Atlantic States Marine Fisheries Commission

Research Priorities and Recommendations to Support Interjurisdictional Fisheries Management

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Sustainable and Cooperative Management of Atlantic Coastal Fisheries

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Input is also provided by the Commission's Habitat Committee, Committee on Economics and Social Sciences, and Management and Science Committee. The research topics listed in this publication are consistent with those developed by the National Marine Fisheries Service Northeast Fisheries Science Center for organization and classification of Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) research recommendations. The Commission extends its appreciation to the members of the Management and Science Committee for providing oversight to the effort to identify and prioritize Commission research needs.

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Preface

Research priorities listed in this document were identified from Atlantic States Marine Fisheries Commission (Commission) fishery management plans and amendments, annual plan reviews, special reports conducted by the Commission on species technical and stock assessment issues, Commission external peer reviews, and Stock Assessment Workshop (SAW) documents by the Stock Assessment Review Committee (SARC, since 1996) in the Northeast US and SouthEast Data, Assessment and Review (SEDAR, since 2002) process in the Southeast US in collaboration with the National Marine Fisheries Service. This publication is a living version of Special Report #89 Research Priorities and Recommendations to Support Interjurisdictional Fisheries Management published by the Commission in 2013. Updates are completed after each new assessment via the Commission's website at www.asmfc.org. Research Priorities for each species are also available on individual species' pages.

Research priorities were prioritized by Commission stock assessment subcommittees and technical committees under the purview of the Plan Development/Review Teams. Additional input to priorities is provided periodically by Advisory Committees, Management Boards, the Habitat Committee, the Committee on Economics and Social Sciences, and the Management and Science Committee.

It is the intent of the Commission to continually update this document as research priorities are either met or as new research needs are identified. The overall purpose of this document is to encourage state, federal, and university research programs to develop projects to meet the research priorities of Commission-managed species and thereby improve the overall management of these fisheries. It is also hoped that state, federal, and non-profit organizations will utilize this document in prioritization of research projects for future funding programs.

Abbreviations and Acronyms

ACCSP	Atlantic Coastal Cooperative Statistics Program
ASMFC	Atlantic States Marine Fisheries Commission
ASPIC	A Stock Production Model Incorporating Covariates
ASPM	Age structured production model
BMP	Best management practice
BRD	Bycatch reduction device
CAA	Catch-at-age analysis
CFD	Computer fluid dynamics
CPUE	Catch per unit effort
CSA	Collie-Sissenwine Analysis; also Catch Survey Analysis
DFO	Department of Fisheries and Oceans (Canada)
DO	Dissolved oxygen
EFH	Essential Fish Habitat
F	Instantaneous fishing mortality rate
FERC	Federal Energy Regulatory Commission
FMP	Fishery Management Plan
GIS	Geographic Information Systems
GLM	Generalized linear model
GLOBEC	Global Ocean Ecosystems Dynamics
GPS	Global Positioning System
HAPC	Habitat areas of particular concern
IPN	Infectious pancreatic necrosis
LPUE	Landings-per-unit-effort
M	Instantaneous natural mortality rate
MARMAP	Marine Resources, Monitoring, Assessment, and Prediction
MCMC	Markov chain Monte Carlo
MEDMR	Maine Department of Marine Resources
MRIP	Marine Recreational Information Program
MSE	Management Strategy Evaluation
MSVPA	Multispecies virtual population analysis
MSY	Maximum sustainable yield
NEAMAP	Northeast Area Monitoring and Assessment Program
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCC	Northeast Regional Coordinating Council
PCB	Polychlorinated biphenyl
PIT	Passive integrated transponder
PRFC	Potomac River Fisheries Commission
SARC	Stock Assessment Review Committee

SCA	Statistical catch-at-age
SCDNR	South Carolina Department of Natural Resources
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	SouthEast Data, Assessment, and Review
SS	Stock Synthesis
SSB	Spawning stock biomass
TAL	Total allowable landings
TIP	Trip Interview Program
TOR	Terms of Reference
TRAC	Transboundary Resources Assessment Committee
USFWS	United States Fish and Wildlife Service
VPA	virtual population analysis
VT	Virginia Tech University
VTR	Vessel Trip Reporting
YOY	Young-of-the-year
YPR	Yield-per-recruit

Annual Monitoring Programs

Annual monitoring programs are a critical component of stock assessments and resource management. These programs include both fishery-dependent monitoring, such as catch and effort reporting and biological sampling, and fishery-independent monitoring, such as surveys that track abundance and biological characteristics (e.g., growth, maturity) that vary over time. Without annual monitoring, stock assessment scientists' ability to detect and account for this variability is degraded and assessment results will be less certain.

In the species-specific research priorities that follow, for species where the current level of annual monitoring is inadequate, recommendations to increase sampling levels, develop new surveys, etc. are provided. However, the Atlantic States Marine Fisheries Commission stresses that maintaining current levels of annual monitoring is vital for all species.

Fishery-dependent monitoring programs provide essential information for stock assessments every year. While knowing how many fish are removed by the commercial and recreational fisheries is important, annual biological sampling from the catch provides information on growth, reproduction, mortality, and the size, age, and movement of fish. For example, annual age-length keys remain the standard for age-based assessments. However, pooling data across years to fill gaps when annual monitoring is not conducted should be avoided. For example, interannual variability in year-class strength results in differing proportions of age-at-length keys from year to year, therefore, when data are pooled across years, the keys will not be able to accurately separate age-classes in the catch, making strong year-classes appear weaker and weak year-classes appear stronger. This makes the estimates of fishing mortality, recruitment, and abundance from age-structured models less reliable. For similar reasons, it is important to collect length frequency data on the catch every year and to provide the most accurate annual data on what components of the population are being harvested and/or being subjected to discard mortality.

Fishery-independent monitoring should also be conducted every year and maintained over time. Fishery-independent surveys provide information on annual year-class strength, which is important to monitor every year given the interannual variability of recruitment in marine and anadromous populations. Fishery-independent monitoring also allows us to track changes in abundance from year to year, compare that to trends in annual harvest, and assess the impact of fishing on the population annually. In addition, fishery-independent monitoring is an important source of biological data, especially for very small and very large fish that are not well-represented in the catch sampling and for fisheries where collecting hard parts is expensive or time-consuming. As a result, fishery-independent monitoring helps supplement fishery-dependent sampling to develop more complete age-length keys. Fishery-independent monitoring can also provide data on species with closed fisheries (or low quotas). It can provide data for areas closed to commercial fishing regulations, which are data that would not be obtained at all or in a large enough sample size by fishery-dependent monitoring.

As the focus of fisheries management expands from single-species to ecosystem-based fisheries management, the need for information that fisheries-independent monitoring provides has also increased significantly. For example, in addition to the ongoing baseline data required for effective management of recreational and commercial fisheries, improved information is needed on predator and prey species' life histories and interactions, essential fish habitat needs, and environmental conditions. This information is vital to enhancing fisheries management and is captured by annual fisheries-independent monitoring programs.

In addition to enhancing fisheries management, question-specific research projects can build on and/or compliment these monitoring programs. While annual monitoring programs are a significant investment of time and money, they are the cornerstone of reliable assessments and management decisions, and are a high research priority for the Commission.

Research Priorities by Species/Species Complex

AMERICAN EEL

Fishery-Dependent Priorities

High

- Monitor catch and effort in bait fisheries (commercial and personal-use) and in personal-use fisheries that are not currently covered by MRIP or commercial fisheries monitoring programs.
- Improve knowledge of the proportion of the American eel population and the fisheries occurring south of the US that may affect the US portion of the stock.
- Require standardized reporting of trip-level landings and effort data for all states in inland waters. Data should be collected using the ACCSP standards for collection of catch and effort data (ACCSP 2004).
- Compare buyer reports to reported state landings.
- *Moderate*
- Collect site specific information on the recreational harvest of American eel in inland waters, potentially through expansion of MRIP to riverine/inland areas.
- Monitor discards in targeted and non-targeted fisheries.
- Require states to collect fishery-dependent biological information by life stage, potentially through collaborative monitoring and research programs with dealers. Samples should be collected from gear types that target each life stage.[1]
- Review the historical participation level of subsistence fishers and relevant issues brought forth with respect to those subsistence fishers involved with American eel to provide information on the changing exploitation of American eels.
- Investigate American eel harvest and resource by subsistence harvesters (e.g., Native American tribes, Asian and European ethnic groups).

Fishery-Independent Priorities

High

- Maintain and update the list of fishery-independent surveys that have caught American eels and note the appropriate contact person for each survey.
- Request that states record the number of eels caught by fishery-independent surveys. Recommend states collect biological information by life stage including length, weight, age, and sex of eels caught in fishery-independent sampling programs; at a minimum, length samples should be routinely collected from fishery-independent surveys.
- Encourage states to implement surveys that directly target and measure abundance of yellow and silver stage American eels, especially in states where few targeted eel surveys are conducted.
- Develop a coastwide sampling program for yellow and silver stage American eels using standardized and statistically robust methodologies.

[1] SASC is developing a draft protocol for sampling fisheries.

- Continue the ASMFC-mandated YOY surveys; these surveys could be particularly valuable as an early warning signal of recruitment failure. Standardize sampling across all surveys. Develop proceedings document for the 2006 ASMFC YOY Survey Workshop. Follow-up on decisions and recommendations made at the workshop.

Moderate

- Develop standardized sampling gear, habitat, and ageing methods and conduct intensive age and growth studies at regional index sites to support development of reference points and estimates of exploitation.

Modeling / Quantitative Priorities

High

- Perform periodic stock assessments (every 5-7 years) and establish sustainable reference points for American eel required to develop a sustainable harvest rate in addition to determining whether the population is stable, decreasing, or increasing. Investigate if a longer time interval (8-10 years) between assessments will improve population trend estimates. Longer time periods may better reflect eel generation time.
- *Moderate*
- Develop new assessment models (e.g., delay-difference model) specific to eel life history and fit to available indices.
- Develop GIS-type model incorporating habitat type, abundance, contamination, and other environmental factors.

Life History, Biological, and Habitat Priorities

High

- Monitor non-harvest losses due to barriers such as impingement, entrainment, spill, and hydropower turbine mortality.
- Develop, investigate, and improve technologies for upstream and downstream American eel passage at various barriers for each life stage. Identify effective low-cost alternatives to traditional passage designs. Develop design standards for upstream passage devices.[2]
- Evaluate the impact, both upstream and downstream, of barriers to eel movement with respect to population and distribution effects. Determine relative contribution of historic loss of habitat to potential eel population and reproductive capacity.
- Implement large-scale (coastwide or regional) tagging studies of eels at different life stages to determine growth, passage mortality, movement and migration, validated ageing methods, reporting rates, and tag shredding/tag attrition rates.[3]

[2] An ASMFC Eel Passage Workshop occurred in 2011 reviewing details on passage design.

[3] Current tagging studies are ongoing in the St. Lawrence River system. A tagging study to examine local and regional movement has been completed by a graduate student at Delaware State University.

- Identify the mechanism driving sexual determination and the potential management implications.
- Identify spatially explicit, sex specific, triggering mechanism for metamorphosis to mature adult and silver eel life stage, with specific emphasis on the size and age at onset of maturity. A maturity schedule (proportion mature by size or age) would be extremely useful in combination with migration rates.
- Improve understanding of the effects of contaminants on fecundity, natural mortality, and overall health (non-lethal population stressors). Research the effects of bioaccumulation with respect to impacts on survival and growth by age and effect on maturation and reproductive success.[4]
- Conduct research on the prevalence, incidence of infection, and effects of the swim bladder parasite *Anguillicola crassus* on American eel growth and maturation, migration to the Sargasso Sea, and spawning potential. Investigate the impact of the introduction of *A. crassus* into areas that are presently free of the parasite.

Moderate

- Recommend monitoring of upstream and downstream movement at migratory barriers that are efficient at passing eels (e.g., fish ladder/lift counts). Data that should be collected include presence/absence, abundance, and biological information. Provide standardized protocols for monitoring eels at passage facilities, coordinate compilation of these data, and provide guidance on the need and purpose of site-specific monitoring.
- Evaluate eel impingement and entrainment at facilities with NPDES authorization for large water withdrawals. Quantify regional mortality and determine if indices of abundance could be established at specific facilities.
- Assess available drainage area over time to account for temporal changes in carrying capacity and sex ratio. Develop GIS of major passage barriers.
- Assess characteristics and distribution of American eel habitat and value of habitat with respect to growth and sex determination. Develop GIS of American eel habitat in US. This will have to be a habitat-specific analysis based on past studies that show high habitat-specific variability in sex ratios within a drainage system.
- Improve understanding of within-drainage behavior and movement and the exchange between freshwater and estuarine systems.
- Improve understanding of predator-prey relationships, behavior and movement of eel during their freshwater residency, oceanic behavior, and movement and specific spawning location of adult mature eel in the Sargasso Sea. Determine if larger females have a size refuge during the freshwater phase.
- Examine the mechanisms for exit from the Sargasso Sea and transport across the continental shelf to determine implications for recruitment. Examine migratory routes and guidance mechanisms for silver eel in the ocean.
- Research mechanisms of recognition of the spawning area by silver eel, mate location in the Sargasso Sea, spawning behavior, and gonadal development in maturation.

[4] USFWS currently has a project examining maternal transfer of contaminants in American eel.

- Continue investigation of the length and weight specific fecundities of American eel.
- Examine age-at-entry of glass eel into estuaries and freshwater to determine time lag between spawner escapement and glass eel recruitment.
- Improve understanding of all information on the leptocephalus and glass stages of eel, including mode of nutrition and transport/recruitment mechanisms.
- Develop a monitoring framework to collect and provide coastwide information on the influence of environmental factors and climate change on recruitment for future modeling.

Additional Habitat Research Recommendations

- Research the behavior of silver eels at downstream passages; determine specific behavior of eels migrating downstream, and research how they negotiate and pass hydropower facilities.
- Research the behavior of American eel approaching hydropower dams to determine searching behavior and preferred routes of approach to confirm best siting options for upstream passage.
- Investigate how river flow, lunar phase, water temperature, and behavior near artificial lighting impact the behavior of American eel, and influence the amount of time that the eels spend at a dam.
- Investigate the impact of stream velocity/discharge and stream morphology on upstream migration of glass eel and elvers.
- Research the factors that cause American eel to initiate downstream migration and affect their patterns of movement.
- Examine the environmental conditions required for the hatching success of American eel.
- Research the changes in ocean climate and environmental quality that might influence larval and adult eel migration, spawning, recruitment, and survival, including oceanic heat transport and interactions with the atmosphere and greenhouse gas warming.
- Determine the importance of coastal lakes and reservoirs to American eel populations.
- Investigate the impact of seaweed harvesting on American eel.

Management, Law Enforcement, and Socioeconomic Priorities

High

- Implement a special permit for use of commercial fixed gear (e.g., pots and traps) to harvest American eels for personal use. Special-use permit holders should be subject to the same reporting requirements for landings and effort as the commercial fishery.
- Coordinate monitoring, assessment, and management among agencies that have jurisdiction within the species' range.
- Perform a joint US-Canadian stock assessment.
- Improve compliance with landing and effort reporting requirements as outlined in the ASMFC FMP for American eel.

Moderate

- Continue to require states to report non-harvest losses in their annual compliance reports.

- Conduct socioeconomic studies to determine the value of the fishery and the impact of regulatory management.
- Develop population targets based on habitat availability at the local level.

American Eel Research Priorities Identified as Being Met

- ✓ Accurately document the commercial eel fishery so that our understanding of participation in the fishery and the amount of directed effort could be known. *Trip-level reporting of catch and effort became mandatory in 2007.*
- ✓ Evaluate the use of American eel as a water quality indicator.
- ✓ Investigate practical and cost-effective methods of re-establishing American eel in underutilized habitat.

AMERICAN LOBSTER

FISHERY-DEPENDENT MONITORING

a. *Port and Sea Sampling (High priority)*

Accurate and comparable landings data are the principal data needed to assess the impact of fishing on lobster populations. The quality of landings data has not been consistent spatially or temporally. Limited funding, and in some cases, elimination of sea sampling and port sampling programs will negatively affect the ability to characterize catch and conservation discards, limiting the ability of the model to accurately describe landings and stock conditions. It is imperative that funding for critical monitoring programs continues, particularly for offshore areas from which a large portion of current landings originate in Southern New England (SNE). The Commercial Fisheries Research Foundation (CFRF) Lobster and Jonah crab Research Fleet has improved these data needs and will continue to be imperative in describing landings for future stock assessments. Programmatically, sea sampling should be increased in Long Island Sound (Statistical Area 611), and in the statistical areas in federal waters, particularly those fished by the Lobster Conservation Management Area (LCMA) 3 fleet, via a NMFS-implemented lobster-targeted sea sampling program. These fishery-dependent programs are essential for accurate lobster assessments and must have dedicated funding.

b. *Commercial Data Reporting*

Spatial Resolution (High Priority)

Spatial resolution and compliance of reporting have made it a challenge to understand how commercial harvest has varied through time. These data are paramount in understanding how landings align between statistical area and LCMAs. While this remains to be a major data need for the stock assessment, progress is anticipated to be made with Addendum 26, which will improve spatial resolution by implementing 10-minute square resolution reporting, require reporting the number of vertical lines used, and require 100% of lobster fishers to report in the near future. Vessel tracking is still in the pilot program phase, but, if found feasible and cost effective, is recommended for federal vessels. Once in place, the new spatial data should be analyzed for comparison to current spatial understanding of harvest.

Lobster versus Jonah Crab Effort (High Priority)

The growing Jonah crab fishery in SNE continues to complicate how to differentiate directed lobster versus Jonah crab effort. This phenomenon complicates understanding which species are targeted in a given trip. Truesdale et al. (2019) has begun data collection for differentiating via semi-structured interviews with fishers, but more data must be collected from sea sampling trips and reported landings to better differentiate the two fisheries' activities.

Bait Usage (Low Priority)

Shortage of Atlantic herring due to reduced herring recruitment and quotas has raised concerns on bait availability for the lobster fishery, particularly for the Gulf of Maine (GOM). However, fishers across both stocks use a variety of baits based on availability and prices. Bait use information collected as part of sea sampling trips and trip reports would provide better guidance on what is currently being used and could be included in future economic analyses of the lobster industry.

c. *Catch-per-Unit-Effort (CPUE) Indices (Low Priority*)

In SNE, lobsters appear to be shifting offshore and into deeper waters (Rheuban et al. 2017, Mazur et al. 2020, Tanaka et al. 2020); these regions have traditionally been minimally sampled, and existing surveys in the region may not fully be capturing this new redistribution in lobsters. This contraction or movement in and lack of survey overlap to the population is likely attributing to difficulties in modeling the population. CFRF ventless trap data should be explored to determine if a post-stratified CPUE index can be constructed to inform a metric of abundance trends in offshore waters.

FISHERT-INDEPENDENT MONITORING

a. *Ventless Trap Survey* (*High Priority*)

Calibration work to determine how catch in the ventless trap surveys relates to catch in the bottom trawl surveys remains an important and unaddressed topic of research. It is likely that at low densities, when trawl survey indices have dropped to near zero, ventless trap surveys will still catch lobsters due to the attractive nature of the gear and the ability to fish the gear over all habitat types. Conversely, it is possible that trawl surveys may be able to detect very high levels of lobster abundance, if trap saturation limits the capacity of the ventless traps. Ventless traps may be limited in their ability to differentiate between moderately high and extremely high abundance, and calibration with bottom trawl surveys may help to clarify how *q* might change with changes in lobster density. Currently, inference on these dynamics are limited to the estimated non-linear *q* values from the University of Maine Model (UMM), which for some surveys are sensitive and variable. A prospective starting place may be to examine the overlapping data between ventless trap and trawl catch rates in Long Island Sound (Dominion Nuclear Power Station) and Rhode Island state waters.

b. *Early Benthic Phase Lobsters (Medium Priority)*

To date, many indices for the lobster assessment have focused on spawning stock biomass, recruits, or young of the year. However, few annual abundance indices exist for early-benthic (≤ 40-50mm) and these trends have been largely unexamined by the Stock Assessment Subcommittee (SAS). Examination of available datasets and survey protocols (for consistency between surveys) should be undertaken, and if possible, such indices could be incorporated as

model-free indicators in future assessments. These may better describe changes in lobster abundance in nursery habitats across a broader portion of their life cycle.

c. *Northeast Area Monitoring and Assessment Program (NEAMAP) Trawl Survey Protocols (High Priority)*

The SAS recommends that the NEAMAP Trawl Survey sampling protocol be modified for all lobsters caught to be sorted by sex. If a subsample is necessary, subsamples be taken by sex for additional biological data (size, egg presence and stage, vnotch, etc.) This modification would align the biological sampling methodology with other trawl surveys used in the assessment, and perhaps allow the survey to not be collapsed by sex into survey slots.

REPRODUCTIVE BIOLOGY

a. Maturity (Medium Priority)

Recent work has demonstrated that size at maturity changes over time (Waller et al. 2019, Haarr et al 2018), which has direct implications for estimating spawning stock biomass and lobster growth rates. Extensive efforts made since the previous assessment have updated maturity data in statistical areas from which significant landings originate (see Appendix 1 and Appendix 2 in the stock assessment report) resulting in more accurate spawning stock biomass estimates. Future maturity work should focus on additional statistical areas with large landings contributions. Exploration of non-invasive techniques to assess maturity are also desirable, allowing for more frequent and efficient updates to maturity estimates. Methods to allow for time-varying maturity in the assessment model should also be explored, to better capture the influence of a changing environment on lobster population dynamics. Finally, it is extremely important for the newly updated maturity data to be applied towards updating the growth matrix underlying the assessment model.

b. Mating Success (Medium Priority)

Depleted stock conditions in SNE and the female-skewed sex ratio observed in the Georges Bank (GBK) sub-stock raise questions about the mating and reproductive success in these systems. Low population abundance may cause a mate-finding Allee effect (Stephens et al. 1999, Gascoigne et al. 2009), and contributing to the dramatically reduced recruits per spawner relationship observed in SNE (Section 6.3.2 in the stock assessment report). More research to characterize reproductive success (mating activity and subsequent larval production) under the current population and environmental conditions in SNE will be important to understanding the rebuilding potential of the stock. In the GBK sub-stock, there is limited information to describe the timing of events such as spawning, egg hatch, and molting; additional data from the CFRF fleet could improve understanding of reproductive cycles in this region. Further research incorporating the timing of these events and a characterization of the operational sex ratio during the molting/mating season should be initiated to increase understanding of reproductive dynamics in the GBK region. This will help to determine what role the GBK sub-stock plays in

terms of source/sink dynamics of the overall GOMGBK stock, and whether the skewed sex ratios are negatively influencing reproductive output in the region.

AGE AND GROWTH

a. *Time Varying Growth (High Priority)*

Growth of American lobster has been found to change through time (McMahan et al. 2016), yet the ability to incorporate this dynamic in the assessment model currently is unavailable. Accounting for interannual changes in the growth matrix, including those in increment, probability, and seasonality, is imperative for model convergence. This issue was faced in ASMFC (2015a) when an early molt occurred in 2012 in GOM, leading to discrepancies in observed landings and predicted abundance. Data suggests that changes in growth may also be occurring for the SNE stock, where alterations in molt probability and increment with size in recent years could be causing challenges for describing recruitment size composition and survey's size selectivity. Modification to the assessment model is needed to allow for time varying growth matrices to be used to reflect changing growth in the stocks.

b. *Expansion of Growth Matrices (High Priority)*

The UMM currently has lobsters recruit into the population between 53 and 77mm. However, many of the processes driving recruitment are not captured by the input or model abundances given they happen at sizes less than 53mm. Exploration of expanding the model size structure to smaller sizes could allow to better capture changes in recruitment for the population by incorporating < 53mm lobster abundances from the surveys currently used, as well as incorporating additional surveys that currently are not model inputs for the assessment, such as those from the young of year settlement surveys. Due to decreased recruitment in SNE and some areas in GOMGBK, available survey data should be evaluated to determine whether current data sources for small sizes are sufficient for expanding the size structure and growth matrices.

ENVIRONMENTAL INFLUENCE ON LOBSTER LIFE HISTORY PROCESSES

a. *Temperature-Molt Dynamics (High Priority)*

Sea temperatures have direct impacts on the molting dynamics of American lobster (Section 2.1 in the stock assessment report). Growth is directly influenced by water temperatures, with evidence in SNE suggesting increased temperatures have resulted in increased molt frequency and decreased molt increments (DNC 2013). Interannually varying and long-term increases in temperature through time suggest the molting dynamics have also changed over the last several decades. Understanding how the timing for molting, molt increments, and probability by size vary with temperature for all stocks would allow for more accurate and realistic depictions of growth via updated annual growth matrices. The work of Groner et al. (2018)

should be expanded by using the Millstone data to specifically analyze how molt frequency and increment has changed seasonally and interannually.

b. ***Larval Ecology (High Priority)***

Recent work has highlighted the importance of coastal oceanography and *Calanus finmarchicus* on the early life history of American lobster, with implications for their settlement and future recruitment (Carloni et al. 2018). The importance of ocean temperature and secondary productivity have also been correlated to adult abundances (Mazur et al. 2020), and major changes through time for these variables and the GOMGBK stock seem to co-occur (Section 2.9.5.1.1). To date, many of these analyses are based on a larval dataset with small spatial coverage in a relatively shallow area and are correlative in nature. This warrants spatial expansion of larval surveys and further testing particularly in areas like the eastern GOM and GBK that lack any studies of this nature. Studies that explore greater spatial coverage of larval sampling and examine lobster larval diets, in situ development time in current conditions, larval interactions with well-mixed versus stratified water columns, and varying growth and mortality with temperature would allow for greater context on these variables' influence on recruitment.

c. ***Deepwater Settlement (High Priority*****)**

Settlement and YOY trends from inshore sampling sites have continued to reflect poor conditions despite record abundance levels for older, larger lobsters in the GOMGBK stock, a trend that has continued since the last assessment five years ago. Following work by Goode et al. (2019) indicating settlement trends might not be as poor as the inshore sites reflect if deeper, newly suitable settlement habitat was sampled and accounted for, there is a need to determine settlement success in habitat not currently sampled and its contribution to overall stock productivity. Industry supported work in the eastern and western regions of the Maine coast show evidence of settlement, but research needs to explore the levels of detectability, impact of stratification, and interannual temperature effects on the indices. The CFRF fleet provides another potential platform to sample presence/absence of deep-water settlement, but specifically designed fishery-independent monitoring is needed to characterize trends through time. Additionally, it will be important to understand whether there are differences in growth and survival in these deeper habitats, particularly relative to the desire to expand the growth matrix into smaller size ranges for modeling purposes.

POPULATION DYNAMICS AND ASSESSMENT MODELING

a. ***SNE Recruitment Failure (High Priority)***

Many variables are attributed to the decline in the SNE stock, such as warming waters, predation pressure increases, and disease prevalence. However, the direct cause of the precipitous declines in recruitment under less variable spawning stock biomass is largely unknown. Research designed to understand the causes driving recruitment failure is vital for any efforts toward rebuilding the SNE stock. In addition, being able to predict similar conditions

in GOMGBK could allow management the opportunity to respond differently. Such research could address: egg production and mating success, larval survival and connectivity to the early benthic phase, benthic habitat changes in historical SNE nursery grounds, predator-prey dynamics, and disease impacts (both lethal and sublethal).

b. ***Index Modeling (Moderate Priority)***

Further expand Vector Autoregressive Spatio-Temporal (VAST) work that currently integrates survey indices into sex-specific stock-wide indices (Hodgdon et al. In Press) to construct accompanying stock and sex-specific time series of size composition.

c. ***Supporting Models (Moderate Priority)***

For SNE, less data-intensive or data-limited models should be explored to compare recent trajectories of Reference Abundance and Exploitation to those produced by the UMM.

d. ***Modeling Program (High Priority)***

Other software programs, such as Template Model Builder, should be evaluated as a new platform to host the UMM and allow more flexible, efficient coding capabilities across SAS members.

STOCK CONNECTIVITY

a. Stock Structure Working Group (High Priority)

There are a couple of ongoing studies that the SAS is aware of, and presumably others, to inform a re-assessment of stock boundaries that were not ready in time for this assessment. The SAS recommends that a workshop on stock boundaries be convened prior to the initiation of the next assessment to review results of any new research and re-evaluate appropriate stock boundaries. Inclusion of Canadian researchers at this workshop would be beneficial to share data and knowledge on this shared resource. Several research topics relevant to evaluation of stock boundaries are listed below, but this list could be expanded upon.

b. ***Spatial Analyses of Fisheries-Independent Data (High Priority)***

Northeast Fisheries Science Center (NEFSC) trawl survey data remains one of the richest data sources to understand abundance and distribution patterns through time for lobsters by size and sex. While preliminary data analyses have been conducted, formal analyses should be performed and described for the Management Board and/or scientific peer-review. Deeper investigations should also be conducted for the ME/NH Trawl Survey. The Ecosystem Monitoring (EcoMon) Program's larval lobster information should also be considered. Integrating the former into analyses with the NEFSC Trawl may provide greater insight into coastal-offshore movement patterns with temperature. While EcoMon sampling techniques

and seasonality may not best describe lobster larvae abundance and phenology, efforts to investigate its use in stock definitions remain worthwhile.

c. *Tagging Studies (Medium Priority)*

Ongoing tagging work to examine the movement of lobsters between GOM and GBK will be completed shortly and presented to the Technical Committee (TC) for incorporation into future discussions regarding stock boundaries. Additional tagging efforts that target specific areas, lobster demographics, and seasons that were not covered in this work would fill remaining gaps. Similar tagging studies in SNE would also be useful, as much of current understanding of lobster movement for this stock is based on information from decades before rapid warming.

d. *Larval Transport (Medium Priority)*

Transport modeling of lobster larvae has improved understanding in specific regions, such as inshore southern Massachusetts and coastal Maine-Massachusetts connectivity. However, there are several regions for which further research could greatly inform stock boundaries and connectivity. For example, determining whether larvae released in the offshore regions of GOM or GBK remain within that region or are transported to other stocks, especially to SNE locations, will identify the role offshore regions play in recruitment dynamics. Similar modeling exercises focusing on the fate of larvae released from offshore SNE can determine whether the offshore shift of the SNE stock is resulting in a larval sink, or whether there is a linkage to viable settlement habitat. Transport modeling work would benefit from a component that couples predicted destinations to an examination of habitat suitability for settlement success, and sampling to ground-truth results.

e. *Genetics* (*Low Priority*)

Additional genetics information would provide further insight on stock structure and on potential environmentally driven changes. For example, western Long Island Sound (LIS) lobsters were genetically distinct from those in other areas of LIS (Crivello et al. 2005b), raising the possibility that this is the result of selective forces producing lobsters adapted to the stressful environment of WLIS. Additional work to test this hypothesis and to examine in detail what might promote survival in that habitat could clarify whether lobsters in SNE might be able to adapt to the new, warmer environment. Benestan et al (2016) similarly suggested future work should incorporate environmental variables to understand localized selective pressures and their influence on lobster population structure. Comparisons of lobsters from disparate areas, such as SNE and GBK canyons, GOM and Canadian deep waters, and the northern and southern portions of the SNE stock may shed additional light on connectivity and potential for localized adaptations. Work that links adult movements, ocean currents and larval dispersal, and genetic population structure should be explored in order to characterize source/sink dynamics and identify whether sub-populations exist that disproportionately influence recruitment.

NATURAL MORTALITY

a. *Reevaluate Baseline Natural Mortality Rate (High Priority)*

Natural mortality (M) has been estimated by a variety of methods such as life history approaches, cohort analysis and tagging. Estimates of M range from 0.02 to 0.35 (Fogarty and Idoine 1988, ASMFC 2000). Early stock assessments assumed M=0.1 (NEFSC 1992, 1993). Subsequent assessments utilized M=0.15 for assessment models and partitioned M into hardshell (0.10) and softshell (molting) (0.05) for egg per recruit reference points (NEFSC, 1966, ASMFC 2000). Besides the question regarding how well the current value used for M reflects the actual M experienced by the stocks, there are additional questions such as how has M changed through time, and how the interactive abiotic stressors that results from changing climate may exacerbate or mitigate mortality during all life stages. Further, while scientifically many acknowledge size varying mortality for lobsters, there is little data to support or quantify this and thus the assessment model currently uses the same mortality rate for all lobsters. Intensive hypothesis-driven sensitivity analyses should be conducted to evaluate the base mortality rate for both stocks by season and year. Canadian tagging data should be examined to determine how natural mortality rates derived from these data compare to the assumptions used currently in the model and sensitivity analyses. Exploration of additional time series representing natural mortality hypotheses (e.g. sea temperature, shell disease prevalence, predators) should be continued to either inform time-varying natural mortality or correlate to rates produced in sensitivity analyses.

b. *Tagging Studies (Medium Priority)*

A tagging study specifically designed to quantify natural mortality should be conducted for both stocks. Traditional tagging studies designed to document movement or growth often do not allow for generating sound estimates of natural mortality. A directed study on natural mortality would provide empirical data needed to understand total and size-specific rates.

c. *Predation Studies (High Priority)*

Lobsters are subject to a suite of predators, and the abundance of many of these predators have fluctuated substantially through time. As such, it is often suspected that a given predator's role in lobster natural mortality has changed through time. Predation laboratory studies and gut content analyses would provide greater guidance on individual species' roles in lobster natural mortality. With this information, predation-indices as a function of predator annual abundances and their contribution to stock-specific lobster mortality would be immensely valuable, particularly in SNE.

d. *Shell Disease (Med*ium *Priority)*

Many studies have aimed at describing epizootic shell disease, including its pathology, environmental correlates (e.g. warm sea temperatures), and demographics. The relative

difference in mortality rates for lobsters with and without shell disease has been examined (Hoenig et al. 2017), but the existing datasets have limitations relative to scaling mortality estimates up to regional or population-level estimates. The true impact of shell disease on the population remains uncertain. Studies designed specifically to generate robust estimates of mortality for diseased lobsters that can be scaled up to the stock are necessary to understand the direct effect of this disease on mortality. Additionally, more work is needed to understand the impact(s) of sublethal effects of shell disease and other diseases on vital population rates (growth, reproduction, etc.). Sensitivity analyses for the SNE model included using shell disease time series data to inform interannual changes in natural mortality (Section 6.4.2 in the stock assessment report), but indices representing the totality of the stock would provide more sound inferences on disease's contribution to natural mortality.

MANAGEMENT AND ECONOMIC ANALYSES

a. ***Management Strategy Evaluation (High Priority)***

Since the previous assessment, a projection tool was developed to assess how certain management actions may impact lobster populations. However, the projection tool lacks the ability to refit the model iteratively with new years' simulated data to best understand the feedback of a given suite of management measures. Developing a true management strategy evaluation tool that can iteratively project and refit the operating model would best inform future management discussions on rebuilding the SNE stock or providing resiliency for the GOM stock and fishery. Development of consensus statements by the Board with input from industry about management objectives will be critical to evaluating the results of any projection tool.

b. ***Economic Reference Points (High Priority)***

The SAS developed new reference points using change point analyses to propose when management action should be taken for the different stocks recognizing there are different levels of productivity with changing environmental conditions. To trigger management action, previous target reference points for the GOMGBK, based on historical abundances prior to 2003, required a substantial population decline to occur and the downward trend to reach that level would likely be challenging to reverse in changing environmental conditions. Recognizing that the GOMGBK stock is currently in a high productivity regime and experiencing record high abundances that may not be sustainable, the SAS proposed the Abundance Limit level based on the medium productivity regime, but was concerned that significant adverse economic impacts would be experienced before the population reached that Abundance Limit. The SAS proposed a new reference point to address this issue based on the high productivity regime but did not incorporate economic information that should be used to inform this Fishery/Industry Target. Economic analyses considering landings, ex-vessel value, costs, associated economic multipliers, number of active participants, and other factors are imperative to truly discern how declines in the population would impact the GOMGBK industry. The SAS strongly recommends a thorough economics analysis be conducted by a

panel of experts to more properly inform economic-based reference points, and ultimately provide resiliency to both the GOMGBK stock and fishery.

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AMERICAN SHAD

System-specific research recommendations are provided for some systems under *Research Recommendations* subheadings in Section 3 of the stock assessment report. The following research recommendations are broadly applicable to most or all systems and/or mixed-stock aggregations.

Data Collection Recommendations

- Transition historical biological sampling data and store all future biological sampling data into digital, query-able databases with standardized fields and format. Unique identifiers should be assigned to individual fish to link all associated data collected. (short-term, moderate priority)
- Develop a centralized repository for agencies to submit and store genetic sampling data for future analysis. The Atlantic sturgeon repository at the United States Geological Survey (USGS) Leetown Science Center should serve as an example. (long-term, high priority)
- Collect genetic samples from young-of-year (YOY) and returning mature adults during spawning runs for future analysis of baseline genetic population structure and site fidelity/straying rates. These data will help define stock structure, identify stock composition from genetic sampling of American shad catch in mixed-stock fisheries, and provide information on recolonization capabilities in defunct American shad systems. (long-term, high priority)
- Conduct annual stock composition sampling through existing and new observer programs from all mixed-stock fisheries (bycatch and directed). Potential methods include tagging (conventional external tags or acoustic tags) of discarded catch and genetic sampling of retained and discarded catch. Mortality rates of juvenile fish in all systems remain unknown and improvement in advice from future stock assessments is not possible without this monitoring. Known fisheries include the Delaware Bay mixed-stock fishery and all fisheries operating in the Atlantic Ocean (U.S. and Canada) that encounter American shad (see Section 4.1.4 in the stock assessment report). (long-term, high priority)
- Otoliths should be collected as the preferred age structure. If collection of otoliths presents perceived impact to conservation of the stock, an annual subsample of paired otolith and scales (at least 100 samples if possible) should be collected to quantify error between structures. (short-term, high priority)
- Repeated estimates of spawn mark counts should be incorporated into data collection protocols to improve understanding of error in these data. (short-term, moderate priority)
- Conduct tagging studies to increase sample size of fish with known spawn mark histories. Focus tagging efforts on fish most likely to be virgin spawners. (long-term, moderate priority)

- Add age at first spawn, identification of skip spawning, and the age at which skip spawning occurred as standard data fields from spawn mark counts. (short-term, low priority)
- Error between structures, if scales are the primary age structure collected, and for spawn mark count estimates (either between multiple readers or within reader) should be quantified on an annual basis. A mean coefficient of variation (CV) of 5% and detection of no systematic bias should serve as targets for comparisons. (short-term, high priority)
- Two readers should determine consensus ages and spawn mark counts based on improvements in ageing error in the Delaware system when consensus-based estimates were part of the ageing protocol. (short-term, high priority)
- Conduct a coastwide age/spawn mark workshop to develop a standardized ageing/spawn mark count protocol for American shad. The example protocol included in this assessment (section 1.1.4.1 in the stock assessment report) can be used as a foundation for a final protocol. (short-term, moderate priority)
- Collect standardized maturity status data to provide greater resolution on data for length-weigh relationships. Maturity status codes should be: Immature, mature resting, gravid/not yet ripe, flowing, or spent. (short-term, moderate priority)
- Conduct acoustic tagging studies to determine skip spawning behavior and iteroparity rates. This information will also improve understanding of selectivity by in-river fisheries and monitoring programs. (short-term, moderate priority)
- Implement fishery-independent YOY and spawning run surveys in all systems with open fisheries. Surveys should collect catch rates, length, individual weight, sex (spawning runs), and age (spawning runs) data at a minimum to allow for assessment of stocks with legal harvest. Require these surveys be in operation in systems with requested fisheries before opening fisheries. (long-term, high priority)
- Task survey leads with providing as much insight as possible on suspected catchability effects (e.g. environmental covariates) with catch rate data during future stock assessments to improve standardization of abundance trends. Collect necessary data to support standardization model estimation of catchability effects. (short-term, moderate priority)
- Mark hatchery-reared fish and sample nursery habitat after stocking to obtain data that could be used to estimate absolute YOY abundance. (long-term, moderate priority)
- Conduct complete in-river catch monitoring in all systems with open fisheries. Monitoring programs should collect total catch, effort, size, individual weight, and age data at a minimum. Require these surveys be in operation in systems with requested fisheries before opening fisheries. (long-term, high priority)

- Require total catch and biological sampling of fish removed for broodstock purposes as these are useful data that can be obtained with little additional costs. (long-term, moderate priority)
- As catch of other bait species (i.e., Atlantic herring) is reduced, characterize changes in use of American shad as bait to supplement these primary bait species. (long-term, low priority)

Assessment Methodology Recommendations

- Determine appropriate uses of age composition data collected from semelparous stocks. (short-term, moderate priority)
- Investigate how anthropogenic sources of production (i.e., YOY stocking) affect population dynamics and assessment of stocks against traditional biological reference points. (long-term, low priority)
- Develop density-based reference points (number of fish per acre of habitat) from GIS mapping analysis that can be compared to passage counts at fishways. See Maine Department of Marine Resources river herring Sustainable Fishery Management Plan (SFMP) as an example. (long-term, moderate priority)
- Conduct more frequent analyses connecting YOY abundance trends with mature adult abundance trends to provide warning of unfavorable stock conditions due to changes in mortality during the data gap between these life stages. (short term, moderate priority)
- Develop targets for power of abundance indices. (short-term, low priority)

Future Research Recommendations

- Explore implications (predator-prey relationships, recruitment success, interactions with various fisheries) of climate change on environmental spawning cues. (long-term, moderate priority)
- Quantify precision of Oxytetracycline (OTC) mark identification. (long-term, moderate priority)
- Conduct maturity studies designed to accommodate the unique challenges American shad reproductive behavior (i.e., segregating by maturity status during spawning runs) poses on traditional monitoring programs. This information will also improve understanding of selectivity by in-river fisheries and monitoring programs. (long-term high priority)
- Investigate hooking and handling induced mortality in recreational fisheries. This pertains to all system because catch-and-release fisheries are still allowed for systems under moratoria. (long-term, moderate priority)
- Conduct fish passage research at barriers with adults for both upstream and downstream migration and movements and with juveniles for downstream as discussed in Section 1.1.9.5 of the stock assessment report. (long-term, high priority)

Management-related Recommendations

- As additional stock structure information becomes available, continue working on standard definitions of stock systems for use in future assessment and management of unique stocks. These should be described in text and associated maps included in SFMPs to capture all inland waterbodies with shad habitat considered part of the stock system. (long-term, low priority)
- Request managers provide future guidance on management goals in terms of productivity potential. Are goals to rebuild populations to historic levels of productivity or manage stocks relative to recent productivity potential? Clear guidance would help provide assessment advice on stock status. (short-term, low priority)

ATLANTIC CROAKER

Short-term

HIGH PRIORITY

- Increased observer coverage for commercial discards, particularly the shrimp trawl fishery. Develop a standardized, representative sampling protocol for collection of individual lengths and ages of discarded finfish.
- Describe the coast-wide distribution, behavior, and movement of croaker by age, length, and season, with emphasis on collecting larger, older fish.

MEDIUM PRIORITY

- Conduct studies of discard mortality for recreational and commercial fisheries by each gear type in regions where removals are highest.
- In the recreational fishery, develop sampling protocol for collecting lengths of discarded finfish and collect otolith age samples from retained fish.
- Encourage fishery-dependent biological sampling, with proportional landings representative of the distribution of the fisheries. Develop and communicate clear protocols on truly representative sampling.

Long-term

HIGH PRIORITY

- Continue state and multi-state fisheries-independent surveys throughout the species range and subsample for individual lengths and ages. Ensure NEFSC trawl survey continues to take lengths and ages. Examine potential factors affecting catchability in long-term fishery independent surveys.
- Quantify effects of BRDs and TEDs implementation in the shrimp trawl fishery by examining their relative catch reduction rates on Atlantic croaker.
- Continue to develop estimates of length-at-maturity and year-round reproductive dynamics throughout the species range. Assess whether temporal and/or density- dependent shifts in reproductive dynamics have occurred.
- Re-examine historical ichthyoplankton studies for an indication of the magnitude of estuarine and coastal spawning. Pursue specific estuarine data sets from the states (NJ, VA, NC, SC, DE, ME) and coastal data sets (MARMAP, EcoMon).

MEDIUM PRIORITY

- Investigate environmental covariates in stock assessment models, including climate cycles (e.g., Atlantic Multi-decadal Oscillation, AMO, and El Nino Southern Oscillation, El Nino) and recruitment and/or year class strength, spawning stock biomass, stock distribution, maturity schedules, and habitat degradation.
- Use NMFS Ecosystem Indicators bi-annual reports to consider folding indicators into the assessment; identify mechanisms for how environmental indicators affect the stock
- Encourage efforts to recover historical landings data, determine whether they are available at a finer scale for the earliest years than are currently reported.

- Collect data to develop gear-specific fishing effort estimates and investigate methods to develop historical estimates of effort.
- Develop gear selectivity studies for commercial fisheries with emphasis on age 1+ fish.
- Conduct studies to measure female reproductive output at size and age (fecundity, egg and larval quality) and impact on assessment models and biomass reference points
- Develop and implement sampling programs for state-specific commercial scrap and bait fisheries in order to monitor the relative importance of Atlantic croaker. Incorporate biological data collection into program.
- Investigate the relationship between estuarine nursery areas and their proportional contribution to adult biomass. I.e., are select nursery areas along Atlantic coast ultimately contributing more to SSB than others, reflecting better quality juvenile habitat?

ATLANTIC MENHADEN

Many of the research and modeling recommendations from the last benchmark stock assessment (SEDAR 2015)[5] remain relevant for this update stock assessment. Research recommendations are broken down into two categories: data and modeling. While all recommendations are high priority, the first recommendation is the highest priority. Each category is further broken down into recommendations that can be completed in the short term and recommendations that will require long term commitment. Notes have been added for this report regarding work that has been addressed or initiated since SEDAR 2015.

Annual Data Collection

Short-term (next 3-6 years):

1. Continue current level of sampling from bait fisheries, particularly in the Mid-Atlantic and New England. Analyze sampling adequacy of the reduction fishery and effectively sample areas outside of that fishery (e.g., work with industry and states to collect age structure data and biological data outside the range of the fishery). **NOTE**: Work to assess the sampling adequacy of the bait and reduction fisheries has been initiated by Genevieve Nesslage's research group at the University of Maryland Center for Environmental Science.
2. Ageing:
    a. Conduct ageing validation study (e.g., scale:otolith comparison), making sure to sample older age classes. Use archived scales to do radio isotope analysis.
    b. Ageing precision: conduct an ageing workshop to assess precision and error among readers (currently planned for January 2015). **NOTE**: A workshop was completed and described in ASMFC 2015[6] and Atlantic menhaden scales have been added to the annual ASMFC QA/QC Fish Ageing Workshop (ASMFC 2017)[7] to address an ongoing need for information on ageing precision and error.
3. Conduct a comprehensive fecundity study. **NOTE**: This work has been initiated and is ongoing with Rob Latour's research group at Virginia Institute of Marine Science.
4. Place observers on boats to collect at-sea samples from purse-seine sets, or collect samples at dockside during vessel pump-out operations (as opposed to current top of hold sampling) to address sampling adequacy.
5. Investigate relationship between fish size and school size in order to address selectivity (specifically addressing fisher behavior related to harvest of specific school sizes).
6. Investigate relationship between fish size and distance from shore (addressing selectivity).

[5] Southeast Data, Assessment, and Review (SEDAR). 2015. SEDAR 40 - Atlantic menhaden stock assessment report. SEDAR, North Charleston SC. 643 p.

[6] Atlantic States Marine Fisheries Commission (ASMFC). 2015. Atlantic Menhaden Ageing Workshop Report. ASMFC, Arlington, VA.

[7] Atlantic States Marine Fisheries Commission (ASMFC). 2017. Report of the Quality Assurance/Quality Control Fish Ageing Workshop. ASMFC, Arlington, VA.

7. Evaluate alternative fleet configurations for the removal and catch-at-age data.

Long-term (6+ years):

1. Develop a menhaden specific coastwide fishery-independent index of adult abundance at age. One possible methodology is an air spotter survey complemented with ground truthing for biological information (e.g., size and age composition). In all cases, a sound statistical design is essential (involving statisticians in the development and review of the design; some trial surveys may be necessary). **[Highest Priority] NOTE:** Design of a winter pelagic survey of adult Atlantic menhaden in the Mid-Atlantic has been initiated by Genevieve Nesslage's research group at the University of Maryland Center for Environmental Science.
2. Conduct studies on spatial and temporal dynamics of spawning (how often, how much of the year, batch spawning, etc.)
3. Conduct studies on productivity of estuarine environments related to recruitment. **NOTE**: Anstead et al. 2016[8] and 2017[9] used otolith chemistry to evaluate the proportional contribution of each nursery area along the US Atlantic coast for recruits for 2010-2012.
4. Investigation of environmental covariates related to recruitment. **NOTE**: Buchheister et al. 2016[10] evaluated coast wide recruitment patters from 1959-2013 and found the Atlantic Multidecal Oscillation was the best predictor of regional recruitment. Simpson et al. 2016[11] evaluated several environmental covariates for an effect on larval survival and found temperature had the greatest effect on early life survival which was more related to recruitment than larval supply.

<u>Assessment Methodology</u>

Short term (3-6 year):

1. Conduct management strategy evaluation (MSE). **[Highest Priority] NOTE:** This work has been initiated and is ongoing with Amy Schueller's research group at the Southeast Fisheries Science Center in Beaufort, North Carolina.
2. Conduct multi-objective decision analysis (MODA). **[Highest Priority] NOTE:** This will be addressed through the ongoing BERP WG activities.
3. Continue to develop an integrated length and age based model (e.g., SS3).
4. Continue to improve methods for incorporation of natural mortality (e.g., multi-species

[8] Anstead, K. A., J. J. Schaffler and C.M. Jones. 2016. Coast-wide nursery contribution of new recruits to the population of Atlantic Menhaden. Transactions of the American Fisheries Society, 145(3): 627-636.
[9] Anstead, K. A., J. J. Schaffler and C.M. Jones. 2017. Contribution of Nursery Areas to the Adult Population of Atlantic Menhaden. Transactions of the American Fisheries Society 146(1): 36-46.
[10] Buchheister, A., T. J. Miller, E. D. Houde, D. H. Secor, and R. J. Latour. 2016. Spatial and temporal dynamics of Atlantic menhaden (Brevoortia tyrannus) recruitment in the Northwest Atlantic Ocean. ICES Journal of Marine Science: Journal du Conseil, fsv260.
[11] Simpson, C. A., M. J. Wilberg, H. Bi, A. M. Schueller, G. M. Nesslage, and H. J. Walsh. 2016. Trends in Relative Abundance and Early Life Survival of Atlantic Menhaden during 1977–2013 from Long-Term Ichthyoplankton Programs. Transactions of the American Fisheries Society, 145(5): 1139-1151.

statistical catch-at-age model). **NOTE**: This work will be addressed by McNamee's doctoral thesis (*in prep*)[12] and through current BERP WG activities.

5. During the next benchmark stock assessment process (scheduled for 2019), the SAS recommends that the following items be considered during modeling workshops:
    a. Re-examine the methodology and surveys used for the development of the NAD index.
    b. Explore the likelihood component for the length composition data.
    c. Examine the age composition of the bait fishery.

Long term (6+ years):

1. Develop a seasonal spatially-explicit model, once sufficient age-specific data on movement rates of menhaden are available.

[12] McNamee, J. E. *in prep*. A Multispecies statistical catch-at-age (MSSCAA) model for a Mid-Atlantic species complex. Doctoral dissertation for University of Rhode Island.

ATLANTIC SEA HERRING

Fishery-Dependent Priorities

High

- Develop (simple) methods to partition stocks in mixed stock fisheries.
- Investigate bycatch and discards in the directed herring fishery through both at sea and portside sampling.
- Continue commercial catch sampling of Atlantic herring fisheries according to ACCSP protocols.

Fishery-Independent Priorities

High

- Conduct more extensive stock composition sampling including all stocks (i.e., Scotian Shelf).
- Expand monitoring of spawning components.

Low

- Continue to utilize the inshore and offshore hydroacoustic and trawl surveys to provide an independent means of estimating stock sizes. Collaborative work between NMFS, DFO, state agencies, and the herring industry on acoustic surveys for herring should continue to be encouraged.
- Consider alternative sampling methods such as HabCam.

Modeling / Quantitative Priorities

High

- Evaluate use of length based models (Stock Synthesis and Chen model).
- Develop statistical comparison of consumption estimates and biomass from model M.

Moderate

- Develop indices at age from shrimp survey samples.
- Conduct simulation studies to evaluate ways in which various time series can be evaluated and folded into the assessment model.
- Develop new approaches to estimating recruitment (i.e., juvenile abundance) from fishery-independent data.
- Examine the possible effects of density dependence (e.g., reduced growth rates at high population size) on parameter estimates used in assessments.

Low

- Develop an industry based LPUE or some other abundance index (Industry Based Survey).
- Conduct a retrospective analysis of herring larval and assessment data to determine the role larval data plays in anticipating stock collapse and as a tuning index in the age structured assessment.
- Investigate the M rate assumed for all ages, the use of CPUE tuning indices, and the use of NEFSC fall bottom trawl survey tuning indices in the analytical assessment of herring.
- Develop objective criteria for inclusion of novel data streams (consumption, acoustic, larval, etc.) and how this can be applied.

Life History, Biological, and Habitat Priorities

High

- Consider information on consumption from other sources (i.e. striped bass in other areas) and predators inshore of the current surveys.

Moderate

- Continue tagging and morphometric studies to explore uncertainties in stock structure and the impacts of harvest mortality on different components of the stock. Although tagging studies may be problematic for assessing survivorship for a species like herring, they may be helpful in identifying the stock components and the proportion of these components taken in the fishery on a seasonal basis.
- Analyze diet composition of archived mammal and sea bird stomachs. Improve knowledge on prey size selectivity of mammals and sea birds.
- Evaluate prey field to determine what other prey species are available to predators that could explain some of the annual trends in herring consumption.
- Investigate why small herring are not found in the stomachs of predators in the NEFSC food habits database.

Low

- Research depth preferences of herring.

Management, Law Enforcement, and Socioeconomic Priorities

High

- Evaluate the current herring spawning closure design in terms of areas covered, closure periods, catch-at-age within (before fishing prohibition in 2007) and outside of spawning areas to determine minimal spawning regulations (Maine DMR).
- Continue to organize annual US-Canadian workshops to coordinate stock assessment activities and optimize cooperation in management approaches between the two countries.

Moderate

- Develop a strategy for assessing individual spawning components to better manage heavily exploited portion(s) of the stock complex, particularly the Gulf of Maine inshore spawning component.
- Develop socioeconomic analyses appropriate to the determination of optimum yield.

Low

- Develop economic analyses necessary to evaluate the costs and benefits associated with different segments of the industry.

ATLANTIC STRIPED BASS

Fishery-Dependent Priorities

High

- Continue collection of paired scale and otolith samples, particularly from larger striped bass, to facilitate development of otolith-based age-length keys and scale-otolith conversion matrices.
- Develop studies to provide information on gear specific (including recreational fishery) discard morality rates and to determine the magnitude of bycatch mortality.
- Conduct study to directly estimate commercial discards in the Chesapeake Bay.
- Collect sex ratio information on the catch and improve methods for determining population sex ratio for use in estimates of female SSB and biological reference points.

Moderate

- Improve estimates of striped bass harvest removals in coastal areas during wave 1 and in inland waters of all jurisdictions year round.

Fishery-Independent Priorities

High

- Develop and index of relative abundance from the Hudson River Spawning Stock Biomass survey to better characterize the Delaware Bay/Hudson River stock.
- Improve the design of existing spawning stock surveys for Chesapeake Bay and Delaware Bay.

Moderate

- Develop a refined and cost-efficient, fisheries-independent coastal population index for striped bass stocks.

- Collect sex ratio information from fishery-independent sources to better characterize the population sex ratio.

Modeling / Quantitative Priorities

High

- Develop better estimates of tag reporting rates; for example, through a coastwide tagging study.
- Investigate changes in tag quality and potential impacts on reporting rate.
- Explore methods for combining tag results from programs releasing fish from different areas on different dates.
- Develop field or modeling studies to aid in estimation of natural mortality and other factors affecting the tag return rate.
- Compare M and F estimates from acoustic tagging programs to conventional tagging programs.

Moderate

- Examine methods to estimate temporal variation in natural mortality.

Low

- Evaluate truncated matrices to reduce bias in years with no tag returns and covariate based tagging models to account for potential differences from size or sex or other covariates.

Life History, Biological, and Habitat Priorities

High

- Continue in-depth analysis of migrations, stock compositions, sex ratio, etc. using mark-recapture data.
- Continue evaluation of striped bass dietary needs and relation to health condition.
- Continue analysis to determine linkages between the *Mycobacteriosis* outbreak in Chesapeake Bay and sex ratio of Chesapeake spawning stock, Chesapeake juvenile production, and recruitment success into coastal fisheries.

Moderate

- Examine causes of different tag based survival estimates among programs estimating similar segments of the population.
- Continue to conduct research to determine limiting factors affecting recruitment and possible density implications.
- Conduct study to calculate the emigration rates from producer areas now that population levels are high and conduct multi-year study to determine inter-annual variation in emigration rates.

Additional Habitat Research Recommendations

- Passage facilities should be designed specifically for passing striped bass for optimum efficiency at passing this species.
- Conduct studies to determine whether passing migrating adults upstream earlier in the year in some rivers would increase striped bass production and larval survival, and opening downstream bypass facilities sooner would reduce mortality of early emigrants (both adult and early-hatched juveniles).
- All state and federal agencies responsible for reviewing impact statements and permit applications for projects or facilities proposed for striped bass spawning and nursery areas shall ensure that those projects will have no or only minimal impact on local stocks, especially natal rivers of stocks considered depressed or undergoing restoration.
- Federal and state fishery management agencies should take steps to limit the introduction of compounds which are known to be accumulated in striped bass tissues and which pose a threat to human health or striped bass health.
- Every effort should be made to eliminate existing contaminants from striped bass habitats where a documented adverse impact occurs.

- Water quality criteria for striped bass spawning and nursery areas should be established, or existing criteria should be upgraded to levels that are sufficient to ensure successful striped bass reproduction.
- Each state should implement protection for the striped bass habitat within its jurisdiction to ensure the sustainability of that portion of the migratory stock. Such a program should include: inventory of historical habitats, identification of habitats presently used, specification of areas targeted for restoration, and imposition or encouragement of measures to retain or increase the quantity and quality of striped bass essential habitats.
- States in which striped bass spawning occurs should make every effort to declare striped bass spawning and nursery areas to be in need of special protection; such declaration should be accompanied by requirements of non-degradation of habitat quality, including minimization of non-point source runoff, prevention of significant increases in contaminant loadings, and prevention of the introduction of any new categories of contaminants into the area. For those agencies without water quality regulatory authority, protocols and schedules for providing input on water quality regulations to the responsible agency should be identified or created, to ensure that water quality needs of striped bass stocks are met.
- ASMFC should designate important habitats for striped bass spawning and nursery areas as HAPC.
- Each state should survey existing literature and data to determine the historical extent of striped bass occurrence and use within its jurisdiction. An assessment should be conducted of those areas not presently used for which restoration is feasible.

Management, Law Enforcement, and Socioeconomic Priorities

Moderate

- Examine the potential public health trade-offs between the continued reliance on the use of high minimum size limits (28 inches) on coastal recreational anglers and its long-term effects on enhanced PCB contamination among recreational stakeholders.

ATLANTIC STURGEON

Benchmark Assessment Recommendations (TC/SAS)

Research recommendations have been categorized as future research, data collection, and assessment methodology and ranked as high or moderate priority. Recommendations with asterisks (**) indicate improvements that should be made before initiating another benchmark stock assessment.

Future Research

High Priority

- Identify spawning units along the Atlantic coast at the river or tributary and coastwide level.
- **Expand and improve the genetic stock definitions of Atlantic sturgeon, including developing an updated genetic baseline sample collection at the coastwide, DPS, and river-specific level for Atlantic sturgeon, with the consideration of spawning season-specific data collection.
- Determine habitat use by life history stage including adult staging, spawning, and early juvenile residency.
- Expand the understanding of migratory ingress of spawning adults and egress of adults and juveniles along the coast.
- Identify Atlantic sturgeon spawning habit through the collection of eggs or larvae.
- Investigate the influence of warming water temperatures on Atlantic sturgeon, including the effects on movement, spawning, and survival.

Moderate Priority

- Evaluate the effects of predation on Atlantic sturgeon by invasive species (e.g., blue and flathead catfish).

Data Collection

High Priority

- **Establish regional (river or DPS-specific) fishery-independent surveys to monitor Atlantic sturgeon abundance or expand existing regional surveys to include annual Atlantic sturgeon monitoring. Estimates of abundance should be for both spawning adults and early juveniles at age. See Table 8 in the Assessment Report[13] for a list of surveys considered by the SAS.
- **Establish coastwide fishery-independent surveys to monitor Atlantic sturgeon mixed stock abundance or expand existing surveys to include annual Atlantic sturgeon monitoring. See Table 8 in the Assessment Report for a list of surveys considered by the SAS.
- **Continue to collect biological data, PIT tag information, and genetic samples from Atlantic sturgeon encountered on surveys that require it (e.g., NEAMAP). Consider including this level of data collection from surveys that do not require it.
- **Encourage data sharing of acoustic tagged fish, particularly in underrepresented DPSs, and support programs that provide a data sharing platform such as The Atlantic Cooperative

[13] Atlantic States Marine Fisheries Commission. 2017. Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report. ASMFC, Arlington, VA. 456pp.

Telemetry Network. Data sharing would be accelerated if it was required or encouraged by funding agencies.

- **Maintain and support current networks of acoustic receivers and acoustic tagging programs to improve the estimates of total mortality. Expand these programs in underrepresented DPSs.
- **Collect DPS-specific age, growth, fecundity, and maturity information.
- **Collect more information on regional vessel strike occurrences, including mortality estimates. Identify hot spots for vessel strikes and develop strategies to minimize impacts on Atlantic sturgeon.
- **Monitor bycatch and bycatch mortality at the coastwide level, including international fisheries where appropriate (i.e., the Canadian weir fishery). Include data on fish size, health condition at capture, and number of fish captured.

Assessment Methodology

High Priority

- **Establish recovery goals for Atlantic sturgeon to measure progress of and improvement in the population since the moratorium and ESA listing.
- **Expand the acoustic tagging model to obtain abundance estimates and incorporate movement.

Moderate Priority

- Evaluate methods of imputation to extend time series with missing values. ARIMA models were applied only to the contiguous years of surveys due to the sensitivity of model results to missing years observed during exploratory analyses.

Peer Review Recommendations (Review Panel)

In general, the Review Panel agrees with the research recommendations and priorities developed by the Atlantic sturgeon Technical Committee (see Assessment Report, Section 8, pp. 107-109). Currently there are severe data limitations restricting the type, scope, and usefulness of assessment methodologies that can be applied to Atlantic sturgeon. Most importantly, there is an incomplete accounting for temporal and spatial variability in life-history parameters, an imperfect understanding of the temporal and spatial organization of reproductively discrete spawning populations, and major uncertainties in the scope for direct harm arising from interaction with ongoing human activities (e.g., bycatch, ship strikes) to the recovery of Atlantic sturgeon. To assist in identifying areas with significant data gaps, the Review Panel created a data gaps table (Table 3 in the Peer Review Report) based on the current Atlantic sturgeon assessment report.

The Review Panel provides the following suggested changes to existing research priorities, as well as a set of new research recommendations that are critical to advancing Atlantic sturgeon science, modeling, and future stock assessments.

Future Research

High Priority

- Develop standardized methods that can be used to create reliable indices of abundance for adults and young juveniles (Age 1) to reflect the status of individual DPSs
    - A workshop is recommended to assess the efficacy of existing 'sturgeon surveys' (e.g., those presently conducted in NY, SC) and new approaches
- Expand and improve the genetic stock definitions of Atlantic sturgeon, including the continued development of genetic baselines that can be applied coastwide, within- and among-DPS's, and at the river-specific level. Consideration of spawning season-specific data collection will be required. Particular emphasis should be placed on collecting additional information from the Gulf of Maine and Carolina DPSs (Table 3).

Moderate Priority

- Determine a permitting process to enable authorizations to sample and collect biological materials from any dead Atlantic sturgeon encountered
    - Pectoral fin spines to support age determination are considered to be of high value
    - Additional materials could include gonad tissues to support development of maturation schedules for males and females and fecundity
- Evaluate potential reference point targets and their efficacy for Atlantic sturgeon. Options include (but are not limited too):
    - number of fish in spawning runs
    - number of rivers with sturgeon presence/absence (by DPS and coastwide)
    - frequency of catch in indices and/or observer sampling
    - evaluate rivers where you don't have sturgeon, setting minimum bar
- Determine freshwater, estuarine, and ocean habitat use by life history stage including adult staging, spawning, small and large juvenile residency, and larvae
- Identify spawning units, using appropriate techniques (genetics, tagging, eDNA, collections of eggs or larvae, etc.), along the Atlantic coast that best characterize the meta-population structure of U.S. Atlantic sturgeon
    - Recent search efforts both in previously un-sampled rivers/tributaries and rivers thought to have lost their native populations have revealed evidence of spawning activity that results in the production of young juveniles. Such instances require particular attention to determine whether they are the result of reproduction by self-sustaining populations
- Investigate the influence of warming water temperatures on Atlantic sturgeon, including the effects on movement, spawning, and survival

Low Priority

- Evaluate incidence of and the effects of predation on Atlantic sturgeon

Data Collection

High Priority

- Establish centralized data management and data sharing protocols and policies to promote greater use of all available Atlantic sturgeon data. Priority data sets include (but are not limited to):
    - genetics/tissue samples
    - pectoral fin spines and associated age estimates
    - acoustic tagging and hydrophone metadata
    - external and PIT tag data

  Emphasis should be placed on extracting all available data in underrepresented DPSs. Concurrently, continue to support programs that provide data sharing platforms such as the Atlantic Cooperative Telemetry Network. These initiatives will benefit from the support of federal funding agencies enforcing the requirement to make data collected via federal funds part of the public record within a reasonable period of time. If not a current requirement of funded Atlantic sturgeon research, this should become a requirement.

- Implement directed monitoring of Atlantic sturgeon that is designed to support assessments both coastwide and at the DPS level and/or expand existing regional surveys to include annual Atlantic sturgeon monitoring. Monitoring two or more reproductively discrete populations within each recognized DPS is suggested. Use of emergent technologies such as validated side scan sonar surveys and acoustic tracking may allow for more cost effective monitoring of river runs.
    - Monitoring protocols that enable data gathering for a number of species (e.g., Shortnose sturgeon) is encouraged
    - Development of adult, YOY (or Age 1), and juvenile indices are a high priority, and considerations should be made for the use of appropriate survey gears
        - Associated length and age composition information is needed so that relative abundance-at-age information can be obtained from the adult and juvenile indices
    - See Table 8 in the assessment report for a list of surveys considered by the SAS during the assessment
    - See Table 3 of the review report to see current data gaps identified by the Review Panel
- Continue to collect biological data, PIT tag information, and genetic samples from Atlantic sturgeon encountered on surveys that require it (e.g., NEAMAP). Consider including this level of data collection from surveys that do not require it. Push permitting agencies to allow sampling (to the extent possible) of all encountered Atlantic sturgeon via scientific research activities.
- Maintain and support current networks of acoustic receivers and acoustic tagging programs to improve the estimates of total mortality. Expand these programs in underrepresented DPSs, using a power analysis to define direction and magnitude of expansion, as required to support next assessment.

- Collect sub-population specific (river, tributary, or DPS level) life history information (e.g., age, growth, fecundity, maturity, spawning frequency). Where feasible, emphasis should be on collecting information by sex and for reproductive information by size/age. Particular focus should be on collecting information on Atlantic sturgeon from the South Atlantic DPS given less data and suspected regional life history differences (see Table 3).
- Improve monitoring of bycatch in other fisheries, gears, and locations (notably northern and southern range). When scaling up to unobserved trips, need better data/measures of effective effort that can be reasonably expected to encounter Atlantic sturgeon. This may include collection of more detailed information on type of gear deployed, locations of deployment, etc. To assess the potential for currently missing significant sources of Atlantic sturgeon bycatch, do a simple query of all observed fisheries to see if Atlantic sturgeon are encountered in other gears beyond gillnet and trawl (e.g., scallop dredges)
- Investigate and account for extra-jurisdictional sources of mortality. Include data on fish size, health condition, and number of fish affected.

Moderate Priority

- Collect more information on regional vessel strike occurrences, including mortality estimates. Identify hot spots for vessel strikes and develop strategies to minimize impacts on Atlantic sturgeon.
- Promote greater Canadian-US Atlantic sturgeon data sharing, cooperative research, and monitoring. Exploring interactions between Canadian and US Atlantic sturgeon may more fully explain mortality trends, particularly with regards to the Gulf of Maine DPS.

Assessment Methodology

High Priority

- Establish recovery goals and risk tolerance for Atlantic sturgeon to measure progress of and improvement in the population since the moratorium and ESA listing
- Expand the acoustic tagging model to incorporate movement
- Conduct a power analysis to determine sufficient acoustic tagging sampling sizes by DPS

Moderate Priority

- Evaluate methods of imputation to extend time series with missing values. ARIMA models were applied only to the contiguous years of surveys due to the sensitivity of model results to missing years observed during exploratory analyses.
- Explore feasibility of combining telemetry tagging and sonar/acoustics monitoring to generate abundance estimate

BLACK DRUM

HIGH PRIORITY

- Age otoliths that have been collected and archived.
- Collect information to characterize the size composition of fish discarded in recreational fisheries.
- Collect information on the magnitude and sizes of commercial discards. Obtain better estimates of bycatch of black drum in other fisheries, especially juvenile fish in south Atlantic states.
- Increase biological sampling in commercial fisheries to better characterize the size and age composition of commercial fisheries by state and gear.
- Increase biological sampling in recreational fisheries to better characterize the size and age composition by state and wave.
- Obtain estimates of selectivity-at-age for commercial fisheries by gear, recreational harvest, and recreational discards.
- Continue all current fishery-independent surveys and collect biological samples for black drum on all surveys.
- Develop fishery-independent adult surveys. Consider long line and purse seine surveys. Collect age samples, especially in states where maximum size regulations preclude the collection of adequate adult ages.
- Develop a protocol to alert the SASC to any major changes in harvest and F that could trigger a reassessment of the reference points similar to the 'rumble strips' approach developed by the MAFMC for data-poor stocks.
- Increase age sampling along the coast. Juvenescence of the population is a good indicator of overfishing, and the availability of age data is crucial to being alerted to such changes in age structure.
- Indices, such as the South Carolina trammel net survey, could be used directly in an extended version of DB-SRA. The implementation of xDB-SRA could instead specify stock status at an earlier time period, thus allowing the most recent catches to inform population dynamics and thus stock status.

MODERATE PRIORITY

- Conduct reproductive studies, including: age and size-specific fecundity, spawning frequency, spawning behaviors by region, and movement and site fidelity of spawning adults.
- Conduct a high reward tagging program to obtain improved return rate estimates. Continue and expand current tagging programs to obtain mortality and growth information and movement at size data.
- Improve sampling of night time fisheries.
- Conduct studies to estimate catch and release mortality rates in recreational fisheries.

- 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.
- Obtain better estimates of harvest from the black drum recreational fishery (especially in states with short seasons).

BLACK SEA BASS

Fishery-Dependent Priorities

High

- Increase sampling of commercial landings.
- Increase sample size of at sea observers and dockside validation for headboats. Increase recreational fisheries sampling.
- Determine depth, temperature, and season specific discard mortality rates. Assess and incorporate the impact of circle hook fishing regulations on discard mortality. Obtain more depth specific information from the private recreational fleet, MRIP At-Sea observer program, and Headboat Survey in the range of the southern stock.

Moderate

- Collect better spatial information in black sea bass fisheries to determine potential localized depletion effects.

Low

- Determine the impact/landings of the historical foreign fleet in the South Atlantic.

Additional Fishery-Dependent Priorities

- Develop hard part sampling coordinated with intercept surveys.
- Expand electronic reporting of headboat logbook for full implementation.

Fishery-Independent Priorities

High

- Conduct a pot survey throughout the range of the northern management unit and consider for an index of abundance.[14]
- Expand fishery-independent surveys to sample all sizes and age classes to develop more reliable catch-at-age and CPUE.
- Expand sampling to cover the entire range of the southern stock over a longer time period.

Additional Fishery-Independent Priorities

- Conduct at sea sex sampling to determine trend of sex change timing and assess the potential influence of population size on sex switching.[15]

Modeling / Quantitative Priorities

High

- Investigate the effect of sex transition rates, sex ratio, and differential M by sex on the calculations of SSB per recruit and eggs per recruit.

Moderate

- Explore alternative assessment models, including non-age based alternatives.

Additional Modeling / Quantitative Priorities

- Continue development of a standardized method for calculating incomplete weight data.

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[14] A pilot project is ongoing and proposals are being considered for funding to expand the program.

[15] The NEFSC and UMass-Dartmouth are working on trends in sex change timing for the northern stock and UNC-Wilmington is working on the same for the southern stock.

- Further develop the tagging model described by Rudershausen et al. (2010) to address the assumptions of the model.

Life History, Biological, and Habitat Priorities

High

- Analyze size or age specific spawning frequency and seasonality.
- Investigate the movement and migrations of black sea bass using otolith microchemistry, genetic studies, and expanding tagging studies.
- Conduct meta-analysis of patterns of M in protogynous fishes, specifically black sea bass. Determine sex specific mortality rates and growth rates.
- Determine the implications of removing large males on population dynamics through field studies or large scale mesocosm experiments.
- Conduct studies on the efficacy of recompression techniques such as venting to reduce discard mortality.
- Study the movement and mixing of larval and juvenile black sea bass in the southern stock.

Moderate

- Further delineate essential fish habitat (EFH), particularly in nursery areas. Further investigate possible gear impacts on EFH.
- Identify transport mechanisms or behaviors that transport early juvenile black sea bass into estuaries.
- Evaluate overwintering habitat of all black sea bass life stages.
- Evaluate feeding of black sea bass larvae and overwintering adults.
- Develop mariculture techniques.

Low

- Conduct studies determining the value of artificial reefs for increased production of black sea bass to improve potential yield estimates.

Additional Life History, Biological, and Habitat Priorities

- Continue ageing studies to provide a foundation for an age based assessment. Compare scale to otolith age estimates.
- Conduct ageing validation studies to examine the implications of sex change, as well as temperature and salinity changes associated with movement onshore and offshore, on ageing reliability.
- Continue genetics work to determine potential stock delineation in the northern range.

Management, Law Enforcement, and Socioeconomic Priorities

- Evaluate the potential influence of non-compliance on high assumed M.
- Analyze logbook programs to determine current compliance and develop recommendations for improving compliance (i.e., increased education on the effect of not reporting accurately).
- Continue evaluation of methodology for mandatory reporting in the For-hire sector (e.g., Gulf MRIP Pilot).

BLUEFISH

Fishery-Dependent Priorities

High

- Evaluate magnitude and length frequency of discards from the commercial and recreational fisheries.
- Increase sampling of size and age composition of the fisheries by gear type and statistical area.[16]
- Target commercial (especially in the northeast region) and recreational landings for biological data collection and increase intensity of sampling when possible.
- Investigate species associations with recreational angler trips targeting bluefish (on a regional and seasonal basis) to accurately estimate effort for of the MRIP index (reduce risk of hyperstability)
- Determine whether NC scale data from 1985-1995 are available for age determination; if available, re-age based on protocols outlined in ASMFC (2011).

Fishery-Independent Priorities

High

- Develop additional adult bluefish indices of abundance (e.g., broad spatial scale longline survey or gillnet survey) to adequately characterize dynamics of older fish that are currently not well sampled by fishery independent trawl surveys.
- Expand age structure of SEAMAP index; currently, the SEAMAP index used in the assessment indexes age 0 abundance only, but recent age data from SEAMAP suggests collection of age 1 and 2 fish that would help inform the south Atlantic bight age structure

Modeling / Quantitative Priorities

Moderate

- Continue to examine alternative models that take advantage of length-based assessment frameworks.
- Evaluate the source of bimodal length frequency in the catch (e.g., migration, differential growth rates).
- Modify thermal niche model to incorporate water temperature data more appropriate for bluefish in a timelier manner [e.g., sea surface temperature data & temperature data that cover the full range of bluefish habitat (SAB and estuaries)].

Life History, Biological, and Habitat Priorities

Moderate

[16] A biological sampling program has been implemented for states that accounted for >5% of the coast wide bluefish harvest between 1998 and 2008. See Addendum 1 to Amendment 1 of the ASMFC Bluefish FMP.

- Explore age- and time-varying natural mortality from, for example, predator prey relationships; quantify effects of age- and time-varying natural mortality in the assessment model.
- Continue to evaluate the spatial, temporal, and sector-specific trends in bluefish growth and quantify their effects in the assessment model to address the appropriateness of pooling age data spatially (and temporally) and to identify potential changes to improve the efficiency of the biological collection program

Low

- Continue work on catch and release mortality.[17]
- Further evaluate the relationship between environmental factors (temperature, salinity etc.) and coastwide bluefish distribution.

[17] Some work completed, see: Fabrizio, et al. 2008. Factors affecting catch-and-release mortality of bluefish. *North American Journal of Fisheries Management* 28:533-546.

COASTAL SHARKS

- More research is necessary on review/improvement/development of shrimp bycatch estimation models for both data-poor and data-rich species
- More research is necessary on integration of various local abundance indices into a global abundance index based on spatio-temporal, physical-biological characteristics and variability.

Previous Research Recommendations for All Coastal Sharks

Fishery-Dependent Priorities

High

- Initiate or expand dockside sampling for sharks to verify landings information and species composition.

Moderate

- The Atlantic menhaden fishery data should be examined to determine shark bycatch estimates, if available.
- Conduct additional length sampling and age composition collection to improve information for developing selectivities.
- Shrimp trawl observer coverage should be expanded to 2 to 5% of total effort, particularly during periods of regulatory or gear changes. The observer coverage program should strive for even spatial coverage (particularly adding more south Atlantic coverage), randomness in vessel selection and full identification of elasmobranch species (continuing on from the 2009 Bycatch Characterization Protocol).
- Increase research on post-release survivorship of all shark species by gear type.
- Continue to acquire better species specific landings information on number of species, by weight, from dealers.[18]

Fishery-Independent Priorities

High

- Investigate the appropriateness of using vertebrae for ageing adult sandbar sharks. If appropriate, implement a systematic sampling program that gathers vertebral samples from entire size range for annual ageing to allow tracking the age distribution of the catch as well as updating of age-length keys.[19]

Moderate

- Develop a fishery-independent porbeagle shark survey to provide additional size composition and catch rate data to calculate an index of abundance.

[18] All dealers must report landings by species.

[19] Recent bomb radiocarbon research has indicated that past age estimates based on tagging data for sandbar sharks may be correct and that vertebral ageing may not be the most reliable method for mature individuals. See Andrews et al. 2011.

- Develop a stock wide fishery-independent monitoring program in state coastal waters for dusky sharks that includes annual samples of length and age frequencies.

Modeling / Quantitative Priorities

High

- Explore modeling approaches that do not require an assumption that the population is at virgin level at some point in time.

Moderate

- Develop empirically based estimates of natural mortality.
- Explore alternative approaches to age-length keys for estimating age from length.
- Improve estimates of removals by identifying and incorporating the sources of uncertainty (species misidentification, non-reporting).
- Quantify the uncertainty in time series of catch data.
- Perform exploratory analyses with CPUE indices to identify indices that contribute the most information on stock trends.
- Conduct simulation tests (management strategy evaluation) to assess the performance of alternative assessment methods (including the catch-free model, ASPM, ASPIC, SS, or stock specific models), recruitment parameterizations, harvest control rules, assessment frequency and data collection.
- Develop a two sex model for more direct estimation of the dusky and blacknose shark spawning stocks.
- Explore alternative modeling approaches in the presence of uncertain reproductive information that model reproduction as a function of the number of mature females. Integrate uncertainty in the reproductive frequency, fecundity, and pup-survival into a single parameter (the slope at the origin of the stock-recruit function) and incorporate this uncertainty via priors on the parameter.

Low

- Conduct sensitivity analyses to determine if discard survival estimates have a significant impact on the estimated status of the dusky and blacknose shark stocks in relation to MSY reference points.
- Develop a set of indicators (age-structure, total mortality estimates from catch curves, changes in abundance indices values) to determine whether dusky shark stock status has changed sufficiently to warrant a full assessment.

Life History, Biological, and Habitat Priorities

High

- Re-evaluate finetooth life history in the Atlantic Ocean in order to validate fecundity and reproductive periodicity.[20]
- Develop and conduct tagging studies on dusky and blacknose stock structure with increased international collaboration (e.g., Mexico) to ensure wider distribution and returns of tags.

[20] Work by Frazier, Belcher, and Gelsleichter is underway.

Expand research efforts directed towards tagging of individuals in south Florida and Texas/Mexico border to get better data discerning potential stock mixing.

- Examine female sharks during the spawning periods to determine the proportion of spawning females.[21]

Moderate

- Continue life history studies for all species of the shark complex to allow for additional species specific assessments. Particularly, natural mortality, age, fecundity, and reproductive frequency. Update age, growth, and reproductive studies of blacknose sharks, with emphasis on smaller individuals in the Atlantic and larger individuals in the Gulf of Mexico.
- Coordinate a biological study for Atlantic sharpnose so that samples are made at least monthly, and, within each month, samples would be made consistently at distinct geographic locations. For example, sampling locations would be defined in the northern Gulf, west coast of Florida, the Florida Keys (where temperature is expected to be fairly constant over all seasons), and also several locations in the South Atlantic, including the east coast of Florida, Georgia, South Carolina, and North Carolina. This same sampling design could be applied to all small coastal sharks.
- Population level genetic studies are needed that could lend support to arguments for stock discriminations using new loci and/or methodology that has increased levels of sensitivity.

Low

- Determine what is missing in terms of experimental design and/or data analysis to arrive at incontrovertible (to the extent that it may be scientifically possible) conclusions on the reproductive periodicity of the sandbar shark stock.

Management, Law Enforcement, and Socioeconomic Priorities

High

- Conduct species specific assessments for all shark species, with a priority for smooth dogfish.

[21] Biological information indicates that females of some shark species spawn less often then annually.

COBIA (ATLANTIC MIGRATORY GROUP)

Life History

- The Life History Work Group recommends implementation of a tagging study along the entire east coast of Florida and the evaluation of genetic samples from the same to determine more precise stock boundaries.
- Recommend developing a tagging program for inshore and offshore South Atlantic cobia populations. The goal would be to deploy tags inshore during the spring migration and offshore during the fall and winter to get a clearer picture of fall and spring migrations and to better identify spawning areas and aggregations.
- Explore the feasibility of satellite tags for cobia movement studies.
- Provide genetic sampling kits to interested groups to better understand the stock division line between the Gulf and Atlantic cobia stocks. Possible collectors of genetic samples could include Charter operators, fishing clubs and state fisheries personnel.
- Further research is needed on cobia and Spanish mackerel release mortality.
- To increase the overall amount of data available on Cobia, it is recommended that port samplers do complete workups when sampling, including otolith removal for aging, length, weight, sex, genetic sampling and record a catch location.

Commercial

- Although under the category of research recommendations, this list is not research per se, but rather suggestions to improve data collection. The first three recommendations were modified from the SEDAR17 DW report.
    - Need to expand observer coverage
    - Expand TIP sampling to better cover all statistical strata
    - Trade off with lengths versus ages, need for more ages (i.e., hard parts)
    - Consider the use of VMS to improve spatial resolution of data
    - During discussions at the data workshop it was noted that the logbook categories for discards (all dead, majority dead, majority alive, all alive) are not useful for informing discard mortality. Consider simplified logbook language in regard to discards (e.g., list them as dead or alive)
    - Uniformity between state and federal reporting systems/forms would vastly improve the ease and efficiency of data compilation.
    - Establish online reporting and use logbooks as a backup.
    - Establish a mechanism for identifying age samples that were collected by length or market categories, so as to better address any potential bias in age compositions.
    - Compiling commercial data is surprisingly complex. As this is the 28th SEDAR, one might expect that many of the complications would have been resolved by now through better coordination among NMFS, ACCSP, and the states. Increased attention should be given toward the goal of "one-stop shopping" for commercial data.

Recreational Statistics

- Increase proportion of fish with biological data within MRFSS sampling.
- Continue to develop methods to collect a higher degree of information on released fish (length, condition, etc.) in the recreational fishery.
- Require mandatory reporting for all charter boats state and federal.
- Continue development of electronic mandatory reporting for for-hire sector.
- Continued research efforts to incorporate/require logbook reporting from recreational anglers.
- Establish a review panel to evaluate methods for reconstructing historical landings (SWAS, FWS, etc.).
- Quantify historical fishing photos for use in reconstructing recreational historical landings.
- Narrow down the sampling universe. Identify angler preference and effort. Require a reef fish stamp for anglers targeting reef fish, pelagic stamp for migratory species, and deepwater complex stamp for deep-water species. The program would be similar to the federal duck stamp required of hunters. This would allow the managers to identify what anglers were fishing for.
- 9) Continue and expand fishery dependent at-sea-observer surveys to collect discard information, which would provide for a more accurate index of abundance.

Indices

- Explore SEFIS video data as a potential fishery independent index of abundance for cobia
- Using simulation analysis, evaluate the utility of including interaction terms in the development of a standardized index and identify the potential effects these interaction terms have on stock assessments

HORSESHOE CRAB

Fishery-Dependent Priorities

Moderate

- Characterize the proportion of states' landings that comprise crabs of Delaware Bay origin. This can be done through a directed tag/release study, genetics/microchemistry study, or both.
- Improve measures to characterize landings and bycatch in the commercial fisheries by life stage.
- Estimate fishing discard numbers and associated mortality rates.
- Investigate supplemental bait and alternative trap designs to reduce the commercial fisheries need for horseshoe crabs.

Fishery-Independent Priorities

High

- Expand or implement fishery-independent surveys (e.g., spawning, benthic trawl, tagging) to target horseshoe crabs throughout their full range including estuaries. Highest priority should be given to implementing directed surveys in the New England and New York regions.[22]
- Estimate catchability for gear used in benthic trawl surveys and determine effect of size, sex, substrate, topography, timing, and temperature.
- Investigate factors (habitat, harvest, sampling methods, etc.) that might be causing the large discrepancies between Delaware and New Jersey in egg survey numbers.

Moderate

- Estimate the proportion of the Delaware Bay population that is available in time and space within existing VT benthic trawl survey area. Estimate the selectivity of gear used in the survey. These estimations should take into account age class (i.e., primiparous, multiparous).
- Ground truth sub-sampling method used in Delaware Bay spawning survey for calibration to the "population" scale.

Modeling / Quantitative Priorities

High

- Estimate age/size specific survival of all life stages (e.g., age 0 to adult) and growth rate by instar within Delaware Bay.
- Estimate size specific fecundity of Delaware Bay females.
- Model relationship between egg availability and spawning biomass/abundance.

Moderate

- Further develop catch-survey analysis and apply assessment modeling beyond the Delaware Bay region.

[22] Some survey design work done by Landi (2011).

- Continue to conduct additional stock assessments and determine F. Use these data to develop a more reliable sustainable F.
- Estimate mortality from the entire biomedical collection process, from capture to post-return.[23]

Life History, Biological, and Habitat Priorities

High

- Assess horseshoe crab prey availability and determine whether horseshoe crab population growth will be/is limited by prey availability.
- Evaluate the impacts of beach nourishment projects on horseshoe crab populations.

Moderate

- Characterize essential horseshoe crab habitat, other than spawning habitat, in different regions.
- Further evaluate life table information including sex ratio and population age structure.
- Estimate the proportion of sub-tidal spawning and determine if this affects spawning success (i.e., egg survivability).
- Conduct tagging studies and analyze tagging data to identify costal populations, population abundance, mortality rates, migration, and other movements.[24]
- Characterize abundance and size structure of juveniles coastwide as indicators of recruitment to adulthood.
- Evaluate the effect of mosquito control chemicals on horseshoe crab populations.
- Evaluate the importance of horseshoe crabs to other marine resources such as sea turtles.
- Conduct risk assessment for the effect of oil spill (timing, location, and amount) on horseshoe crab and shorebird populations and determine best practices to reduce risk.

Notes:
Several priority research needs are currently being addressed through the following surveys:

<u>Delaware Bay spawning beach survey:</u>

a) Determine sampling frame or list of beaches in the Bay with a nonzero probability of being sampled in a given year.
b) Determine how many beaches need to be surveyed on how many days to meet survey objectives.
c) Determine whether subsampling effort (no. of quadrats per beach) was adequate.
d) Consider a survey design that includes both fixed and random beaches.

<u>Delaware Bay egg count survey:</u>

a) Set primary objective of egg count surveys to be shorebird food availability and focus on density of eggs at the surface (< 5cm).

[23] Tagging work has been done by DeLancey and Floyd (SC DNR) in South Carolina to evaluate mortality from the biomedical bleeding process.
[24] United States Fish and Wildlife Service tagging program in progress.

b) Determine survey frequency (i.e., survey eggs annually, every 3 years, every 5 years, or other?).
c) Determine where, along the beach profile, eggs should be sampled.
d) Determine sample size for sampling eggs on a beach.
e) Determine the relationship between spawning activity and density of eggs at the surface (<5cm). Is there a threshold of spawning activity below which eggs remain buried and unavailable to shorebirds?

<u>Offshore benthic survey:</u>

a) Design comparative surveys or experiments to determine gear efficiencies.

JONAH CRAB

STOCK ASSESSMENT AND POPULATION DYNAMICS

A coastwide stock assessment has yet to be completed for Jonah crab but is considered a high priority need. An assessment was initiated in 2021 and is anticipated to be completed in 2023. The assessment will provide much needed data on the status of the Jonah crab resource as well as contribute to recommendations for additional management needs, if any. The following recommendations are from a report on pre-assessment data workshops conducted in 2020 and 2021.

(Full Citation: Atlantic States Marine Fisheries Commission. 2021. Jonah Crab Pre-Assessment Data Workshop Report. Arlington, VA.)

High Priority

- Information should be collected to help delineate stock boundaries (e.g. genetics). Identification of stock boundaries is an essential step in stock assessment that will inform many subsequent steps including development of input data and identification of methods applicable to the stock(s). Note: Some genetic research is currently being conducted by the Gloucester Marine Genomics Institute that may address this recommendation.
- Female migration pathways/seasonality and larval duration and dispersal need to be researched. Anecdotal information suggests seasonal aggregations in inshore areas, but research would help to understand these mechanisms and inform stock boundaries.
- Inter-molt duration of adult crabs is currently unknown and growth increment data for mature crabs is limited. These data will be necessary to transition to size- or age-based assessment methods.
- Develop fisheries-independent surveys (e.g. trap survey) to index post-settlement Jonah crab abundance from offshore areas where most of the fishery is executed.
- Increase fisheries-dependent monitoring of the offshore fleet. Sampling intensity by statistical area should be based on landings.
- Reproductive studies pertaining to male-female spawning size ratios, the possibility of successful spawning by physiologically mature but morphometrically immature male crabs, and potential for sperm limitations should be conducted.
- The amount of directed commercial effort on Jonah crabs vs. lobster should be quantified on a per trip basis.

Moderate Priority

- Cohort tracking analyses with existing data should be conducted across and within surveys to better understand if surveys are tracking true abundance signals and provide information on growth, mortality, and other demographic factors.
- Investigate the efficacy of existing lobster ventless trap surveys, including interaction between lobster and Jonah crab, to determine utility for indexing Jonah crab abundance. Research has shown that as lobster trap catch increases; crab catch within

the same trap decreases (Miller and Addison 1995, Richards et al. 1983). This suggests abundance trends for Jonah crab will be heavily influenced by lobster density.

Low Priority

- Additional sampling to expand upon the University of Maine Settlement Collector Sampling should be conducted to provide a more comprehensive understanding and tracking of temporal and spatial settlement dynamics.
- The development of aging methods or determination of the mechanism responsible for the suspected annuli formation found in the gastric mill should be explored.
- Food habits data should be analyzed from offshore areas to better understand predation of Jonah crab.

NORTHERN SHRIMP

Fishery-Dependent Priorities

High

- Evaluate selectivity of shrimp by traps and trawls
- Continue sampling of the northern shrimp commercial fishery, including port, sea, and RSA sampling to confirm, and if necessary update, the length-frequency of the species and identify any bycatch in the fishery

Moderate

- Conduct a study comparing the effectiveness of the compound grate versus the double-Nordmore grate

Fishery-Independent Priorities

High

- Continuing sampling through summer shrimp survey despite the current low abundance of shrimp and the closure of the shrimp fishery in 2013

Moderate

- Explore ways to quantify age 1 and younger shrimp
- Adapt the current model-based approach for estimating trawl biomass indices to estimates of length structure
- Evaluate potential benefits of re-stratification of the ASMFC Shrimp Survey. Two strata have already been dropped, and the remaining strata may be less optimal. Given the possibility that shrimp may move to deeper waters as surface waters warm, higher depth resolution of strata may be useful
- As the GOM northern Shrimp stock is the southernmost stock, it is highly likely to be sensitive to changing temperature regimes. If temperatures continue to increase, a substantial change in the spatial distribution of the stock may result. The current spatial distribution and potential changes in distribution should be explored, with a particular view to how the future data may inform subsequent model runs.

Modeling / Quantitative Priorities

High

- Continue research to refine annual estimates of consumption by predators, and include in models as appropriate
- Explore alternate forms of time-varying natural mortality, relaxing the current assumption of direct linear dependence of M_t on PPI
- Extend the current modelling approach to allow for directly estimating the functional relationship between M_t and PPI or other environmental factors
- Conduct more thorough evaluation and estimation of uncertainty and covariances (e.g., by either predicting data out of sample, resampling approaches to quantify the uncertainty in

model predictions, evaluation of the impacts of effective sample size on model outputs, etc.)

Moderate

- Investigate growth parameters for the UME length-based model and the feasibility of adding a spatial-temporal structure to the model framework
- Improve representation of temperature and other environmental predictors on recruitment. Currently the variance scaler used for sensitivity tests assumes temperature and recruitment deviations have equivalent uncertainties, whereas the relationship between temperature and recruitment deviations could be directly estimated in the model

Low

- Develop a spatially-implicit model with length-specific mortality rates varying seasonally to determine what effects this might have on the fishery

Life History, Biological, and Habitat Priorities

High

- Investigate application of newly developed direct ageing methods to ground truth assumed ages based on size and stage compositions.
- Evaluate larval and adult survival and growth, including frequency of molting and variation in growth rates, as a function of environmental factors and population density.
- Study the effects of oceanographic and climatic variation (i.e., North Atlantic Oscillation) on the cold water refuges for shrimp in the Gulf of Maine.
- Explore the mechanisms behind the stock-recruitment and temperature relationship for Gulf of Maine northern shrimp.

Low

- Re-evaluate size-based relationships for maturity and fecundity which are used to expand fishery-independent data and to inform the model.

Management, Law Enforcement, and Socioeconomic Priorities

High

- Characterize demographics of the fishing fleet by area and season. Perform comparative analysis of fishing practices between areas.[25]
- Develop an understanding of product flow and utilization through the marketplace. Identify performance indicators for various sectors of the shrimp industry. Identify significant variables driving market prices and how their dynamic interactions result in the observed intra-annual and inter-annual fluctuations in market price for northern shrimp.
- Explore new markets for Gulf of Maine shrimp, including community supported fisheries.[26]

[25] Dunham and Muller at the University of Maine conducted an economic study characterizing demographics of the fishing fleet by area and season in 1976. This study should be updated.

[26] Maine Fishermen's Forum panel discussions, 2006 and 2007

- Develop a framework to aid evaluation of the impact of limited entry proposals on the Maine fishing industry.[67,27]
- Develop a socioeconomic analysis assessing the importance of the northern shrimp fishery in annual activities of commercial fishing.
- Determine the relative power relationships between the harvesting and processing sector and the larger markets for shrimp and shrimp products.
- Develop an economic-management model to determine the most profitable times to fish, how harvest timing affects markets, and how the market affects the timing of harvesting.

Moderate

- Perform cost-benefit analyses to evaluate management measures.

[27] Maine Coastal Fishery Research Priorities, 2001, online at http://www.maine.gov/dmr/research/table_of_contents.htm

RED DRUM

Short and long-term research recommendations are prioritized, with the highest priorities listed first under each section and the lowest priorities listed last under each section.

Short-term

- Conduct experiments using logbooks to develop estimates of the B2 catch length composition in both the North and South regions.
- Determine if existing and historic recreational data sources (e.g., tagging) can be used to evaluate better B2 selectivities.
- Further study is needed to determine discard mortality estimates for the Atlantic coast, both for 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).
- Continued and expand observer coverage for the NC and VA gill net fisheries (5-10% coverage).
- Expand observer coverage to include other gears of concern (i.e. haul seine, pound net, trawls).
- Expand biostatistical sampling (ages and lengths) to better cover all statistical strata (gears/states - principally NC and VA) and collect more ages proportional to lengths, preferably otoliths. Conduct statistical analysis to determine appropriate sample sizes to adequately characterize the age-size composition of removals.
- Conduct a tagging study using emerging technologies (i.e., acoustic tagging, satellite tagging, genetic tags) to evaluate stock mixing and identify movement of sub-adult fish transitioning to maturity.
- Determine batch fecundity estimates of red drum. Need to include age-specific spawning frequency and spawning season length for this indeterminate spawner.
- Update maturity schedules for Atlantic red drum from Florida to Virginia. Preferably, gonad histology samples should be collected from all sizes over time and archived.
- Otolith microchemistry analysis should be considered to look at state level differences between regions to support stock structure differentiation.
- Continue cooperation between state ageing labs, such as the October 2008 red drumageing workshop, to provide consistent age verification between labs.

Long Term

- Investigate iterative re-weighting of data components to identify the appropriate weights given to each data component in the objective function.
- Investigate alternative functions for retention to include recreational harvest and dead releases in the same fleets. Commercial discards should also be considered as a discard component of the landings fleet.

- Allow for time varying reporting rate of tag recaptures in the assessment model. This would allow use of more recent tag-recapture data from NC and estimates of changes over time in both regions.
- Continue genetic analyses (i.e, SC DNR analyses) to evaluate stock structure and mixing and temporal changes in genetic composition of the red drum population.
- Consider a pilot Virginia adult survey and expanding current adult fishery-independent survey coverage in Florida waters.
- Identify impacts of water quality, environmental, and ecosystem changes on red drum stock dynamics. Incorporate in the stock assessment models.
- Quantify habitat changes for future management planning.

RIVER HERRING

Assessment

- Improve methods to develop biological benchmarks used in assessment modeling (fecundity-at-age, mean weight-at-age for both sexes, partial recruitment vector/maturity schedules) for river herring stocks. (short term, moderate priority)
- Explore use of peer-reviewed stock assessment models for use in additional river systems in the future as more data become available. (long term, moderate priority)
- Analyze the consequences of interactions between the offshore bycatch fishery and population trends in the rivers. (short term, high priority)

Implementation

- Develop better fish culture techniques and supplemental stocking strategies for river herring. (long term, low priority)
- Encourage studies to quantify and improve fish passage efficiency and support the implementation of standard practices. (long term, high priority)

Population Dynamics

- Investigate contribution of landlocked versus anadromous produced fish. (long term, low priority)
- Continue genetic analyses to determine population stock structure along the coast and enable determination of river origin of incidental catch in non-targeted ocean fisheries. (short term, high priority)
- Determine and quantify which stocks are impacted by mixed stock fisheries (including bycatch fisheries). Methods to be considered could include otolith microchemistry, oxytetracycline otolith marking, genetic analysis, and/or tagging. (long term, high priority)
- Develop models to predict the potential impacts of climate change on river herring distribution and stock persistence. (short term, low priority)
- Validate [better estimate] the different values of natural mortality (*M*) for river herring stocks and improve methods for calculating *M*. (long term, high priority)
- Continue to assess current ageing techniques for river herring, using known-age fish, scales, otoliths, and spawning marks. (short term, high priority)
- Conduct biannual ageing workshops to maintain consistency and accuracy in ageing fish sampled in state programs. (long term, high priority)
- Summarize existing information on predation by striped bass and other species; quantify consumption through modeling (e.g., MSVPA), diet, and bioenergetics studies. (long term, moderate priority)

- Investigate the relation between juvenile river herring production and subsequent year class strength, with emphasis on the validity of juvenile abundance indices, rates and sources of immature mortality, migratory behavior of juveniles, and life history requirements. (long term, high priority)
- Evaluate the performance of hatchery fish in river herring restoration. (long term, low priority)

Monitoring

- Improve reporting of harvest by waterbody and gear. (short term, high priority)
- Investigate additional sources of historic catch data of the U.S. small pelagic fisheries to better represent or construct earlier harvest of river herring. (short term, moderate priority)
- Develop and implement monitoring protocols and analyses to determine river herring population responses and targets for rivers undergoing restoration (dam removals, fishways, supplemental stocking, etc.). (short term, high priority)
- Develop comprehensive angler use and harvest survey techniques for use by Atlantic states with open or future fisheries to assess recreational harvest of river herring. (long term, low priority)
- Expand observer and port sampling coverage to quantify additional sources of mortality for alosine species, including bait fisheries, as well as rates of incidental catch in other fisheries. (long term, high priority)
- Evaluate and ultimately validate large-scale hydroacoustic methods to quantify river herring escapement (spawning run numbers) in major river systems. (long term, moderate priority)
- Explore the sources of and provide better estimates of incidental catch in order to reduce uncertainty in incidental catch estimates. (short term, high priority)
- Develop bottom and mid-water trawl catch-per-unit-effort (CPUE) indices of offshore biomass. (short term, moderate priority)
- Consider the use of generalized linear models (GLM) to provide better trend estimates and to better characterize uncertainty in trends. (short term, moderate priority)

SCUP

The following research topics were identified by the MAFMC SSC in 2019 -2020 with respect to the 2019 scup operational assessment. A Peer Review Committee provided responses on the status of each during the 2021 management track assessment.

- Characterize the pattern of selectivity for older ages of Scup in both surveys and fisheries. Response : this is currently ongoing estimation in assessment
- Explore the applicability of the pattern of fishery selectivity in the model to the most recent catch data to determine whether a new selectivity block in the model is warranted. Response: updated in 2021 MTA, new 2013+ selectivity block added to model.
- Mean weights-at-age have declined and age-at-maturity has increased slightly (the proportion mature at age 2 has decreased) in recent years. Continued monitoring of both is warranted. Response: ongoing monitoring in assessment.
- It was conjectured that the increase in stock biomass since 2000 resulted from increased recruitments due to the imposition of gear restriction areas (GRAs), to minimize interactions between Scup and squid fisheries, and from increases in commercial mesh sizes. Long-term climate variation is a potential alternative explanation for increased recruitments from 2000 to 2015. Research to explore the validity of both hypotheses is warranted. Response: no new research progress
- Improve estimates of discards and discard mortality for commercial and recreational fisheries. Response: no additional progress, but no concerns expected if current levels of sampling are maintained.
- Evaluate the degree of bias in the catch, particularly the commercial catch. Response: no stock-specific progress, but GARFO/NEFSC CAMS proposed for 2020+ data
- Conduct experiments to estimate catchability of Scup in NEFSC surveys. Response: no progress.
- Explore the utility of incorporating ecological relationships, predation, and oceanic events that influence Scup population size on the continental shelf and its availability to resource surveys used in the stock assessment model. Response: no new research progress.
- Explore additional sources of age-length data from historical surveys to inform the early part of the time series, providing additional context for model results. Response: no success, likely alternative is to begin model in 1984 in next RTA
- An MSE could evaluate the effectiveness of Scup management procedures. Response: no progress.
- The Scup Statistical Catch at Age assessment model uses multiple selectivity blocks. The final selectivity block (2006-2018) is the longest in the model. The applicability of the most recent selectivity block to the current fishery condition is uncertain. If the fishery selectivity

implied in this block changes, estimates of stock number, spawning stock biomass, and fishing mortality become less reliable. Response: updated in 2021 MTA – new 2013+ selectivity block added to model

- Recruitment indices for Scup have been declining in recent years. The 2021 management track assessment should consider the implications on stock biomass projections should this trend continue. Response: evaluated in the 2021 MTA assessment model and associated projections
- Most of the fishery-independent indices used in the model provide estimates of the abundance of Scup < age 3. One consequence is that much of the information on the dynamics of Scup of older ages arises largely from the fishery catch-at-age and from assumptions of the model, and are not conditioned on fishery-independent observations. As a result, the dynamics of these older fish remain uncertain. Knowledge of the dynamics of these older age classes will become more important as the age structure continues to expand. Response: no new research progress, but assessment indicated the abundance of older fish increasing in fishery and survey catches, and there is evidence of possible density dependent effects on growth and maturity
- The projection on which the ABC was determined assumes that the quotas would be landed in 2019, 2020, and 2021; however, landings in recent years have been below the quotas and perhaps a more realistic assumption should be used in future projections: given the uncertainty of fishery dynamics and catch estimated for 2020, the 2021 MTA projections assumed the ABCs would be caught in 2020-2021. Response: preliminary 2020 catch is 94% of 2020 ABC.
- Uncertainty exists with respect to the estimate of natural mortality used in the assessment. Response: no new research progress.
- Uncertainty exists as to whether the MSY proxies (SSB40%, F40%) selected and their precisions are appropriate for this stock. Response: no new research progress
- Survey indices are particularly sensitive to Scup availability, which results in high interannual variability. Efforts were made to address this question in the Stock Assessment Workshop and Stock Assessment Review Committee (SAW/SARC) in 2017 that should be continued in the 2021 management track assessment. Response: no new research progress

Research recommendations form the most recent SAW/SARC

Modeling / Quantitative Priorities

- Evaluation of indicators of potential changes in stock status that could provide signs to management of potential reductions of stock productivity in the future would be helpful.[28]
- A management strategy evaluation of alternative approaches to setting quotas would be helpful.
- Current research trawl surveys are likely adequate to index the abundance of scup at ages 0 to 2. However, the implementation of new standardized research surveys that focus on accurately indexing the abundance of older scup (ages 3 and older) would likely improve the accuracy of the stock assessment.[29]
- Continuation of at least the current levels of at-sea and port sampling of the commercial and recreational fisheries in which scup are landed and discarded is critical to adequately characterize the quantity, length and age composition of the fishery catches.[30]
- Quantification of the biases in the catch and discards, including non-compliance, would help confirm the weightings used in the model. Additional studies would be required to address this issue.
- The commercial discard mortality rate was assumed to be 100% in this assessment. Experimental work to better characterize the discard mortality rate of scup captured by different commercial gear types should be conducted to more accurately quantify the magnitude of scup discard mortality.
- Refine and update the Manderson et al.[31] availability analysis when/if a new ocean model is available (need additional support). Explore alternative niche model parameterizations including laboratory experiments on thermal preference and tolerance.
- Explore the Study fleet data in general for information that could provide additional context and/or input for the assessment.
- Explore additional sources of length/age data from fisheries and surveys in the early parts of the time series to provide additional context for model results.

[28] The WG noted that some progress in SSC work on 'rumble strip' analysis – used in 2013. The 2015 assessment explored the potential use of the Conn (2010) hierarchical method to combine indices across time and space; more developmental work is needed.

[29] The WG noted that the RI Industry Cooperative Trap survey was implemented during 2005-2012. This survey had a higher catch rate for larger and older fish of age 3+ than the bottom trawl surveys. A peer review indicated that some of the design elements should be modified and this advice was followed; however, funding was halted after 2012.

[30] The WG noted that adequate sampling has been maintained (see assessment tables and figures).

[31] Manderson JP, Schmidt A, Palamara L, Richardson D, Kohut J, Bonzek C. MS 2015. TOR 3: Describe the thermal habitat and its influence on the distribution and abundance of scup, and attempt to integrate the results into the stock assessment. 2015 SAW 60 Scup Working Group Working Paper A11. 52 p.

Fishery-Dependent Priorities

- Improve estimates of discards and discard mortality for commercial and recreational fisheries SBRM estimates of commercial fishery discards, which exhibit a less variable time series pattern and improved precision compared to previous estimates, were developed and accepted for this assessment.
- A standardized fishery-dependent CPUE of scup targeted tows, from either NEFOP observer samples or the commercial study fleet, might be considered as an additional index of abundance to complement survey indices in future benchmark assessments.

Fishery-Independent Priorities

- Evaluate indices of stock abundance from new surveys.[32]
- Explore experiments to estimate the catchability of scup in NEFSC and other research trawl surveys (side-by-side, camera, gear mensuration, acoustics, etc.).
- A scientifically designed survey to sample larger and older scup would likely prove useful in improving knowledge of the relative abundance of large fish.

Life History, Biological, and Habitat Priorities

- Quantify the pattern of predation on scup.[33]

Previous Research Recommendations

Fishery-Dependent Priorities

- Continue current level of sea and port sampling of the various fisheries in which scup are landed and discarded to adequately characterize the length composition of both landings and discards. Expanded age sampling of scup from commercial and recreational catches would be beneficial, with special emphasis on the acquisition of large specimens.[34]
- Commercial discard mortality had previously been assumed to be 100% for all gear types. Studies need to be conducted to better characterize the mortality of scup in different gear types to more accurately assess discard mortality.
- Additional information on compliance with regulations (e.g., length limits) and hooking mortality is needed to interpret recreational discard data and confirm weightings used in stock assessment model.

[32] The WG noted that the RI Cooperative Trap (ended in 2012), NEAMAP spring and fall surveys, indices at age from the RIDFW spring and fall surveys, and indices at age from the NYDEC survey are now included in the assessment documentation.

[33] The WG noted that the limited NEFSC survey food habits data for scup were reviewed and it is not possible to calculate absolute estimates of consumption of scup by predators due to sample size considerations (~500 identifiable scup in the ~40 year time series).

[34] Improved sampling intensity of landings and increased funding for the observer program since 2004 have improved discard sampling in the directed and bycatch fisheries for scup.

Fishery-Independent Priorities

- Fund, support, and expand the spatial coverage of the ventless trap-based Scup and Black Sea Bass Survey of Hard Bottom Areas.
- Collect total and fork lengths from individual scup in a standardized manner throughout their size and geographic range and across gear types to improve upon the length conversion equation currently cited in the FMP (Hamer, 1979).

Modeling / Quantitative Priorities

- Continue exploration of relative biomass and relative exploitation calculations based on CPUE data from fishery-dependent data (e.g., observer, commercial, P/C VTR, MRIP, etc).
- Evaluate the current biomass reference point and consider alternative proxy reference points such as B_{MAX} (the relative biomass associated with F_{MAX}).
- Explore other approaches for analyzing survey data, including bootstrap resampling methods to generate approximate confidence intervals around the survey index point estimates.[35]
- Evaluate indicators of potential changes in stock status that could provide signs to management of potential reductions of stock productivity in the future.

Life History, Biological, and Habitat Priorities

- Conduct an ageing comparison workshop to (1) compare otoliths and scales and (2) compare state age-length keys.[36]
- Conduct biological studies to investigate factors affecting annual availability of scup to research surveys and maturity schedules.

Management, Law Enforcement, and Socioeconomic Priorities

- A Management Strategy Evaluation of alternative approaches to setting quotas, with attention paid to compliance related to minimum size, would be helpful.

[35] Completed for the NEFSC surveys, could be applied to state survey data.

[36] Contact and inform Eric Robillard of NEFSC Population Biology Branch.

SPANISH MACKEREL

Fishery-Dependent Priorities

- Increase proportion of fish with biological data within MRIP sampling.
- Continue to develop methods to collect a higher degree of information on released fish (length, condition, etc.) in the recreational fishery.
- Require mandatory reporting for all charter boats state and federal.
- Continue development of electronic mandatory reporting for for-hire sector.
- Continue research efforts to incorporate/require logbook reporting from recreational anglers.
- Establish a review panel to evaluate methods for reconstructing historical landings (SWAS, FWS, etc.).
- Quantify historical fishing photos for use in reconstructing recreational historical landings.
- Narrow down the sampling universe. Identify angler preference and effort. Require a reef fish stamp for anglers targeting reef fish, pelagic stamp for migratory species, and deepwater complex stamp for deep-water species. The program would be similar to the federal duck stamp required of hunters. This would allow the managers to identify what anglers were fishing for.
- Continue and expand fishery-dependent at-sea-observer surveys to collect discard information, which would provide for a more accurate index of abundance.
- Implement observer coverage for the fisheries for Spanish mackerel (gillnets, castnets (FL), handlines, poundnets, and shrimp trawls for bycatch). Allocate 5-10% observer coverage by strata within states and collect maximum information from fish.
- Expand TIP sampling to better cover all statistical strata, predominantly from FL and by gillnet and castnet gears.
- Determine the tradeoff with length versus ages, need for more ages (i.e., hard parts).
- Consider the use of VMS to improve spatial resolution of data.
- Consider simplified logbook language in regard to discards (e.g., list them as dead or alive).[37]
- Develop uniform state and federal reporting systems/forms to improve the ease and efficiency of data compilation.
- Establish online reporting and use logbooks as a backup.
- Establish a mechanism for identifying age samples that were collected by length or market categories, so as to better address any potential bias in age compositions.
- Continue improving “one-stop shopping” for commercial data from NMFS, ACCSP, and states.

Fishery-Independent Priorities

- Collect and analyze fishery independent data for adult Spanish mackerel.

[37] Current logbook categories for discards (all dead, majority dead, majority alive, all alive) are not useful for informing discard mortality.

Modeling / Quantitative Priorities

- Using simulation analysis, evaluate the utility of including interaction terms in the development of a standardized index and identify the potential effects these interaction terms have on stock assessments.
- Establish a fishery-independent survey meant to capture the population trends of coastal pelagic in the south Atlantic.
- Examine how schooling or migratory dynamics may influence the catchability of the species. In particular, research the assumption of the hyperstability of indices that sample the schooling portion of the stock.
- Determine whether it is important to model both sexes in the population for assessment purposes.
- Investigate steepness and alternative models for the stock recruit relationship. In particular, evaluate if there is newer data available on steepness from other analyses of S-R for pelagic stocks with similar reproductive strategies.[38]

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Life History, Biological, and Habitat Priorities

- Utilize recently developed genetic techniques to investigate the stock structure of Spanish mackerel. Microsatellite information should be explored to consider both stock identity and internal population structure.
- Collect Spanish mackerel maturity data from both regions and both sexes from specimens approximately 275 mm FL and lower to be staged via histological methods.

[38] The Review Panel for the 2012 SEDAR was uncertain as to how much the analysis would further inform the model or management at present

SPINY DOGFISH

Fishery-Dependent Priorities

High

- Determine area, season, and gear specific discard mortality estimates coastwide in the recreational, commercial, and non-directed (bycatch) fisheries.[39]
- Characterize and quantify bycatch of spiny dogfish in other fisheries.

Moderate

- Increase the biological sampling of dogfish in the commercial fishery and on research trawl surveys.

Low

- Further analyses of the commercial fishery is also warranted, especially with respect to the effects of gear types, mesh sizes, and market acceptability on the mean size of landed spiny dogfish.

Fishery-Independent Priorities

Moderate

- Conduct experimental work on NEFSC trawl survey gear performance, with focus on video work to study the fish herding properties of the gear for species like dogfish and other demersal roundfish.
- Investigate the distribution of spiny dogfish beyond the depth range of current NEFSC trawl surveys, possibly using experimental research or supplemental surveys.

Low

- Continue to analyze the effects of environmental conditions on survey catch rates.

Modeling / Quantitative Priorities

High

- Continue work on the change-in-ratio estimators for mortality rates and suggest several options for analyses.

Moderate

- Examine observer data to calculate a weighted average discard mortality rate based on an assumption that the rate increased with catch size.

Life History, Biological, and Habitat Priorities

High

- Conduct a coastwide tagging study to explore stock structure, migration, and mixing rates.
- Standardize age determination along the entire East Coast. Conduct an ageing workshop for spiny dogfish, encouraging participation by NEFSC, NCDMF, Canada DFO, other interested agencies, academia, and other international investigators with an interest in dogfish ageing.

[39] A discard mortality study in the North Carolina near-shore trawl and gillnet fisheries conducted by East Carolina University has been considered in previous stock assessments.

Moderate

- Identify how spiny dogfish abundance and movement affect other organisms.

Management, Law Enforcement, and Socioeconomic Priorities

Moderate

- Monitor the changes to the foreign export markets for spiny dogfish, and evaluate the potential to recover lost markets or expand existing ones.

Low

- Update on a regular basis the characterization of fishing communities involved in the spiny dogfish fishery, including the processing and harvesting sectors, based upon Hall-Arber et al. (2001) and McCay and Cieri (2000).
- Characterize the value and demand for spiny dogfish in the biomedical industry on a state by state basis.
- Characterize the spiny dogfish processing sector

SPOT

Short-term:

HIGH PRIORITY

- Expand collection of life history data for examination of lengths and age, especially fishery- dependent data sources.
- Organize an otolith exchange and develop an ageing protocol between ageing labs.
- Increased observer coverage for commercial discards, particularly the shrimp trawl fishery. Develop a standardized, representative sampling protocol and pursue collection of individual lengths and ages of discarded finfish.

MEDIUM PRIORITY

- Develop and implement sampling programs for state-specific commercial scrap and bait fisheries in order to monitor the relative importance of Spot. Incorporate biological data collection into program.
- Conduct studies of discard mortality for commercial fisheries. Ask commercial fishermen about catch processing behavior for Sp/Cr when trawl/gillnets brought over the rail.
- Conduct studies of discard mortality for recreational fisheries.
- Collect data to develop gear-specific fishing effort estimates and investigate methods to develop historical estimates of effort.

Long-term:

HIGH PRIORITY

- Continue state and multi-state fisheries-independent surveys throughout the species range and subsample for individual lengths and ages. Ensure NEFSC trawl survey continues to take lengths and ages. Examine potential factors affecting catchability in long-term fishery independent surveys.
- Continue to develop estimates of length-at-maturity and year-round reproductive dynamics throughout the species range. Assess whether temporal and/or density-dependent shifts in reproductive dynamics have occurred.
- Re-examine historical ichthyoplankton studies for an indication of the magnitude of estuarine and coastal spawning. Pursue specific estuarine data sets from the states (NJ, VA, NC, SC, DE, ME) and coastal data sets (MARMAP, EcoMon).

MEDIUM PRIORITY

- Identify stocks and determine coastal movements and the extent of stock mixing, via genetic and tagging studies.
- Investigate environmental and recruitment/ natural mortality covariates and develop a time series of potential covariates to be used in stock assessment models.
- Investigate environmental covariates in stock assessment models, including climate cycles (e.g., Atlantic Multi-decadal Oscillation, AMO, and El Nino Southern Oscillation, El Nino) and recruitment and/or year class strength, spawning stock biomass, stock distribution, maturity schedules, and habitat degradation.

- Investigate the effects of environmental changes (especially climate change) on maturity schedules for spot, particularly because this is an early-maturing species, and because the sSPR estimates are sensitive to changes in the proportion mature.
- Investigate environmental and oceanic processes in order to develop better understanding of larval migration patterns into nursery grounds.
- Investigate the relationship between estuarine nursery areas and their proportional contribution to adult biomass. I.e., are select nursery areas along Atlantic coast ultimately contributing more to SSB than others, reflecting better quality juvenile habitat?
- Develop estimates of gear-specific selectivity.

SPOTTED SEATROUT

Fishery-Dependent Priorities

High

- Collect data on the size and age of spotted seatrout released alive by anglers and the size and age of commercial discards.
- Increase observer coverage in states that have a commercial fishery for spotted seatrout.
- Expand the MRIP to assure adequate data collection for catch and effort data, increase intercepts, and include state add-ons of social and economic data needs.

Moderate

- Collection of commercial and recreational landings data should be continued and expanded.
- Improve precision of effort reporting through commercial trip ticket programs.

Fishery-Independent Priorities

High

- Develop state-specific juvenile abundance indices.
- Initiate fishery-independent surveys of spotted seatrout.
- Emphasis should be placed on collecting the necessary biological data to be able to conduct stock assessments and to assist in drafting fishery management plans.

Modeling / Quantitative Priorities

High

- Utilize age structure analyses by sex in stock assessments.
- Conduct state specific stock assessments to determine the status of stocks relative to the plan objective of maintaining a spawning potential of at least 20%.
- Provide state specific batch fecundity estimates for use in stock assessments.[40]

Life History, Biological, and Habitat Priorities

High

- Identify essential habitat requirements.
- Evaluate effects of environmental factors, especially cold winters, on spawning frequency and stock density.
- Continue work to examine the stock structure of spotted seatrout on a regional basis, with particular emphasis on advanced tagging and molecular techniques.[41]
- Conduct telemetry tagging surveys to provide precise estimates of mortality attributed to winter kills.[42]

Management, Law Enforcement, and Socioeconomic Priorities

High

- Initiate collection of social and economic aspects of the spotted seatrout fishery.

[40] South Carolina fecundity information available in Roumillat and Brouwer (2002).

[41] Masters project in progress examining the genetic structure of spotted seatrout along the Atlantic coast and the effects of winter conditions on genetic diversity of spotted seatrout.

[42] Masters project in progress examining lethal temperature thresholds of spotted seatrout.

SUMMER FLOUNDER

Fishery-Dependent Priorities

- Develop a program to annually sample the length and age frequency of summer flounder discards from the recreational fishery.[43]
- A comprehensive collection of otoliths, for all components of the catch-at-age matrix, needs to be collected on a continuing basis for fish larger than 60 cm (~7 years). The collection of otoliths and the proportion at sex for all of the catch components could provide a better indicator of stock productivity.[44]
- Develop a reference collection of summer flounder scales and otoliths to facilitate future quality control of summer flounder production ageing. In addition, a comparison study between scales and otoliths as ageing structures for summer flounder should be completed.[45]
- Collect and evaluate information on the reporting accuracy of recreational discards estimates in the recreational fishery.[46]
- Evaluate potential changes in fishery selectivity relative to the spawning potential of the stock; analysis should consider the potential influence of the recreational and commercial fisheries.[47]
- Use NEFSC fishery observer age-length keys for 1994 and later years (as they become available) to supplement NEFSC survey data in ageing the commercial fishery discard.

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[43] The SDWG noted that to date, ongoing programs are in place in the MRFSS/MRIP recreational sampling and the American Littoral Society (ALS). Most states have volunteer angler surveys (NC, VA, MD, NJ, NY, CT, RI, MA) which collects length of fish discarded (and landed) via several different methods (e.g., surveys, e-logbooks, etc.). Some progress has been made, but more synoptic data and potentially less biased data are needed including the length, age, and sex-frequency of discards.

[44] The SDWG noted that through a PMAFS study, 2 years of data collection has occurred to determine sex ratios in the commercial and recreational landings (Working Paper A13). This is not an ongoing study. One year of data collection has occurred to determine the sex of fish in the NJ state survey, and the MA state survey has had ongoing collection of sex data in their survey (2009-present). The Northeast region fishery sampling program now collects otoliths and scales for commercial landings, and is scheduled to start collecting individual weights.

[45] The SDWG noted that an exchange of aging structures between NEFSC and NCDMF was completed and a report was reviewed by the 2007 SDWG, in response to a 2005 SAW 41 high priority Research Recommendation. An additional exchange occurred between the NC-DMF and NEFSC in 2009. The SDWG notes that while the exchanges indicate that the current level of ageing consistency between NC and NEFSC is acceptable, there is a need to conduct and fund exchanges between all production ageing entities (e.g., NC, VIMS, ODU, NEFSC) using scales and otoliths more frequently, on a schedule consistent with benchmark assessments.

[46] The SDWG noted that some research has been conducted on reporting accuracy in the recreational for-hire fishery (Bochenek et al. 2011); however, comprehensive work across all fishing modes has not been completed.

[47] The SDWG noted that some progress has been made on this topic in a report prepared for the MAFMC SSC describing a MSE for the recreational fishery.

- Collect data to determine the sex ratio for all of the catch components.[48]
- Evaluate the size distribution of landed and discarded fish, by sex, in the summer flounder fisheries.
- Develop and ongoing sampling program for the recreational fishery landings and discards (i.e., collect age, length, sex) to develop appropriate age-length keys for ageing the recreational catch.

Fishery-Independent Priorities

- Collect information on overall fecundity for the stock, both egg condition and production, as a better indicator of stock productivity.[49]

Modeling / Quantitative Priorities

- Investigate trends in sex ratios and mean lengths and weights of summer flounder in state agency and federal survey catches.[50]
- Examine the sensitivity of the summer flounder assessment to the various unit stock hypothesis and evaluate spatial aspects of the stock to facilitate sex and spatially explicit modeling of summer flounder.[51]
- Determine the appropriate level for the steepness of the S-R relationship and investigate how that influences the biological reference points.
- Evaluate uncertainties in biomass to determine potential modifications to default OFL CV.
- Evaluate past and possible future changes to size regulations on retention and selectivity in stock assessments and projections.
- Incorporate sex -specific differences in size at age into the stock assessment.
- Apply standardization techniques to all of the state and academic-run surveys, to be evaluated for potential inclusion in the assessment.
- Conduct sensitivity analyses to identify potential causes of the recent retrospective pattern. Efforts should focus on identifying factors in both survey and catch data that could contribute to the decrease in cohort abundance between initial estimates based largely on survey observations and subsequent estimates influenced by fishery dependent data as the cohort recruits to the fishery.

[48] The SDWG noted that through a PMAFS study, 2 years of data collection has occurred to determine sex ratios in the commercial and recreational landings (WPA13). This is not an ongoing study.
[49] The SDWG noted that this recommendation has not been fully addressed and remains an ongoing data collection need. An ongoing study conducted by Dr. Chris Chambers (NOAA NMFS NEFSC Sandy Hook Laboratory) is examining summer flounder fecundity and egg condition.
[50] The SDWG noted that these trends were examined in great detail for the federal surveys for this assessment (WPA1). MADMF surveys collect sex data. The VIMS NEAMAP surveys collect sex data.
[51] The SDWG noted that progress has been made on aspects of this recommendation in WPA1, WPA8, WPA11, WPA12, and WPA15.

- Further work examining aspects that create greater realism to the summer flounder assessment (e.g., sexually dimorphic growth, sex-specific F, differences in spatial structure [or distribution by size?] should be conducted. This could include:
    a) Simulation studies to determine the critical data and model components that are necessary to provide reliable advice, and need to determine how simple a model can be while still providing reliable advice on stock status for management use, and should evaluate both simple and most complex model configurations.
    b) Development of models incorporating these factors that would create greater realism.
    c) These first steps (a or b) can be used to prioritize data collection, and determine if additional investment in data streams (e.g., collection of sex at age and sex at length and maturity data from the catch, additional information on spatial structure and movement, etc.) are worthwhile in terms of providing more reliable assessment results.
    d) The modeling infrastructure should be simultaneously developed to support these types of modeling approaches (flexibility in model framework, MCMC/bootstrap framework, projection framework).
- Develop methods that more fully characterize uncertainty and ensure coherence between assessments, reference point calculation and projections.

Life History, Biological, and Habitat Priorities

- Examine the male to female ratio at age-0 and potential factors (e.g., environmental) that may influence determination of that ratio.[52]
- Conduct further research to examine the predator-prey interactions of summer flounder and other species, including food habitat studies, to better understand the influence of these other factors on the summer flounder population.[53]
- Evaluate range expansion and change in distribution and their implications for stock assessment and management.
- Continued evaluation of natural mortality and the differences between males and females. This should include efforts to estimate natural mortality, such as through mark-recapture programs, telemetry.
- Develop comprehensive study to determine the contribution of summer flounder nursery area to the overall summer flounder population, based off approaches similar to those developed in WPA12.
- Continue efforts to improve understanding of sexually dimorphic mortality and growth patterns. This should include monitoring sex ratios and associated biological information in

[52] The SDWG noted that the male female ratio has been updated for the NEFSC surveys. The SDWG reviewed information in Luckenbach et al. 2009 which describes potential environmental factors that may affect sex ratios at age-0.

[53] The SDWG noted that WPA1 reviewed food habits data available on summer flounder predators and prey. The SDWG concludes that the data are not sufficient to estimate predator consumption of summer flounder and has not attempted to estimate summer flounder consumption of prey.

the fisheries and all ongoing surveys to allow development of sex-structured models in the future.

Management, Law Enforcement, and Socioeconomic Priorities

- Consider use of management strategy evaluation techniques to address the implications of harvest policies that incorporate consideration of retrospective patterns (see ICES Journal of Marine Science issue of May 2007). [54]

Previous Research Recommendations

Fishery-Dependent Priorities

High

- Develop a program to annually sample the length and age frequency of summer flounder discards from the recreational fishery.
- Collect and evaluate information on the reporting accuracy of recreational discard estimates in the recreational fishery.
- Conduct more comprehensive collection of otoliths, for all components of the catch-at-age matrix, on a continuing basis for fish larger than 60 cm (~7 years). The collection of otoliths and the proportion at sex for all of the catch components could provide a better indicator of stock productivity.
- Develop a reference collection of summer flounder scales and otoliths to facilitate future quality control of summer flounder production ageing. In addition, a comparison study between scales and otoliths as ageing structures for summer flounder should be completed.[55]
- Examine mesh selectivity patterns for a range of commonly used mesh sizes greater than the currently mandated sizes (5.5 Diamond/6 inch square).[56]
- Continue to collect and analyze age-length samples and CPUE data from the commercial and recreational fisheries throughout the range of summer flounder.

Moderate

[54] The SDWG noted that given the retrospective pattern has changed since this recommendation was developed (i.e., smaller and less problematic), this recommendation is no longer considered relevant by the SDWG.

[55] The SDWG reported that an exchange of aging structures between NEFSC and NCDMF was completed and a report was reviewed by the 2007 SDWG, in response to a 2005 SAW 41 high priority Research Recommendation. The SDWG noted that while the Fall 2006 ageing exchange between NC-DMF and the NEFSC indicated that the current level of ageing consistency between NC and NEFSC is acceptable, there is a need to conduct and fund these exchanges more frequently, on a schedule consistent with benchmark assessments.

[56] This research should only be a high priority if managers want to change the commercial minimum size. This research should wait until changes in minimum size are anticipated so outdated research does not have to be updated.

- Research directed at evaluating the mesh exemption program should be continued, with increased sample sizes to allow reliable statistical testing of results.
- Use NEFSC fishery observer age-length keys for 1994 and later years (as they become available) to supplement NEFSC survey data in ageing the commercial fishery discard.
- Undertake research to determine hooking mortality on summer flounder by circle, kahle, and regular "J" hooks and make the results of work already completed available to the Management Board.
- Collect data to determine the sex ratio for all of the catch components.
- Develop fish excluder devices to reduce bycatch of immature flatfish in fisheries that target species other than flounder.

Fishery-Independent Priorities

High

- Collect information on overall fecundity for the stock, both egg condition and production, as a better indicator of stock productivity.[57]
- Continue fishery-independent surveys and expand existing surveys to capture all sizes and age classes in order to develop independent catch-at-age and CPUE should focus on YOY and the southern region.

Modeling / Quantitative Priorities

High

- Investigate trends in sex ratios and mean lengths and weights of summer flounder in state agency and federal survey catches.

Low

- Examine the sensitivity of the summer flounder assessment to the various unit stock hypotheses and evaluate spatial aspects of the stock to facilitate sex and spatially explicit modeling of summer flounder.[58]

Life History, Biological, and Habitat Priorities

Moderate

- Develop or determine stock identification methods via meristics, morphometrics, biochemical research, and tagging (particularly off Virginia and North Carolina).

Low

[57] The SDWG noted that observed change in the sex ratio in NEFSC survey samples may result in the SSB estimates not translating as directly to egg production since there are more males proportionally in those older age categories. While these trends have not been examined in the state survey catches, these trends were examined in the NEFSC spring, autumn, and winter survey data. Additional work to examine and explain these trends in greater detail should be conducted.

[58] Current ASAP model lacks the capability to do sex and spatial modeling, so Stock Synthesis version of this approach (e.g., M. Maunder 2008 SAW 47 work) would be necessary. Above all, there is a lack of sufficient time series data to sex all catch and surveys, and lack of information on spatial movement and/or recruitment patterns.

- Evaluate effects of dissolved oxygen and water current requirements for adult summer flounder and summer flounder eggs.
- Evaluate the relationship between recruitment of summer flounder to nursery areas and Ekman transport or prevailing directions of water flow.
- Examine male female ratio at age 0 and potential factors (e.g., environmental) that may influence determination of that ratio.
- Conduct the basic research necessary to develop land and pen culture techniques.
- Conduct further research to examine the predator-prey interactions of summer flounder and other species, including food habitat studies, to better understand the influence of these other factors on the summer flounder population.

Management, Law Enforcement, and Socioeconomic Priorities

Moderate

- Consider use of MSE techniques to address the implications of harvest policies that incorporate consideration of retrospective patterns (see ICES Journal of Marine Science issue of May 2007).
- Conduct a detailed socioeconomic study of the summer flounder fisheries.

TAUTOG

Fishery-Dependent Priorities

High

- Expand biological sampling of the commercial catch for each gear type over the entire range of the stock (including weight, lengths, age, sex, and discards).
- Continue collecting operculum from the tautog catch as the standard for biological sampling in addition to collecting paired sub-samples of otoliths and operculum.
- Increase catch and discard length sampling from the commercial and recreational fishery for all states from Massachusetts through Virginia.
- Increase collection of effort data for determining commercial and recreational CPUE.
- Increase MRIP sampling levels to improve recreational catch estimates by state and mode. Current sampling levels are high during times of the year when more abundant and popular species are abundant in catches, but much lower in early spring and late fall when tautog catches are more likely.

Fishery-Independent Priorities

High

- Conduct workshop and pilot studies to design a standardized, multi-state fishery independent survey for tautog along the lines of MARMAP and the lobster ventless trap survey.
- Establish standardized state by state long-term fisheries-independent surveys to monitor tautog abundance and length-frequency distributions, and to develop YOY indices.
- Enhance collection of age information for smaller fish (<20 cm) to better fill in age-length keys.
- Address finer-scale spatial issues through techniques like otolith microchemistry analysis and next-generation genetic sequencing.

Modeling / Quantitative Priorities

Moderate

- Develop an alternative flexible selectivity curve to use in the stock assessment model given the characteristics of multiple gear types in the tautog fisheries.
- Consider using alternative catch-at-age modeling frameworks (e.g., Stock Synthesis) in order to overcome some constraints of the ASAP model in the NMFS Toolbox. Simpler methods, such as xDB-SRA, can also be performed in Stock Synthesis, providing a common modeling framework to develop and compare different models and their specifications.

Life History, Biological, and Habitat Priorities

Moderate

- Define local and regional movement patterns and site fidelity in the southern part of the species range. This information may provide insight into questions of aggregation versus recruitment to artificial reef locations, and to clarify the need for local and regional assessment.

- Assemble regional reference collections of paired operculum and otolith samples and schedule regular exchanges to maintain and improve the precision of age readings between states that will be pooled in the regional age-length keys.
- Calibrate age readings every year by re-reading a subset of samples from previous years before ageing new samples. States that do not currently assess the precision of their age readings over time should do so by re-ageing a subset of their historical samples.
- Obtain biological metrics to match the spatial scale of the proposed models, to determine if there is biological justification for such models.

Low

- Evaluate the potential impacts of climate change on tautog range, life history, and productivity.
- Conduct a tag retention study to improve return rates, particularly in the northern region.
- Define the status (condition and extent) of optimum or suitable juvenile habitats and trends in specific areas important to the species. It is critical to protect these habitats or to stimulate restoration or enhancement, if required.
- Define the specific spawning and pre-spawning aggregating areas and wintering areas of juveniles and adults used by all major local populations, as well as the migration routes used by tautog to get to and from spawning and wintering areas and the criteria or times of use. This information is required to protect these areas from damage and overuse or excessive exploitation.
- Define larval diets and prey availability requirements. This information can be used as determinants of recruitment success and habitat function status. Information can also be used to support aquaculture ventures with this species.
- Define the role of prey type and availability in local juvenile/adult population dynamics over the species range. This information can explain differences in local abundance, movements, growth, fecundity, etc. Conduct studies in areas where the availability of primary prey, such as blue mussels or crabs, is dependent on annual recruitment, the effect of prey recruitment variability as a factor in tautog movements (to find better prey fields), mortality (greater predation exposure when leaving shelter to forage open bottom), and relationship between reef prey availability/quality on tautog condition/fecundity.
- Define the susceptibility of juveniles to coastal/anthropogenic contamination and resulting effects. This information can explain differences in local abundance, movements, growth, fecundity, and serve to support continued or increased regulation of the inputs of these contaminants and to assess potential damage. Since oil spills seem to be a too frequent coastal impact problem where juvenile tautog live, it may be helpful to conduct specific studies on effects of various fuel oils and typical exposure concentrations, at various seasonal temperatures and salinities. Studies should also be conducted to evaluate the effect of common piling treatment leachates and common antifouling paints on YOY tautog. The synergistic effects of leaked fuel, bilge water, treated pilings, and antifouling paints on tautog health should also be studied.
- Define the source of offshore eggs and larvae (in situ or washed out coastal spawning).
- Confirm that tautog, like cunner, hibernate in the winter, and in what areas and temperature thresholds, for how long, and if there are special habitat requirements during

these times that should be protected or conserved from damage or disturbance. This information will aid in understanding behavior variability and harvest availability.

Management, Law Enforcement, and Socioeconomic Priorities

Moderate

- Collect data to assess the magnitude of illegal harvest of tautog.

Low

- Collect basic sociocultural data on tautog user groups including demographics, location, and aspects of fishing practices such as seasonality.

WEAKFISH

Fishery-Dependent Priorities

High

- Increase observer coverage to identify the magnitude of discards for all commercial gear types from both directed and non-directed fisheries.[59]

Moderate

- Continue studies on temperature, size, and depth specific recreational hook and release mortality rates, particularly catches from warm, deep waters. Investigate methods to increase survival of released fish.
- Continue studies on mesh size selectivity, particularly trawl fisheries.[60]
- Improve methods to estimate commercial 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.

Low

- Determine the onshore versus offshore components of the weakfish fishery.
- Collect catch and effort data including size and age composition of the catch, determine stock mortality throughout the range, and define gear characteristics. In particular, increase length frequency sampling in fisheries from Maryland and further north.
- Develop latitudinal, seasonal, and gear specific age length keys coastwide. Increase sample sizes for gear specific keys.

Modeling / Quantitative Priorities

High

- Evaluate predation of weakfish, by an expanded suite of predators (e.g., marine mammals), including leveraging ongoing ASMFC work on multispecies models by including weakfish as both predator and prey.
- Develop a bioenergetics model that encompasses a broader range of ages than Hartman and Brandt (1995) and use it to evaluate diet and growth data.
- Conduct simulations with the proposed Z based control rules, or thresholds/targets in a time varying environment to explore alternative management options, particularly under a stock recovery scenario.
- Transfer Bayesian model code to more broadly accessible platform. The method likely has broad applicability for other stocks in the region and beyond.

Moderate

- Analyze the recruitment dynamics of weakfish and examine the effects of the relationship between adult stock size and environmental factors on year class strength; explore inconsistencies between YOY and Age 1 results from the assessment model.

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[59] Some additional Mid-Atlantic trawl fleet observer coverage has been implemented under ACCSP funding.

[60] Gillnet selectivity has been investigated by Swihart et al (2000). Some gear selectivity information in Amendment 3 to the ASMFC Weakfish FMP. Information can also be obtained from the North Carolina Pamlico Sound Independent Gill Net Survey.

- Conduct a simulation-estimation analysis to explore trends in natural mortality.
- Look for consistency and similarity among GLM survey estimation methods and check for sensitivity to collinearity of different drivers with the YEAR effect.
- Currently, spatial asynchrony in the Bayesian model includes a variance parameter for each age and year, but most of the variation seems to be among years. Evaluate whether annual variance is more parsimonious.
- Assessment model input weights-at-age are poorly estimated or at best variable. Conduct sensitivity analyses to evaluate how much of this is real and how it affects model performance.

Low

- Explore alternatives for dealing with uncertainties in age-length keys and catch data through length based or condition-based models, recognizing these come with new issues, like proper representation of growth.
- Catch measurement errors appeared relatively small; explore whether other process or measurement error processes are perhaps overly constraining the fit, possibly through simulation estimation.

Life History, Biological, and Habitat Priorities

High

- Develop a coastwide 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.[61]
- Monitor weakfish diets over a broad regional and spatial scale, with emphasis on new studies within estuaries.
- Continue to investigate the geographical extent of weakfish hybridization.
- Estimate weakfish mortality through independent approaches (e.g. alternative models, tagging) to corroborate trends in mortality from the assessment model.
- Conduct a meta-analysis of all factors likely to influence changes in natural mortality to see if the aggregate effect shows stronger statistical likelihood of occurrence than the significance shown by each individual driver effect on its own.

Moderate

- Identify and delineate weakfish spawning habitat locations and environmental preferences to quantify spawning habitat.
- Compile data on larval and juvenile distribution from existing databases to obtain preliminary indications of spawning and nursery habitat location and extant.
- Examine geographical and temporal differences in growth rate (length and weight-at-age).

[61] Tagging work to evaluate mortality, movement, stock mixing, and weakfish predator information was begun in North Carolina in 2013. Otolith samples have been obtained by Old Dominion University, but funding has not been available for processing.

- Determine the impact of power plants and other water intakes on larval, post larval, and juvenile weakfish mortality in spawning and nursery areas. Calculate the resulting impact on adult stock size.[62]
- Monitor predation on weakfish from both fish and marine mammal species.
- Determine the impact of scientific monitoring surveys on juvenile weakfish mortality. Calculate the resulting impact on adult stock size.

Management, Law Enforcement, and Socioeconomic Priorities

High

- Improve implementation of the process for organizing and collecting data from different agencies and sources to assure timely and high quality data input into the model.

Moderate

- Assemble socioeconomic data as it becomes available from ACCSP.

Low

- Define restrictions necessary for implementation of projects in spawning and over wintering areas and develop policies on limiting development projects seasonally or spatially.

[62] Data are available for power plants in the Delaware Bay area and North Carolina. Also see Heimbuch et al. 2007. Assessing coastwide effects of power plant entrainment and impingement on fish populations: Atlantic menhaden example. *North American Journal of Fisheries Management*. 27: 569-577.

WINTER FLOUNDER

Coast Wide

Fishery-Dependent Priorities

High

- Increase the intensity of commercial fishery discard length sampling.
- Expand sea sampling to validate commercial discard estimates from VTR.

Fishery-Independent Priorities

Moderate

- Evaluate the maturity-at-age of fish sampled in inshore surveys (i.e., MEDMR, MADMF, NEAMAP, etc.).[63]
- Encourage support for Industry Based Surveys, which can provide valuable information on stock abundance, distribution, and catchability in research surveys that are independent of and supplemental to NMFS effort.

Modeling / Quantitative Priorities

Moderate

- Investigate the skipped spawning percentage for each stock and estimate inter-annual variation when sufficient data have been collected.

Low

- Develop mortality estimates from the American Littoral Society tagging data, if feasible.
- Explore use of a more complex Stock Synthesis model with small rates of migration between stocks.
- Revise the NEFSC assessment software to include the ability to model stock-recruit functions including environmental factors with errors/probabilities.
- Develop time series of winter flounder consumption by the major fish predators of winter flounder.
- Explore development of an index of winter flounder larval abundance based on MARMAP, GLOBEC, and other time series.

Life History, Biological, and Habitat Priorities

High

- Focus research on quantifying mortality associated with habitat loss and alteration, contamination by toxins, and power plant entrainment and impingement. Examine the implications of these anthropogenic mortalities on estimation of YPR, if feasible.

[63] See McBride et al. 2013. Latitudinal and stock-specific variation in size- and age-at-maturity of female winter flounder, *Pseudopleuronectes americanus*, as determined with gonad histology. *Journal of Sea Research*. 75: 41-51.

- Conduct studies to delineate all major sub-stocks in terms of geographic spawning area and seasonal offshore movements (e.g., exposure to fishing pressure).[64,99]

Moderate

- Update and investigate migration rates between stocks and movement patterns. Investigate localized structure/genetics within the stocks.[98,65]

Low

- Conduct studies of flounder populations in impacted areas to quantify physiological adaptation to habitat alteration, and interactive effects, on an individual and population level.

Management, Law Enforcement, and Socioeconomic Priorities

High

- Investigate ways to improve compliance to help VTR. Currently about 300 of the 1,500 permitted vessels consistently under report the number of statistical areas fished.

Southern New England – Mid-Atlantic Stock Complex

Modeling / Quantitative Priorities

Low

- Quantify adult sex ratio to determine the possibility of population decline due to a skewed sex ratio.

Life History, Biological, and Habitat Priorities

Moderate

- Examine egg and larvae distribution and abundance to determine YPR to predict future biomass development for the fishery.
- Assess distribution of winter flounder during each life stage by conducting tagging methods, focusing on juvenile to adult life stages. This information would be useful for estimating YPR and helpful to find answers as to why recruitment is at a vulnerable state.[99]
- Examine winter flounder distribution, abundance, and productivity based on oceanographic and climate warming and how that impacts biomass for the fishery.

Low

- Examine predator-prey relationships due to increased populations of cormorants, seals, and striped bass (examine stomach contents of predators to get a better idea on the quantification of predation on winter flounder by these predators).

Georges Bank Stock

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[64] The most recent comprehensive tagging study was completed in the 1960's (Howe and Coates). Some telemetry work done in southern Gulf of Maine, see DeCelles and Cadrin 2010. Movement patterns of inter flounder (*Pseudopleuronectes americanus*) in the southern Gulf of Maine: observations with the use of passive acoustic telemetry. *Fisheries Bulletin*. 108: 408-419.

[65] See Fairchild et al. 2009. Using telemetry to monitor movements and habitat use of cultured and wild juvenile winter flounder in a shallow estuary. *Tagging and Tracking of Marine Animals with Electronic Devices.* 9: 5-22.

Fishery-Independent Priorities

High

- Examine maturity data from NEFSC strata on Nantucket Shoals and near Georges Bank separately from more inshore areas.[97]

Life History, Biological, and Habitat Priorities

High

- Investigate use of periodic gonad histology studies to validate maturity estimates, with particular attention to obtaining sufficient samples from the Georges Bank stock.[97]
- Conduct studies to better understand recruitment processes of winter flounder, particularly in the Gulf of Maine and on Georges Bank.

Moderate

- Further explore the relationship between large scale environmental forcing (e.g., temperature, circulation, and climate) for effects on life history, reproduction, and recruitment in the Georges Bank stock.

Gulf of Maine Stock

Fishery-Dependent Priorities

High

- Improve sampling for biological data (particularly hard parts for ageing) of commercial landings for winter flounder.
- Process archived age samples from surveys and commercial landings and develop analytical based assessments.[66]

Low

- Estimate and evaluate the effects of catch and release components of recreational fishery on discard-at-age.

Fishery-Independent Priorities

Moderate

- Evaluate size selectivity performance of survey gear compared to typical commercial gear and implications for estimation of commercial discards from research survey length frequency information.

Modeling / Quantitative Priorities

Low

- Evaluate the effects of smoothed length frequency distributions on the relationship between survey and commercial catches-at-length.

Life History, Biological, and Habitat Priorities

High

[66] Maine DMR has archived winter flounder otoliths since 2002.

- Examine growth variations within the Gulf of Maine, using results from the Gulf of Maine Biological Sampling Survey (1993-94).[67]
- Conduct studies to better understand recruitment processes of winter flounder, particularly in the Gulf of Maine and on Georges Bank.

Moderate

- Further examine the stock boundaries to determine if Bay of Fundy winter flounder should be included in the Gulf of Maine stock complex.[98]

[67] Biological data on winter flounder has been collected on the Maine DMR trawl survey from 2000-2008 and should be included.

Common Research Recommendations for All Commission Managed Diadromous Species

Dams and Other Obstructions

General Fish Passage

- States should work in concert with the USFWS and the NOAA Fisheries Service to identify hydropower dams that pose significant impediment to diadromous fish migration and target them for appropriate recommendations during FERC relicensing.
- States should identify and prioritize barriers in need of fish passage based on clear ecological criteria (e.g., amount and quality of habitat upstream of barrier, size, status of affected populations, etc.). These prioritizations could apply to a single species, but are likely to be more useful when all diadromous species are evaluated together.
- A focused, coordinated, well supported effort among federal, state, and associated interests should be undertaken to address the issue of fish passage development and efficiency. The effort should attempt to develop new technologies and approaches to improve passage efficiency with the premise that existing technology is insufficient to achieve restoration and management goals for several East Coast river systems.
- Where obstruction removal is not feasible, install appropriate passage facilities, including fish lifts, fish locks, fishways, navigation locks, or notches (low-head dams and culverts).
- At sites with passage facilities, evaluate the effectiveness of upstream and downstream passage; when passage is inadequate, facilities should be improved.
- Dams/obstructions where upstream passage structures will be installed should be evaluated for effectiveness of downstream passage. Upstream passage structures should not be installed at these sites, unless downstream passage can be made safe, effective, and timely.
- Facilities for monitoring the effectiveness of the pass should be incorporated into the design where possible.
- Before designing and constructing fish passage systems, determine the behavioral response of each species of interest to major physical factors so that effectiveness can be maximized.
- Protection from predation should be provided at the entrance, exit, and throughout the pass.
- The passage facility should be designed to work under all conditions of head and tail water levels that prevail during periods of migration.
- Passages are vulnerable to damage by high flows and waterborne debris. Techniques for preventing damage include robust construction, siting facilities where they are least exposed to adverse conditions, and removing the facilities in the winter.
- Evaluate performance of conventional fishways, fish lifts, and eel ladders, and determine features common to effective passage structures and those common to ineffective passage structures.
- Conduct basic research into diadromous fish migratory behavior as it relates to depth, current velocity, turbulence, entrained air, light, structures, and other relevant factors.
- Use information from the previous two research recommendations to conduct CFD modeling to develop more effective fishway designs.

- Research technologies (barriers, guidance systems, etc.) for directing emigrating fish to preferred passage routes at dams.
- Identify low-cost alternatives to traditional fishway designs.
- Develop effective downstream passage strategies to reduce mortality.

Upstream Fish Passage

- Diadromous fish must be able to enter the passage facility with little effort and without stress.
- To prevent fish from becoming entrained in intake flow areas of hydropower facilities, construct behavioral barrier devices and re-direct them to safer passage areas.
- Fish ascending the pass should be guided/routed to an appropriate area so that they can continue upstream migration, and avoid being swept back downstream below the obstruction.

Downstream Fish Passage

- To enhance survival at dams during emigration, evaluate survival of fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and pass fish via the route with the best survival rate.

Other Dam Issues

- Where practicable, remove obstructions to upstream and downstream migration.
- Locate facilities along the river where impingement rates are likely to be lowest.
- Alter water intake velocities, if necessary, to reduce mortality to diadromous species.
- To mitigate hydrological changes from dams, consider operational changes such as turbine venting, aerating reservoirs upstream of hydroelectric plants, aerating flows downstream, and adjusting in-stream flows.
- Natural river discharge should be taken into account when alterations are being made to a river because it plays a role in the migration patterns of diadromous fish.
- Document the impact of power plants and other water intakes on larval, post-larval, and juvenile mortality in anadromous fish spawning areas, and calculate the resultant impacts to adult population sizes.
- Evaluate the upstream and downstream impacts of barriers on diadromous species, including population and distribution effects.

Water Quality and Contamination

- Maintain water quality and suitable habitat for all life stages of diadromous species in all rivers with populations of diadromous species.
- Non-point and point source pollution should be reduced in diadromous fish habitat areas.
- Implement BMPs along rivers and streams, restore wetlands, and utilize stream buffers to control non-point source pollution.
- Implement erosion control measures and BMPs in agricultural, suburban, and urban areas to reduce sediment input, toxic materials, and nutrients and organics into streams.
- Upgrade wastewater treatment plants and remove biological and organic nutrients from wastewater.
- Reduce the amount of thermal effluent into rivers. On larger rivers, include a thermal zone of passage.

- Provide management options regarding water withdrawal and land use to minimize the impacts of climate change on temperature and flow regimes.
- Discharge earlier in the year to reduce impacts to migrating fish.
- Conduct studies to determine the effects of dredging on diadromous habitat and migration; appropriate best management practices, including environmental windows, should be considered whenever navigation dredging or dredged material disposal operations would occur in a given waterway occupied by diadromous species.
- Introduction of new categories of contaminants should be prevented.
- Determine effects of change in temperature and pH for all life stages of all diadromous species. Use this information to model impacts of climate change on species.
- Develop studies to document which contaminants have an impact on the various life stages of each diadromous species; also note the life stages that are affected and at what concentrations.
- Determine unknown optima and tolerance ranges for depth, temperature, salinity, dissolved oxygen, pH, substrate, current velocity, and suspended solids.

Habitat Protection and Restoration

- Use multi-scale approaches (including GIS) to assess indicators of suitable habitat, using watershed and stream-reach metrics if possible (it should be noted, that where site specific data is lacking, it may not be appropriate to assess at this scale).
- Use multi-scale approaches for restoring diadromous fish habitat, including vegetated buffer zones along streams and wetlands, and implementing measures to enhance acid-neutralizing capacity.
- Conduct studies on the effects of land use change on diadromous species population size, density, distribution, health, and sustainability.
- Examine how deviation from the natural flow regime impacts all diadromous species. This work should focus on key parameters such as rate of change (increase and decrease), seasonal peak flow, and seasonal base flow, so that the results can be more easily integrated into a year-round flow management recommendation by state officials.
- Investigate consequences to diadromous stocks from wetland alterations.
- When states have identified habitat protection or restoration as a need, state marine fisheries agencies should coordinate with other agencies to ensure that habitat restoration plans are developed, and funding is actively sought for plan implementation and monitoring.
- Any project resulting in elimination of EFH (e.g., dredging, filling) should be avoided.
- Substrate mapping of freshwater tidal portions of rivers should be performed to determine suitable diadromous fish habitat, and that habitat should be protected and restored as needed.
- States should notify in writing the appropriate federal and state regulatory agencies of the locations of habitats used by diadromous species. Regulatory agencies should be advised of the types of threats to diadromous fish populations, and recommended measures that should be employed to avoid, minimize, or eliminate any threat to current habitat quantity or quality.

- Each state encompassing diadromous fish spawning rivers and/or producer areas should develop water use and flow regime guidelines protective of diadromous spawning and nursery areas to ensure the long-term health and sustainability of the stocks.

Permitting

- Develop policies for limiting development projects seasonally or spatially in spawning and nursery areas; define and codify minimum riparian buffers and other restrictions where necessary.
- Projects involving water withdrawal (e.g., power plants, irrigation, water supply projects) should be scrutinized to ensure that adverse impacts resulting from impingement, entrainment, and/or modifications of flow and salinity regimes due to water removal will not adversely impact diadromous fish stocks.
- State fishery regulatory agencies should develop protocols and schedules for providing input on Federal permits and licenses required by the Clean Water Act, Federal Power Act, and other appropriate vehicles, to ensure that diadromous fish habitats are protected.

Other

- Determine survival and mortality rates for all life stages of all diadromous species.
- Investigate predator-prey relationships for all life stages of all diadromous species.
- Determine the effects of channel dredging, shoreline filling, and overboard spoil disposal in the Atlantic coast on diadromous species.
- Define restrictions necessary for implementation of energy projects in diadromous species habitat areas and develop policies on limiting development projects seasonally and/or spatially.
- Promote cooperative interstate research monitoring and law enforcement. Establish criteria, standards, and procedures for plan implementation as well as determination of state compliance with management plan provisions.
- Diadromous fish may be vulnerable to mortality in hydrokinetic power generation facilities, and such projects should be designed and monitored to eliminate, or minimize, fish mortality.
- The use of any fishing gear that is deemed by management agencies to have an unacceptable impact on diadromous fish habitat should be prohibited within appropriate essential habitats (e.g., trawling in spawning areas or primary nursery areas should be prohibited).

Common Socioeconomic Research Recommendations for all Commission Managed Species

- Establish time series of social and economic data for use in management decisions. This is analogous to biological time series data that are currently being used in decision making for monitoring and fisheries management.
- Existing social and economic data sets are deficient and remedial. Develop and collect baseline of sociodemographic data for all Atlantic states by state, species, and community for commercial fishing and by state, species, community, and sector (boat, shore, and for-hire) for recreational and subsistence fisheries. Community profiles should include information on the infrastructure in support of the fisheries (e.g., provision of boat launches, haul-out yards, marine suppliers, recreational fishing docks).
- Update baseline data on a regular basis (e.g., every 3 years).
- Focus on research additional to the baseline for decisions to be made in the next few years.
- Evaluate existence value and non-consumptive use value (cultural and economic) for species that the ASMFC has protected through moratoria.