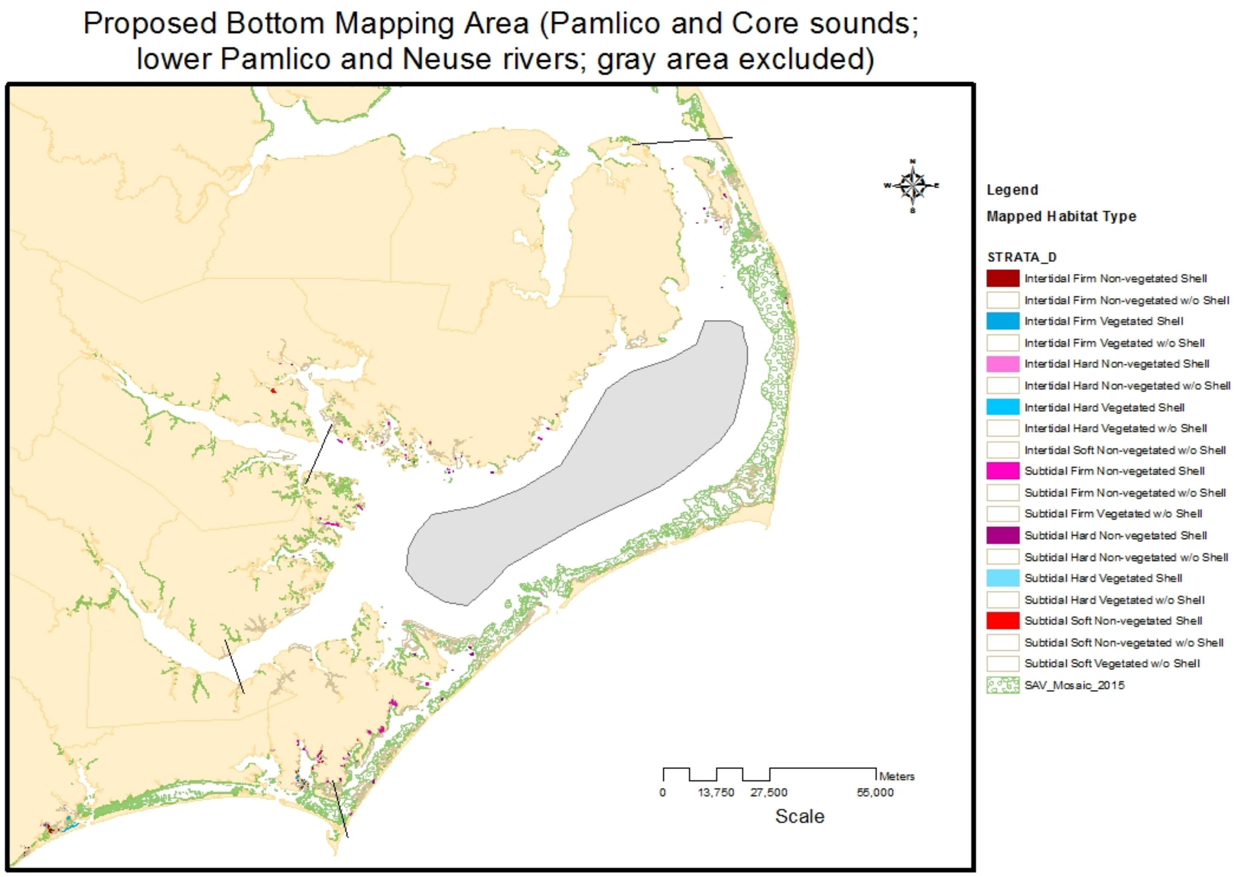

Figure A4.3. Proposed bottom mapping area for SAV mapping.

Equipment Costs

Initial costs for a side scan sonar including the hardware, vessel, computer, and insurance add up to over $205,000. The NCDMF already owns this equipment, so costs for the use of this equipment for the BACI habitat monitoring studies discussed above will include only the recurring annual costs for the eight-year time span estimated to complete these studies. Annual recurring costs that include insurance on both the vessel and the side scan equipment is estimated at $3,097 (Table A4.2). The SonarWiz software extended maintenance agreement (EMA) costs $1,195 each year. The computer equipment is estimated to be replaced every three years, but will only be replaced as needed and costs $1,529 per replacement (Table A4.3). Total recurring equipment costs over the 18-year study period is estimated to be $86,430 (Table A4.4). This would include annual costs for the side scan equipment and the vessel, as well as computer costs every three years throughout the study period. The 18-year period includes 2.5 years to map soft bottom before changes, six years to map oyster reef/SAV abundance before rule implementation, one year for the Petitioned rules to be in place, and 2.5 years and six years of mapping after implementation. These costs do not include any additional staff time needed to operate the sonar, vessel fuel, or routine maintenance on the vessel or equipment. The NCDMF would incur the annual recurring equipment costs to conduct other division sampling that depends on side scan sonar, regardless of the BACI; however, they are included here to provide an overall high estimate of the total equipment costs.

Table A4.2. Estimated recurring annual costs for side scan sonar equipment and vessel.

Vessel Insurance	$ 900
Survey Equipment Insurance	$ 2,197
SonarWiz EMA	$ 1,195
Total	$ 4,292

Table A4.3. Estimated cost of computer equipment needed to accompany side scan sonar.

Item	**Quantity**	**Cost per Item**	**Total Cost**
Laptop	1	$ 1,208	$ 1,208
Monitor	1	$ 132	$ 132
1TB external HDD	3	$ 54	$ 162
Wireless keyboard	1	$ 18	$ 18
Wireless mouse	1	$ 9	$ 9
Total			$ 1,529

Table A4.4. Annual breakdown for 3-year cycle of recurring costs for use of side scan sonar.

Item	**Year1**	**Year2**	**Year3**	**3-Year Total**
Insurance (vessel, survey equipment)	$ 3,097	$ 3,097	$ 3,097	$9,291
SonarWiz EMA	$ 1,195	$ 1,195	$ 1,195	$3,585
Computer Equipment	$ -	$ -	$ 1,529	$1,529
Subtotal	$ 4,292	$ 4,292	$ 5,821	$14,405
Grand Total (six cycles)				**$86,430**

Cost Summary

Grand total cost to complete sampling as described in this Appendix over an 18-year time span, at a maximum, would be $2,954,356 (Table A4.5).

Table A4.5. Summary of total costs for 18-year BACI study period.

Item	Total Cost
Sediment and Water Quality	$319,150–$380,000
Mapping Topography of Soft Bottom Habitat	$537,626
Changes to Oyster Reef and SAV Abundance – Oyster	$1,290,300
Changes to Oyster Reef and SAV Abundance – SAV	$660,000
Equipment Costs	$86,430
Grand Total	**$2,893,506–$2,954,356**

*Cost estimates are not adjusted for inflation or other variables.

APPENDIX 5 Excerpt from 2015 North Carolina Shrimp Fishery Management Plan Amendment 1

12.10 BYCATCH MANAGMENT RECOMMENDATIONS

12.10.1 Trawling in the New River above the Highway 172 Bridge

Marine Fisheries Commission Preferred Management Strategy

Status quo (Continue to prohibit otter trawls in the New River special secondary nursery area above the Highway 172 Bridge)

Advisory Committee Recommendation

Allow skimmer and otter shrimp trawling in the New River special secondary nursery area (above the Highway 172 Bridge).

Division Recommendation

Status quo (Continue to prohibit otter trawls in the New River special secondary nursery area above the Highway 172 Bridge)

12.10.2 Evaluation of the skimmer trawl and other gears used for shrimping in North Carolina

Marine Fisheries Commission Preferred Management Strategies

Allow hand cast netting of shrimp in all closed areas and increase the limit to four quarts, with heads on per person.

Status quo on a license requirement to fish a cast net for shrimp

Advisory Committee and Division Recommendation

Allow hand cast netting of shrimp in all closed areas and increase the limit to four quarts, with heads on per person. **Division added "heads on".**

Advisory Committee Recommendation

Require a fishing license from DMF to fish a cast net.

Division Recommendation

Status quo on a license requirement to fish a cast net for shrimp

12.10.3 The use of TEDs in commercial skimmer trawl operations

Marine Fisheries Commission Preferred Management Strategy

Upon federal adoption of TEDs in skimmer trawls, the division will support the federal requirement.

Advisory Committee Recommendation

Status quo

Division Recommendation

Upon federal adoption of TEDs in skimmer trawls, the division will support the federal requirement (Rule 15A NCAC 03L .0103 (g) allows for state enforcement).

12.10.4 Consideration of a commercial live bait shrimp fishery in North Carolina

Marine Fisheries Commission Preferred Management Strategy

Establish a permitted live shrimp bait fishery and for DMF to craft the guidelines and permit fees after reviewing permitted operations in other states, and to allow live bait fishermen with a permit to fish until 12 p.m. (noon) on Saturday.

Advisory Committee Recommendation

Establish a permitted live shrimp bait fishery and for DMF to craft the guidelines and permit fees after reviewing permitted operations in other states.

Division Recommendation

Status quo (continue to manage the live shrimp bait fishery the same as food shrimp fishery).

12.10.5 Gear Modifications in North Carolina shrimp trawls to reduce finfish bycatch

Marine Fisheries Commission Preferred Management Strategies

Allow any federally certified BRD in all internal and offshore waters of North Carolina.

Update the scientific testing protocol for the state’s BRD certification program.

Convene a stakeholder group to initiate industry testing of minimum tail bag mesh size, T-90 panels, skylight panels, and reduced bar spacing in TEDs to reduce bycatch to the extent practicable with 40% target reduction.

- o Upon securing funding, testing in the ocean and internal waters will consist of three years of data using test nets compared to a control net with a Florida fish eye, a federally approved TED, and a 1.5-inch mesh tailbag.

- o Results should minimize shrimp loss and maximize reduction of bycatch of finfish. Promising configurations will be brought back to the MFC for consideration for mandatory use.
- o This stakeholder group may be partnered with DMF and Sea Grant.
- o Members should consist of fishermen, net/gear manufacturers and scientist/gear specialists.

Require either a T-90 panel/ square mesh tailbag or other applications of square mesh panels (e.g., skylight panel), reduced bar spacing in a TED, or another federal or state certified BRD in addition to existing TED and BRD requirements in all skimmer and otter trawls.

Advisory Committee Recommendations

Allow any federally certified BRD in all NC internal and offshore waters.

Update and certify bycatch reduction devices through the state bycatch reduction program.

Convene an ongoing stakeholder workgroup charged with suggesting new trawl gear or trawl gear modification.

Initiate industry testing of new or modified bycatch reduction devices and gear modifications under the supervision of the DMF. After testing and collection of scientific data, regulations should be implemented to require or allow such devices or modifications to be used in NC internal and offshore waters.

Test a three-inch bar-spaced turtle excluder device to see if it can be certified as a bycatch reduction device.

Allow the shrimp industry a two-year period to test bycatch reduction devices.

Division Recommendations

Allow any federally certified BRD in all NC internal and offshore waters.

Update the scientific testing protocol for the state BRD certification program.

Convene a stakeholder group to initiate industry testing of minimum tail bag mesh size, T-90 panels, skylight panels, and reduced bar spacing in TEDs to reduce bycatch to the extent practicable.

- o Upon securing funding, testing in the ocean and internal waters will consist of three years of data using test nets compared to a control net with a Florida Fish Eye, a federally approved TED, and a one and a half inch tailbag.
- o Results should minimize shrimp loss and maximize reduction of bycatch of finfish. Promising configurations will be brought back to the MFC for consideration for mandatory use.
- o This stakeholder group may be partnered with DMF and Sea Grant.

- Members could consist of fishermen, net/gear manufacturers and scientist/gear specialists.

Require either a T-90 panel/ square mesh tailbag or other applications of square mesh panel (e.g., skylight panel), reduced bar spacing in a TED, or another federal or state certified BRD in addition to existing TED and BRD requirements in all skimmer and otter trawls.

Marine Fisheries Commission Recommendation **At November 2013 MFC meeting, requested this recommendation be reviewed by public, regional and standing committees.*

*Convene a stakeholder group to initiate a three-year study to test minimum tail bag mesh size, T-90 (square mesh) panels, skylight panels, reduced bar spacing in TEDs and any other new methods of reducing unwanted finfish bycatch to achieve a minimum of a 40 percent reduction of finfish by weight.

- Compare these to a control net with a Florida fish eye, a federally approved TED, and a one and half inch mesh tail bag.
- The stakeholder group should partner with DMF and Sea Grant to help secure funding for the study.
- If the 40 percent target reduction by weight in finfish is not achieved, further restrictions will be placed on the shrimp trawl industry to achieve the 40 percent reduction.
- Additional restrictions on the shrimp trawl industry will be reviewed and discussed at that time.

12.10.6 Effort Management for bycatch reduction in the North Carolina shrimp trawl fishery

Marine Fisheries Commission Preferred Management Strategy

Status quo on effort management (no changes in season, weekend or nighttime fishing)

Advisory Committee Recommendation

Status quo (no changes in season, weekend or nighttime fishing)

Division Recommendation

Status quo (no changes in season, weekend or nighttime fishing)

12.10.7 Characterization of the North Carolina commercial shrimp trawl fleet

Marine Fisheries Commission Preferred Management Strategy

In order to put a cap on fleet capacity as a management tool, establish a maximum combined headrope length of 220 feet in all internal coastal waters where there are no existing maximum combined headrope requirements (i.e., 90-foot requirement) with a two-year phase out period.

Advisory Committee Recommendation

Status quo (no additional maximum combined headrope requirements)

Division Recommendation

In order to put a cap on fleet capacity as a management tool, establish a maximum combined headrope length of 220 feet in all internal coastal waters where there are no existing maximum combined headrope requirements (i.e., 90-foot requirement).

12.10.8 Area restrictions to reduce shrimp trawl bycatch in North Carolina's internal coastal waters

Marine Fisheries Commission Preferred Management Strategies

Prohibit shrimp trawling in the IWW channel from the Sunset Beach Bridge to the SC state line, including Eastern Channel, lower Calabash River and Shallotte River.

Recommend the MFC Habitat and Water Quality Advisory Committee to consider changing the designation of special secondary nursery areas that have not been opened to trawling since 1991 to permanent secondary nursery areas.

Advisory Committee and Division Recommendation

Prohibit shrimp trawling in the IWW channel from the Sunset Beach Bridge to the SC line, including Eastern Channel, lower Calabash River and Shallotte River.

Division Recommendation

Recommend the MFC Habitat and Water Quality Advisory Committee to consider changing the designation of special secondary nursery areas that have not been opened to trawling since 1991 to permanent secondary nursery areas. Based on the outcome of AC input, rule changes may follow under the authority of the Shrimp FMP.