

Atlantic States Marine Fisheries Commission

Research Priorities and Recommendations to Support Interjurisdictional Fisheries Management for Selected Species



January 2019

Sustainably Managing Atlantic Coastal Fisheries

Acknowledgments

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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 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

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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.

¹ SASC is developing a draft protocol for sampling fisheries.

- Develop a coastwide sampling program for yellow and silver stage American eels using standardized and statistically robust methodologies.
- 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.

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

- Research mechanisms of recognition of the spawning area by silver eel, mate location in the Sargasso Sea, spawning behavior, and gonadal development in maturation.
- 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

Outstanding 2009 Lobster Stock Assessment Peer Review Research Recommendations Updated with Responses (in italics) from 2015 Benchmark Stock Assessment

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HIGH PRIORITY: While improvements such as mandatory dealer reporting have been made, the 2009 Panel feels commercial landings and fishing efforts continue to be recorded piecemeal over the stock range. We recommend that they be standardized. The Panel recommends a statistically-designed survey (rather than current ad hoc approach) be implemented for collection of biological characteristics of the catch. The Panel commends the improvement in the spatial coverage of sea and port biological sampling from commercial landings since the last stock assessment, but stresses the need to continue this sampling so as to achieve representative coverage of all segments of the fishing fleet. These data were especially helpful in evaluating Georges Bank stock status in the 2009 stock assessment. In particular, the Panel recommends annual reporting by state agencies of the data needed for the assessment model be implemented so that data are readily available for annual updates of stock indicators to be presented to the Lobster Management Board and for assessment model updates every five years.

- *Additional funds are needed to address the staffing needed to complete annual data reporting due to the scale and complexity of the fishery.*
- *A first cut of sampling power was attempted in this assessment, and has identified statistical areas in need of sampling and others that are adequately sampled.*

MEDIUM PRIORITY: While growth and mortality are key factors influencing population dynamics, recruitment often is the driver behind population resilience. The lobster stock assessment models define recruitment as entry into the fishery and thus bypass the early life stages. Nevertheless, we think research into larval mortality and distributions should be carried out. In particular, the biophysical coupled modeling approach (Xue et al. 2008) that simulates the patterns of egg production, temperature-dependent larval growth, stage-explicit vertical distributions of larvae, and mortality in a realistically simulated physical environment should be extended to other areas to understand recruitment sources for the U.S. lobster stocks. It will likely provide insight for the assessment team with regard to stock connectivity and shed some light on the conundrum of unusual stock resilience. In particular, the Panel recommends use of the model to understand whether larval sources are the same for below average and strong year classes. Identifying sources of recruits may provide managers with options to help ensure the continued resilience of this stock.

- *A long-term stock-wide larval study would be necessary to complete this, which requires funding and research.*

HIGH PRIORITY: Include an option to estimate a stock-recruitment relationship within the length-based model.

- *This research recommendation was not completed in the 2015 assessment because attention was focused on implementing recruit covariates to deal with environmental effects on recruitment, which appear more important in all stock areas during recent years. Interested users can use preliminary spawning biomass estimates as recruit covariates until these modifications are made to achieve nearly the same effect.*

HIGH PRIORITY: Examine the implications of varying the weightings on components of the overall likelihood on model fits. Such exploration is considered good practice in assessment modeling. With respect to model output presentation, the Panel also would have liked to have seen the actual likelihood values from the base case and alternative model runs, rather than just relative differences.

- *The 2015 assessment team used relative differences which are presented in the report and neglected to provide absolute values as requested.*

LOW PRIORITY: Allow more surveys as input.

- *The structure of the current code prevents reprogramming to allow an arbitrary number of surveys. It would be easier to reprogram the model than to make this type of change to the existing code. For the 2015 assessment, the model was modified to accommodate up to sixteen surveys which can be broken down by sex and season for efficient use of the available slots. The updated model sufficed for this assessment but the model should be reprogrammed for the next assessment.*

HIGH PRIORITY: The success of MSE relies heavily on the assumed stock-recruitment relationship. The Panel recommends completing a meta-analysis of stock-recruitment relationships for long-lived crustaceans so that some reasonable parameter estimates for the stock-recruitment relationship may be identified for the lobster stock, and then be implemented in the MSE.

- *Funding and research is needed to complete a MSE.*

Outstanding 2010 CIE Review Recommendations of the TC Report on SNE Recruitment Failure Updated with Responses (in italics) from 2015 Benchmark Stock Assessment

- Lobster recruitment surveys should be continued into the future, and if possible their sampling intensity should be increased to enhance their power to detect changes in larval or young-of-year abundance. New surveys are also recommended to give a spatially comprehensive picture of spawning patterns across SNE. Deployment of passive postlarval collectors is a promising methodology for such surveys. These surveys should be used (a) to improve understanding of recruitment processes, (b) to provide early feedback on the success of management measures aimed at protecting spawning

potential, and (c) to allow forecasts of recruitment and landings for both inshore and offshore area.

- *MA has added 4 new YOY sampling stations; RI has done additional sampling at 2 existing YOY stations. Additional sampling requires more funding, current state fiscal resources are limiting.*
- It is recommended that the UMM model and the model used in the report be investigated to determine which estimates of female abundance are most likely.
 - *This recommendation was not directly addressed in the 2015 assessment but female abundance estimates and trends for SNE were similar in the basecase and a range of sensitivity analyses.*
- It is recommended that the MA survey be relocated to a region where it is a better prediction of abundance and CPUE in the MA region.
- It is recommended that more reliable effort data is routinely collected from the fishery and that CPUE replace landings in assessing the fishery.
 - *Since the previous assessment most states have moved to 100% harvester reporting but the largest landing state still only collects 10% harvester reporting with 100% dealer reporting. This is an issue for the management to address.*
- It is recommended that effort be reduced in the fishery to a level equivalent to the 1980s and that a socio-economic study be implemented to determine the economic viability of effort reductions.
 - *This is an issue for the management board.*
- It is recommended that a study be undertaken to investigate the longer term future of the fishery. This could be achieved by using the downscaled IPCC climate models.
 - *Additional funds are necessary to apply IPCC modeling to the lobster fishery.*
- It is recommended that a decision rule process be considered that involves both government and industry and that incorporates both fishery independent (e.g. YOY) and fishery dependent (e.g. regional CPUEs) indices.
 - *This is an issue for the management board.*
- It is recommended that several low recruitment scenarios be determined and included in the projections. Each scenario needs to define what the recruitment value is compared to a base case (e.g. the BH-R).
- Further studies are undertaken to attempt to separate F from M.
 - *Additional funds are necessary to meet this objective.*

- It is recommended that the ASFMC adopts a definition of recruitment failure that is consistent with the criteria used to determine the threshold reference point that is used to assess whether the lobster stock is overfished.
 - *This is an issue for the management board.*
- It is recommended that, if and when exploitation of the SNE lobster stock is permitted, male lobster are preferentially exploited and female lobster are protected to the extent that is possible, *e.g.*, through use of a V-notch program or male-only fishery. It is also recommended that, if male lobster are preferentially exploited, monitoring programs are established to detect whether such exploitation produces a significant reduction in the number of females that are mated, or a significant reduction in the fecundity of females of different lengths.
 - *This is an issue for the management board.*
- It is recommended that managers impose a five-year moratorium on exploitation of the SNE lobster stock.
 - *This is an issue for the management board.*

2015 Lobster Stock Assessment Research Recommendations

Model Recommendations

Examine the use of a hierarchical modeling technique (Conn, 2010) to aggregate survey information for the different stock areas as an alternative to internally weighting indices in the model or using area-swept information.

Program Research

New research and expansion of existing monitoring programs in the following areas would provide information needed to improve future stock assessments.

FISHERY-DEPENDENT INFORMATION

- Accurate and comparable landings 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 our 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, and increased monitoring efforts for offshore areas, particularly those from which a large portion of landings originate, are necessary. These types of programs are essential for accurate lobster assessments and must have dedicated funding.
- There are some indications that lobster harvest may be under-reported and this under-reporting may be significant during some periods in the time series examined for this

assessment. It is recommended that future research examine this potential under-reporting, and this examination should include simulation testing of these potential periods of under-reporting. One particular area that can be examined is the period prior to the implementation of the 100/500 possession rule for non-pot gear, as landings by non-pot gear may have been a significant source of under-reporting.

- A thorough investigation of methods for determining optimal biological sampling intensity based on variability in catch and spatial/temporal landings information should be undertaken. This investigation should explore other metrics that may be more variable than length composition (i.e. conservation discards, sex ratio, legal proportions), as well as an examination of the importance of the different Statistical Areas to the assessment and how this may interplay with the needed level of sampling from those areas.

FISHERY-INDEPENDENT INFORMATION

- ***Ventless Trap Survey- (High priority)*** Calibration work to determine how catch in the ventless trap surveys relates to catch in the bottom trawl surveys would be a useful 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.
- Now that funding for long-term ventless trap surveys appears to be more secure, there are some outstanding questions regarding this survey method that would benefit from further research. Namely, understanding trap saturation, in terms of high lobster densities and the capacity of the traps, along with the ensuing behavioral interactions that affect trapping of particular individuals, is a prime topic of interest to understand how density might impact the segment of the population represented in the survey catch. Also, the efficiency of the standardize survey gear could be explored in relation to effective fishing circles.

MATURITY AND GROWTH

- ***(High priority)*** Increases in water temperatures over the past several decades (see Section 2.2) have likely resulted in changes to size at maturity and growth patterns, since temperature has such a strong influence on these vital processes (see Section 2.1). Maturity data used in this assessment are more than 20 years old, making it likely that changes have since occurred. Evidence to suggest that decreases in the size at which females reach maturity exists in both the GOM stock (see Pugh et al. 2013) and the SNE

stock (see DNC 2013, Landers et al. 2001). Changes in sizes at maturity will subsequently affect growth, since female molting frequency decrease after reaching sexual maturity. Additionally, growth is directly influenced by water temperatures, and evidence exists in SNE for increased molt frequency and decreased molt increments (DNC 2013). It is critical to collect updated information on maturity and growth in order to appropriately assign molt probabilities to lobsters in the U. Maine length-based model.

AGE

- If a definitive age-length relationship can be developed, a research recommendation will be to confirm the transition matrices used in the University of Maine model and improve the current assessment.
- In 2013 the Maine Department of Marine Resources contracted with the University of Maine for a five year \$250,000 project designed to apply Kilada et al.'s (2012) approach to ageing for lobster. This work will focus on lobsters ranging in size from newly settled lobsters to fully recruited sizes. Regional temperature regimes will be tested as well as differences between laboratory and field scenarios. Anticipated deliverables should be directly applicable to future assessment and will include size-at-age estimates, molt increments and molt frequency.

ENVIRONMENTAL INFLUENCE ON LOBSTER LIFE HISTORY PROCESSES

- Examine methods for determining age- or length-varying natural mortality, as well as looking at more rigorous ways of determining time-varying natural mortality for lobster, which may be driven by climactic shifts and changing predator fields. Additionally, interplay between natural mortality and the potential for underreported harvest should be examined to determine how these factors may impact assessment outcomes.
- Continue exploring relationships between environmental drivers (temperature) and recruitment. Develop techniques to enhance predictive capabilities of YOY indices used together with temperature time series. Improve methods to incorporate environmental data into population modeling.
- Examine post-larval settlement dynamics in relation to movement/re-distribution of spawning stock. Develop habitat suitability models for spawning stock and settling post-larvae. Integrate climate projections into habitat suitability models for lobster.
- The Maine Department of Marine Resources conducted a three year study (2010-2013) where settlement was measured in randomly selected sites, based on depth and substrate, and compared to standardized sentinel locations in Mid-Coast Maine. Mid-Coast Maine is the region with the longest time series for settlement, dating back to

1989. For this reason, it was important to investigate the patterns of settlement from fixed and randomly selected sites. Initial results indicate fixed and random stations have similar magnitude and trend with respect to settlement density for this region.

In other regions in Maine, there may be evidence that thermal conditions may have changed, providing additional habitat for settlement. Annis et al. (2013) suggest that small differences in water temperature may shape settlement patterns through either behavioral avoidance of colder settlement sites or elevated post-settlement mortality of postlarvae settling at colder sites. Wahle et al. (2013) observed young-of-year lobsters as deep as 80 m. If available substrate has increased in eastern/northern Maine, simply as a result of increasing water temperatures, then fixed sentinel sites in shallow water may miss a broader pattern of settlement in the region. As such, deep water settlement should be investigated, using an appropriate number of passive settlement collectors (see Wahle et al. 2009) to detect anticipated settlement in conditions where the lack of thermal stratification would tend to distribute postlarvae evenly with depth.

- With the high prevalence of shell disease in the SNE stock, particularly in ovigerous females, some exploration of the potential sub-lethal effects of disease should be examined. These effects could include negative impacts to larval quality, fecundity issues in females who need to re-direct physiological resources to dealing with the disease, and male sperm quality (see Comeau and Benhalima 2009). Any sub-lethal effects of shell disease could further impede the potential for the SNE stock to rebuild.

POPULATION DYNAMICS AND MATING SUCCESS

- With the SNE stock in such poor condition, questions arise regarding how the population functions at some basic levels. In particular, because of the nature of the American lobster mating system (wherein males establish mating shelters and females seek out and choose to mate with dominant males; see Atema 1986, Atema and Vogt 1995 for reviews), low population abundance may be causing a mate-finding Allee effect (Stephens et al. 1999, Gascoigne et al. 2009). There is some evidence indicating that larger, presumably reproductively mature females have not mated in some inshore regions (Pugh et al. 2013, Pugh 2014). In order to understand the potential the SNE stock has to rebuild, it is important to know whether current stock conditions have disrupted the mating system. Additional work to examine female mating activity and success should be initiated.

Due to the continuation of female-skewed sex ratios observed in the GBK stock (on-going since the previous assessment), questions regarding the reproductive capacity of these large females should be considered. Recent laboratory work showed that females who mated with smaller males, or who mated under female-skewed sex ratios, did not have completely filled seminal receptacles, and may have been sperm-limited (Pugh 2014). As such, information regarding the location and timing of the female molt (thus mating) would be required to determine whether the skewed sex ratios and larger

female size structure might impact female reproductive output. Additionally, sampling of the large females to determine whether they have mated would also be informative with regards to reproductive activity, as preliminary data indicated some large females had not mated (Goldstein et al. 2014).

STOCK CONNECTIVITY

- **(High priority)** There is need for a comprehensive large scale tagging study to examine stock connectivity between the Gulf of Maine and Georges Bank. Historical tagging studies demonstrate movement from the inshore Gulf of Maine to locations east of Cape Cod in the inshore portions of Georges Bank, from the Scotian Shelf to Georges Bank, and from inshore areas east of Cape Cod to inshore Gulf of Maine (see Section 2.9). What is lacking is a tagging study of lobsters in the fall/winter on Georges Bank proper, prior to seasonal migrations which occur in the spring. This information would be extremely valuable to help complement other data used to justify the combination of the Gulf of Maine and Georges Bank stock and to confirm the connectivity of the Gulf of Maine and Georges Bank.

AMERICAN SHAD AND RIVER HERRING

Contact Jeff Kipp, jkipp@asmfc.org

Fishery-Dependent Priorities

High

- Expand observer and port sampling coverage to quantify additional sources of mortality for alosine species, including bait fisheries, as well as rates of bycatch in other fisheries to reduce uncertainty.⁵

Moderate

- Identify directed harvest and bycatch losses of American shad in ocean and bay waters of Atlantic Maritime Canada.

Low

- Identify additional sources of historical catch data of the US small pelagic fisheries to better represent earlier harvest of river herring and improve model formulation.

Fishery-Independent Priorities

Moderate

- Develop demersal and pelagic trawl CPUE indices of offshore river herring biomass.

Modeling / Quantitative Priorities

High

- Conduct population assessments on river herring, particularly in the south.⁶
- Analyze the consequences of interactions between the offshore bycatch fisheries and population trends in the rivers.
- Quantify fishing mortality for major river stocks after ocean closure of directed fisheries (river, ocean bycatch, bait fisheries).
- Improve methods to develop biological benchmarks used in assessment modeling (fecundity-at-age, sex specific mean weight-at-age, partial recruitment vector/maturity schedules) for river herring and American shad of both semelparous and iteroparous stocks.
- Improve methods for calculating M.

Moderate

- Consider standardization of indices with a GLM to improve trend estimates and uncertainty characterization.
- Explore peer-reviewed stock assessment models for use in additional river systems as more data become available.

Low

- Develop models to predict the potential impacts of climate change on river herring distribution and stock persistence.

⁵ A prior statistical study of observer allocation and coverage should be conducted (see Hanke et al. 2012).

⁶ A peer reviewed river herring stock assessment was completed in 2012 by the ASMFC.

Life History, Biological, and Habitat Priorities

High

- Conduct studies to quantify and improve fish passage efficiency and support the implementation of standard practices.
- Assess the efficiency of using hydroacoustics to repel alosines or pheromones to attract alosines to fish passage structures. Test commercially available acoustic equipment at existing fish passage facilities. Develop methods to isolate/manufacture pheromones or other alosine attractants.
- Investigate the relationship between juvenile river herring/American shad 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.
- Develop an integrated coastal remote telemetry system or network that would allow tagged fish to be tracked throughout their coastal migration and into the estuarine and riverine environments.
- Verify tag-based estimates of American shad.
- Continue studies to determine river herring population stock structure along the coast and enable determination of river origin of catch in mixed stock fisheries and incidental catch in non-targeted ocean fisheries. Spatially delineate mixed stock and Delaware stock areas within the Delaware system. Methods to be considered could include otolith microchemistry, oxytetracycline otolith marking, genetic analysis, and/or tagging.⁷
- Validate the different values of M for river herring and American shad stocks through shad ageing techniques and repeat spawning information.
- Continue to assess current ageing techniques for river herring and American shad, using known-age fish, scales, otoliths, and spawning marks. Conduct biannual ageing workshops to maintain consistency and accuracy of ageing fish sampled in state programs.⁸
- Summarize existing information on predation by striped bass and other species. Quantify consumption through modeling (e.g., MSVPA), diet, and bioenergetics studies.
- Refine techniques for tank spawning of American shad. Secure adequate eggs for culture programs using native broodstock.

Moderate

- Determine the effects of passage barriers on all life history stages of American shad and river herring. Conduct studies on turbine mortality, migration delay, downstream passage, and sub-lethal effects.
- Evaluate and ultimately validate large-scale hydroacoustic methods to quantify river herring and American shad escapement in major river systems.
- Conduct studies of egg and larval survival and development.
- Conduct studies on energetics of feeding and spawning migrations of American shad on the Atlantic coast.

⁷ Genetic research currently underway in combination with otolith chemistry.

⁸ River herring ageing workshop to occur in 2013.

- Resource management agencies in each state shall evaluate their respective state water quality standards and criteria and identify hard limits to ensure that those standards, criteria, and limits account for the special needs of alosines. Primary emphasis should be on locations where sensitive egg and larval stages are found.
- Encourage university research on hickory shad.
- Develop better fish culture techniques, marking techniques, and supplemental stocking strategies for river herring.

Low

- Characterize tributary habitat quality and quantity for Alosine reintroductions and fish passage development.
- States should identify and quantify potential shad and river herring spawning and nursery habitat not presently utilized, including a list of areas that would support such habitat if water quality and access were improved or created, and analyze the cost of recovery within those areas. States may wish to identify areas targeted for restoration as essential habitat.¹¹
- Investigate contribution of landlocked versus anadromous produced river herring.

Additional Habitat Research Recommendations

- When considering options for restoring alosine habitat, include study of, and possible adjustment to, dam-related altered river flows.
- Ascertain how abundance and distribution of potential prey affect growth and mortality of early life stages of alosines.
- Determine factors that regulate and potentially limit downstream migration, seawater tolerance, and early ocean survival of juvenile alosines.
- Determine if chlorinated sewage effluents are slowing the recovery of depressed shad stocks.
- Determine if intermittent episodes of pH depressions and aluminum elevations (caused by acid rain) affect any life stage in freshwater that might lead to reduced reproductive success of alosines, especially in poorly buffered river systems.
- ASMFC should designate important shad and river herring spawning and nursery habitat as HAPC.⁹
- When populations have been extirpated from their habitat, coordinate alosine stocking programs, including: reintroduction to the historic spawning area, expansion of existing stock restoration programs, and initiation of new strategies to enhance depressed stocks.
- When releasing hatchery-reared larvae into river systems for purposes of restoring stocks, synchronize the release with periods of natural prey abundance to minimize mortality and maximize nutritional condition. Determine functional response of predators on larval shad at restoration sites to ascertain appropriate stocking level so that predation is accounted

⁹ River-specific habitat recommendations for American shad can be found in: Atlantic States Marine Fisheries Commission. 2007. American shad stock assessment report for peer review, volumes II and III. Atlantic States Marine Fisheries Commission Stock Assessment Report No. 07-01 (Supplement), Washington, D.C.

for, and juvenile out-migration goals are met. Also, determine if night stocking will reduce mortality.

Management, Law Enforcement, and Socioeconomic Priorities

High

- Develop and implement monitoring protocols and analyses to determine river herring and American shad population responses and targets for rivers and tributaries, particularly those undergoing restoration (passage, supplemental stocking, etc.).
- Determine the impact of directed fisheries on American shad and river herring stocks and reduce F.
- Mandate FMPs for rivers with active restoration plans for American shad or river herring.
- Improve spatial and gear specific reporting of harvest.

Low

- Conduct and evaluate historical characterization of socioeconomic development (potential pollutant sources and habitat modification) of selected shad rivers along the east coast.⁵
- Develop appropriate Habitat Suitability Index Models for alosine species in the fishery management plan. Possibly consider expansion of species of importance or go with the most protective criteria for the most susceptible species.

ATLANTIC MENHADEN

Many of the research and modeling recommendations from the last benchmark stock assessment (SEDAR 2015)¹⁰ 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.

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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 2015¹¹ and Atlantic menhaden scales have been added to the annual ASMFC QA/QC Fish Ageing Workshop (ASMFC 2017)¹² 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).

¹⁰ Southeast Data, Assessment, and Review (SEDAR). 2015. SEDAR 40 - Atlantic menhaden stock assessment report. SEDAR, North Charleston SC. 643 p.

¹¹ Atlantic States Marine Fisheries Commission (ASMFC). 2015. Atlantic Menhaden Ageing Workshop Report. ASMFC, Arlington, VA.

¹² Atlantic States Marine Fisheries Commission (ASMFC). 2017. Report of the Quality Assurance/Quality Control Fish Ageing Workshop. ASMFC, Arlington, VA.

6. Investigate relationship between fish size and distance from shore (addressing selectivity).
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. 2016¹³ and 2017¹⁴ 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. 2016¹⁵ evaluated coast wide recruitment patterns from 1959-2013 and found the Atlantic Multidecadal Oscillation was the best predictor of regional recruitment. Simpson et al. 2016¹⁶ 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.

Assessment Methodology

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.

¹³ 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.

¹⁴ 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.

¹⁵ 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.

¹⁶ 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.

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 statistical catch-at-age model). **NOTE:** This work will be addressed by McNamee's doctoral thesis (*in prep*)¹⁷ 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.

¹⁷ 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

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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

Contact: Katie Drew, kdrew@asmfc.org

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 mortality 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.

Contact: Katie Drew, kdrew@asmfc.org

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 Report¹⁸ 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.

¹⁸ Atlantic States Marine Fisheries Commission. 2017. Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report. ASMFC, Arlington, VA. 456pp.

- ****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 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 SEA BASS

Contact: Caitlin Starks, cstarks@asmfc.org

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.¹⁹
- 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.²⁰

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.

¹⁹ A pilot project is ongoing and proposals are being considered for funding to expand the program.

²⁰ 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.

Additional Modeling / Quantitative Priorities

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

Contact: Katie Drew, kdrew@asmfc.org

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.²¹
- 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)].

²¹ 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.

Life History, Biological, and Habitat Priorities

Moderate

- 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.²²
- Further evaluate the relationship between environmental factors (temperature, salinity etc.) and coastwide bluefish distribution.
- 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.

²² 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

Contact Kirby Rootes-Murdy, krootesmurdy@asmfc.org

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.²³

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.²⁴

Moderate

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

²³ All dealers must report landings by species.

²⁴ 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.

- 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.²⁵
- 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. 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.²⁶

²⁵ Work by Frazier, Belcher, and Gelsleichter is underway.

²⁶ Biological information indicates that females of some shark species spawn less often than annually.

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.

JONAH CRAB

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STOCK ASSESSMENT AND POPULATION DYNAMICS

A coastwide stock assessment has yet to be completed for Jonah crab but is considered a high priority need. 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.

RESEARCH AND DATA NEEDS

Biological

- **Maturity:** The Massachusetts Division of Marine Fisheries recently received a Saltonstall-Kennedy Grant to conduct research to determine male and female gonadal and morphometric maturity for the Gulf of Maine, Georges Bank, and Southern New England areas. Other maturity factors that still need further research include sperm limitations in a male dominated fishery and size ratios of mating crabs.
- **Mortality Rates in the Claw Fishery:** Research is needed to determine the fishery-mortality rates of crabs with claws removed as well as the spawning success of crabs missing claws. The time needed to regenerate a new claw is also unknown and is a research priority.
- **Claw-Carapace Width Ratio:** A study is needed to establish a claw length to shell width ratio. This will help inform management in the claw fishery.
- **Growth Rates:** Research is needed to determine the growth rates of Jonah crabs which are largely unknown. Furthermore, it needs to be determine whether Jonah crabs experience a terminal molt and have a maximum size.
- **Seasonality of Growth and Reproduction:** Seasonal changes in the molting and mating of Jonah crabs across their range is unknown and needs to be determined.

Economic

- **Fishery Description:** Information on the fishery is lacking including the proportion of the market for live/claw/processed crab and the proportion of the fishery sold directly to consumers and dealers.

Habitat

- **Migration:** Studies are needed to determine migrations of the Jonah crab population as well as seasonal habitat preferences.

NORTHERN SHRIMP

Contact: Katie Drew, kdrew@asmfc.org

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.²⁷
- 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.²⁸
- Develop a framework to aid evaluation of the impact of limited entry proposals on the Maine fishing industry.^{67,29}

²⁷ 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.

²⁸ Maine Fishermen's Forum panel discussions, 2006 and 2007

²⁹ Maine Coastal Fishery Research Priorities, 2001, online at http://www.maine.gov/dmr/research/table_of_contents.htm

- 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.

SPINY DOGFISH

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Fishery-Dependent Priorities

High

- Determine area, season, and gear specific discard mortality estimates coastwide in the recreational, commercial, and non-directed (bycatch) fisheries.³⁰
- 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.

³⁰ 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.

- 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.

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

WINTER FLOUNDER

Contact: Katie Drew, kdrew@asmfc.org

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.).³¹
- 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.

³¹ 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).^{32,99}

Moderate

- Update and investigate migration rates between stocks and movement patterns. Investigate localized structure/genetics within the stocks.^{98,33}

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

³² 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.

³³ 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.³⁴

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

³⁴ 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).³⁵
- 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

³⁵ 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

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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

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- 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.