

Research Priorities for the North Carolina Division of Marine Fisheries for 2021

Biological Review Team Research Priority
Subcommittee

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N.C. DIVISION OF MARINE FISHERIES

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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 biological data and management knowledge gaps can create uncertainty about stock assessment model estimations. To better inform stock assessment analyses and refine potential management approaches, species-specific research priorities are distinguished by 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 North Carolina Division of Marine Fisheries (NCDMF) directly develops fishery management plans (FMPs) for fourteen stocks and partners with interjurisdictional agencies to manage at least another twenty-four fisheries. All these species have associated research priorities that are 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 that are determined to be critical for upcoming assessments. For species managed within North Carolina, research needs that have been 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) has been included. Several species are short lived with variable annual recruitment and are considered an annual crop. While no traditional stock assessment is conducted for these short-lived species, research priorities regarding understanding of population dynamics and habitat effects are still necessary for implementing management strategies.

The purpose of this document is to publicize research needs, identified by NCDMF, for marine species managed within North Carolina. Researchers are encouraged to propose scientific examinations that 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 all regions of the state; although a promising uptick was seen in October 2020 sampling in Core Sound. The main harvest season (last Monday in

January through April 1) was not opened in any regions of the state in 2020 due to limited availability of scallops.

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@ncdenr.gov or 1-800-682-2632 or (252) 808-8193.

2.2 Blue Crab

Stock Overview

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

Results of the most recent stock assessment, which included data from 1995 to 2016, passed peer review and determined the stock was 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 assessment methods that can account for these environmental factors**
- Develop better estimates of life-history parameters, especially growth and natural mortality
- Collect information on diamondback terrapin interactions with the crab pot fishery statewide
- Conduct gear research to minimize bycatch of prohibited blue crabs and other species

Contact

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2.3 Eastern Oyster

Stock Overview

- Stock Assessment: None
- 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 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 since prolonged exposure of oysters to some environmental variables can impact regional population dynamics

Contact

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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 could not be determined. Commercial harvest has averaged approximately 24.5 million clams over the past 26 years but have steadily declined since 2014. Annual landings in 2019 were the lowest in the 26-year period at 6.1 million clams. Little recreational harvest data on hard clams has 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 clams per sampling site from 2008 to 2020 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
- Survey commercial shellfish license holders without a record of landings to estimate hard clam harvest from this group

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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 a knowledge about migration dynamics, no traditional stock assessment analysis is conducted for kingfishes. 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 priority for southern kingfish
- Conduct an age validation study with priority for southern kingfish

Contact

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2.6 Red Drum

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2013
- 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 NCDMF conducts several sampling surveys of red drum that provide indices of abundance for various life stages of red drum. These include a juvenile seine index, a subadult gillnet index and an adult longline index. These surveys provide critical inputs for the current stock assessment used to manage this fishery.

Research Needs

- **Determine the size and age structure of regulatory discards occurring in the recreational fishery**
- 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 covariates affecting discard mortality (e.g., depth, size, seasonality), and explore methods of determining *in situ* mortality (as opposed to tank studies) and mitigating mortality (e.g., gear types, handling methods, etc.).
- 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.
- Evaluate factors that contribute to recruitment variability, including impacts of natural environmental perturbations and spawning stock biomass.
- 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 (tackle, geographic location, bait, water temperature, seasonality, hook types, etc.)

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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

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. Recently, 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 North Carolina Division of Marine Fisheries 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 to monitor all stock status indicators outlined in the fisheries management plan**
- 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 stock assessments. 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. A coastwide (North Carolina through the east coast of Florida) stock assessment is currently under development.

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**
- **Conduct studies on size- and age-specific selectivity by gear type**
- Initiate a sheepshead tagging program to develop estimates of growth, natural mortality, fishing mortality, and track the movement of adults throughout the stock's range; include methods to estimate tag retention, reporting rate, and tagging-induced mortality
- Determine the patterns and triggers of inshore-offshore migrations

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 species that exhibit highly variable annual recruitment abundance; 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 industry.

Research Needs

- **Create a long-term shrimp trawl observer program to characterize bycatch across all strata (for example: dominant species, protected species, season, areas, gear type, vessel type, number of nets/rigs, headrope length, TED position, etc.).**
- **Determine the cumulative impacts of shrimp trawl bycatch on fish population dynamics and the ecosystem**
- **Develop and test methods to reduce bycatch in the commercial and recreational shrimp trawl fisheries**
- Develop alternative non-bottom disturbing gears to efficiently catch shrimp
- Create and validate juvenile abundance indices for white and pink shrimp

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

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 to be 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 independent surveys that are used to create an index of general (juvenile and adult) abundance.

Research Needs

- **Implement a tagging study to estimate immigration, emigration (unit stock), and mortality rates**
- **Develop a fisheries-independent survey of 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: 2012
- Overfishing: No
- Overfished/Depleted: No

Spotted seatrout is one of the most commonly targeted recreational fish species in North Carolina and is also harvested, mostly as bycatch, by a number of different commercial fisheries. The 2014 North Carolina spotted seatrout stock assessment indicated that the stock in North Carolina and Virginia is not overfished and overfishing is not occurring. The stock is currently managed using size and bag 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 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 the number, size, age, and disposition of commercial discards**
- 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 and Roanoke River Management areas)

Stock Overview

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

Results from the 2020 benchmark stock assessment update 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. 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

- **Estimate delayed discard mortality from the Albemarle Sound Management Area commercial gill net fisheries**
- Improve estimates of catch-and-release discard losses in the recreational fishery during the closed harvest season
- Investigate relationship between river flow and striped bass recruitment for consideration of input into future stock assessment models
- Evaluate the contribution of the Albemarle Sound-Roanoke River stock to the Atlantic Migratory stock to inform future stock assessments
- Investigate the potential impact of blue catfish on the A-R striped bass population (e.g., habitat, predation, forage)

Contact

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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 a 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 this striped bass stock.

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**
- Develop better estimates of life-history parameters, especially growth and factors influencing rates of natural mortality for all striped bass life stages
- Determine factors impacting survivability of stocked fish in each system

Contact

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2.14 Striped Mullet

Stock Overview

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

Based on results of the 2017 stock assessment update, the striped mullet stock was not experiencing overfishing, but the overfished status could not be determined. Since 2015, the striped mullet commercial fishery has been managed using minimum and maximum commercial landings triggers of 1.13 million pounds and 2.76 million pounds, respectively. If landings fall below the minimum trigger, the NCDMF initiates further analysis of the data to determine if the decrease in landings is attributed to stock decline, decreased fishing effort, or both. If landings exceed 2.76 million pounds, the division initiates analysis to determine if harvest is sustainable and assess what factors are driving the increase in harvest. In 2016, commercial landings fell below the minimum trigger initiating further analysis of the data and completion of the stock assessment update. Fisheries-independent sampling of adult striped mullet is conducted through the Striped Mullet Electrofishing Survey and the Independent Gill Net Survey.

Research Needs

- **Create and validate a juvenile abundance index for striped mullet**
- **Initiate a striped mullet tagging program to estimate fishing and natural mortality and the unit stock; include evaluations of tag retention, tagging mortality, and tag reporting rates**
- Initiate an acoustic tagging study to determine spatial and temporal variations in habitat use throughout the state
- Initiate how catchability of striped mullet by electrofishing gear (specifically NCDMF Program 146) is affected by variations in salinity and conductivity
- Improve recreational fisheries statistics to reliably characterize the magnitude, length, and age structure of recreational fisheries losses

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: 2016
- Overfishing: Unknown
- Overfished/Depleted: Yes (Depleted)

Stock status of American eel is poorly understood due to limited stock assessment results and non-standard sampling protocols across the species' range. An update to the 2012 benchmark stock assessment conducted in 2017 indicated the stock is at or near historically low levels due to a combination of historical overfishing, habitat loss, predation, turbine mortality at hydroelectric dams, environmental changes, toxins, contaminants, and disease. No range-wide estimate of abundance exists and reliable indices of abundance for this species are scarce. The ASMFC is in the early stages of conducting a new benchmark stock assessment for American eel.

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 fish way designs for passage of eel
- Investigate various life stage survival and mortality to assist in the assessment of annual recruitment

Contact

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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 that the adult status for total mortality rate in the Albemarle Sound and Neuse River systems is sustainable. An 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 coastwide metapopulation abundance was determined to be depleted based on the decline in coastwide 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-the-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 catch per unit effort and fishing mortality from fisheries-independent surveys. As of 2019, annual updates to sustainability parameters have not triggered further management measures. Annual updates for 2020 are unavailable due to incomplete sampling in response to the Covid-19 pandemic.

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 10 years. In North Carolina, a juvenile abundance index for Atlantic croaker is obtained based on catch per unit effort from the NCDMF Pamlico Sound Survey (Program 195).

Research Needs

- **Collect bio-profile 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: 2017
- Overfishing: No
- Overfished/Depleted: No

The Atlantic menhaden fishery provides 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 based on sustaining Atlantic striped bass at their biomass target and threshold. The 2020

benchmark stock assessment determined the stock was neither overfished nor experiencing overfishing. In North Carolina, a juvenile index of relative abundance for menhaden is obtained based on a catch per unit of effort from the NCDMF Pamlico Sound Independent Gill Net Survey.

Research Needs

- **Conduct diet analysis of species that predate on 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 coastwide and at the distinct population segment level relative to historic abundance; however, on a coast-wide basis the 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 program to identify abundance and age composition of 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 Sea Bass (north of Cape Hatteras)

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2018
- Overfishing: No
- Overfished/Depleted: No

Black sea bass (north of Cape Hatteras) is a popular commercial and recreational fishery in the mid-Atlantic region. In 2018, North Carolina commercial landings represented over a million dollars in revenue. Both commercial and recreational harvest have been increasing since 2014. The 2019 black sea bass operational stock assessment determined the stock to be neither overfished nor experiencing overfishing. In North Carolina, there is currently no active survey that directly estimates a juvenile abundance index for this stock. Black sea bass south of Cape Hatteras are managed by the South Atlantic Fishery Management Council and included in the snapper grouper complex (see section 3.15 Snapper Grouper Complex).

Research Needs

- **Evaluate population sex change and sex ratio, particularly comparing dynamics among communities**
- **Investigate and document social and spawning dynamics**
- **Increase work to understand habitat use and seasonal changes**
- 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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3.7 Black Drum

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2012
- Overfishing: No
- Overfished/Depleted: No

Generally, harvest of black drum in North Carolina coincided with the seasonal migration of black drum as they move northward and inshore each spring and southward and offshore by late fall. The 2015 ASMFC black drum stock assessment determined that the stock is not overfished and not experiencing overfishing. In North Carolina, a relative index of abundance for black drum is obtained based on a catch per unit of effort from the NCDMF Pamlico Sound Independent Gill Net Survey. This index, an input in the 2015 benchmark stock assessment, provides an indication of relative stock abundance for black drum in Pamlico Sound.

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 implanted radio tracking tags that are compatible with coastal tracking arrays along the Atlantic coast in order 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

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3.8 Bluefish

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2018
- Overfishing: No
- Overfished/Depleted: Yes

An operational stock assessment, completed in 2019, indicates that bluefish are overfished but are not experiencing overfishing. The stock is broadly managed using a coast-wide quota. As a result of the 2019 assessment, reductions in the coastwide quota have been enacted for the 2020 and 2021 fishing years and the Mid-Atlantic Fishery Management Council is in the process of developing a plan to restore the stock to its target spawning stock biomass levels. The North Carolina relative index of abundance for bluefish is obtained from the NCDMF Pamlico Sound Independent Gill Net Survey. This index was used as part of the 2019 operational stock assessment.

Research Needs

- **Evaluate magnitude and length frequency of discards from the commercial and recreational fisheries**
- **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. Nine species' stocks have been assessed in the United States in the Atlantic Ocean, three species have been reviewed internationally, and the remaining 32 species have not yet been evaluated. Species-specific overfished status has been designated for shortfin mako, sandbar shark, porbeagle shark, blacknose shark, dusky shark, and scalloped hammerhead shark. Overfishing status has been designated for the shortfin mako, scalloped hammerhead, blacknose, and dusky shark.

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 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

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3.10 Cobia

Stock Overview

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

The most recent cobia stock assessment, conducted in 2019 with data through 2017, indicated that the stock is not overfished and not undergoing overfishing; however, spawning stock biomass declined in the last several years of the 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.

Research Needs

- **Institute fisheries independent sampling programs to obtain estimates of cobia abundance**
- **Better characterize the life history of cobia including age sampling of the recreational sector, update age-and length-at-maturity, batch fecundity, spawning seasonality, and spawning frequency information**
- Obtain more precise and timely estimates of harvest from the Atlantic cobia recreational fishery
- Investigate release mortality and fishing mortality within the commercial and recreational fisheries
- Increase reporting of recreational harvest and better characterize the recreational and for-hire fisheries

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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 are 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 hickory shad in North Carolina or a coast-wide assessment by the ASMFC; therefore, the population size of hickory shad and the rate of removal from the population 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

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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/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

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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 that the status of both the North and South monkfish stocks are unknown. During the 2016 monkfish stock assessment, scientific evidence suggested that 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 remains 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

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3.15 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), red grouper, and snowy grouper. Stocks experiencing overfishing are: American red snapper, speckled hind, Warsaw grouper, red 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 by 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>)

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3.16 Scup (north of Cape Hatteras)

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2018
- Overfishing: No
- Overfished/Depleted: No

The 2019 scup operational stock assessment indicated the stock was not overfished and overfishing was not occurring in 2018. 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 directed fisheries-independent monitoring for 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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3.17 Spanish Mackerel

Stock Overview

- Stock Assessment: Yes
- Terminal Year of Last Assessment: 2012
- Overfishing: No
- Overfished/Depleted: No

The most recent Spanish mackerel stock assessment, conducted in 2012, indicated that the stock was not overfished, and overfishing was not occurring. Additionally, estimates of stock size have been steadily increasing since 1995 with observed fishing mortality decreasing since the early 1990s. 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 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/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 coast-wide quota. The 2018 stock assessment update, conducted by the NOAA Northeast Fisheries Science Center (NEFSC), determined spiny dogfish are not overfished and not experiencing overfishing. In North Carolina commercial landings have decreased since 2014 and recreational landings remain low.

Research Needs

- **Determine area, season, and gear-specific discard mortality estimates coast wide 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 10 years. In North Carolina, a juvenile abundance index for spot is obtained based on catch per unit effort 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**
- Investigate the effects of environmental changes on maturity schedules for spot
- Conduct discard mortality studies for gears used in the recreational and commercial fisheries
- Conduct an age validation study and expand collection of life history data
- Investigate environmental recruitment and natural mortality covariates 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

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 0.307, above the fishing mortality threshold of 0.240. 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 model averaging approach to estimate annual fishing mortality with tag-based models; review validity and sensitivity to year groupings

Contact

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3.21 Summer Flounder

Stock Overview

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

The 2018 summer flounder benchmark stock assessment indicated that the stock was not overfished, and overfishing was not occurring. SSB was well above the threshold while fishing mortality was below the threshold and recruitment was below average since 2011. 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 coast-wide 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 summer flounder within Pamlico Sound
- Develop a program to annually sample the length and age frequency of discards from the recreational fishery

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

Contact

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3.23 Weakfish

Stock Overview

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

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 are not at a level that is 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 positive signs toward the rebuilding of the stock; sampling data from the NCDMF indicates a small increase in age-0 and 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

The 2016 Coastal Habitat Protection Plan (CHPP) selected four priority issues to focus efforts over the next five years. These priority issues are: oyster restoration, living shorelines, sedimentation, and generating metrics. Habitat research priorities include topics that address these priority issues as well as other research related to ecosystem functions and threats. The CHPP was drafted in cooperation with several divisions under the Department of Environmental Quality, making these research priorities applicable to these divisions, academia, other potential research partnerships as well as NCDMF. After the 2021 CHPP Amendment is approved, the research priorities will be updated for 2022.

- Examine the effectiveness and long-term stability of natural and nature-based methods for shoreline stabilization and ecosystem enhancement, particularly after storm events. Assessments are needed across the spectrum of biotic composition and hardness. This information can be used to map and model areas where living shorelines would be ecologically and economically preferred to traditional erosion methods (Priority: Living Shorelines)
- Investigate and determine magnitude and change in sedimentation rates and sources, especially in the upper estuaries on primary and secondary productivity and juvenile nursery function. Also examine the effectiveness of current vegetated buffers in the coastal plain and the design needed to limit sediment and nutrient inputs into estuarine waters (Priority: Sedimentation)
- Conduct fish and habitat sampling to validate selected Strategic Habitat Areas in the Albemarle and Pamlico regions, using established NCDMF monitoring protocol (Program 215). Analyze data to assess productivity of Strategic Habitat Areas and to provide data on coastal habitat metrics occurring in the region (water column, shell bottom, SAV, wetlands, soft bottom, hard bottom) (Priority: Generating Metrics)
- Expand habitat mapping and monitoring for North Carolina estuarine waters. Focus on developing remote sensing mapping and monitoring methods for coastal habitats, to develop indicator metrics, improve our ability to report the status and trends, and assess change over time (Priority: Oyster Restoration & Generating Metric)
- Quantify the extent and frequency of bottom trawls in North Carolina sounds and rivers (especially Pamlico Sound) and their effect on benthos (Priority: Ecosystem Functions and Threats, Physical Threats to Habitats)
- Identify obstructions to diadromous fish spawning migration routes, including culverts, altered water flow conditions, and dams, and assess criteria needed for successful fish migration to spawning grounds (Priority: Ecosystem Functions and Threats, Hydrological Alterations)
- Assess effect of agricultural flood control on the condition of designated Primary Nursery Areas and/or submerged aquatic vegetation (Priority: Ecosystem Functions and Threats, Hydrological Alterations)
- Investigate the source(s) contributing to increased occurrence of algal blooms in coastal river systems, particularly the Chowan, Tar-Pamlico, and Cape Fear rivers and means of

reducing prevalence and severity of such blooms in the future (Priority: Ecosystem Functions and Threats, Water Quality Impacts)

- Develop a network of continuous water quality monitoring stations across coastal North Carolina with focus on the Albemarle and Pamlico sound systems to better evaluate long-term water quality conditions in these critical estuarine systems (Priority: Ecosystem Functions and Threats, Water Quality Impacts)
- Evaluate habitat and juvenile fish productivity in areas with and without existing nursery area designations to determine if designation changes are needed (Priority: Ecosystem Functions and Threats, Water Quality Impacts)
- Quantify the impact of water quality degradation and habitat loss on fishery species in North Carolina (Priority: Ecosystem Functions and Threats, Water Quality Impacts)

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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
- Develop monitoring metrics and simple methods for surveying multi-substrate oyster sanctuaries that provide relevant data for determining sanctuary performance and longevity
- Assess the current distribution and production of oyster sanctuaries to guide future sanctuary construction

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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
- 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

Contact

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5.3 Artificial Reefs

Research Needs

- Develop reference tools to guide new enhancement decision-making toward positive biological impacts. Evaluate temporal changes in fish assemblages or connectivity to other hard bottom habitats. Information is specifically needed for a broad spatial scale, surveying reef sites in all five artificial reef regions.

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6 SOCIO-ECONOMIC RESEARCH PRIORITIES

Research Needs

- 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
- Estimates on consumer demand preference for local seafood, including influence of price premiums and labelling effects
- Community reliance studies on commercial fishing operations and fishing communities
- Studies on commercial fishing gear manufacturers and the economic impact of this market within North Carolina
- Profile of North Carolina shellfish mariculture industry in relation to cost structure and contribution to state economy

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