Research Priorities for the North Carolina Division of Marine Fisheries for 2024

Biological Review Team Research Priority Subcommittee

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N.C. DIVISION OF MARINE FISHERIES

TABLE OF CONTENTS

1 INTRODUCTION

When assessing the status of marine fisheries, data gaps regarding our understanding of species life history, the effects of habitat and water quality perturbations on marine populations, and characterization of fishing behaviors are often identified. These data and management knowledge gaps can introduce uncertainty into stock assessment model estimates. To better inform stock assessment analyses and refine potential management approaches, species-specific research priorities are provided by stock assessment scientists and fisheries biologists to directly address these information needs.

Broadly, marine species managed within North Carolina fall into two categories: state-managed and interjurisdictional managed species. Currently, the N.C. Division of Marine Fisheries (NCDMF) directly develops fishery management plans (FMPs) for fourteen stocks and partners with other agencies to manage at least another twenty-four interjurisdictional fisheries. All these species have associated research priorities designed to directly address certain knowledge gaps. Since many species have several identified research priorities, they are often presented in a hierarchical framework to highlight priorities critical for upcoming stock assessments. For species managed within North Carolina, research needs categorized as high priority are formatted in **bold** font. To aid in contextualizing these research needs, information regarding the latest stock assessment determination (including the terminal year of data used in the assessment) is included. Several species are short lived with variable annual recruitment and are considered annual crops. While no traditional stock assessment is conducted for these short-lived species, research priorities regarding the understanding of population dynamics and habitat effects are still necessary for implementing effective management strategies.

The purpose of this document is to publicize research needs, identified by NCDMF, for marine and estuarine species managed within North Carolina. Researchers are encouraged to propose scientific examinations to address these knowledge gaps. Contact information for the NCDMF biological species leads, habitat coordinator, and socioeconomic analyst are provided for further inquiries.

2 TOP RESEARCH PRIORITIES – STATE FMP STOCKS

2.1 Bay Scallop

Stock Overview

- Stock Assessment: No (annual crop)
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

Bay scallop is a short-lived species that exhibits highly variable annual recruitment abundance. Therefore, this stock is considered an annual crop, and a traditional stock assessment analysis is not conducted for bay scallop. Annual commercial landings of bay scallops show large fluctuations through time and are presumed to be driven by factors that affect natural mortality such as changing climate conditions (i.e., winter freezes, high freshwater runoff), poor water quality, predation, and red tide. Additionally, trends in fisheries-independent monitoring over the past ten years have shown bay scallop abundance is very low in most regions of the state, although a promising upward

trend was observed from 2019 to 2022 before dropping back to low levels in 2023 in Core Sound. The main harvest season (last Monday in January through April 1) was opened in Core Sound in 2021, 2022, and 2023.

Research Needs

- **Develop better methods to quantify the population, including more precise measures of spatial and temporal variability both within and between sound scales**
- **Identify viable stock enhancement techniques**
- Continue to identify strategic coastal habitats that will enhance protection of bay scallops and accelerate mapping of all shell bottom in North Carolina
- Develop surveys of recruitment and spat settlement to identify critical areas
- Identify the role water quality and nutrient loading has in failed recruitment and develop methods for improvement

Contact

Jeff Dobbs at Jeffrey.Dobbs@deq.nc.gov or 1-800-682-2632 or (252) 515-5640.

2.2 Blue Crab

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2016
  - Overfishing: Yes
  - Overfished/Depleted: Yes (Overfished)

Results of the most recent stock assessment, which included data from 1995 to 2016, were endorsed by an independent, external peer review panel and accepted for management use by the NCDMF. The stock is overfished with overfishing occurring. Data were available from commercial fishery monitoring programs and several fishery-independent surveys that monitor adult and juvenile abundance. The model estimated an overall declining trend in catch, relative abundance indices, and population size.

Research Needs

- **Develop statewide fishery-independent survey(s) to monitor the abundance of all blue crab life stages**
- **Identify key environmental factors that significantly impact North Carolina's blue crab stock and investigate stock assessment methods that can account for these environmental factors**
- **Research mature female migration routes and seasonal habitat use (e.g., inlets, staging areas)**
- Develop better estimates of life history parameters, especially growth and natural mortality
- Conduct gear research to minimize bycatch of prohibited blue crabs and other species

Additional research needs for blue crab associated with the CHPP can be found in section 4.5.

Contact

Robert Corbett at Robert.Corbett@deq.nc.gov or (252) 381-6010.

2.3 Eastern Oyster

Stock Overview

- Stock Assessment: No
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

There are insufficient data to conduct a traditional stock assessment for the eastern oyster; therefore, population size and the rate that oysters are removed from the population due to fishing could not be determined. Eastern oyster population abundance is believed to be influenced by habitat disturbance, pollution, disease, and other biological and environmental stressors. Due to these numerous potential sources of natural mortality, oysters are believed to be more vulnerable to overharvest. Commercial oyster landings have been in decline for most of the past century and the most recent fisheries-independent juvenile abundance index (2019) was the lowest of the past 10 years.

Research Needs

- **Improve the reliability of estimating recreational harvest**
- Develop regional juvenile and adult abundance indices or methods to monitor abundance of the oyster population (fisheries-independent)
- Establish and monitor sentinel sites for shell bottom habitat condition; develop shell bottom metrics to monitor
- Develop a program to monitor oyster reef height, area, and condition
- Explore water quality data sources (i.e., National Oceanic and Atmospheric Administration—NOAA, U.S. Geological Survey, FerryMon, Shellfish Growing Areas and Recreational Water Quality programs, meteorology sources) and their use in analyses that incorporates environmental variables that can impact regional population dynamics

Additional research needs for eastern oyster associated with the CHPP can be found in section 4.4. Unlike other state-managed species, the division administers two oyster habitat enhancement programs. These programs are the Oyster Sanctuary Program and Cultch Planting Program. The goal of these programs is to protect oyster broodstock in strategic areas and develop suitable oyster habitat available to the fishery, respectively. Information on research needs and contacts for these programs can be found in section 5.

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2.4 Hard Clam

Stock Overview

- Stock Assessment: No

- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

There are insufficient data to conduct a traditional stock assessment for hard clam; therefore, population size and the rate that hard clams are removed from the population due to fishing could not be determined. Commercial harvest has averaged approximately 23.7 million clams over the past 28 years but have steadily declined since 2014. Annual landings in 2021 were the second lowest in the 28-year period at 4.3 million clams. Little recreational harvest data on hard clams have been collected and recreational landings are generally unknown. Limited fisheries-independent sampling in Core Sound has indicated a low and variable relative abundance ranging from 0.27 to 1.27 hard clams per sampling site from 2008 to 2023 with no discernable trends.

Research Needs

- **Develop hard clam sampling methodology to monitor regional adult abundance**
- **Map and characterize hard clam habitat use by bottom type**
- **Develop a survey to better quantify recreational harvest**
- Determine natural mortality estimates
- Investigate causes of recent clam-kills and overall decline in hard clam abundance in the New River

Contact

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2.5 Kingfishes

Stock Overview

- Stock Assessment: No
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

Due to a lack of knowledge about migration dynamics, no traditional stock assessment analysis is conducted for kingfishes (southern, northern, and gulf). Instead, an annual trend analysis with management triggers is used to evaluate the stock. Monitored trends include relative fishing mortality and several fisheries-independent indices for both adult and juvenile kingfish. Informed by these biological surveys, management triggers may be activated, and new management approaches may be implemented. The activation of any two management triggers two years in a row (regardless of category) warrants further data evaluation and potential management action. Results from the trend analysis suggest there are no concerns with the stock and no need for management at this time.

Research Needs

- **Investigate techniques to estimate natural and fishing mortality, investigate stock structure, and understand movement patterns**
- Conduct a coast-wide stock assessment of southern kingfish along the Atlantic Coast including estimation of biological reference points for sustainable harvest

- Develop a fisheries-independent survey in the ocean for juvenile and adult kingfishes
- Collect histological data to develop maturity schedule with a priority for southern kingfish
- Conduct an age validation study with a priority for southern kingfish

Contact

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2.6 Red Drum

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2017
  - Overfishing: No
  - Overfished/Depleted: Unknown

According to the most recent stock assessment, red drum in North Carolina are not experiencing overfishing. Management targets continue to be met based on results from the 2017 Atlantic States Marine Fisheries Commission (ASMFC) stock assessment. The next ASMFC stock assessment is scheduled to be completed in October 2024. In North Carolina, the commercial fishery is managed using an annual cap and size limit. Recreationally, red drum is managed using size and bag limits. The NCDMF conducts several fishery-independent surveys that provide indices of relative abundance for various life stages of red drum. These include a juvenile seine index, a subadult gill-net index, and an adult longline index. These surveys provide critical inputs for stock assessments used to manage this fishery.

Research Needs

- **Implement surveys (e.g., logbooks, electronic methods) to determine the length composition (and age distribution, if possible) of recreational discards (B2) of red drum. This information has been highlighted as the single largest data gap in previous assessments.**
- Determine/further refine discard mortality estimates for both recreational and commercial gears. Additionally, discard estimates should examine the impact of slot-size limit management and explore regulatory discard impacts due to high-grading. Investigate how targeting of adult red drum spawning and post-spawning aggregations via catch-and-release hook-and-line fisheries by anglers are affecting the reproductive potential of the stock due to both direct lethal and sub-lethal effects.
- Refine maturity schedules on a geographic basis. Thoroughly examine the influence of size and age on reproductive function. Investigate the possibility of senescence in female red drum.
- Assess the effects of environmental factors on stock density and year-class strength. Determine whether natural environmental perturbations affect recruitment and modify relationships with spawning stock size.
- Conduct a comprehensive study to characterize users of the resource; in particular, gill-net fishers (including information on species targeted, gear characteristics, and areas fished) and fishers in the adult recreational fishery (e.g., tackle, geographic location, bait, water temperature, seasonality, hook types).

Contact

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2.7 River Herring

Stock Overview

- Stock Assessment: Yes (Chowan River, blueback herring)
- Terminal Year of Last Assessment: 2015
  - Overfishing: No (Harvest moratorium)
  - Overfished/Depleted: Yes (Depleted)

River herring fisheries in North Carolina's coastal sounds and rivers were once among the largest freshwater fisheries in the world; however, habitat loss, water quality degradation, and high levels of fishing mortality contributed to declines in river herring landings beginning in the mid- to late 1980s. In response to this observed stock decline, the commercial and recreational harvest of river herring has been prohibited in all coastal and joint waters of the state since 2007. The 2017 coastwide stock assessment update for blueback herring, the indicator river herring species for North Carolina, determined that the population is overfished but overfishing is not occurring. Current research is being conducted by the NCDMF in the Albemarle Sound area to re-evaluate spawning habitat, expand juvenile sampling, and monitor the Chowan River adult spawning stock.

Research Needs

- **Develop sampling protocols and survey design for directed surveys in North Carolina to monitor restoration targets outlined in the 2017 coastwide stock assessment**
- Assess spawning and nursery habitat areas in all tributaries of the Albemarle Sound and expand fisheries-independent sampling programs to include all additional areas of the state
- Investigate approaches to better quantify additional sources of mortality, including incidental catch in other fisheries
- Conduct empirical investigations using genetic approaches to better delineate stock identification
- Validate ageing techniques for river herring using known-age fish and continue efforts to standardize ageing techniques

Contact

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2.8 Sheepshead

Stock Overview

- Stock Assessment: No
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

Sheepshead are a highly prized recreational fish and harvested in many commercial fisheries. Concerns over potential increased targeting of sheepshead combined with limited knowledge of its basic life history prompted management regulations in 2015, which included size, bag, and trip

limits. The NCDMF is continuing to collect fisheries-independent and fisheries-dependent data to estimate trends in abundance of sheepshead and provide information for a stock assessment. Currently, research is also being conducted at North Carolina State University to develop indices of abundance, characterize juvenile habitat, and identify major spawning areas within the state.

Research Needs

- **Conduct reproductive studies including spawning periodicity, age- and size-specific fecundity, update maturity schedule, and conduct spawning area surveys in North Carolina and throughout the stock's range**
- **Expand discard sampling to collect information on gear, depth, location, and age and size distribution of discarded fish for the recreational and commercial sectors throughout North Carolina and the stock's range**
- **Conduct studies on size- and age-specific selectivity by gear type**
- Complete an age validation study using known age fish
- Determine the patterns and triggers of inshore-offshore and potential north-south migrations to aid in characterizing stock structure

Contact

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2.9 Shrimp

Stock Overview

- Stock Assessment: No (annual crop)
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

All three commercially important shrimp species harvested in North Carolina are short-lived and exhibit highly variable annual recruitment; therefore, this stock is considered an annual crop, and a traditional stock assessment analysis is not conducted. Broadly, shrimp are considered resilient to high fishing effort or natural population fluctuations because of their high reproductive output (fecundity) and migratory behavior. Currently, the NCDMF calculates an annual juvenile abundance index for brown shrimp and cooperative research is being conducted to reduce finfish bycatch in the shrimp trawl fishery.

Research Needs

- **Create a long-term shrimp trawl observer program to characterize bycatch across all strata (e.g., dominant species, protected species, season, areas, gear type, vessel type, number of nets/rigs, headrope length, TED position)**
- **Improve accuracy of self-reported license gear survey data or investigate other means of accurately obtaining shrimp fleet characteristics**
- **Collect improved effort data (e.g., headrope length, number of nets, tow time, number of tows) to provide bycatch estimates based on actual time fished (or number of tows), rather than number of trips**
- Create and validate juvenile abundance indices for white and pink shrimp

- Determine the cumulative impacts of shrimp trawl bycatch on individual species population dynamics and the ecosystem

Contact

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2.10 Southern Flounder

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2017
  - Overfishing: Yes
  - Overfished/Depleted: Yes (Overfished)

Southern flounder is a highly lucrative finfish species across sectors for North Carolina. In 2017, a regional south Atlantic stock assessment, that included partners from North Carolina, South Carolina, Georgia, and Florida, indicated the stock is overfished with overfishing occurring. There are concerns about the sustainability of current harvest levels due to coast-wide trends in juvenile and adult abundance and the high percentage of immature fish in the harvest. Currently, the NCDMF has four fisheries-independent surveys that are used to create an index of relative (juvenile and adult) abundance.

Research Needs

- **Expand tagging studies to estimate immigration and emigration and any potential influence they have on the unit stock**
- **Develop a fisheries-independent survey for the ocean component of the stock**
- **Collect data on discards (numbers, species ratio, mortality rates, and length distribution) in commercial gig, pound net, trawl, and recreational catch-and-release fisheries**
- Determine spawning locations/aggregations of southern flounder
- Complete an age validation study using known age fish

Contact

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2.11 Spotted Seatrout

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2019
  - Overfishing: Yes
  - Overfished/Depleted: No

Spotted seatrout is one of the most targeted recreational fish species in North Carolina and is also harvested commercially. The 2022 North Carolina spotted seatrout stock assessment indicated the stock in North Carolina and Virginia is not overfished but overfishing is occurring. The stock is currently managed using size and bag/trip limits. Large fluctuations in annual natural mortality

resulting from prolonged and/or severe winter cold stun events likely influence spotted seatrout population dynamics. A juvenile index for spotted seatrout is calculated each year from the North Carolina Estuarine Juvenile Trawl Survey and serves as an indicator of relative juvenile abundance in the state. Results from the survey typically track well with years following a cold stun and can indicate potential recovery. Adult relative abundance is estimated from the NCDMF fishery-independent gill-net survey.

Research Needs

- **Determine size-specific and batch fecundity estimates for spotted seatrout in North Carolina**
- **Collect data on the size, age, and disposition of spotted seatrout released by anglers and increase data collection on the number, size, age, and disposition of commercial discards**
- **Design and validate an improved juvenile abundance index for spotted seatrout**
- Develop area-specific spawning surveys, which may help in delineating area specific closures to protect females in spawning condition
- Investigate the relationship of temperature and salinity on release mortality in the commercial and recreational fisheries

Contact

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2.12 Striped Bass (Albemarle Sound and Roanoke River management areas)

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2021
  - Overfishing: Yes
  - Overfished/Depleted: Yes (Overfished)

Results from the 2022 update to the benchmark stock assessment indicate the Albemarle-Roanoke striped bass stock is experiencing overfishing and is overfished. Currently, the commercial fishery is managed using total allowable landings and size limits. Similarly, the recreational sector is managed using total allowable landings, along with size and bag limits. As a result of low calculated total allowable landings, no harvest is allowed from the Albemarle Sound in 2024. The NCDMF conducts juvenile striped bass sampling with beach seines and trawls to observe trends in annual recruitment success. Recruitment is likely influenced by several biological and environmental variables, and these indices are used to inform striped bass stock assessment models.

Research Needs

- **Identify environmental factors (e.g., flow, salinity, predation, dissolved oxygen, algal blooms) affecting survival of striped bass eggs, larvae, and juveniles and investigate methods for incorporating environmental variables into stock assessment models.**
- **Expand, modify, or develop fishery-independent sampling programs to fully encompass all bass life stages (egg, larval, juvenile, and adult).**

- Determine mixing rates between A-R and CSMA striped bass stocks to better inform stock assessments and management.
- Refine discard mortality estimates for recreational and commercial fisheries by conducting delayed mortality studies to estimate discard losses for recreational and commercial gear during all seasons factoring in relationships between salinity, dissolved oxygen, and water temperature (if significant).
- Investigate the potential impact of blue catfish on the A-R striped bass population (e.g., habitat, predation, forage).

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2.13 Striped Bass (Central Southern Management Area)

Stock Overview

- Stock Assessment: No
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

The lack of adequate data and life history information make it difficult to quantitatively assess the Central Southern Management Area (CSMA) stocks regarding the overfishing and overfished status. The need for continued conservation measures to achieve sustainable harvest are supported by the lack of natural recruitment, constrained size and age distributions, low abundance, the absence of older fish in all stocks, and high percentage of hatchery stocked fish supporting populations. Currently, the NCDMF fishery-independent gill net survey is used to estimate relative abundance for these striped bass stocks. In 2017, the NCDMF initiated juvenile striped bass sampling in the CSMA with beach seines and trawls to observe trends in annual recruitment success.

Research Needs

- **Determine minimum flow and other water quality and habitat requirements for successful spawning, egg development, and larval transport of striped bass to nursery grounds**
- **Conduct egg abundance and egg viability studies**
- **Conduct delayed mortality studies for recreational and commercial gear during all seasons factoring in relationships between salinity, dissolved oxygen, and water temperature (if significant)**
- Develop better estimates of life history parameters, especially factors impacting survivability of stocked fish in each system and factors influencing rates of natural mortality for all striped bass life stages
- Estimate spawning population size by expanding PIT tagging to the Tar-Pamlico and Neuse rivers

Contact

Central: Todd Mathes at Todd.Mathes@deq.nc.gov or 1-800-338-7804 or (252) 948-3872.

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2.14 Striped Mullet

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2019
  - Overfishing: Yes
  - Overfished/Depleted: Yes (Overfished)

Based on results of the 2022 stock assessment, the striped mullet stock is overfished and overfishing is occurring. In response to results of the 2022 stock assessment, Supplement A to Amendment 1 to the Striped Mullet FMP was approved in 2023 to end overfishing on the stock by implementing regional closed seasons at the end of the year. Amendment 2 to the Striped Mullet FMP is scheduled to be adopted in 2024 and will implement management to end overfishing and achieve sustainable harvest for the North Carolina striped mullet stock.

Research Needs

- **Sample recreational mullet catches to determine the proportion of striped versus white mullet, improve estimates of recreational harvest, and improve characterization of the length and age structure of recreational fisheries removals**
- **Conduct a tagging study to provide estimates of stock size, fishing mortality, and natural mortality**
- **Conduct a genetic and/or tagging study to examine extent of unit stock and explore movement patterns**
- Conduct an age validation study of known age fish to provide estimates of ageing error
- Develop a reliable fisheries-independent abundance index for larger juveniles to characterize trends in recruitment

Contact

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2.15 Unmanaged Species

In recent years, interest and concern for unmanaged species has increased with both fisheries managers and the public. The reason for concern for unmanaged species ranges from consideration as forage species to emerging fisheries. To adequately assess the need for management of any species there is basic data that must be available to fisheries managers. This includes information on fishery removals (both harvest and discards) and biological information (e.g., age or length of maturity, fecundity, growth rate, age structure, maximum age, unit stock definition).

Research Needs

- Analyze commercial and recreational fishery data and identify emerging fisheries for unmanaged species
- Perform a review of forage species literature and identify unmanaged species that could be considered for management as forage species or ecosystem component species

- Perform a literature review and compile relevant biological information that will be needed to evaluate an unmanaged species for management
- Analyze fishery-independent data to identify population trends in unmanaged species that may be of concern
- Develop criteria to evaluate if management should be considered for an unmanaged species

Contact

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3 TOP RESEARCH PRIORITIES—INTERJURISDICTIONAL FMP STOCKS

3.1 American Eel

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2019
  - Overfishing: Unknown
  - Overfished/Depleted: Yes (Depleted)

The 2023 benchmark stock assessment concluded that the stock is depleted, meaning it is at or near historically low levels due to a combination of historical overfishing, habitat loss, food web alterations, predation, turbine mortality, environmental changes, toxins and contaminants, and disease. Based on trend analyses, the stock was also considered depleted in the 2012 and 2017 assessments. A "depleted" stock status is often used by the ASMFC when a statistical model and reference points cannot be developed due to data limitations, but trend analyses or other data-poor methods indicate the stock is below historic levels. In all assessments for American eel, it has been noted that assessing only a portion of the species range (i.e., coastal Maine through Florida) is not as meaningful for a panmictic species and the assessments recommend collaborating with scientists and agencies, inland and international, to consider a range-wide assessment in the future.

Research Needs

- **Develop a fisheries-independent sampling program for yellow American eels using standardized and statistically robust methodologies**
- Sample female American eels to investigate fecundity, length, and weight relationships in North Carolina
- Sample male and female American eels to determine growth rates in North Carolina and acquire age and maturity data
- Investigate, develop, and improve technologies for American eel passage upstream and downstream at various barriers for each life stage; in particular, investigate low cost alternatives to traditional fishway designs for eel passage
- Investigate survival and mortality at various life stages to assist in the assessment of annual recruitment

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3.2 American Shad

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2017
  - Overfishing: Unknown
  - Overfished/Depleted: Yes (Depleted)

A coast-wide benchmark stock assessment for American shad was completed in August 2020, which indicated the current adult total mortality rate in the Albemarle Sound and Neuse River systems is sustainable. Adult abundance status was only determined for two systems, the Hudson River and Albemarle Sound. The Albemarle Sound system is not depleted/not overfished, while the Hudson River system is depleted/overfished. Despite the finding that the Albemarle Sound abundance status is not depleted, the coast-wide metapopulation abundance was determined to be depleted based on the decline in coast-wide landings and the lack of consistent increasing trends in abundance indices. The stock assessment provided status determinations for adults only due to the lack of data on juvenile American shad. There is a data gap as they transition from young of year to mature spawning adults, which can impact overall status determinations. The Tar-Pamlico and Cape Fear river systems remain unknown for adult stock status and adult abundance. The Neuse River system adult abundance status is also unknown, despite the sustainable adult total mortality rate. Since 2012, an American shad sustainable fishery plan has established management triggers based on monitored results of female relative abundance and fishing mortality from fisheries-independent surveys. As of 2020, annual updates to sustainability parameters have not triggered further management measures.

Research Needs

- **Evaluate spawning and nursery habitat areas in all tributaries of the Albemarle Sound as well as expand all fisheries-independent sampling programs to include all areas of the state**
- **Conduct age validation for all ageing structures including scales, otoliths, and spawning marks**
- Identify and determine the effects of migratory passage impediments on all life history stages and develop strategies to minimize the impacts of these blockages
- Identify all fisheries where bycatch occurs and quantify the amount and disposition
- Conduct empirical investigations using genetic approaches to better delineate stock identification

Contact

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3.3 Atlantic Croaker

Stock Overview

- Stock Assessment: No
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A

- Overfished/Depleted: N/A

A benchmark stock assessment for Atlantic croaker was completed in 2017 but was not accepted for management use by a peer review panel; therefore, stock status with relation to overfished or overfishing designation is unknown. The Atlantic croaker traffic light analysis, used to monitor the stock between stock assessments, tripped management triggers in 2019 by exceeding the 30 percent threshold for both the harvest and abundance composite indices in three of the four most recent years (2016–2019). Management action established in Addendum III specifies all non *de minimis* states will be required to institute a bag limit of no more than 50 Atlantic croaker per person per day for the recreational sector and institute a quantifiable measure to reduce commercial harvest by 1% of the average state commercial harvest from the previous ten years. A benchmark stock assessment for Atlantic croaker is underway. In North Carolina, a juvenile abundance index for Atlantic croaker is obtained from the NCDMF Pamlico Sound Survey (Program 195).

Research Needs

- **Collect biological information and conduct studies on growth rates, age structure, estimates of fecundity, and maturity schedule**
- **Investigate environmental, including climate cycles, recruitment, and natural mortality covariates and develop a time series of potential covariates to be used in stock assessment models**
- Quantify effects of Bycatch Reduction Devices (BRD) and Turtle Excluder Devices (TED) implementation in the shrimp trawl fishery by examining their relative catch reduction rates on Atlantic croaker
- Conduct studies of discard mortality for commercial and recreational fisheries
- Conduct an age validation study and expand collection of life history data

Contact

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3.4 Atlantic Menhaden

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2021
  - Overfishing: No
  - Overfished/Depleted: No

The Atlantic menhaden stock supports an important bait fishery in North Carolina. Historically, landings also contributed to a substantial reduction industry in the state. In August 2020, Ecological Reference Points (ERP) were adopted establishing ERP fishing mortality (F) target and threshold values based on sustaining Atlantic striped bass at their biomass target and threshold values. The 2019 single species benchmark stock assessment determined the stock was neither overfished nor experiencing overfishing. In North Carolina, a juvenile index of abundance for Atlantic menhaden is obtained from the NCDMF Estuarine Trawl Survey while age-1+ index of abundance is obtained from the NCDMF Pamlico Sound and Rivers Independent Gill-Net Survey.

Research Needs

- **Conduct diet analysis of species that predate on Atlantic menhaden, specifically identifying consumption rates, size selectivity, and seasonal and temporal variations**
- Work with industry to collect age structure data outside the range of the fishery
- Conduct a comprehensive fecundity study

Contact

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3.5 Atlantic Sturgeon

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2015
  - Overfishing: No (Harvest moratorium)
  - Overfished/Depleted: Yes (Depleted)

The ASMFC is responsible for managing Atlantic sturgeon and considers the stocks to be depleted along the Atlantic coast. Atlantic sturgeon was listed under the Endangered Species Act on April 6, 2012, and there is a coast-wide prohibition on possession. This listing resulted in the NCDMF developing an application for a Section 10 Incidental Take Permit which was authorized and signed effective September 1, 2014. Estuarine anchored gill-net fisheries will have to follow the protocols outlined in this permit and Implementation Agreement. A coast-wide stock assessment was completed in 2017 and indicated the Atlantic sturgeon population remains depleted coast wide and at the distinct population segment level relative to historic abundance; however, the coast-wide population appears to be recovering slowly since implementation of the coast-wide moratorium in 1998. Focus on population status and incidence of bycatch in various fisheries should be considered a high priority in the list below.

Research Needs

- **Develop a novel survey design and sampling protocols to monitor and estimate juvenile year-class strength and abundance**
- **Develop a program to identify abundance and age composition of the spawning population**
- **Characterize incidence of bycatch in various fisheries and associated mortalities**
- Conduct tag and recapture studies to evaluate migrations and movements between distinct population segments (DPS)
- Identify spawning habitats

Contact

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3.6 Black Drum

Stock Overview

- Stock Assessment: Yes

- Terminal Year of Last Assessment: 2020
  - Overfishing: No
  - Overfished/Depleted: No

The 2023 ASMFC Black Drum Stock Assessment determined the stock is not overfished and not experiencing overfishing. Results indicated greater certainty that the stock is not overfished; however, there was less certainty regarding the exploitation status. While overall stock indicators that monitor year class strength, sub-adult abundance, exploitable abundance, range expansion, and regional catch did not appear negative, it is recommended they be closely monitored between assessments. The next benchmark stock assessment is scheduled to occur in 2027. The North Carolina relative index of abundance for black drum is obtained from the NCDMF Independent Gill-Net Survey conducted in the Pamlico Sound and Neuse, Pamlico, and Pungo river systems; data from this survey were used in the 2023 assessment.

Research Needs

- **Conduct reproductive studies including age- and size-specific fecundity, spawning frequency, spawning behaviors by region, and movement and site fidelity of spawning adults**
- **Initiate studies to characterize the size composition and mortality rates of discarded fish in recreational and commercial fisheries**
- Initiate tagging studies using acoustic tags that are compatible with coastal tracking arrays along the Atlantic coast to track movement and migration of adults
- Collect genetic material (i.e., create "genetic tags") over a long-time span to obtain information on movement and population structure, and potentially estimate population size

Contact

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3.7 Black Sea Bass (north of Cape Hatteras)

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2019
  - Overfishing: No
  - Overfished/Depleted: No

Black sea bass (north of Cape Hatteras) is a popular commercial and recreational fishery in the mid-Atlantic region. The 2021 black sea bass management track stock assessment determined the stock to be neither overfished nor experiencing overfishing in 2019. In North Carolina, there is currently no active survey that directly estimates a juvenile relative abundance index for this stock. Black sea bass south of Cape Hatteras are managed by the South Atlantic Fishery Management Council and are included in the snapper grouper complex (see section 3.16 Snapper Grouper Complex).

Research Needs

- **Evaluate population sex change and sex ratio, particularly comparing dynamics among communities**
- **Continue and expand genetic studies to evaluate the potential of population structure north of Cape Hatteras**
- **Conduct research on habitat use and seasonal changes in habitat**
- Study catchability in a variety of survey gear types
- Continue and expand the tagging program to provide increased age information and increased resolution on mixing rates among putative populations

Contact

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3.8 Bluefish

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2019
  - Overfishing: No
  - Overfished/Depleted: Yes (Overfished)

A management track stock assessment, completed in 2021, indicates that bluefish are overfished but are not experiencing overfishing. This assessment was an update of the 2019 operational assessment, which also determined bluefish are overfished but are not experiencing overfishing. In 2022, a research track stock assessment, which can incorporate larger revisions to the stock assessment model, was conducted to inform the upcoming 2023 management track stock assessment for the species. The research track stock assessment made notable data and model changes designed to improve the assessment and reduce uncertainty. Bluefish are a coast-wide stock and data for the assessment came from all coastal Atlantic states. The North Carolina relative index of abundance for bluefish used in the assessments is from the NCDMF Pamlico Sound Independent Gill-Net Survey. As a result of the 2019 assessment, a rebuilding plan was initiated to rebuild the stock. In September 2021, the Bluefish Allocation and Rebuilding Amendment (Amendment 7) was passed. Amendment 7 revised the goals and objectives of the fishery management plan, reallocated quota between the commercial and recreational fisheries, reallocated commercial quota among the states, implemented a rebuilding plan, revised the sector quota transfer process, and revised how management uncertainty is applied during the specifications process.

Research Needs

- **Evaluate magnitude and length frequency of discards from the commercial and recreational fisheries, especially recreational discard lengths in the mid-Atlantic and southern regions**
- **Develop additional adult bluefish indices of abundance (e.g., broad spatial scale longline survey or gill-net survey) to better characterize dynamics of older bluefish not well sampled by fisheries-independent trawl surveys**

- Evaluate the source of bimodal length frequency in the catch (e.g., migration, differential growth rates)
- Explore age- and time-varying natural mortality from, for example, predator-prey relationships; quantify effects of age- and time-varying mortality on the assessment model
- Investigate potential spatial distribution shifts of the Atlantic stock

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3.9 Coastal Sharks

Stock Overview

- Stock Assessment: Varies by species/complex
- Terminal Year of Last Assessment: Varies by species/complex
  - Overfishing: Varies by species/complex
  - Overfished/Depleted: Varies by species/complex

The ASMFC developed a Coastal Shark fisheries management plan in 2008. Stock status is determined by species or by species complex depending on the availability of data for an individual assessment by various federal agencies. Atlantic stocks have been assessed in the United States for nine species, three species have been reviewed internationally, and the remaining 32 species have not yet been individually evaluated. Species-specific overfished status has been designated for shortfin mako, sandbar, porbeagle, blacknose, dusky, and scalloped hammerhead sharks. Overfishing status has been designated for the shortfin mako, scalloped hammerhead, blacknose, and dusky shark. As of the most recent stock assessments, the Atlantic sharpnose, finetooth, smooth dogfish, blue, and blacktip shark Atlantic stocks are not overfished or experiencing overfishing. A stock assessment for bonnethead sharks has been conducted, but the stock status was determined to be unknown. A stock assessment for blue sharks was scheduled for 2023 (ICCAT), a shortfin mako stock assessment is scheduled for 2024 (ICCAT), and an assessment for hammerhead sharks was scheduled for 2023 (SEDAR 77).

Research Needs

- **Investigate the appropriateness of using vertebrae for ageing adult sandbar shark, and if appropriate, begin systematic biological monitoring sampling that will allow tracking of age distribution of catch and update age-length keys**
- Update age, growth, and reproductive studies for all species currently assessed, especially for studies with low sample sizes or are over 20 years old, and determine life history information for data-poor species that are currently not assessed
- Continue investigations into stock structure of coastal sharks using genetic, conventional, and electronic tags to determine appropriate management units
- Increase research on post-release survivorship of all shark species by gear type
- Develop empirically based estimates of natural mortality

Contact

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3.10 Atlantic Cobia

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2017
  - Overfishing: No
  - Overfished/Depleted: No

The most recent Atlantic cobia stock assessment, conducted in 2019 with data through 2017, indicated the stock is not overfished and overfishing is not occurring; however, spawning stock biomass declined in the last several years of the stock assessment. In 2015, 2016, and 2018, the total annual catch limit for Atlantic cobia was exceeded by over 200 percent. Excessive harvest observed in these years warrants continued monitoring of the stock. The next stock assessment for Atlantic cobia is tentatively scheduled for 2025.

Research Needs

- **Institute fisheries-independent sampling programs to obtain estimates of adult and/or juvenile cobia abundance and better define Atlantic cobia habitat**
- **Better characterize the life history of Atlantic cobia including age sampling of the recreational and commercial sectors, update age and length at maturity, batch fecundity, spawning seasonality, and spawning frequency information**
- **Implement a satellite tagging study to help understand onshore-offshore movement and the use of over-wintering habitat**
- Investigate release mortality and fishing mortality within the commercial and recreational fisheries
- Investigate estimates of bycatch and mortality of Atlantic cobia in other fisheries, especially juvenile fish

Contact

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3.11 Dolphin

Stock Overview

- Stock Assessment: No
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

Currently, no formal stock assessment on dolphin in the U.S. Atlantic has been accepted for management. Lack of fisheries-independent data, uncertainties in the boundaries of the stock, the life cycle of the fish, and the lack of jurisdictional cooperation necessary to fully characterize the harvest across the range of the species make stock determination arduous. Time-series data of catch and size of individuals in the fishery indicate no decline of stock abundance or substantial decrease in average size of fish. Dolphin is a fast growing, early maturing fish with high

recruitment and these life history characteristics may allow for dolphin to be resilient to fishing mortality.

Research Needs

- **Identify essential fish habitat and evaluate its importance to all life history stages of the species**
- **Collect age, length, and reproductive data to improve estimates of growth, fecundity, etc.**
- **Investigate the high levels of uncertainty in interannual variation in abundance of dolphin through examination of oceanographic and other environmental factors**
- Investigate assessment needs for the species
- Investigate potential for developing fishery-dependent indices of abundance

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3.12 Hickory Shad

Stock Overview

- Stock Assessment: No
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

There are insufficient data to conduct a traditional stock assessment for shad in North Carolina or a coastwide assessment by the ASMFC; therefore, the population size of hickory shad and the rate of removal from the population due to fishing cannot be determined. The NCDMF has not conducted directed sampling for hickory shad since 1993, although they are encountered sporadically in other sampling programs. Like American shad and river herring, loss of spawning habitat and degraded water quality have most likely contributed to low hickory shad population abundance.

Research Needs

- **Develop fisheries-dependent and fisheries-independent monitoring programs and ageing directed at hickory shad to be used in the development of stock assessments and FMPs**
- Evaluate spawning and nursery habitat areas in all tributaries of the Albemarle Sound as well as expand all fisheries-independent sampling programs to include all areas of the state
- Identify all fisheries where bycatch occurs and quantify the amount and disposition
- Identify migratory passage impediments and determine the effects of these impediments during all life history stages and develop strategies to minimize the impacts of these blockages
- Develop sampling programs to adequately monitor recreational landings and takes of hickory shad throughout all areas of the state

Contact

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3.13 King Mackerel

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2017
  - Overfishing: No
  - Overfished/Depleted: No

The most recent stock assessment update for king mackerel, completed in 2020, indicated the stock was not overfished and overfishing was not occurring. Overall, observed stock and spawning stock biomass have shown increases from the late 1990s until 2010. From 2010 to 2013 spawning stock biomass declined slightly; however, since 2013, total biomass and spawning stock biomass estimates have steadily increased. North Carolina currently has a three-fish recreational bag limit, 24-inch fork length size limit, 3,500-pound commercial trip limit, and permit requirements for commercial harvesters for their season (March through February).

Research Needs

- **Develop a survey to obtain reliable age and size composition data and relative abundance of adult fish**
- Investigate and quantify mixing between Atlantic, eastern Gulf, and western Gulf populations
- Examine population connectivity throughout the Gulf and South Atlantic using otolith elemental and stable isotope signatures of age-0 fish as natural tags of various regions
- More accurately characterize juvenile growth by increasing samples of age-0 and age-1 fish
- Determine if female spawning periodicity varies by size or age

Contact

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3.14 Monkfish

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2019
  - Overfishing: Unknown
  - Overfished/Depleted: Unknown

The 2016 stock assessment conducted by the National Oceanic and Atmospheric Administration (NOAA) Northeast Fisheries Science Center (NEFSC) determined the status of both the north and south monkfish stocks are unknown. During the 2016 monkfish stock assessment, scientific evidence suggested the ageing technique (vertebral ageing) for monkfish was no longer valid which resulted in a lack of biological reference points. Therefore, the stock status of monkfish could not be determined. A new operational assessment was conducted by NEFSC in 2019. Due

to the lack of biological reference points, stock status was not addressed in the 2019 assessment and the stock status for both stocks are unknown.

Research Needs

- **Investigate monkfish life history focusing on age and growth, longevity, reproduction, and natural mortality**
- **Evaluate the use of alternative hard structures for age determination**
- **Conduct studies of stock structure/stock identification and implications for stock assessment and fisheries management**
- Obtain better estimates of commercial discards
- Investigate migration patterns focusing on short- and long-term movements with respect to management areas, off-shelf movements, and habitat use

Contact

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3.15 Scup (north of Cape Hatteras)

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2022
  - Overfishing: No
  - Overfished/Depleted: No

The 2023 scup management track stock assessment indicated the stock was not overfished and overfishing was not occurring relative to 2022 reference points. In North Carolina, the winter trawl fishery (primarily flounder trawls) has been the main commercial fishery for scup and there have been no reported recreational catches of scup since 2015. Since there is no fisheries-independent monitoring program that catches sufficient numbers of juvenile scup in North Carolina, no juvenile abundance index value is available (from North Carolina).

Research Needs

- **Develop ways to improve estimates of catch and discards in both the commercial and recreational fisheries**
- Design sampling surveys to quantify abundance and estimate catchability
- Conduct research to better understand scup maturity schedule and annual availability

Contact

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3.16 Snapper Grouper Complex

Stock Overview

- Stock Assessment: Varies by species/complex
- Terminal Year of Last Assessment: Varies by species/complex
  - Overfishing: Varies by species/complex

- Overfished/Depleted: Varies by species/complex

Of the 55 species in the South Atlantic Fishery Management Council snapper grouper complex, 15 have undergone stock assessments and several are considered overfished: red porgy, American red snapper, hogfish (east Florida), gag grouper, red grouper, and snowy grouper. Stocks experiencing overfishing are: American red snapper, gag grouper, red grouper, snowy grouper, and red porgy. The status of several species within the snapper grouper complex are unknown; however, for some of the species, stock assessments are available through various federal entities that are managed regionally (North Carolina south to eastern Florida). Several species in the complex also have stock status updates provided by NOAA Fisheries. These updates are based on landings data to determine whether the stock is overfished or undergoing overfishing. They are done quarterly and available on the NOAA Fisheries website.

Research Needs

- **Develop adult and juvenile indices of abundance, especially fisheries-independent indices of abundance**
- Evaluate the effectiveness of circle hook and descending devices at reducing discard mortality at a species level and expand discard sampling collecting information on depth, location, and age and size distribution of discarded fish
- Conduct tagging studies of snapper grouper complex species to evaluate movement of species at a state and regional level as well as provide estimates of growth and mortality
- Conduct reproductive biology work on shallow water groupers to determine spawning timing and habits

Note: for species-specific research needs use the following link to find the stock assessment (which contains research needs) for the species of interest (http://sedarweb.org/sedar-projects)

Contact

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3.17 Spanish Mackerel

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2020
- Overfishing: No
- Overfished/Depleted: No

The most recent Spanish mackerel stock assessment, conducted in 2022, indicated that the stock was not overfished and overfishing was not occurring. However, in the terminal year of the assessment (2020), the model found the estimated fishing rate to be above the maximum fishing mortality threshold, indicating that if the 2020 overfishing rate continues, this could result in the stock falling into overfishing status. The assessment estimated that the spawning stock has fluctuated near or above the minimum stock size threshold level on a near-decadal cycle. In North Carolina, the stock is recreationally managed using size and bag limits and commercially with trip limits. Both commercial and recreational fisheries close when the quota is reached.

Research Needs

- **Increase collection of fisheries-dependent length, sex, age, and relative index data to improve stock assessment accuracy; simulations on index trends should be explored and impacts on stock assessment results determined**
- **Investigate the discard mortality of Spanish mackerel in the commercial and recreational trolling fishery, commercial gill-net fishery, and shrimp trawl fishery**
- Develop new fisheries-independent surveys for juvenile and adult Spanish mackerel in the South Atlantic

Contact

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3.18 Spiny Dogfish

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2017
  - Overfishing: No
  - Overfished/Depleted: No

Spiny dogfish is interjurisdictionally managed by the Mid-Atlantic Fishery Management Council and New England Fishery Management Council in federal waters (from 3 to 200 miles offshore) and the ASMFC in state waters (0 to 3 miles from shore). The ASMFC spiny dogfish fishery management plan, implemented in 2002, mandates the establishment of an annual coastwide quota. The 2018 stock assessment update, conducted by the NOAA Northeast Fisheries Science Center (NEFSC), determined spiny dogfish is not overfished and not experiencing overfishing. In North Carolina commercial landings have decreased since 2014. Recreational landings spiked in 2021 but otherwise remain low. A research track stock assessment was completed in late 2022 and management advice from that assessment is pending.

Research Needs

- **Determine area, season, and gear-specific discard mortality estimates coastwide in the recreational, commercial, and non-directed (bycatch) fisheries**
- **Characterize and quantify bycatch of spiny dogfish in other fisheries**
- Examine observer data to calculate a weighted average discard mortality based on an assumption that the rate increases with catch size
- Conduct a coast-wide tagging study to explore stock structure, migration, and mixing rates
- Standardize age determination along the entire east coast and conduct an ageing workshop for spiny dogfish, encouraging participation by NEFSC, NCDMF, Canada Department of Oceans, other interested agencies, academia, and other international investigators with an interest in spiny dogfish ageing

Contact

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3.19 Spot

Stock Overview

- Stock Assessment: No
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

The first benchmark stock assessment for spot was completed in 2017 but was not accepted for management use by a peer review panel; however, the review panel did not identify any major problems in the spot fishery that would require immediate management action. Because there is not an approved stock assessment, the stock status for spot with relation to overfished or overfishing is unknown. The spot traffic light analysis, used to monitor the stock between stock assessments, tripped management triggers in 2019 by exceeding the 30 percent threshold for both the harvest and abundance composite indices in two of the three most recent years (2017-2019). Management action established in Addendum III specifies all non *de minimis* states will be required to institute a bag limit of no more than 50 spot per person per day for the recreational sector and institute a quantifiable measure to reduce commercial harvest by 1% of the average state commercial harvest from the previous ten years. A benchmark stock assessment for spot is underway. In North Carolina, a juvenile abundance index for spot is obtained from the NCDMF Pamlico Sound Trawl Survey.

Research Needs

- **Investigate environmental and oceanic processes in order to develop better understanding of larval migration patterns into nursery grounds**
- **Conduct an age validation study and expand collection of life history data**
- Investigate the effects of environmental changes on recruitment, stock distribution, and maturity schedules for spot
- Conduct discard mortality studies for gears used in the recreational and commercial fisheries
- Investigate environmental covariates for recruitment and natural mortality and develop a time series of potential covariates to be used in stock assessment models

Contact

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3.20 Striped Bass (Atlantic Ocean migratory stock)

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2017
  - Overfishing: Yes
  - Overfished/Depleted: Yes (Overfished)

In 2017, the Atlantic striped bass stock was overfished and experiencing overfishing relative to the updated reference points defined in the 2018 assessment. Female spawning stock biomass (SSB) was estimated at 151 million pounds, below the SSB threshold of 202 million pounds. Total

fishing mortality was estimated at 0.31, above the fishing mortality threshold of 0.24. Despite recent declines in SSB, the stock is still above the SSB levels observed during the moratorium that was in place in the mid-late 1980s. In North Carolina, the commercial fishery is managed using an annual quota, size limit, and a harvest closure for federal waters (3 to 200 miles from shore). Recreationally, striped bass are managed using size and bag limits.

Research Needs

- **Develop a spatial and temporal catch-at-age model incorporating tag-based movement information**
- Develop methods for combining tag results from programs releasing fish from different areas on different dates
- Examine potential biases associated with the number of tagged individuals such as gear-specific mortality (i.e., associated with trawls, pound nets, gill nets, and electrofishing), tag-induced mortality, and tag loss
- Continue improvements to statistical catch-at-age model as recommended by 46th Stock Assessment Review Committee (SARC; e.g., include error from catch estimates, fit each sector of removals individually, run additional diagnostics, account for spatial differences in indices, incorporate stock-recruitment relationship)
- Review the model averaging approach to estimate annual fishing mortality with tag-based models; review validity and sensitivity to year groupings

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3.21 Summer Flounder

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2022
  - Overfishing: Yes
  - Overfished/Depleted: No

The 2023 summer flounder management track stock assessment indicated the stock was not overfished and overfishing was occurring relative to 2022 reference points. Data analyzed by the Northeast Fisheries Science Center indicated that projections from the previous assessment were slightly overoptimistic, underestimating fishing mortality and underestimating biomass. In North Carolina, the summer flounder commercial catch at age and juvenile abundance index from the NCDMF Pamlico Sound Trawl Survey provides the age and recruitment indices used in the annual coastwide stock assessment for summer flounder. Both commercial landings and recreational harvest in North Carolina have generally declined since 2014.

Research Needs

- Collect information on fecundity of the stock
- Determine stock structure of juvenile summer flounder within Pamlico Sound
- Incorporate sex-specific differences in size at age into the stock assessment

Contact

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3.22 Wahoo

Stock Overview

- Stock Assessment: No
- Terminal Year of Last Assessment: N/A
  - Overfishing: N/A
  - Overfished/Depleted: N/A

Currently, no formal stock assessment on wahoo in the U.S. Atlantic has been accepted for management. Lack of fisheries-independent data, uncertainties in the boundaries of the stock, the life cycle of the fish, and the lack of jurisdictional cooperation necessary to fully characterize the harvest across the range of the species make stock determination arduous. Time-series data of catch and size of individuals in the fishery indicate no decline of stock abundance or substantial decrease in average size of fish. Wahoo are a fast growing, early maturing fish with high recruitment and these life history characteristics may allow for wahoo to be resilient to fishing mortality.

Research Needs

- **Identify essential fish habitat and evaluate its importance to all life history stages of the species**
- **Collect age, length, and reproductive data to improve estimates of growth, fecundity, etc.**
- **Investigate the high levels of uncertainty in interannual variation in abundance of wahoo through examination of oceanographic and other environmental factors**
- Investigate assessment needs for the species
- Investigate potential for developing fishery-dependent indices of abundance

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3.23 Weakfish

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2017
  - Overfishing: No
  - Overfished/Depleted: Yes (Depleted)

A stock assessment update was completed in 2019, and results indicated that the stock of weakfish along the U.S. Atlantic coast is depleted, but removals due to fishing were not at a level that was of concern. For example, in North Carolina, the recreational fishery is restricted to one fish per day. Natural mortality for this species (mortality due to factors other than fishing) was high and is most likely contributing to the slow rebuilding of the stock. In addition, the stock assessment uses total mortality benchmarks, which includes both fishing and natural mortality, to prevent an

increase in fishing pressure when natural mortality is high. Thus, no overfishing status was given in this latest stock assessment update. A slight increase in spawning stock biomass and an increase in recruitment (the number of age-1 fish entering the population) in the most recent years of the assessment offers some potential positive signs toward the rebuilding of the stock; sampling data from the NCDMF indicates a small increase in age-1+ weakfish in recent years.

Research Needs

- **Derive estimates of discard mortality rates and magnitude of discards for all commercial gear types from both directed and non-directed fisheries**
- **Quantify trawl bycatch; refine estimates of discard mortality based on factors such as distance from shore and other geographical differences for all sizes including below minimum size**
- **Evaluate predation of weakfish with a more advanced multi-species model (e.g., the ASMFC MSVPA or Ecopath with Ecosim) to validate estimates calculated by production models with predation-competition extensions**
- Analyze the spawner-recruit relationship and examine the relationship between adult stock size and environmental factors on year-class strength
- Develop a coast-wide tagging program to identify stocks and determine migration, stock mixing, and characteristics of stocks in over-wintering grounds; determine the relationship between migratory aspects and the observed trend in weight-at-age

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4 COASTAL HABITAT PROTECTION PLAN RESEARCH PRIORITIES

Research Needs

Healthy fish habitat is vital for sustaining fish populations. The N.C. Coastal Habitat Protection Plan (CHPP) is a Department of Environmental Quality (DEQ) document that requires all the DEQ divisions with authority over coastal habitat and water quality management to assist with drafting the plans (G.S. 143B-279.8). The statute requires the plan be reviewed and amended as necessary on five-year cycles with the goal of long-term enhancement of coastal fisheries associated with each coastal habitat. Habitat related information gaps and research needs are identified through the plan update process. These may relate to habitat function, condition, distribution change, linkages between habitats and specific fish species, or the effect of factors influencing habitat condition. The 2021 CHPP selected five priority issues to focus efforts on over the next five years. Research related to furthering progress on these issues are the highest current priorities; however, there are also research needs on different topics.

Comprehensive mapping and monitoring of coastal fish habitats is critical to understanding status and trends of not only habitat but the fishery species that depend upon them; however, regular habitat assessments are currently limited due to resources. The specific research needs listed below will address specific data gaps and guide establishment of regular habitat monitoring protocol. They do not replace the need for a Coastal Habitat Assessment Program (CHAP) with dedicated positions and funding for regular monitoring of SAV, wetlands, oyster reefs, and Strategic Habitat Areas remains a high priority for sound habitat management.

4.1 Priority: Submerged Aquatic Vegetation (SAV) Protection and Restoration through Water Quality Improvements

- Determine the loading and sources of nutrients and sediments, their quantitative linkages to chlorophyll *a* concentrations, and their effect on water quality and SAV. This should include runoff and subsurface flow of nutrient enriched groundwater from all land use activities.
- Obtain updated accurate estuarine bathymetry data from the National Oceanic and Atmospheric Administration (NOAA).
- Investigate the impacts of agricultural practices and land use change on water quality within SAV waterbody regions to determine types and location of best management practices (BMPs) needed to effectively improve water quality.
- Determine the relationship among SAV species extent, distribution, and composition and the effect of climate change.
- Assess the relationship between light attenuation and concentrations of color dissolved organic matter (CDOM), turbidity, and chlorophyll *a* in oligohaline waters so that an accurate bio-optical model for low salinity SAV can be developed.

4.2 Priority: Wetland Protection and Restoration through Nature-Based Solutions

- Develop or complete coastal vulnerability assessment tools for the N.C. coastal plain, such as siting for living shoreline suitability, marsh migration corridors, and wetland restoration prioritization.
- Determine optimal parameters for thin layer sediment deposition to ensure wetland success.
- Assess trends in salt marsh elevation, inundation, and distribution to prioritize areas for wetland restoration.
- Determine the impact of degrading plastics and marine debris on wetlands, sediment, and the benthos.
- Research the nutrient (nitrogen, phosphorus) reduction benefits provided by living shorelines and use that information to provide incentives for living shoreline projects.

4.3 Priority: Wastewater Infrastructure Solutions for Water Quality Improvement

- Research alternative wastewater collection system designs that may be better suited for coastal conditions (i.e., alternative sewer systems, composting toilets).
- Research the impact of sea level rise (SLR) on Sanitary Sewer Overflows (SSOs) and sites most likely to be impacted to prioritize management strategies.

4.4 Priority: Coastal Habitat Mapping and Monitoring to Assess Status and Trends

- Identify key indicator metrics for assessing status and trends of each coastal habitat and identify data gaps and monitoring needs.
- Investigate the use of emerging mapping technologies to map and assess change in coastal wetlands efficiently and accurately.
- Examine the feasibility of expanding the benthic macroinvertebrate sampling to address spatial sampling gaps for the estuarine soft bottom benthic community condition.

- Evaluate efficacy of side-scan sonar and other remote sensing technologies to map subtidal oyster reefs.

4.5 Other research needs from the 2016 CHPP and relevant to 2021 priorities

- Determine the effect of sedimentation in the upper estuaries on primary and secondary productivity and juvenile nursery function.
- Work with NCDOT to identify road ditches that drain to estuarine waters. Prioritize those that are contributing significant amounts of sediment to waterbodies with sensitive resources, such as designated nursery areas, oyster reefs, or submerged aquatic vegetation.
- Collect data on fish and habitat condition within identified strategic habitat areas (SHAs) in regions 1 and 2 to verify their condition and relative impact of known alterations.
- Assess fish use (abundance, diversity, seasonality) in low-salinity SAV habitat (native and non-native) in North Carolina to better understand the importance of this habitat in oligohaline systems, and how fish respond to inter-annual fluctuations.
- Assess anthropogenic and environmental factors restricting successful river herring migration to spawning grounds.
- Quantify the extent and frequency that bottom in Pamlico Sound is trawled and the effect on benthos.
- Assess effect of agricultural flood control (diking, drainage canals, and active pumping of stormwater) on the condition of designated Primary Nursery Areas in Hyde County and whether conditions in the creeks and upper ditched waterbodies are still suitable and being used as nursery areas.
- Assess the effect of mine dewatering (associated with mines or rapid infiltration systems) on estuarine nursery area habitat and floodplain wetlands.
- Conduct research on low-impact development, best management practices, and other strategies to reduce nonpoint runoff to shellfish waters.
- Assess concentration, and prevalence of endocrine disrupting chemicals in estuarine waters and fishery species, particularly in blue crab and oysters.

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5 HABITAT AND ENHANCEMENT RESEARCH PRIORITIES

5.1 Oyster Sanctuaries

Research Needs

- Define minimum and optimal restoration targets for oyster population density, length-frequency, and reef population size for the Oyster Sanctuary Program
- Improve estimates of long-term population demographic trends at oyster sanctuaries and compare with trends at other oyster reef types (cultch-planting, natural)
- Evaluate effects of oyster sanctuaries on overall oyster populations in North Carolina and their role in Eastern Oyster fishery management.

- Develop sampling methodology to evaluate mortality rates and disease prevalence on sanctuary sites and compare these measures, along with density and length-frequencies, to naturally occurring oyster reefs.
- Using a multivariable modeling approach, analyze environmental factors that may play a role in influencing oyster density and population structure on sanctuary sites.

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5.2 Cultch Planting

Research Needs

- Define minimum and optimal restoration targets for oyster population density, length-frequency, and reef population size for the Cultch Planting Program
- Evaluate impacts of mechanical harvest gear on cultch habitat quality, relative to other gear types
- Scale up habitat mapping to evaluate material retention and effective longevity of cultch sites
- Estimate commercial use of cultch sites and their contribution to annual landings
- Determine optimal reef structure and composition for reef longevity while maintaining harvestability
- Evaluate the role of cultch planting in eastern oyster fishery management and the program's effect on the fishery

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5.3 Artificial Reefs

Research Needs

- Evaluate temporal changes in fish assemblages on artificial reefs.
- Evaluate connectivity between artificial reefs and natural hard bottom habitats, including possible trends associated with artificial reefs sapping fish biomass from natural reefs ("attraction hypothesis"). Information is specifically needed for a broad spatial scale, surveying reef sites in all five artificial reef regions.
- Quantify fishing pressure on artificial reefs by recreational fishers.

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6 SOCIO-ECONOMIC RESEARCH PRIORITIES

Research Needs

- Community reliance studies on commercial fishing operations and fishing communities
- Collect operating costs and sales data on bait/tackle stores to measure economic impacts on the North Carolina economy

- Develop a stated preference valuation survey, revealed preference valuation survey, willingness to pay survey, or contingent valuation survey on artificial reefs of North Carolina to determine the value of these ecosystems to the public and the state economy at-large
- Develop a stated preference valuation survey of recreational anglers' willingness to pay as well as marginal utility of targeting and harvesting select finfish species
- Studies on novel seafood products on market, consumer preferences and willingness to pay for seafood products, and barriers to marketing and scaling new seafood products

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