Ecosystem and Ocean Planning Committee
September 12, 2018 Meeting Summary
Baltimore, MD

EOP Committee Attendees: Warren Elliott (Committee chair), Stew Michels (Committee vice-chair), Peter DeFur, Maureen Davidson (via webinar), Tony DiLernia, Roger Mann, Adam Nowalsky, Rob O'Reilly (via webinar), Ward Slacum, Mike Ruccio (via webinar), Mike Luisi (Council chair)

Additional Attendees: Brandon Muffley (MAFMC staff), Sarah Gaichas (NEFSC), Geret DePiper (NEFSC), Greg DiDomenico (GSSA), Purcie Bennett-Nickerson (PEW), Michelle Duval (Council contractor)

The purpose of the meeting was for the Ecosystem and Ocean Planning (EOP) Committee to utilize the information from the approved Risk Assessment to begin to identify scientific and management priorities, as outlined in the Ecosystem Approach to Fisheries Management (EAFM) guidance document. The Committee considered different ways to evaluate the Risk Assessment to help identify priorities. The EOP then developed a number of recommendations for Council consideration at their October 2018 meeting (**noted in bold and underlined**).

Review of 2017 Risk Assessment

A short presentation was provided by staff that reviewed the process and development of the 2017 Risk Assessment that was approved by the Council in December 2017. Since then, the Risk Assessment document was updated to reflect the latest information regarding Atlantic Mackerel as a result of the recently completed (November 2017) benchmark stock assessment. It also included additional details and justification as to how the risk level scores for the different Management Element factors were derived by MAFMC staff.

The Committee then discussed possible approaches and timing of incorporating new information and updated analyses into the Risk Assessment. For example, the Offshore Habitat risk element was not included in the final Risk Assessment evaluation because, at the time, the Committee felt the analysis for this factor was still too preliminary and not yet ready for use. Staff at the NEFSC have made progress on these analyses and there may be opportunities to further assess their utility in future iterations of the Risk Assessment. Given the Council's intent to make the Risk Assessment an adaptive document that is reflective of changing and improved information, the Committee agreed the Risk Assessment document should be updated and the most appropriate time to make those changes would occur after the Council received the updated State of the Ecosystem (SOE) Report (presented at the April Council meeting). Based on this, **the Committee recommended the EAFM Risk Assessment document be added as a Council deliverable in the annual Implementation Plan to reflect the most recent information available.**

The Committee then discussed pertinent outcomes of a recent SOE Workshop which was convened to discuss updates and improvements to the next SOE report to help provide the Council with the

most relevant information for management. Given the direct linkage and synergy between the Mid-Atlantic SOE and Risk Assessment, workshop participants were interested in possibly including some Management Elements (i.e. Fishing Mortality Control, Technical Interactions, Other Ocean Uses, Regulatory Complexity and Stability, Discards and Allocation) in future SOE reports to track timeseries or annual changes in Management Elements. The Committee had a lengthy discussion as to what elements might be most informative in an ecosystem context and how to appropriately evaluate an element and its actual impact (e.g. impact on status of target fishery versus impact on the greater economic value to the nation). Ultimately, **the Committee recommended Other Ocean Uses and Technical Interaction elements be included in future Mid-Atlantic SOE reports.**

Risk Assessment Prioritization Options and Conceptual Model Development

Sarah Gaichas and Geret DePiper from the NEFSC gave a presentation to the Committee that reviewed the structure framework process outlined the EAFM guidance document on next steps after the Risk Assessment, possible options on how the Committee may want to consider prioritizing the risk factors, example conceptual models based on the possible prioritization options and then how a conceptual model will then inform the development of a comprehensive Management Strategy Evaluation (MSE)[1]. This process is intended to focus efforts and resources to help the Council address ecosystem objectives and answer questions on those elements of high risk and priority. As noted by the Committee, the Risk Assessment, conceptual model development and MSE are iterative tools to be used by the Council to improve management and respond to changing conditions and priorities.

Three different Risk Assessment prioritization options were presented and considered by the Committee.

1. The single species with the greatest number of high risk ranking across all elements – black sea bass and summer flounder tied for the most high risk elements
2. The fishery with the highest landings value (proxy for seafood production and economic benefits) with the greatest high risk elements – the squid fishery complex
3. The risk element with the most high risk rankings across all categories – allocation

The Committee then discussed the different prioritization options and issues and questions the Committee way want to consider when determining a possible preferred species or fishery for further evaluation for a conceptual model. Some members noted that the current prioritization assumes all risk factors are weighted equally and maybe some factors are not as important which could influence what species you might select. In addition, those species, fisheries or functional groups that are the most data rich may want to be considered first. The process of developing the conceptual model will also highlight data needs and help with research priorities.

[1] For more details on next steps, see the "Using the Mid-Atlantic EAFM Risk Assessment: Possible Next Steps" discussion document available under Tab 4 of the October 2018 Council meeting materials: http://www.mafmc.org/briefing/october-2018

Committee Prioritization Discussion and Recommendations

The Committee then began to focus on the possible merits, pros and cons of specific species or fisheries that may be selected as the top priority for continued development. Below are the different species or fishery options discussed by the Committee as well as some rationale for consideration:

1. Black sea bass – lots of high risk factors, many management challenges, managing a species under high abundance,
2. Summer flounder – lots of high risk factors, data rich species, management challenges with a species under lower abundance, stock distribution changes
3. Squid fishery complex – high economic value, better management tools to achieve MSY, climate change implications
4. Scup – not as many management issues (i.e. less pressure), high abundance species, address specific management questions (i.e. appropriateness of GRA's, discards, market influences etc.)

Given the potential complexity and the uncertainty in the process and utility of full MSE in the management process, the Committee supported piloting the development of a conceptual model as the next step but not yet committing to an MSE. Based on the results and outcomes from the pilot conceptual model, the Council could then determine if continuing with an MSE is appropriate and beneficial to addressing priority management questions. Testing out a pilot conceptual model process can also help inform the Council as to whether or not the model and risk assessment tools work, provide for a gap analysis to identify potential research/data needs and highlight the most/least important risk factors, and help establish management priorities.

After extensive discussion, **the Committee recommended using the single species Risk Assessment prioritization approach (option 1 on page 2) and to pilot the development of a summer flounder conceptual model**. The Committee felt that while there are a number of issues and priorities with black sea bass, they center around management process, structure and limitations and a conceptual model is not needed to help the Council understand those issues. For scup, while the Committee felt a conceptual model may help answer some specific issues, those were limited in scope and overall value and taking on bigger issues of greater interest were a higher priority. Similarly, the Committee felt a conceptual model for squid would be limited in overall value and may be constrained by limited information. The Committee offered the following reasons in support of the development of a summer flounder conceptual model:

- **High utility** – the fishery has all the management issues, high interest from stakeholders and there are implications for everyone.
- **True EAFM issue** - recreational and commercial issues, economic and job considerations, allocation, climate drivers, species distribution shifts, management challenges
- **Data rich species** – one of the most extensive data sets for any Mid-Atlantic managed species, ability to utilize the results of the benchmark stock assessment to be completed by end of year and a variety of current economic MSE analyses currently being conducted

Potential outcomes of the pilot summer flounder conceptual model noted by Committee members include information on data availability and needs, relative importance of risk factors and elements (i.e. a change in factor X results this positive/negative result in factor Y) and 10 questions that could be answered using the model and data available. The conceptual model development and the potential 10 priority questions would be developed with input from the Council, Committee and Advisory Panel.

Risk Assessment Use in Council Science and Strategic Planning Priorities

The Committee also spent some time discussing potential other uses of the Risk Assessment results in addition to the development of a conceptual model and subsequent MSE. As recommended previously by the Committee, an updated Risk Assessment document that would be provided to the Council each year would include the color-coded summary tables that will provide a summary of the current risk factor scores at the species, fleet and ecosystem level. The updated information will provide a snapshot on those areas of risk that could then be used by the Council when considering management decisions.

The Risk Assessment and prioritization process can also be used to data gaps or data uncertainty which can then help set Council research priorities at an ecosystem, fleet and/or species level. These results can also be used in the development of annual Council priorities and deliverables. The latest version of the Risk Assessment is included in the October briefing book and available for use by the Executive Committee as they meet to begin setting 2019 priorities. In addition, the Risk Assessment will likely play an integral part in the next iteration of the Council's five-year strategic plan. Dr. Michelle Duval is on contract with the Council to help lead the next strategic plan and attended the Committee meeting to listen to the prioritization process and Committee discussion to help inform the strategic plan process. Dr. Duval will be working with staff and Council to help ensure the Risk Assessment results are incorporated into the planning process.

Mid-Atlantic EAFM Risk Assessment Documentation and Results

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Introduction

The Mid-Atlantic Council approved an Ecosystem Approach to Fisheries Management (EAFM) Guidance Document in 2016 which outlined a path forward to more fully incorporate ecosystem considerations into marine fisheries management. Of particular interest to the Council was the development of tools to incorporate the effects of species, fleet, habitat and climate interactions into its management and science programs. To accomplish this, the Council agreed to adopt a structured framework to first prioritize ecosystem interactions, second to specify key questions regarding high priority interactions and third tailor appropriate analyses to address them. Because there are so many possible ecosystem interactions to consider, risk assessment was adopted as the first step to identify a subset of high priority interactions.

This report documents the use of ecosystem indicators within the Mid-Atlantic Council's EAFM initial risk assessment. This risk assessment will help the Council decide where to focus limited resources to address ecosystem considerations by first clarifying priorities. Overall, the purpose of this document is to provide the Council with a proactive strategic planning tool for the sustainable management of marine resources under its jurisdiction, while taking interactions within the ecosystem into account.

What are we measuring? A **Risk Element** is an aspect that may threaten achieving the biological, economic, or social objectives that the Council desires from a fishery. Risk elements were derived from existing legislation (particularly the Magnuson-Stevens Act), public comment, manager feedback, or a mix of these things. Some Risk Elements may change as conditions change or new information becomes available. Therefore, the Council explicitly planned for this EAFM risk assessment to be a dynamic and evolving process that will be revisited and updated in future years.

Why are we measuring it? The **Risk Definition** clearly states what is at risk. In general, because the Council is charged with managing fisheries for Optimum Yield (OY), risk definitions often centered on a particular element's potential impact on achieving OY. However, some Risk Elements addressed additional Council objectives (e.g. maximizing fishery value, optimizing employment).

How are we measuring it? An **Indicator** is an observation that gives information about the risk element. It may be a time series of data or it may come from an individual study (even a previous risk assessment). To the extent possible, data for defining level of risk needed to be applicable and comparable coast-wide.

The Council selected a range of risk elements to be evaluated at either the managed species level, the species and sector level, or the ecosystem level. An overview of the risk elements with definitions and associated indicators as adopted by the MAFMC is presented in the table below. After the Council approved the list of Risk Elements, the final analytical decision was translating the indicators and other data into a level of risk.

What is the risk? The **Risk Ranking Criteria** were developed iteratively between analysts and the Council to use the available indicator(s). Analysts proposed initial criteria for low, low-moderate, moderate-high, and high risk based on the elements and indicators available. For trend-based risk definitions, a Mann-Kendall test for monotonic trends was used to test significance ($p<0.05$) of both long term (full time

series) and recent (2007-2016) trends. Autocorrelation in the time series was addressed by prewhitening the data as suggested by (Yue et al. 2002).

In the following sections, we describe each risk element in more detail along with proposed definitions of low, low-moderate, moderate-high, and high risk. Indicators are then shown for each risk element and a preliminary risk categorization based on the indicator is presented. For trend-based risk definitions, a Mann-Kendall test for monotonic trends is used to test significance ($p<0.05$) of both long term and recent trends. Autocorrelation in the time series was addressed by prewhitening the data as suggested by (Yue et al. 2002).

At the end of the document, we summarize risk ranking results across elements in three tables.

Risk Element	Definition: Risk to what?	Indicators used
Ecological		
Assessment performance	Risk of not achieving OY due to analytical limitations	Current assessment method/data quality
F status	Risk of not achieving OY due to overfishing	Current F relative to reference F from assessment
B status	Risk of not achieving OY due to depleted stock	Current B relative to reference B from assessment
Food web (MAFMC Predator)	Risk of not achieving OY due to MAFMC managed species interactions	Diet composition, management measures
Food web (MAFMC Prey)	Risk of not achieving OY due to MAFMC managed species interactions	Diet composition, management measures
Food web (Protected Species Prey)	Risk of not achieving protected species objectives due to species interactions	Diet composition, management measures
Ecosystem productivity	Risk of not achieving OY due to changing system productivity	Four indicators, see text
Climate	Risk of not achieving OY due to climate vulnerability	Northeast Climate Vulnerability Assessment
Distribution shifts	Risk of not achieving OY due to climate-driven distribution shifts	Northeast Climate Vulnerability Assessment + 2 indicators
Estuarine habitat	Risk of not achieving OY due to threats to estuarine/nursery habitat	Enumerated threats + estuarine dependence
Offshore habitat	Risk of not achieving OY due to changing offshore habitat	Integrated habitat model index
Economic		
Commercial Revenue	Risk of not maximizing fishery value	Revenue in aggregate
Recreational Angler Days/Trips	Risk of not maximizing fishery value	Numbers of anglers and trips in aggregate
Commercial Fishery Resilience (Revenue Diversity)	Risk of reduced fishery business resilience	Species diversity of revenue
Commercial Fishery Resilience (Shoreside Support)	Risk of reduced fishery business resilience due to shoreside support infrastructure	Number of shoreside support businesses

Risk Element	Definition: Risk to what?	Indicators used
Social		
Fleet Resilience	Risk of reduced fishery resilience	Number of fleets, fleet diversity
Social-Cultural	Risk of reduced community resilience	Community vulnerability, fishery engagement and reliance
Food Production		
Commercial	Risk of not optimizing seafood production	Seafood landings in aggregate
Recreational	Risk of not maintaining personal food production	Recreational landings in aggregate
Management		
Control	Risk of not achieving OY due to inadequate control	Catch compared to allocation
Interactions	Risk of not achieving OY due to interactions with species managed by other entities	Number and type of interactions with protected or non-MAFMC managed species, co-management
Other ocean uses	Risk of not achieving OY due to other human uses	Fishery overlap with energy/mining areas
Regulatory complexity	Risk of not achieving compliance due to complexity	Number of regulations by species
Discards	Risk of not minimizing bycatch to extent practicable	Standardized Bycatch Reporting
Allocation	Risk of not achieving OY due to spatial mismatch of stocks and management	Distribution shifts + number of interests
Put Aside		
Population diversity	Risk of not achieving OY due to reduced diversity	Size composition, sex ratio, genetic diversity
Ecological diveristy	Risk of not achieving OY due to reduced diversity	Fishery independent species diversity
Fishery Resilience (2)	Risk of reduced fishery business resilience due to access to capital	No current indicator avilable
Fishery Resilience (3)	Risk of reduced fishery business resilience due to insurance availabilty	No current indicator available
Fishery Resilience (5)	Risk of reduced fishery business resilience due to access to emerging markets/opportunities	Needs clarification
Commercial Employment	Risk of not optimizing employment opportunities	EOP Committee unconfident in Fisheries of US employment inicator
Recreational Employment	Risk of not optimizing employment opportunities	EOP Committee unconfident in Fisheries of US employment indicator
Seafood safety	Risk of not maintaining market access, human health	Number of public advisories by species

Ecological Elements

Assessment Performance

This element is applied at the species level. The elements below describe risks according to our best understanding of stock status, but assessment methods and data quality shape our understanding. This risk element addresses risk to achieving OY due to scientific uncertainty based on analytical limitations. The MAFMC risk policy accounts for scientific uncertainty in assessments, with methods for determining scientific uncertainty currently being refined by the Scientific and Statistical Committee. Ranking for this risk element will be adjusted if necessary to ensure consistency with SSC methods in the future.

Risk Level	Definition
Low	Assessment model(s) passed peer review, high data quality
Low-Moderate	Assessment passed peer review but some key data and/or reference points may be lacking
Moderate-High	*This category not used*
High	Assessment failed peer review or no assessment, data-limited tools applied

Stocks with low risk due to assessment performance include ocean quahog, surf clam, summer flounder, scup, black sea bass, Atlantic mackerel, butterfish, golden tilefish, and bluefish. Squids and dogfish are assessed with index-based assessment methods which rank low-moderate risk due to incomplete survey coverage in some years, and reference points for squids are lacking. The monkfish 2016 operational assessment was unable to model growth or population status due to innaccurate ageing methods, so both northern and southern stocks rank high risk for this element. At present, blueline tilefish ranks as high risk for assessment type because it is assessed with the data limited methods (DLM) toolbox.

F status and B status

These elements are applied at the species level. Fishing mortality (F) rates and biomass (B) levels relative to established reference points from assessments indicate the level of risk to achieving OY. Risk level definitions for F and B are below.

Risk Level	Definition
Low	F < Fmsy
Low-Moderate	Unknown, but weight of evidence indicates low overfishing risk
Moderate-High	Unknown status
High	F > Fmsy

Risk Level	Definition
Low	B > Bmsy
Low-Moderate	Bmsy > B > 0.5 Bmsy, or unknown, but weight of evidence indicates low risk
Moderate-High	Unknown status
High	B < 0.5 Bmsy

Current assessment results for all MAFMC managed stocks are summarized below. Based on these results, F and B status are both in the low risk category for surfclams, ocean quahogs, scup, black sea bass, and butterfish. Bluefish, golden tilefish, and spiny dogfish F status is in the low risk category, and B risk is in the low-moderate risk category. Summer flounder F status is in the high risk category and B status is in the low-moderate risk category. F and B status for northern and southern monkfish stocks were formerly in the low risk categories, but a recent assessment update was unable to determine status, so they were provisionally ranked low-moderate risk (unknown but weight of evidence supports lower risk). Longfin squid B is above the established B threshold, and both squid stocks have unknown F status, but F is difficult to estimate because it is very low relative to natural mortality, so they were also ranked low-moderate risk. Blueline tilefish are high risk for F status and have unknown B status and little auxiliary information in the Mid-Atlantic region, and so rank moderate-high risk for B status. Finally, Atlantic mackerel has high risk for both F and B status.

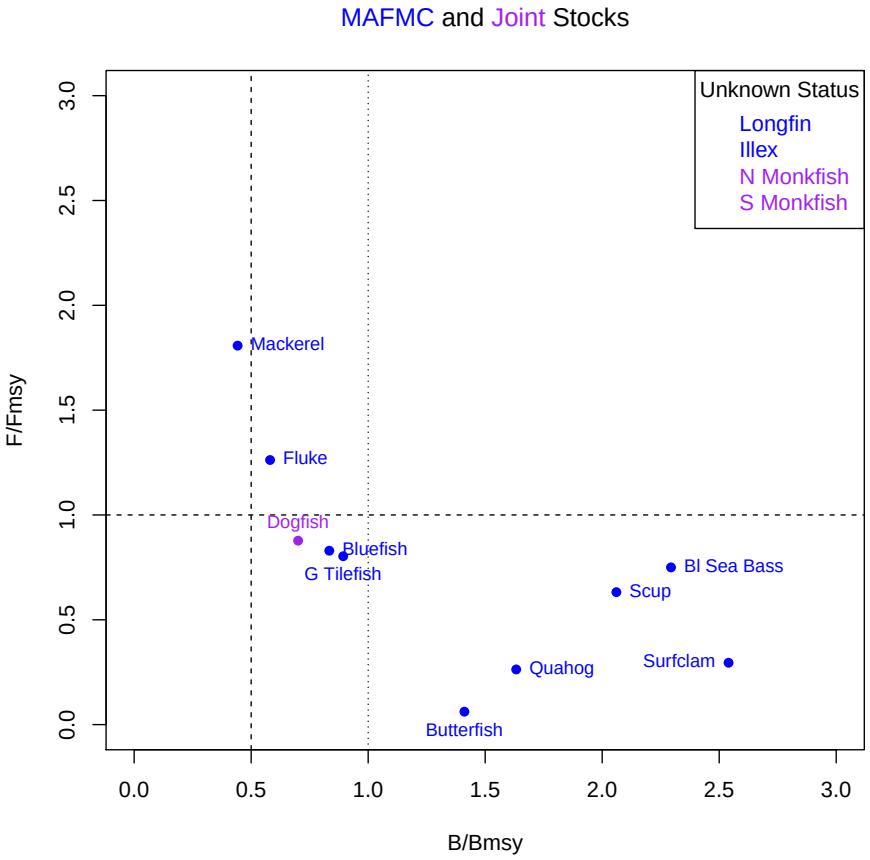

Figure 1: Summary of single species status for MAFMC stocks

Food Web (MAFMC Predators)

This element is applied at the species level. This element ranks the risks of not achieving OY due to predator interactions between MAFMC managed species. To rank these risks, the "importance" of each species as predator must be assessed. There are not clear standardized threshold to define this. Diet information can be used to develop thresholds: an important predator of MAFMC managed species can be defined as having more than a threshold level of MAFMC managed species in the diet by weight. "Dependent" predators warranting a high risk ranking would have a majority (>50%) of diet from an individual MAFMC managed species.

The EOP Committee agreed that high dependence on a single prey represented high risk to a predator, but could not come to agreement on thresholds for intermediate risk levels, so this risk ranking uses only low and high levels.

Risk Level	Definition
Low	Few interactions as predators of other MAFMC managed species, or predator of other managed species in aggregate but below 50% of diet
Low-Moderate	*This category not used*
Moderate-High	*This category not used*
High	Managed species highly dependent on other MAFMC managed species as prey

This information is gathered from the NEFSC food habits database and other sources (Johnson et al. 2008, Smith and Link 2010). Surfclams and ocean quahogs are not predators of other MAFMC managed species, so they rank low risk for this element. Similarly, scup, black sea bass, and golden and blueline tilefish eat primarily benthic invertebrates. Summer flounder, spiny dogfish, bluefish, and monkfish are predators of MAFMC managed species, but do not meet the threshold of >50% of diet. Summer flounder prey on other MAFMC managed species, including longfin and other squid, Atlantic mackerel, scup, and butterfish (not resolved in food web; combined diet >30%). Dogfish have ~20% of total diet from squids and mackerel, bluefish have ~25% of diet from butterfish, squids, bluefish, mackerel, and scup, and monkfish have ~20% of diet from squids, mackerel, summer flounder, scup, and monkfish. Therefore, these three predators rank low risk for food web interactions with other MAFMC managed species.

Food Web (MAFMC Prey)

This element is applied at the species level. This element ranks the risks of not achieving OY due to prey interactions between MAFMC managed species. To rank these risks, the "importance" of each species as prey must be assessed. There are not clear standardized threshold to define this. Diet information and a food web model can be used to develop thresholds. An important prey of MAFMC managed species can be defined as individually comprising above a certain threshold of the predator's diet by weight. "Vulnerable" prey warranting a high risk ranking would comprise a majority (>50%) of diet or have a majority of mortality caused by an individual MAFMC managed species.

The EOP Committee agreed that a high proportion in diet represented high risk as a prey (and also to the predator), but could not come to agreement on thresholds for intermediate risk levels, so this risk ranking uses only low and high levels.

Risk Level	Definition
Low	Few interactions as prey of other MAFMC managed species, or prey of other managed species but below 50% of diet
Low-Moderate	Important prey with management consideration of interaction
Moderate-High	*This category not used*
High	Managed species is sole prey and/or subject to high mortality due to other MAFMC managed species

This information is gathered from the NEFSC food habits database and other sources (Johnson et al. 2008, Smith and Link 2010). Surfclams and ocean quahogs are not prey of other MAFMC managed species, so

they rank low risk for this element. Similarly, spiny dogfish, bluefish, monkfish, summer flounder, scup, black sea bass, and golden and blueline tilefish do not show up individually as >10% of prey by weight in any MAFMC managed species diets, so they rank low risk. While some MAFMC managed species are prey of other managed species, none meet the defined risk threshold, so all are ranked low risk. Atlantic mackerel is a prey of spiny dogfish (~10% of diet with high interannual variability). Butterfish is a prey of bluefish, but is below the threshold (~12% of diet), and the reference point applied to butterfish considers it's role as a forage fish in general. Cephalopods as a group are prey of summer flounder (~33% of diet), with approximately half of this attributed to "Loligo species" in the diet data, very little to Illex species, and the rest as squid unidentified. Similarly, Cephalopods as a group are important prey of shortfin squid (>30% of diet), but how much of this is longfin squid is unknown, and some is cannibalism. Unmanaged forage (e.g. anchovies, sandlance, >50% of inshore diet) are important prey of bluefish, but MAFMC measures restict fishery development on these species so they rank low-moderate risk under this element.

Food Web (Protected Species Prey)

This element is applied at the species level. This element ranks the risks of not achieving protected species objectives due to species interactions with MAFMC managed species. As above, a food web model and updated marine mammal diet information can be used to establish thresholds of "importance" for predators and prey. There are no MAFMC managed species that are important predators of protected species, so here we rank only risks where MAFMC managed species represent prey of protected species. An important prey of protected species is defined here as individually comprising >30% of the predator's diet by weight. "Dependent" predators and prey warranting a high risk ranking would have a majority (>50%) of diet or mortality caused by an individual protected species.

Risk Level	Definition
Low	Few interactions with any protected species
Low-Moderate	Important prey of 1-2 protected species, or important prey of 3 or more protected species with management consideration of interaction
Moderate-High	Important prey of 3 or more protected species
High	Managed species is sole prey for a protected species

Protected species include marine mammals (under the Marine Mammal Protection Act), Endangered and Threatened species (under the Endangered Species Act), and migratory birds (under the Migratory Bird Treaty Act). In the Northeast US, endangered/threatened species include Atlantic salmon, Atlantic and shortnose sturgeon, all sea turtle species, and 5 baleen whales. MAFMC managed species are not important predators of protected species (Smith and Link 2010), even though monkfish occasionally ingest seabirds (Perry et al. 2013). Atlantic salmon, both species of sturgeon, and sea turtles are not major predators of MAFMC managed species, as reviewed in the MAFMC Forage Fish white paper (Shoop and Kenney 1992, Burke et al. 1993, 1994, Johnson et al. 1997, McClellan and Read 2007, Savoy 2007, Seney and Musick 2007). Information sources for marine mammal diets in the Northeast US (Smith et al. 2015), and seabird diets (Powers 1983, Powers and Backus 1987, Powers and Brown 1987, Schneider and Heinemann 1996, Barrett et al. 2007, Bowser et al. 2013) were reviewed.

Diet information for protected species tends to be more uncertain than for fished species, so we consider diet at the family level for these rankings because diet compositions are not reported to the species level. Longfin squids are estimated to comprise >30% of diet for one protectes species, pilot whale, in the Northeast US (Gannon et al. 1997, Smith et al. 2015), therefore we rank this species low-moderate risk for this element. Shortfin squid were identified as important prey for two pelagic seabirds in the Northeast

US (Powers and Backus 1987), and therefore ranked low-moderate risk. Unmanaged forage fish such as sand lance and saury were identified as important prey for >3 seabird species in the Northeast US (Powers and Backus 1987), as well as grey seals (Smith et al. 2015). MAFMC has enacted measures to restrict fishing on these species, such that they rank low-moderate risk for this element. Other MAFMC managed species do not meet the threshold of important prey of protected species based on available information, so they rank low risk for this element.

Ecosystem Productivity

This element is applied at the ecosystem level. This element ranks the risk of not achieving OY due to changes in ecosystem productivity at the base of the food web. Four indicators are used together to assess risk of changing ecosystem productivity. We examine trends in total primary production, zooplankton abundance for a key Mid-Atlantic species, and two aggregate fish productivity measures: condition factor (weight divided by length of individual fish) and a survey based "recruitment" (small fish to large fish) index. Because many MAFMC managed species rely on benthic crustaceans as forage, a benthic production indicator is also desirable, *but not yet available.*

Risk Level	Definition
Low	No trends in ecosystem productivity
Low-Moderate	Trend in ecosystem productivity (1-2 measures, increase or decrease)
Moderate-High	Trend in ecosystem productivity (3+ measures, increase or decrease)
High	Decreasing trend in ecosystem productivity, all measures

For primary production and fish productivity, the spatial scale of analysis is the Mid-Atlantic Ecosystem Production Unit, as indicated in Figure 2.

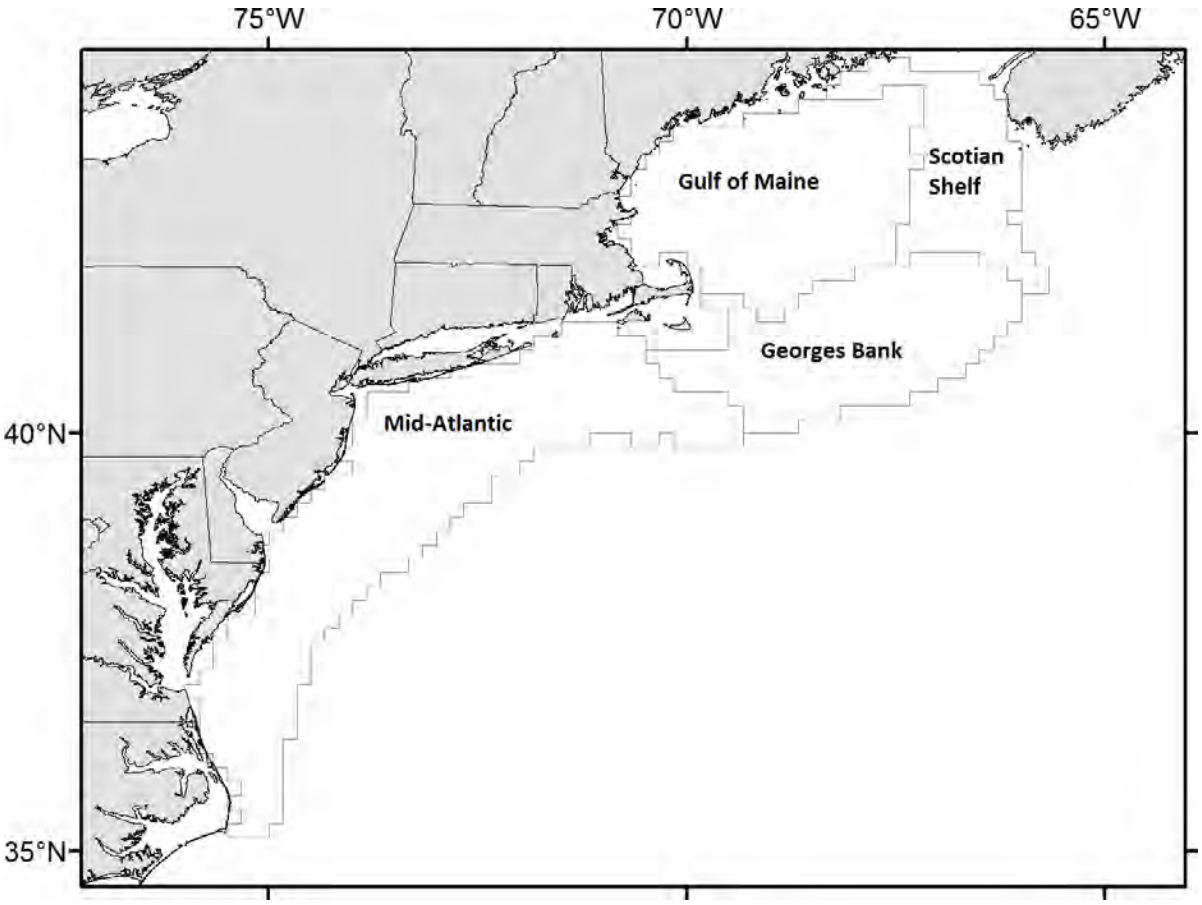

Figure 2: Northeast US Ecosystem Production units.

Primary production

Primary production has fluctuated recently with current conditions near average.

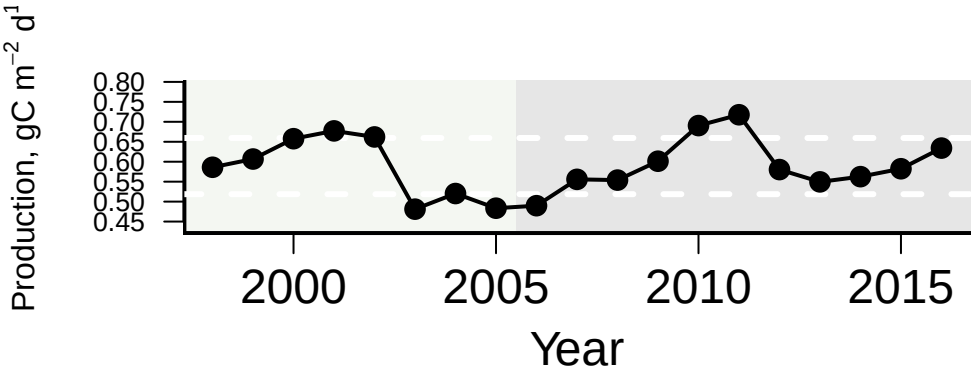

Figure 3: Primary production

The observed stability in system productivity is in contrast to an apparent shift in the timing of the bloom cycle in the Mid-Atlantic. Comparing remote sensing information from the 1970-80s to recent information suggest that winter productivity was higher in the MAB and that the spring bloom we see today was not as prominent. This change in phytoplankton seasonal biomass may be related to the changes seen in the

zooplankton community (see below) suggesting a grazing effect; but, whatever the mechanism associated with these changes, shifts in timing of low trophic level production can affect resource fish species and their early life history stages that feed on zooplankton.

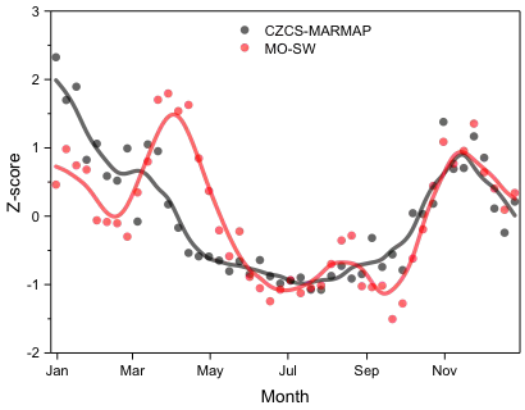

Figure 4: Comparison of 1970-80s annual primary productivity cycle (black) with 1997-present (orange)

Zooplankton

Zooplankton surveys have been conducted since the 1970s and have been most consistently executed in the spring and fall seasons coinciding with the NEFSC bottom trawl survey. The time series of zooplankton biovolume suggest that overall zooplankton production has not changed over time. However, the dominant species of zooplankton in the MAB, *Centropages typicus* shows a seasonal shift in abundance, suggesting a change in timing of zooplankton reproductive cycles, which may be impacting fish species such as mackerel.

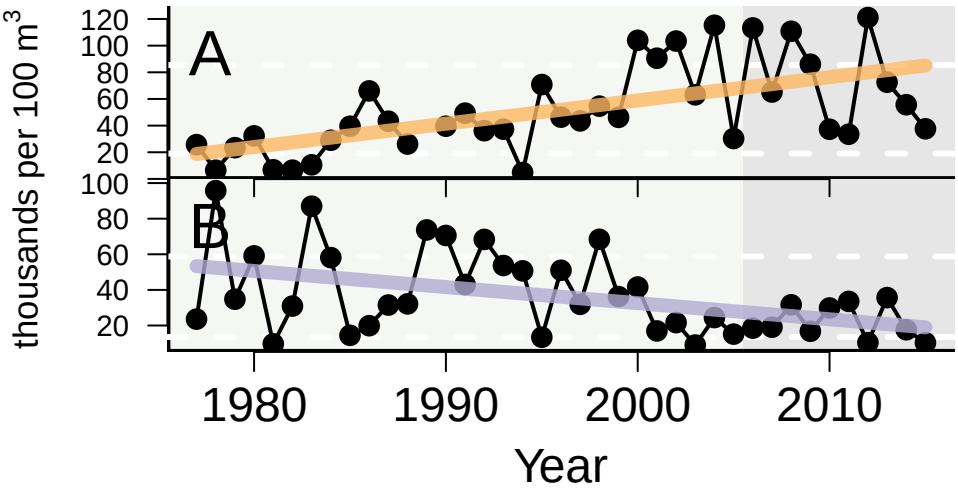

Figure 5: A: Centropages typicus spring, B: Centropages typicus fall

Fish condition

Fish condition is measured as the weight per length–a measure of "fatness". This information is from NEFSC bottom trawl surveys and shows a change in condition across all species at around 2000. Around

2010-2013 many species started to have better condition, while black sea bass remain thinner for their length on average.

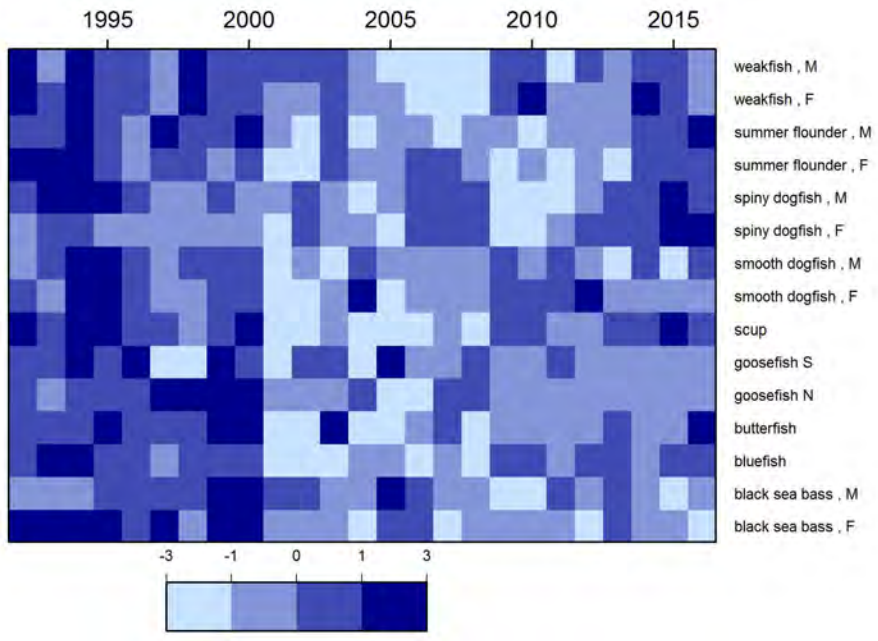

Figure 6: Fish Condition (weight/length)

Fish productivity

The number of small fish relative to the biomass of larger fish of the same species from the NEFSC survey is a simple measure of productivity, intended to complement model-based stock assessment estimates of recruitment for commercial species. There is a general decrease in this indicator when aggregated across managed and unmanaged species in the Mid-Atlantic. The plot includes black sea bass, butterfish, clearnose skate, fourspot flounder, little skate, scup, spiny dogfish, summer flounder, thorny skate, windowpane, winter flounder, and winter skate.

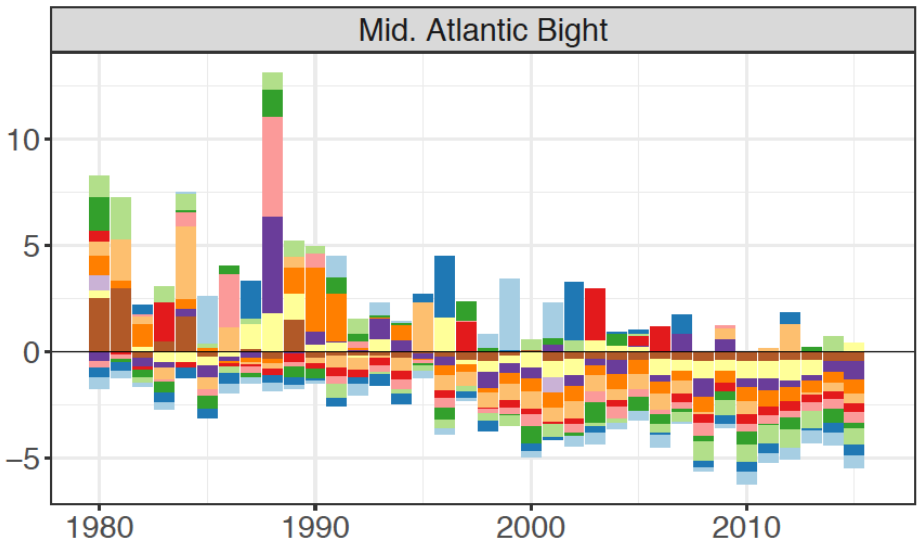

Figure 7: Fish productivity: Anomalies of recruit abundance per spawner biomass for species in the MAB. Annual anomalies shown are the average of spring and fall anomalies.

To summarize, primary production shows no trend (although the seasonal timing of primary production may be changing). Similarly, there are no trends in overall zooplankton abundance, but a dominant Mid-Atlantic species shows different trends by season, possibly also indicating a shift in timing. Fish condition showed a drop across all species in the early 2000s, but most species appear to have recovered. There is a decreasing trend in aggregate numbers of small fish per large fish. This one clear trend, along with changes in timing at lower trophic levels, suggest a low-moderate risk of changing ecosystem productivity in the Mid-Atlantic region.

Climate

This element is applied at the species level. Risks to species productivity (and therefore to achieving OY) due to projected climate change in the Northeast US were evaluated in a comprehensive assessment (Hare et al. 2016). This assessment evaluated exposure of each species to multiple climate threats, including ocean and air temperature, ocean acidification, ocean salinity, ocean currents, precipitation, and sea level rise. The assessment also evaluated the sensitivity (*not extinction risk*) of each species based on habitat and prey specificity, sensitivity to temperature and ocean acidification, multiple life history factors, and number of non-climate stressors. This assessment is intended to be conducted iteratively, so these results can be updated in the future.

Risk Level	Definition
Low	Low climate vulnerability ranking
Low-Moderate	Moderate climate vulnerability ranking
Moderate-High	High climate vulnerability ranking
High	Very high climate vulnerability ranking

Mid-Atlantic species were all either highly or very highly exposed to climate risk in this region, and ranged from low to very high sensitivity to expected climate change in the Northeast US. The combination of exposure and sensitivity results in the overall vulnerability ranking. We applied those climate vulnerability

rankings directly here (Fig. 8).

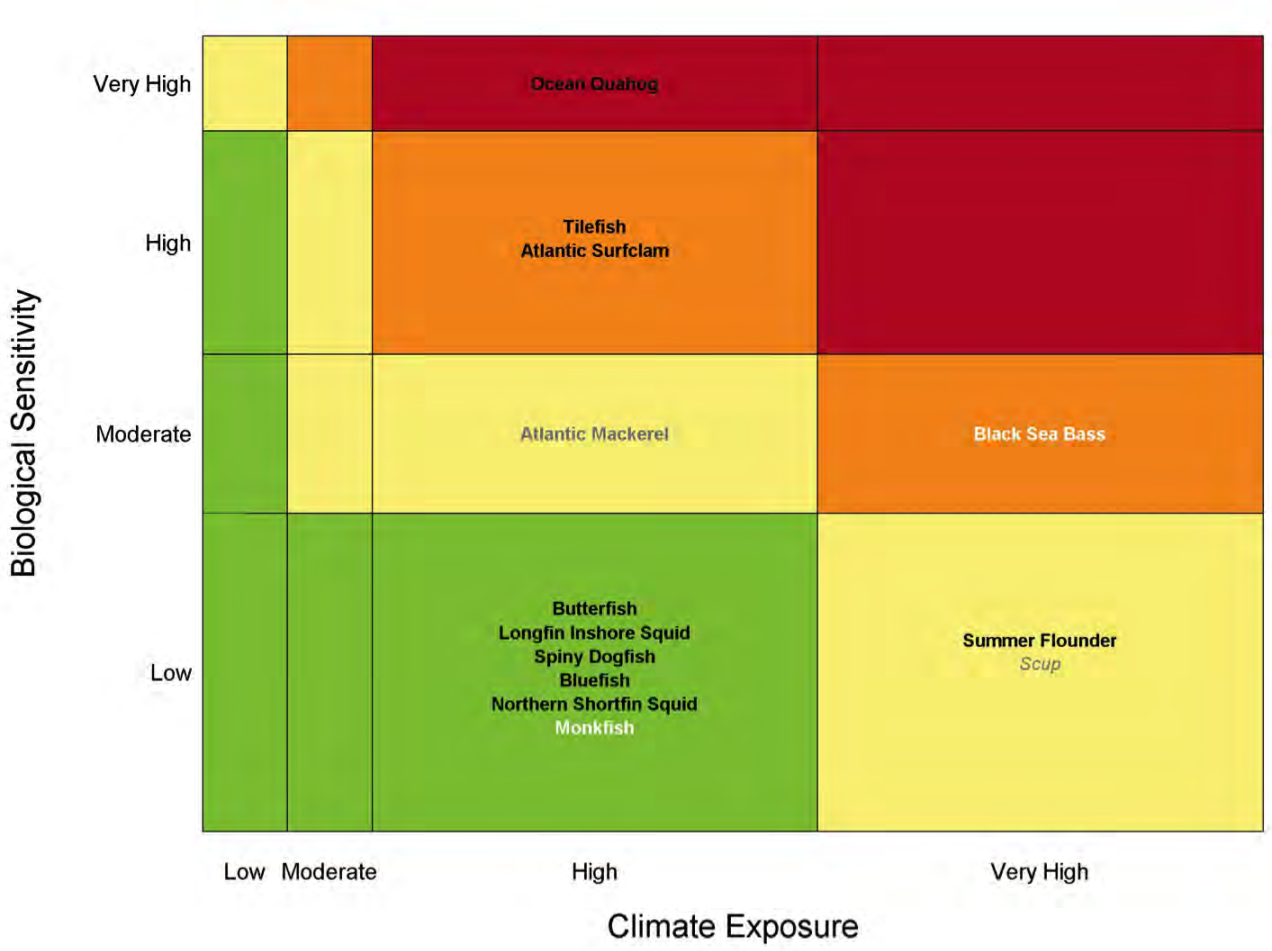

Figure 8: Results of Northeast Climate Vulnerability Analysis (Hare et al. 2016) for Mid-Atlantic species

While this risk assessment focuses on overall vulnerability to impacts of climate, not all impacts will be negative. Some MAFMC managed species may benefit from projected future climate conditions, including black sea bass, bluefish, butterfish, longfin squid, and shortfin squid (Hare et al. 2016).

Distribution Shifts

This element is applied at the species level. Species distribution shifts can increase risks of ineffective spatial catch allocation; if catch distribution is greatly mismatched with species distribution OY may not be achieved. Risks of species distribution shifts due to projected climate change in the Northeast US were assessed in a comprehensive assessment (Hare et al. 2016). We applied those distribution shift risk rankings directly here. In addition, changes in species distribution are monitored using fisheries independent bottom trawl surveys. Two distribution shift indicators are derived from these surveys: kernel density plots of recent distribution compared with 1970s distribution, and time series of the along shelf position of the center of distribution.

Risk Level	Definition
Low	Low potential for distribution shifts
Low-Moderate	Moderate potential for distribution shifts
Moderate-High	High potential for distribution shifts
High	Very high potential for distribution shifts

All Mid-Atlantic species with the exception of golden tilefish had either high or very high risk of distribution shifts in the Northeast US.

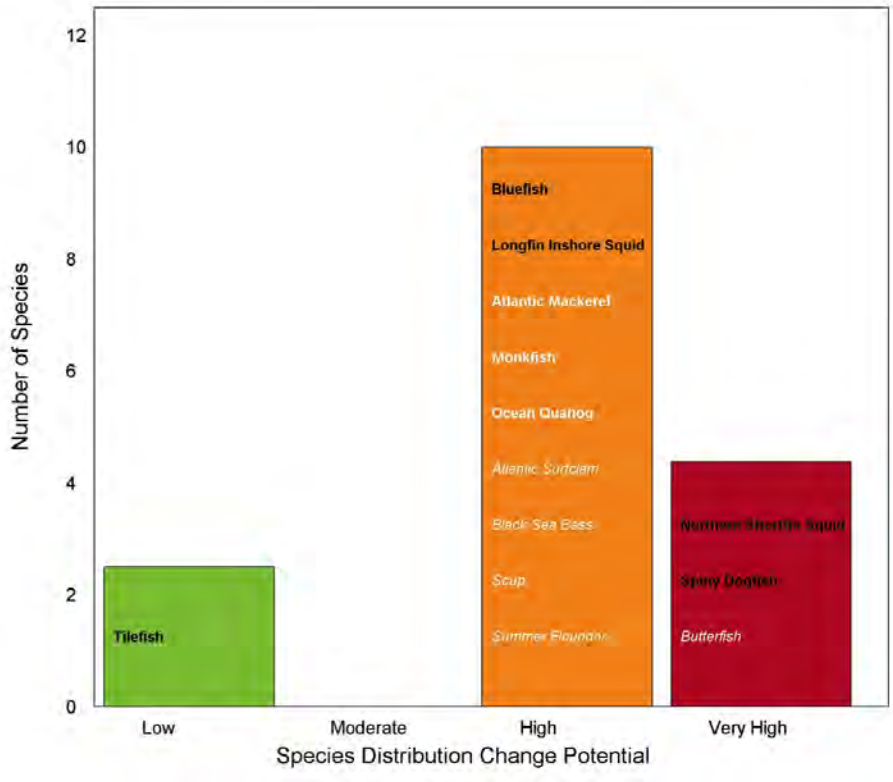

Figure 9: Results of Northeast Climate Vulnerability Analysis (Hare et al. 2016) for Mid-Atlantic species distribution shift risk

Historical vs. Current Distribution Maps

Spatial distribution has changed over time for some species more than for others. Black sea bass distributions measured by NEFSC surveys have shifted northward relative to historical distributions. In contrast, longfin squid distributions in the Mid-Atlantic have remained relatively stable.

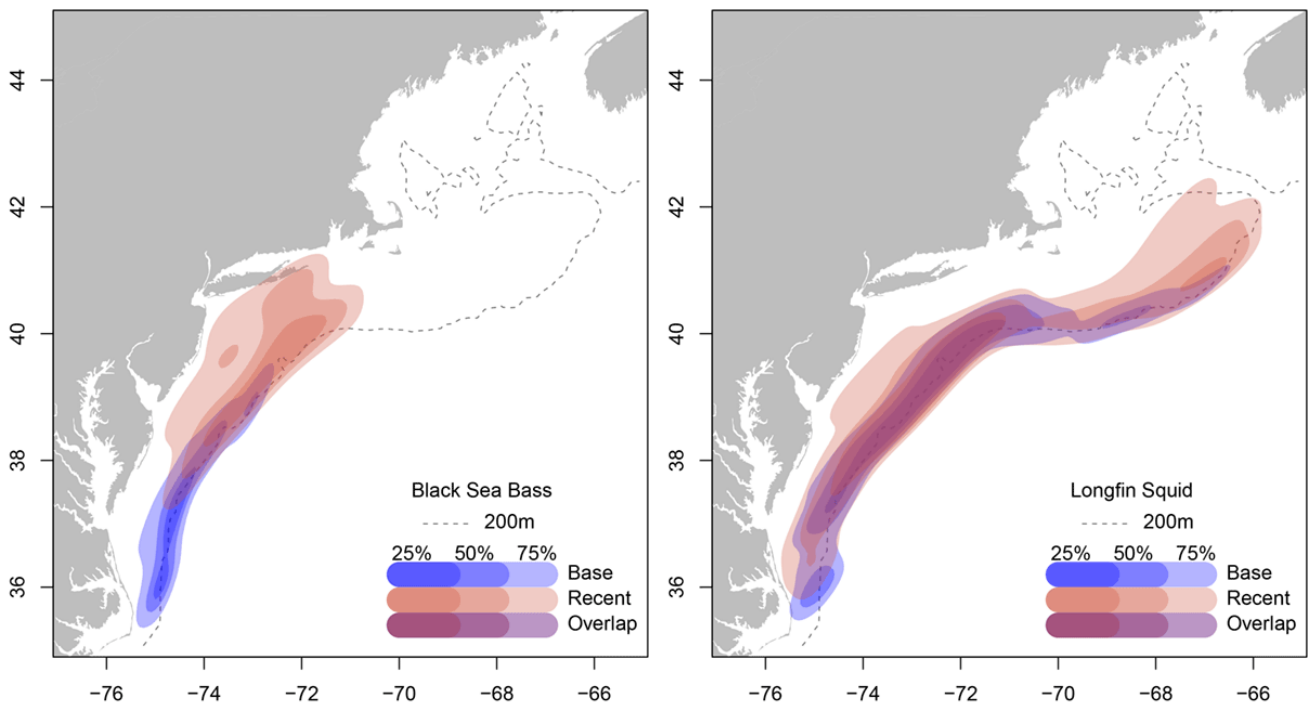

Figure 10: Shifts in species distribution, 1970s (blue), recent (red) and overlap (purple)

A full suite of these maps is available at http://www.nefsc.noaa.gov/ecosys/current-conditions/kernel-density.html.

Changes in Along Shelf Position

Species distribution on the NE Shelf can be characterized by the position in the ecosystem along an axis oriented from the southwest to the northeast, referred to as the along shelf distance, and by depth. Along shelf distances range from 0 to 1360, which relates to positions along the axis from the origin in the southwest to the northeast in kilometer units. The mean along shelf distance for several MAFMC species by year is shown below; most are consistent with the predictions of NEVA and show a northeastward change in distribution aside from squids. Mean depth has not changed significantly for these species. Information for more species is available at http://www.nefsc.noaa.gov/ecosys/current-conditions/species-dist.html.

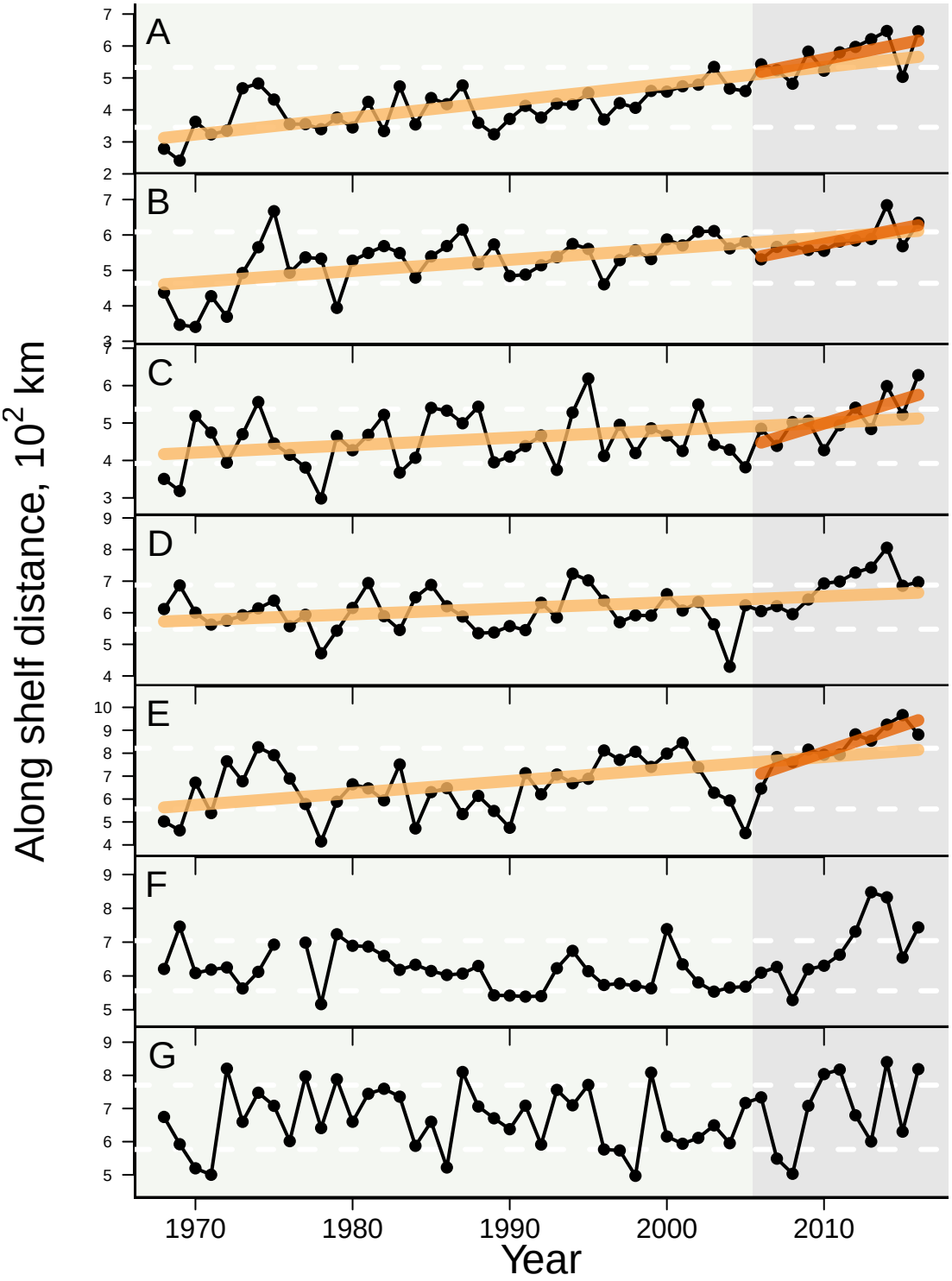

Figure 11: Shifts in species distribution over time; A: Black sea bass, B: Summer flounder, C: Scup, D: Butterfish, E: Atlantic mackerel, F: Longfin squid, G: Shortfin squid

Estuarine and Coastal Habitat

This element is applied at the species level. Risk of not achieving OY due to threats to estuarine and nearshore coastal habitat/nursery grounds was determined by first evaluating the estuarine dependence of

species, and then by enumerating threats to the estuarine habitat required by these species. Here, we include estuarine and nearshore coastal habitat in the term "estuarine" below. Water and habitat quality assessments produced for Chesapeake Bay, Delaware Bay, Long Island Sound and other coastal estuaries can be considered in the future.

Risk Level	Definition
Low	Not dependent on nearshore coastal or estuarine habitat
Low-Moderate	Estuarine dependent, estuarine condition stable
Moderate-High	Estuarine dependent, estuarine condition fair
High	Estuarine dependent, estuarine condition poor

As a start, the US EPA National Coastal Condition Assessment for the Northeast US (US EPA 2012) was used to evaluate estuarine and coastal condition. This report lists water, sediment, benthic, and coastal habitat quality as well as fish contamination. Northeast US coastal waters in the Mid-Atlantic region rated fair to poor for water quality, fair for sediment quality, poor for benthic quality, good to fair for coastal habitat, and fair to poor for fish contamination. These ratings were based on nearshore and estuarine summer sampling 2003-2006. The overall coastal condition was rated fair for the entire region, but this includes offshore conditions which we address in the next element. Therefore, estuarine and nearshore coastal habitat dependent species (summer flounder, scup, black sea bass, and bluefish, (Able 2005)) were ranked high risk based on overall poor estuarine condition for this element, and all others were ranked low risk due to lower dependence on this habitat type.

Offshore Habitat

This element is applied at the species level. The risk of achieving OY due to changes in offshore habitat quality and quantity can be assessed using trends derived from experimental species-specific habitat modeling. *In addition, the number of threats from other human uses can be enumerated; at present this is addressed under "Other Ocean Uses" in the Management section below.*

Risk Level	Definition
Low	No change in offshore habitat quality or quantity
Low-Moderate	Increasing variability in habitat quality or quantity
Moderate-High	Significant long term decrease in habitat quality or quantity
High	Significant recent decrease in habitat quality or quantity

Habitat models using both static and dynamics variables have been developed for many of the resource species on the Northeast Shelf. These models estimate spring and fall habitat for the time series 1992 to 2016 reflecting the use of the ecosystem based on the NEFSC bottom trawl survey. The variables evaluated for use in these models included station salinity, station temperature, benthic complexity, satellite derived chlorophyll concentration and sea surface temperature, the gradient magnitude (front structure) of the satellite data, and zooplankton bio-volume and taxa abundance with station depth included in all models. The random forest approach differentiates variables with strong predictive power and was used to reduce the variable set to 11 variables for each species. The models were used to estimate fall habitat scores over the entire shelf over the time series.

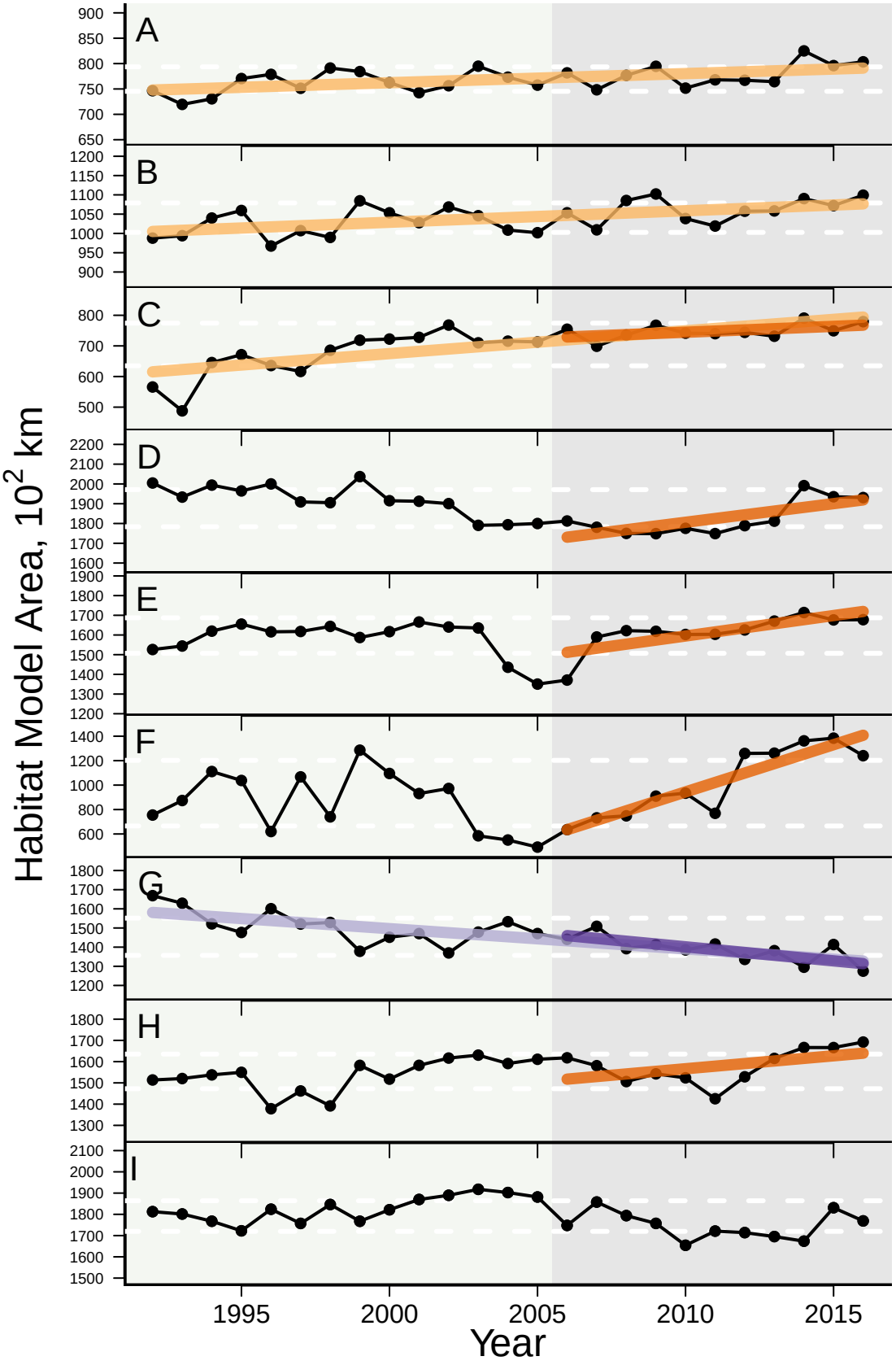

Figure 12: Shifts in modeled species fall habitat area over time; A: Black sea bass, B: Summer flounder, C: Scup, D: Butterfish, E: Atlantic mackerel, F: Longfin squid, G: Shortfin squid, H: Dogfish, I: Goosefish

This experimental habitat index is still being studied and improved, so habitat risk rankings based on this are considered preliminary by the EOP.

Overall, black sea bass, summer flounder, and scup have long term increasing trends in fall offshore habitat, and dogfish, butterfish, Atlantic mackerel and longfin squid have short term increasing trends. Goosefish has no significant trend in fall offshore habitat. Therefore, these species rank low risk for this element. However, shortfin squid has a long term and a short term decreasing trend in offshore habitat. Therefore, shortfin squid ranks high risk for this element.

Ocean quahogs, surfclams, tilefish, and bluefish are not adequately sampled by the bottom trawl survey and were not included in this analysis, similar to unmanaged forage and deepsea corals. Sessile species in particular may be highly vulnerable to habitat changes, so assessments of their habitat are particularly important to develop.

Economic Elements

Commercial Revenue

This element is applied at the ecosystem level, and addresses the risk of not maximizing fishery value. Revenue serves as a proxy for commercial profits, which is the component of a fishery's value that this element is ultimately attempting to assess risk towards.

Risk Level	Definition
Low	No trend and low variability in revenue
Low-Moderate	Increasing or high variability in revenue
Moderate-High	Significant long term revenue decrease
High	Significant recent decrease in revenue

This is aggregate commercial revenue for MAFMC managed species. There is a long term significant decrease in revenue, indicating moderate-high risk to commercial fishery profit. This trend is consistent with the trend first shown in the EAFM Interactions white paper and published in Gaichas et al. (2016) (Figs 2-3).

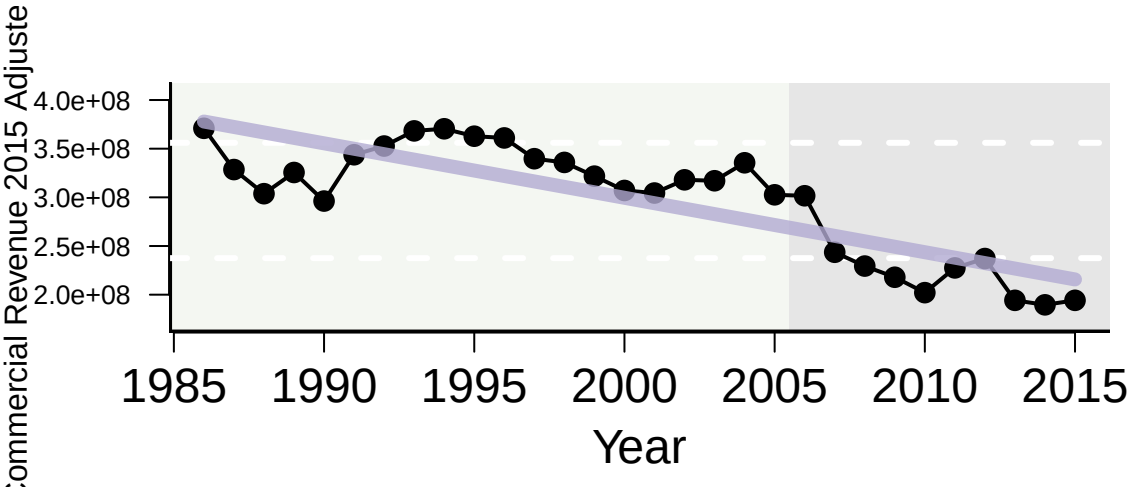

Figure 13: Aggregate Mid-Atlantic managed species revenue

Marine Recreational Angler Days/Trips

This element is applied at both the fleet level and at the ecosystem level where it would apply equally to all recreationally fished species. Angler days and trips are proxies for the welfare (value) generated from recreational fishing. Risk of not maximizing fishery value is evaluated using the number of marine recreational fishing angler-days and number of marine recreational trips, in aggregate.

Risk Level	Definition
Low	No trends in angler days/trips
Low-Moderate	Increasing or high variability in angler days/trips
Moderate-High	Significant long term decreases in angler days/trips
High	Significant recent decreases in angler days/trips

Providing recreational opportunities is a stated goal of optimal fishery management as part of the definition of "benefits to the nation" under MSA. Recreational fishing is important in the Mid-Atlantic region with many coastal communities having high recreational dependence. Although there is an overall trend of increasing recreational fishery participation in terms of number of anglers, the most recent 10 years has shown a striking decline in both recreation indices.

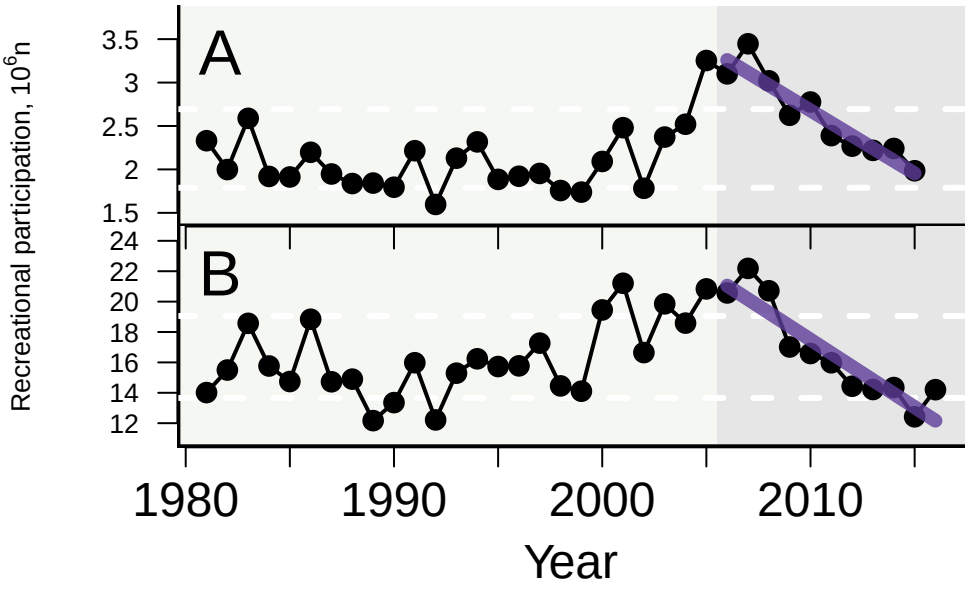

Figure 14: A: number of anglers, B: number of trips

These significant recent decreases in numbers of anglers and numbers of trips alone suggest high risk to recreational value generated from the species with substantial recreational fisheries (summer flounder, scup, black sea bass, bluefish). This is a national trend likely due to shifting demographics and general economic dynamics, among other issues.

Commercial Fishery Resilience (Revenue Diversity)

This element is applied at the ecosystem level. This element addresses the risk of reduced commercial fishery business resilience by evaluating species diversity of revenue at the permit level.

Risk Level	Definition
Low	No trend in diversity measure
Low-Moderate	Increasing or high variability in diversity measure
Moderate-High	Significant long term downward trend in diversity measure
High	Significant recent downward trend in diversity measure

This diversity index is the average effective Shannon index for species revenue at the permit level, for all permits landing any amount of MAFMC FMP species within a year (including both Monkfish and Spiny Dogfish). Although the exact value of the effective Shannon index is relatively uninformative, the major change in diversity seems to have occurred in the late 1990's, with much of the recent index relatively stable.

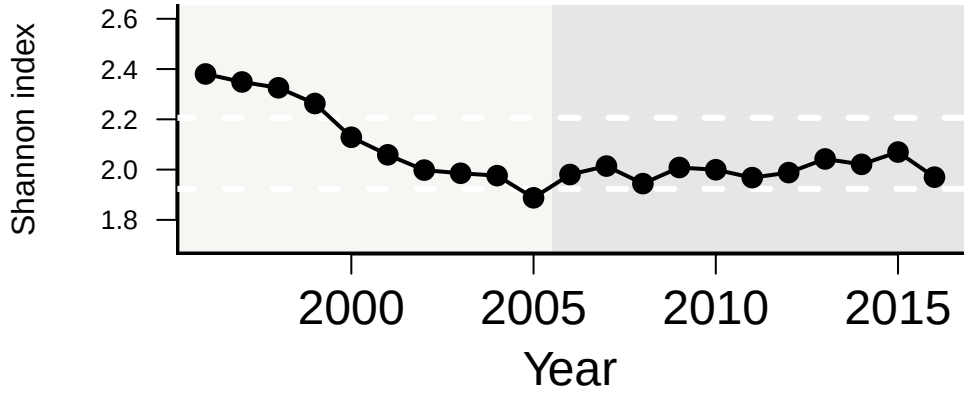

Figure 15: Diversity in species revenue

This index shows no significant trend, which would suggest a low risk to fishery business resilience based on diversity in species revenue.

Commercial Fishery Resilience (Shoreside Support)

This element is applied at the ecosystem level. This element ranks the risk of reduced fishery business resilience due to shoreside support infrastructure by examining the number of shoreside support businesses.

Risk Level	Definition
Low	No trend in shoreside support businesses
Low-Moderate	Increasing or high variability in shoreside support businesses
Moderate-High	Significant recent decrease in one measure of shoreside support businesses
High	Significant recent decrease in multiple measures of shoreside support businesses

The number of shoreside support businesses were tallied for all Mid-Atlantic states in two categories: number of companies (Quarterly Census of Employment and Wages. Obtained September 27, 2017. US Department of Labor, Bureau of Labor Statistics. https://www.bls.gov/cew/home.htm) and number of non-employer entities Nonemployer Statistics." Obtained September 28, 2017. U.S. Census Bureau. https://www.census.gov/programs-surveys/nonemployer-statistics.html), which we consider separately. Nonemployer entities are businesses that have no paid employees (i.e. the owner is the workforce), while

the shoreside support companies include all businesses with paid employees. Some state level data was not included due to confidentiality.

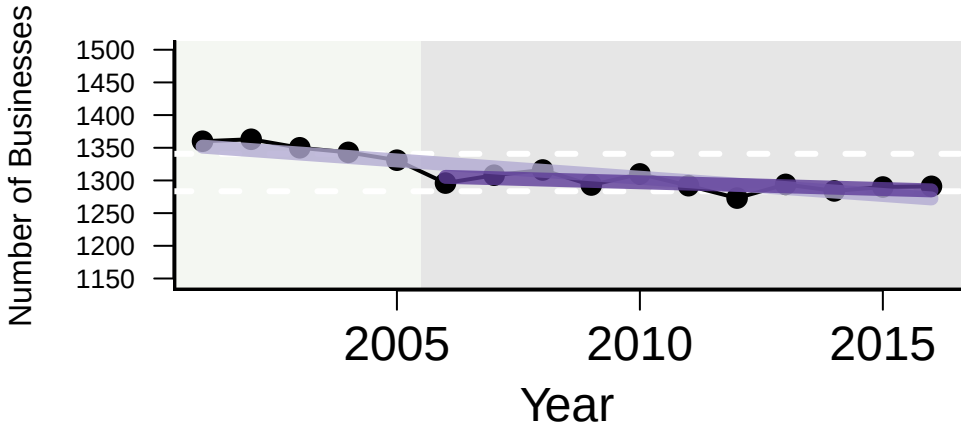

Figure 16: Shoreside support businesses: Number of Companies

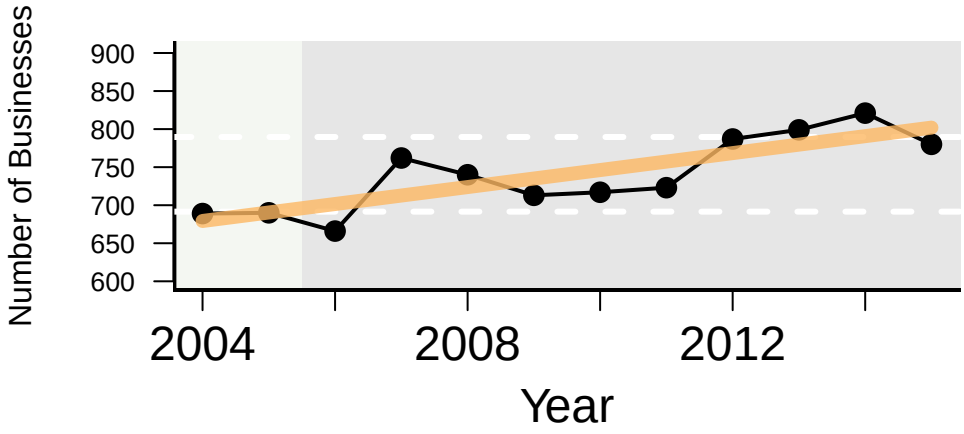

Figure 17: Shoreside support businesses: Number of Nonemployer entities

The number of shoreside support companies that include seafood merchant wholesalers, seafood product preparation and packaging, and seafood markets across all Mid-Atlantic states shows a significant long term and short term decrease, which on its own represents moderate-high risk to fishery resilience. However, the number of non-employer entities which include seafood preparation and packaging and seafood markets shows a long term increase. Trends in other shoreside fishery supporting businesses such as gear manufacturers and welding companies are not included here due to aggregation of the statistics.

Commercial Employment

This element is applied at the state level. This element ranks the risk of not optimizing employment opportunities in the commercial sector. Risks were assessed by examining time series of employment information from Fisheries Economics of the U.S. (NMFS 2017). A full description of the model generating employment estimates can be found here: http://www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf

Risk Level	Definition
Low	No trend in employment
Low-Moderate	Increasing or high variability in employment
Moderate-High	Significant recent decrease in employment for one state
High	Significant recent decrease in employment for multiple states

The EOP Committee lacked confidence in the available employment indicator data, so this element remains unranked at this time.

Recreational Employment

This element is applied at the state level. This element ranks the risk of not optimizing employment opportunities in the recreational sector. Risks were assessed by examining time series of employment information from Fisheries Economics of the U.S. (NMFS 2017).

Risk Level	Definition
Low	No trend in employment
Low-Moderate	Increasing or high variability in employment
Moderate-High	Significant recent decrease in employment for one state
High	Significant recent decrease in employment for multiple states

The EOP Committee lacked confidence in the available employment indicator data, so this element remains unranked at this time.

Social-Cultural Elements

Fleet Diversity

This element is applied at the ecosystem level. This element ranks the risk to maintaining equity in access to fishery resources. Two indicators of commercial fleet diversity, including the number of distinct fleets and diversity of revenue across fleets are used in combination to evaluate current fleet resilience throughout the Mid-Atlantic region.

Maintaining diversity can provide the capacity to adapt to change at the ecosystem level for dependent fishing communities, and can address objectives related to stability. Below are diversity estimates for fleets landing MAFMC-managed species. This measure identifies the diversity in revenue generated by different fleet segments. A fleet is defined here as the combination of gear code (Scallop Dredge, Other Dredge, Gillnet, Hand Gear, Longline, Bottom Trawl, Midwater Trawl, Pot, Purse Seine, or Clam Dredge) and vessel length category (Less than 30 ft, 30 to 50 ft, 50 to 75 feet, 75 ft and above).

Risk Level	Definition
Low	No trend in diversity measure
Low-Moderate	Increasing or high variability in diversity measure
Moderate-High	Significant long term downward trend in diversity measure
High	Significant recent downward trend in diversity measure

A declining trend in diversity indicates a less diverse fleet is currently active in MAFMC-managed fisheries. However, it cannot distinguish whether specialization (by choice), or alternatively stovepiping (constrained choices), is occurring in the Northeastern Large Marine Ecosystem, rather merely that the fleet composition is changing, which might warrant additional scrutiny.

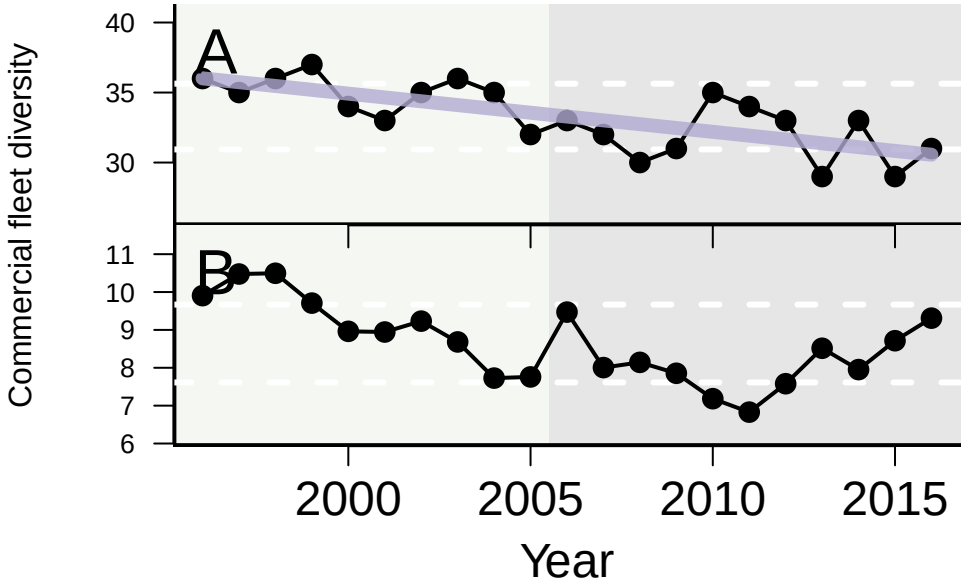

Figure 18: A: fleet count, B: average fleet diversity

There is a long term decrease in the fleet count metric. Therefore this element ranks moderate-high risk. The number of fleets in the Mid-Atlantic seems to be negatively correlated to the revenue diversity metric in the most recent five years, which indicates that the latter results are being dominated by changes in the distribution of revenue across fleets, as opposed to the number of active fleets.

Community Vulnerability

The NOAA Fisheries Community Social Vulnerability Indicators (CSVIs; Jepson and Colburn (2013)) are statistical measures of the vulnerability of communities to events such as regulatory changes to fisheries, wind farms, and other ocean-based businesses, as well as to natural hazards, disasters, and climate change. The CSVIs currently serve as indicators of social vulnerability, gentrification pressure vulnerability, commercial and recreational fishing dependence (with dependence being a function of both reliance and engagement), sea level rise risk, species vulnerability to climate change, and catch composition diversity. We use a combination of these five indicators for the most fishery dependent communities to evaluate overall social risk levels.

Risk Level	Definition
Low	Few (<10%) vulnerable fishery dependent communities
Low-Moderate	10-25% of fishery dependent communities with >3 high vulnerability ratings
Moderate-High	25-50% of fishery dependent communities with >3 high vulnerability ratings
High	Majority (>50%) of fishery dependent communities with >3 high vulnerability ratings

Below is a brief description for each category based on the NOAA social indicator study (Jepson and

Colburn 2013, Colburn et al. 2016):

- **Fishing dependence** indices portray the importance or level of dependence of commercial or recreational fishing to coastal communities.
- **Social vulnerability** indices represent social factors that can shape either an individual or community's ability to adapt to change. These factors exist within all communities regardless of the importance of fishing.
- **Gentrification pressure** indices characterize those factors that, over time may indicate a threat to commercial or recreational working waterfront, including infrastructure.

Communities are ranked as high, medium high, moderate, or low relative to the respective indicator (Table 21). Community dependence on commercial and recreational fishing is mixed, with notably more communities in the Mid-Atlantic dependent on recreational fishing. While communities with high to medium high risk for social vulnerability are broadly distributed in suburban and rural areas of the Mid-Atlantic region, communities with high to medium high gentrification pressure are concentrated in beachfront communities near urban areas in New York and New Jersey.

	Low	Moderate	MedHigh	High
ME	109	20	9	34
NH	34	5	0	1
MA	124	21	4	4
RI	33	3	0	2
CT	72	3	0	0
NY	336	7	2	2
NJ	297	11	3	3
PA	40	1	0	0
DE	69	2	1	2
MD	239	4	0	2
VA	99	3	2	1
NC	113	6	3	4

	Low	Moderate	MedHigh	High
ME	159	11	1	1
NH	36	3	1	0
MA	129	10	7	7
RI	33	5	0	0
CT	69	5	1	0
NY	311	24	6	6
NJ	283	18	8	5
PA	41	0	0	0
DE	62	3	1	8
MD	218	14	6	7
VA	89	10	3	3
NC	85	13	8	20

Table 21: Number of communities at each level of commercial (left) and recreational (right) reliance

The social and economic impacts of climate change have been modeled through application of social indicators of fishing dependent communities (Jepson and Colburn 2013). Assessment of a range of social indicators has been applied in the Mid-Atlantic Region to predict vulnerability of communities to regulatory changes and disasters. More recently this methodology has been extended to include specific indicators of vulnerability to climate change and linked to species vulnerability assessments (Colburn et al. 2016, Hare et al. 2016). The tools developed through this approach are vital to an evaluation of the risks of climate change facing coastal communities dependent on fishing. Below is a description of the CSVIs related to climate change.

- **Sea Level Rise Index** is a measure of the overall risk of inundation from sea level rise based on community area lost from one to six foot level projections over the next ~90 years. A high rank indicates a community more vulnerable to sea level rise.
- **Species Vulnerability** is measured by the proportion of community fish landings that attributed to species vulnerable to climate change.
- **Catch Composition Diversity** is the relative abundance of species landed in a community. It is measured by Simpson's Reciprocal Index, and a higher index value indicates greater diversity. Communities with a diverse array of species landed may be less vulnerable to climate change.

Sea level rise is predicted to have variable impacts on coastal communities. The Mid-Atlantic region has a 3-4 times higher than global average sea level rise rate (Sallenger et al. 2012). Mid-Atlantic communities clustered around the Chesapeake Bay area and the New Jersey shore had especially high vulnerability to sea level rise (Fig. 19). These vulnerabilities include infrastructure (docks, marinas, bait shops, gear storage) and access to shore-based facilities due realignment of coastal communities.

Mid-Atlantic fishing communities with total landings value of $100,000 or more were mapped for their dependence on species vulnerable to climate change and catch composition diversity (Simpson Reciprocal Index). A number of communities in southern New Jersey, Maryland and Virginia are highly dependent on species such as clams that are highly vulnerable to climate change while displaying low catch composition diversity. Communities with this situation are considered more vulnerable to climate change in general.

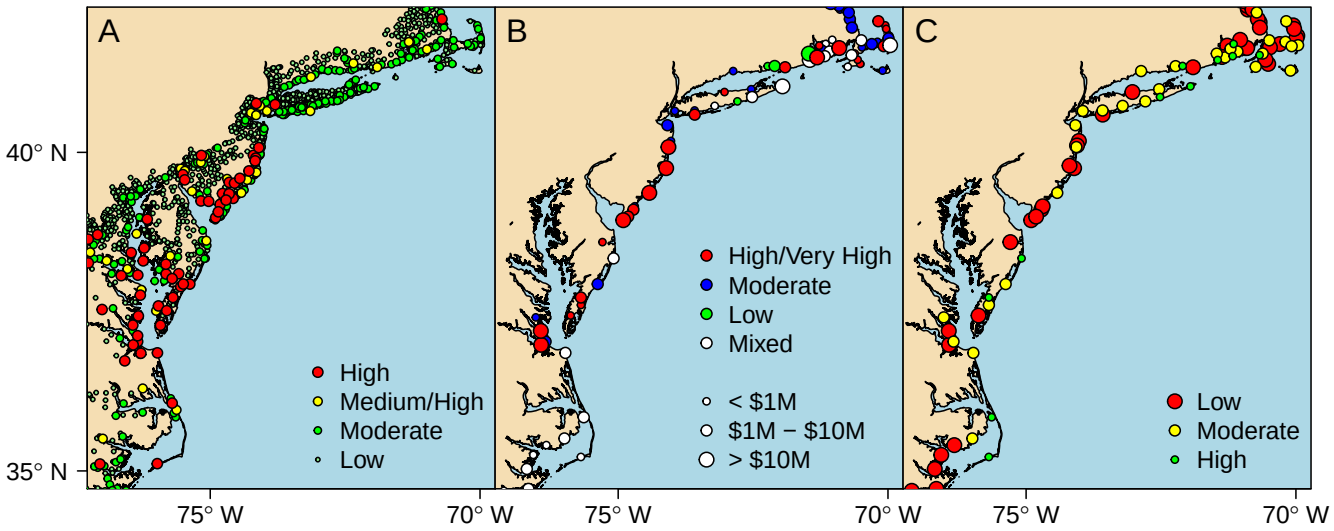

Figure 19: Risks from sea level rise (A), reliance on climate-vulnerable species (B), and catch diversity (C)

While the maps provides an overview of the social and climate indicator results for the Mid-Atlantic coastal communities, Table 22 identifies Mid-Atlantic communities that are most highly dependent on both commercial and recreational fishing. The varying vulnerability level to social factors, gentrification pressure, and climate change in these communities provide a more comprehensive profile and should be taken into account in the decision making process for fishery management.

As a preliminary risk assessment, rankings from Table 22 of MedHigh or High were tallied for social vulnerability and gentrification pressure, along with rankings of High risk from sea level rise, High/Very High species vulnerability, and rankings of Low catch composition diversity. Four of these communities (20%) have three or more of these high risk rankings, so we rank overall social-cultural risk as low-moderate for these Mid-Atlantic communities.

More information on Northeast coastal communities is available here: http://www.nefsc.noaa.gov/read/socialsci/communityProfiles.html

Table 22: Selected Mid-Atlantic Fishing Communities with Medium High to High Dependence on both Commercial and Recreational Fishing

Community	Commercial Fishing Dependence	Recreational Fishing Dependence	Social Vulnerability	Gentrification Pressure	Sea Level Rise Risk	Species Vulnerability	Catch Composition Diversity
Hampton Bays, NY	High	High	Low	MedHigh	Medium	Mixed	Moderate
Montauk, NY	High	High	Medium	MedHigh	Medium	Mixed	High
Barnegat Light, NJ	High	High	Medium	High	Low	High/Very High	Low
Cape May, NJ	High	High	Medium	MedHigh	Medium	High/Very High	Low
Beaufort, NC	High	High	MedHigh	Low	Low	Mixed	Low
Wanchese, NC	High	High	Medium	Low	Medium	Mixed	High
Point Lookout, NY	MedHigh	High	Low	MedHigh	Low	High/Very High	Low
Belmar, NJ	MedHigh	High	Medium	Medium	Low	Moderate	Low
Point Pleasant, NJ	MedHigh	High	Low	Medium	Medium	High/Very High	Moderate
Waretown, NJ	MedHigh	High	Low	Medium	Low	Low	Low
Ocean City, MD	MedHigh	High	Medium	Medium	Medium	Mixed	High
Aurora, NC	MedHigh	High	MedHigh	Medium	Low	N/A	N/A
Hatteras, NC	MedHigh	High	Medium	Low	N/A	Mixed	High
Oriental, NC	MedHigh	High	Medium	Medium	Low	Mixed	Low
Chincoteague, VA	MedHigh	High	Medium	Medium	High	Moderate	Moderate
Wachapreague, VA	MedHigh	High	Medium	Medium	Low	High/Very High	Moderate
Sea Isle City, NJ	MedHigh	MedHigh	Medium	MedHigh	Medium	Moderate	Low
Bowers, DE	MedHigh	MedHigh	Medium	Medium	Low	N/A	N/A
Hobucken, NC	MedHigh	MedHigh	Medium	Medium	N/A	Mixed	Low
Swan Quarter, NC	MedHigh	MedHigh	MedHigh	Low	N/A	Mixed	Low
Hampton, VA	MedHigh	MedHigh	MedHigh	Low	High	Moderate	Moderate
Newport News, VA	MedHigh	MedHigh	MedHigh	Low	High	High/Very High	Low

Food Production Elements

Commercial Seafood Provision

This element is applied at the ecosystem level. This element describes the risk of not optimizing domestic seafood production from MAFMC managed species. Commercial seafood landings (as opposed to total landings which include bait and industrial uses) were used to assess seafood provision.

Risk Level	Definition
Low	No trend or increase in seafood landings
Low-Moderate	Increasing or high variability in seafood landings
Moderate-High	Significant long term decrease in seafood landings
High	Significant recent decrease in seafood landings

This is commercial seafood landings from MAFMC managed species. Because this is total landings, years prior to 1977 do include foreign landings (in particular, of Atlantic mackerel, which account for much of the observed spike). Recent landings are all domestic fisheries. Looking across all regions, there is a significant recent decrease in seafood landings, indicating high risk to regional domestic seafood production.

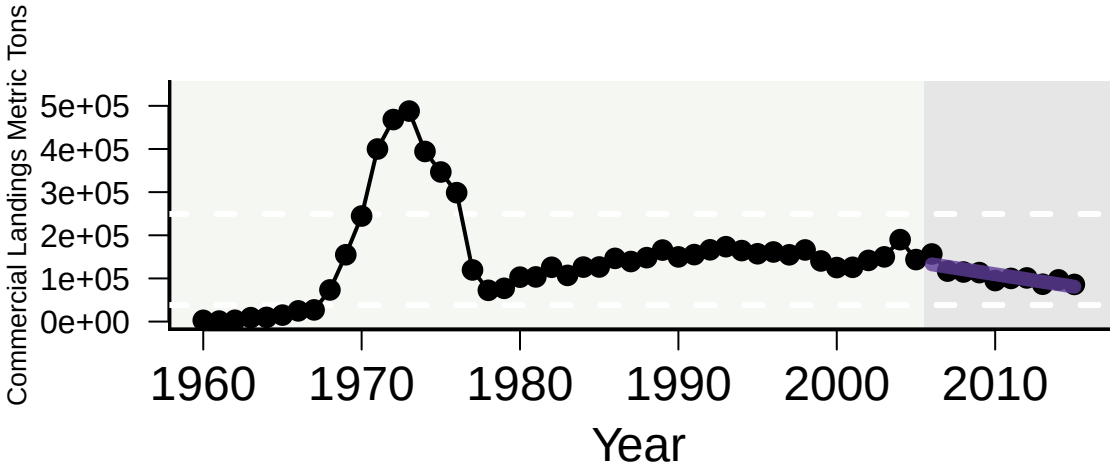

Figure 20: Aggregate Mid-Atlantic managed species landings

Recreational/Subsistence Food Provision

This element is applied at the ecosystem level. This element describes the risk of not maintaining personal food production. Recreational seafood landings (as opposed to total landings which include catch and release that are captured under other risk elements/indicators) were used to assess food use of recreationally caught fish.

Risk Level	Definition
Low	No trend or increase in recreational landings
Low-Moderate	Increasing or high variability in recreational landings
Moderate-High	Significant long term decrease in recreational landings
High	Significant recent decrease in recreational landings

This is total recreational harvest (all species) in the Mid-Atlantic region.

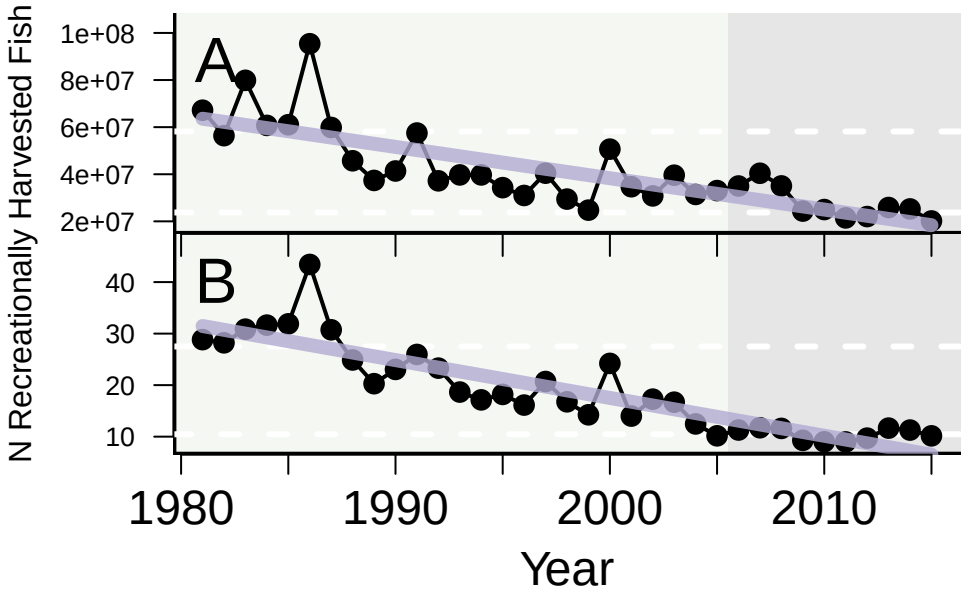

Figure 21: A: Total recreational harvest, B: Harvest per angler

This significant long term decrease in both recreational landings and recreational landings per angler represents a moderate-high risk to food production.

Management Elements

Fishing Mortality Control

This element is applied at the species and sector level. This element addresses the level of management control in terms of catch estimation (measurement) and monitoring to prevent overfishing. Adequate management control indicates a low risk of overfishing, while poor management control indicates a higher risk of overfishing and hence not achieving OY. Actual catch is compared with the specified ABC over the most recent five years of fishery history.

Risk Level	Definition
Low	No history of overages
Low-Moderate	Small overages, but infrequent
Moderate-High	Routine overages, but small to moderate
High	Routine significant overages

The ability to control total annual catch is necessary to prevent overfishing (i.e., defined to occur when total catch exceeds the overfishing level defined in the FMP), which is a fundamental requirement of MSA. Chronic or persistent overfishing can lead to stock depletion and ultimately to a stock being declared as overfished (thus requiring a stock rebuilding plan). The ability to constrain catch is a function of the efficacy of the catch monitoring program for each species which relies on both proactive (in -season closure) and reactive (pay backs for overages in subsequent years) accountability measures which were implemented post-MSA Reauthorization. Under certain circumstances, specification of management measures which

are too strict could lead to "underfishing" (not achieving the desired quota) and hence not achieving OY.

This element was evaluated by fishery sector (commercial and recreational). For the commercial fishery, NMFS dealer data in conjunction with estimates of dead discards are used to compare the annual catch target to actual annual catch. For the recreational sector, Marine Recreational Information Program (MRIP) estimates of recreational landings and dead discards are used to compare the annual catch target to actual annual catch estimates. Small overages are defined as <5%, moderate as 5-10%, and significant overages as >10%. For both sectors, low risk was defined as no history of overages. Low-moderate risk was small but infrequent overages. Moderate-high risk was routine, but small-moderate overages, and high risk was routine, significant overages.

Both surfclam and ocean quahog were low risk because they are well within recent quotas and are managed as ITQ fisheries. Recreational fisheries for scup, Atlantic mackerel, blueline tilefish, and spiny dogfish and commercial fisheries for scup, mackerel, butterfish, longfin squid, shortfin squid, golden and blueline tilefish, bluefish, and spiny dogfish were also low risk with no overages for the past 5 years and generally sufficient measures are in place to avoid overages. Recreational golden tilefish was unranked because there are no catch and landings limits associated with the recreational fishery and appear to be a minor component of total removals. Recreational bluefish and commercial summer flounder and black sea bass fisheries were low-moderate risk with catches always within <2% of quota and limits exceeded by <5% twice in the past 5 years. Recreational summer flounder ranked moderate-high risk with highly variable performance relative to catch limits with two minor overages of the RHL between 2012-2016. Recreational black sea bass was ranked high risk because catch limits were exceeded substantially in all of the past 5 years.

Technical Interactions

This element is applied at the species and sector level. This element addresses the risk of not achieving OY due to interactions with non-MAFMC managed species, including protected species. Here the risk is caused by negative consequences from fishing activity regulated under MAFMC FMPs which interacts with species managed by other agencies, including bycatch of protected species. For example, windowpane flounder accountability measures (AMs) implemented by the New England Council have the potential to negatively impact a number MAFMC managed fisheries if they are triggered. Similarly, interactions with marine mammals protected under the MMPA could result in greater restrictions in MAFMC managed fisheries increasing the risk that OY would not be achieved in those fisheries. For example, the measures necessary for recovery of the critically endangered North Atlantic right whale population have the potential to seriously impact numerous fisheries in the NE US.

Risk Level	Definition
Low	No interactions with non-MAFMC managed species
Low-Moderate	Interactions with non-MAFMC managed species but infrequent, Category II fishery under MMPA; or AMs not likely triggered
Moderate-High	AMs in non-MAFMC managed species may be triggered; or Category I fishery under MMPA (but takes less than PBR)
High	AMs in non-MAFMC managed species triggered; or Category I fishery under MMPA and takes above PBR

Evaluation of this risk element requires quantification of the likelihood that AMs under other non-MAFMC FMPs would be triggered (thus impacting fishing activities for MAFMC managed species). In addition, NMFS manages marine mammal interactions with commercial fishing activity through take reductions

plans. In cases where an MAMFC fishery interacts with marine mammals, conservation measures implemented through a take reduction plan could negatively impact that fishery.

All recreational sector fisheries and commercial fisheries for surfclams, ocean quahogs, bluefish, golden and blueline tilefish were ranked low risk as there are no known interactions with protected resources or AMs in other fisheries. Black sea bass, Atlantic mackerel, butterfish, and shortfin squid commercial fisheries were low-moderate risk as Category II fisheries and/or having infrequent interactions with marine mammals or river herring and shad. Moderate-high risk rankings included commercial sector summer flounder and scup (Category II fisheries with potential to trigger AMs for windowpane flounder, a New England managed species), longfin squid (marine mammal interactions and turtle takes) and spiny dogfish (marine mammal interactions and sturgeon takes).

Other Ocean Uses

This element is applied at the species and sector level. This element addresses the risk of fishery displacement or damage of a fishery resource and/or habitat that supports it as a result of non-fishing activities in the ocean. It also includes evaluation of risk to MAFMC fisheries from area based measures outside of the control of the Council including area closures implemented by other Councils to protect sensitive habitats, spawning areas, etc. and/or through marine monument or other types of area based management designations.

Risk Level	Definition
Low	No overlap; no impact on habitat
Low-Moderate	Low-moderate overlap; minor habitat impacts but transient
Moderate-High	Moderate-high overlap; minor habitat impacts but persistent
High	High overlap; other uses could seriously disrupt fishery prosecution; major permanent habitat impacts

Non-fishing ocean activities (e.g., energy development/sand mining/other industrial, etc.) and/or designation of areas where fishing is prohibited (i.e., marine monument designations or establishment of habitat protected areas by other Councils) could potentially impact MAFMC fisheries because they overlap with historical fishing grounds (physical displacement) and/or through negative impacts on important habitats. This element can be evaluated through GIS analyses which quantify the degree of overlap and/or expert opinion relative impacts on habitat quality and function. In this case, Council staff used expert opinion.

Recreational fisheries for Atlantic mackerel, golden and blueline tilefish, bluefish, and spiny dogfish and commercial fisheries for both tilefish were low risk due to no overlap with other ocean uses. Commercial fisheries for surfclams, ocean quahogs, shortfin squid, and bluefish, and both sectors for summer flounder and scup ranked low-moderate risk due to the potential for minor habitat or fishery impacts from other ocean uses; these will depend on extent of development of those activities (i.e., energy, aquaculture, etc.). Recreational black sea bass and commercial Atlantic mackerel, butterfish, and spiny dogfish ranked moderate-high risk due to potential for loss of access to fishing grounds (especially by mobile gear) and habitat loss due to offshore energy development in some prime fishing areas. However, it was noted for black sea bass that hard subsurface structures associated with energy production might provide some mitigation of habitat loss. Commercial black sea bass (mobile gear) and longfin squid ranked high risk due to potential for loss of access to fishing grounds and habitat loss due to offshore energy development in many prime fishing areas. Deepsea corals are also under management as protected habitat by the Council, and were ranked moderate-high risk for other ocean uses due to their sensitivity to benthic disturbance by a variety of activities.

Regulatory Complexity and Stability

This element is applied at the species and sector level. Constituents have frequently raised concerns about the complexity of fishery regulations and the need to simplify them to improve their efficacy. Complex regulations may lead to non-compliance and/or impact other fisheries.

Risk Level	Definition
Low	Simple/few regulations; rarely if ever change
Low-Moderate	Low-moderate complexity; occasional changes
Moderate-High	Moderate-high complexity; occasional changes
High	High complexity; frequently changed

This element could be evaluated by quantifying the number of regulations and/or the frequency of regulatory changes (based on evaluation of the Code of federal regulations). In terms of recreational fisheries, the magnitude and frequency of change of management measures (size and bag limits, seasons, etc.) could also be evaluated/quantified. For this assessment, Council staff used expert opinion to assess risk.

Surfclam, ocean quahog, recreational bluefish, Atlantic mackerel and spiny dogfish and both golden tilefish fisheries ranked low risk for complexity with only minor/no changes to regulations in recent years, relatively stable catch specifications and/or limited regulatory complexity. Commercial bluefish and shortfin squid ranked low-moderate risk with fairly complex regulations that have been stable over time, but may change in the near future. Both sectors for scup and commercial summer flounder and black sea bass fisheries ranked moderate-high risk with minimum size, commercial gear requirements, quota allocation systems, and reporting all very stable, but regulations can be complex, particularly at the state level with varying trip limits, permitting, and reporting systems. The moderate-high risk rankings for both recreational and commercial blueline tilefish and commercial spiny dogfish fisheries were based on recent and frequent changes in regulations. Recreational fisheries for summer flounder and black sea bass ranked high risk due to nearly annual changes in size, season, and possession limits, significant differences between states, reporting, and data estimation changes. Similarly, commercial fisheries for Atlantic mackerel, butterfish, and longfin squid regulations are highly complex and frequently changed, resulting in a high risk ranking.

Discards

This element is applied at the species and sector level. Stakeholders have identified the reduction of discards as a high priority in the Council management program, especially those caused by regulations since they represent biological and economic waste. Discards of either the target or non-target species in the fishery would be taken into consideration.

Risk Level	Definition
Low	No significant discards
Low-Moderate	Low or episodic discard
Moderate-High	Regular discard but managed
High	High discard, difficult to manage

NMFS provides estimates of discards by species based on at-sea observations collected in the Northeast Fisheries Observer Program for stock assessment purposes and quota monitoring. In addition, the MRIP

provides estimate of discards by species for the recreational fisheries. Discards were evaluated for each species and fishery with focus on identification of discards caused by regulations for each fishery sector (commercial and recreational).

Surfclams and ocean quahogs ranked low risk because discards are a small percentage of total catch; these fisheries are allocated minimal observer coverage as a result. Recreational spiny dogfish , recreational Atlantic mackerel, all tilefish, and shortfin squid fisheries were also determined to be of low risk because of low discards and/or low mortality associated with discards. Commercial fisheries for summer flounder, black sea bass, Atlantic mackerel, bluefish, and spiny dogfish ranked low-moderate risk due to relatively low (<20% of total catch) but consistent levels of overall discards. Moderate-high risk fisheries included scup (both sectors), commercial butterfish, recreational black sea bass, and recreational bluefish due to relatively high, regular discarding. Recreational summer flounder fishery was ranked high risk due to live discards making up over 85% of recreational; however these estimates can be uncertain and variable. Longfin squid fisheries ranked high risk due to high discards of both squid and other species.

Allocation

This element is applied at the species and sector level. This element addresses the risk of not achieving OY due to spatial mismatch of stocks and management allocations or because of sub-optimal allocation by sector and/or area. Indicators for difficulty of allocation include a combination of distribution shifts (see above) and the number of interests (sectors, states, etc.) requiring allocation.

Risk Level	Definition
Low	No recent or ongoing Council discussion about allocation
Low-Moderate	*This category not used*
Moderate-High	*This category not used*
High	Recent or ongoing Council discussion about allocation

Each species and sector's risk level was evaluated based on whether there is ongoing or recent (last three years) discussion of allocation by the Council. The EOP was unable to specify intermediate levels of risk for this element, so only low and high risk criteria were developed.

Surfclam and ocean quahog rank low risk, with a single allocation applied to entire EEZ, plus a small allocation for the Maine quahog fishery and there has been no recent Council discussion of allocation. Similarly, scup (both sectors), butterfish, shortfin squid, golden tilefish (both sectors), and recreational spiny dogfish are not subject to recent allocation discussions, and ranked low risk. All other fisheries (summer flounder, black sea bass, Atlantic mackerel, blueline tilefish, bluefish, and commercial spiny dogfish) have recent and often contentions ongoing allocation discussions and thus rank high risk.

Summary Tables: Risk Analysis Results

Species level

Species	Assess	Fstatus	Bstatus	FW1Pred	FW1Prey	FW2Prey	Climate	DistShift	EstHabitat
Ocean Quahog	l	l	l	l	l	l	h	mh	l
Surfclam	l	l	l	l	l	l	mh	mh	l
Summer flounder	l	h	lm	l	l	l	lm	mh	h
Scup	l	l	l	l	l	l	lm	mh	h
Black sea bass	l	l	l	l	l	l	mh	mh	h
Atl. mackerel	l	h	h	l	l	l	lm	mh	l
Butterfish	l	l	l	l	l	l	l	h	l
Longfin squid	lm	lm	lm	l	l	lm	l	mh	l
Shortfin squid	lm	lm	lm	l	l	lm	l	h	l
Golden tilefish	l	l	lm	l	l	l	mh	l	l
Blueline tilefish	h	h	mh	l	l	l	mh	l	l
Bluefish	l	l	lm	l	l	l	l	mh	h
Spiny dogfish	lm	l	lm	l	l	l	l	h	l
Monkfish	h	lm	lm	l	l	l	l	mh	l
Unmanaged forage	na	na	na	l	lm	lm	na	na	na
Deepsea corals	na	na	na	l	l	l	na	na	na

Species and Sector level

Species	MgtControl	TecInteract	OceanUse	RegComplex	Discards	Allocation
Ocean Quahog-C	l	l	lm	l	l	l
Surfclam-C	l	l	lm	l	l	l
Summer flounder-R	mh	l	lm	h	h	h
Summer flounder-C	lm	mh	lm	mh	lm	h
Scup-R	l	l	lm	mh	mh	l
Scup-C	l	mh	lm	mh	mh	l
Black sea bass-R	h	l	mh	h	mh	h
Black sea bass-C	lm	lm	h	mh	lm	h
Atl. mackerel-R	l	l	l	l	l	h
Atl. mackerel-C	l	lm	mh	h	lm	h
Butterfish-C	l	lm	mh	h	mh	l
Longfin squid-C	l	mh	h	h	h	h
Shortfin squid-C	l	lm	lm	lm	l	l
Golden tilefish-R	na	l	l	l	l	l
Golden tilefish-C	l	l	l	l	l	l
Blueline tilefish-R	l	l	l	mh	l	h
Blueline tilefish-C	l	l	l	mh	l	h
Bluefish-R	lm	l	l	l	mh	h
Bluefish-C	l	l	lm	lm	lm	h
Spiny dogfish-R	l	l	l	l	l	l
Spiny dogfish-C	l	mh	mh	mh	lm	h
Unmanaged forage	na	na	na	na	na	na
Deepsea corals	na	na	mh	na	na	na

Ecosystem level

System	EcoProd	CommProf	RecVal	FishRes1	FishRes4	FleetDiv	Social	ComFood	RecFood
Mid-Atlantic	lm	mh	h	l	mh	mh	lm	h	mh

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Using the Mid-Atlantic EAFM Risk Assessment: Possible Next Steps

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Introduction

The Council approved an EAFM Guidance Document in 2016 which outlined a path forward to more fully incorporate ecosystem considerations into marine fisheries management (http://www.mafmc.org/s/EAFM_Guidance-Doc_2017-02-07.pdf). The Council's stated goal for EAFM is "to manage for ecologically sustainable utilization of living marine resources while maintaining ecosystem productivity, structure, and function." Ecologically sustainable utilization is further defined as "utilization that accommodates the needs of present and future generations, while maintaining the integrity, health, and diversity of the marine ecosystem." Of particular interest to the Council was the development of tools to incorporate the effects of species, fleet, habitat and climate interactions into its management and science programs. To accomplish this, the Council agreed to adopt a structured framework to first prioritize ecosystem interactions, second to specify key questions regarding high priority interactions and third tailor appropriate analyses to address them (Gaichas et al., 2016). Because there are so many possible ecosystem interactions to consider, a risk assessment was adopted as the first step to identify a subset of high priority interactions (Holsman et al., 2017). The risk elements included in the Council's initial assessment spanned biological, ecological, social and economic issues (Table 1) and risk criteria for the assessment were based on a range of indicators and expert knowledge (Table 2).

This document outlines potential next steps to follow up on the Mid-Atlantic Council's initial EAFM risk assessment. The risk assessment was designed help the Council decide where to focus limited resources to address ecosystem considerations by first clarifying priorities. Overall, the purpose of the EAFM risk assessment is to provide the Council with a proactive strategic planning tool for the sustainable management of marine resources under its jurisdiction, while taking interactions within the ecosystem into account.

Discussion

Risk assessment provides a starting point for prioritizing further, more detailed analysis. An indicator-based risk assessment does not provide a mechanistic assessment of the system, which is only possible through a structural modeling approach, which could be focused specifically on fully assessing and mitigating identified risks. According to the Council's accepted framework within the EAFM policy guidance, risk assessment results will be used to prioritize and refine the key management questions and issues for further evaluation (Gaichas et al., 2016). The next step will be the development of example conceptual models which aim to showcase different approaches the

Council could use to move from this initial risk assessment to specifying a more in-depth analysis of particular high prority questions.

One potential prioritization approach focuses on the single species with the largest number of high risk rankings across all elements, which is black sea bass (8 high Risk Elements, Tables 3-5). A second approach focuses on the fishery with the highest landings value (as a proxy for seafood production and economic benefits), which is the squid complex, with uncertainties in assessment and potential for distribution shifts along with high risks identified across multiple management elements (Tables 3-4). A third approach focuses on the risk element with the most high risk categorizations across all categories, which is allocation (12 high risk species/sector combinations; Table 4). These prioritization approaches use only the risk elements that could be ranked; inclusion of additional risk elements of interest to the Council (Table 6) may not change the selected approach but could change the outcome.

An example conceptual model based on the first prioritization approach has been developed to illustrate the process (Fig. 1). This model was developed by modifying the existing Mid-Atlantic conceptual model using the risk assessment results tables to ensure that all key factors affecting black sea bass and its fisheries were considered. We can step through this process briefly during the EOP presentation to illustrate methods for building a model. While it looks complex, this need not be time consuming and the process can incorporate the knowledge of managers, fishery participants, and scientsts to ensure that key interactions and management priorities are considered and accounted for.

A (partial) conceptual model based on the second approach was recently developed as well, which emphasizes habitat linkages affecting availability for longfin squid as well as economic and market factors affecting fishery effort (Fig. 2). Again, this is illustrative of an approach and not intended to be prescriptive.

In the Council EAFM framework, specifying a conceptual model in turn provides the initial scoping for more in-depth management strategy evaluation (MSE), where simulation modeling is used to test alternative methods for achieving specific management objectives under uncertainty (Butterworth, 2007; Punt and Donovan, 2007; Punt et al., 2016; Sainsbury, 2000). Any MSE undertaken by the Council will be a deliberative process and will include a variety of stakeholder and Council engagement/involvement. MSE is generally recognized as a core component of the ecosystem approach (Levin et al., 2009, 2014; Smith et al., 2007), but because it necesessitates a high level of engagement, MSE can be a resource-intensive process when applied even to relatively simple single species harvest control rules (e.g., Jones et al., 2016). EAFM potentially expands the scope of interactions and uncertainties to consider in evaluating harvest control rules and other fishery management procedures. How can managers ensure that the most important MSE gets done first? Risk assessment provides a systematic framework to ensure that limited MSE resources address the highest priority ecosystem interactions and risks. A risk matrix, such as the one developed by the Council, can be used to quickly evaluate where further integrated analysis and MSE should be focused–which fishery management plans, which species, and which Risk Elements need to be included in the analysis. Further, because the risk assessment includes social and economic elements as well as the more standard ecological elements, the conceptual model and resulting MSE are designed to include the relevant linkages and therefore avoid unintended consequences of management actions (Degnbol and McCay, 2007).

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Figures

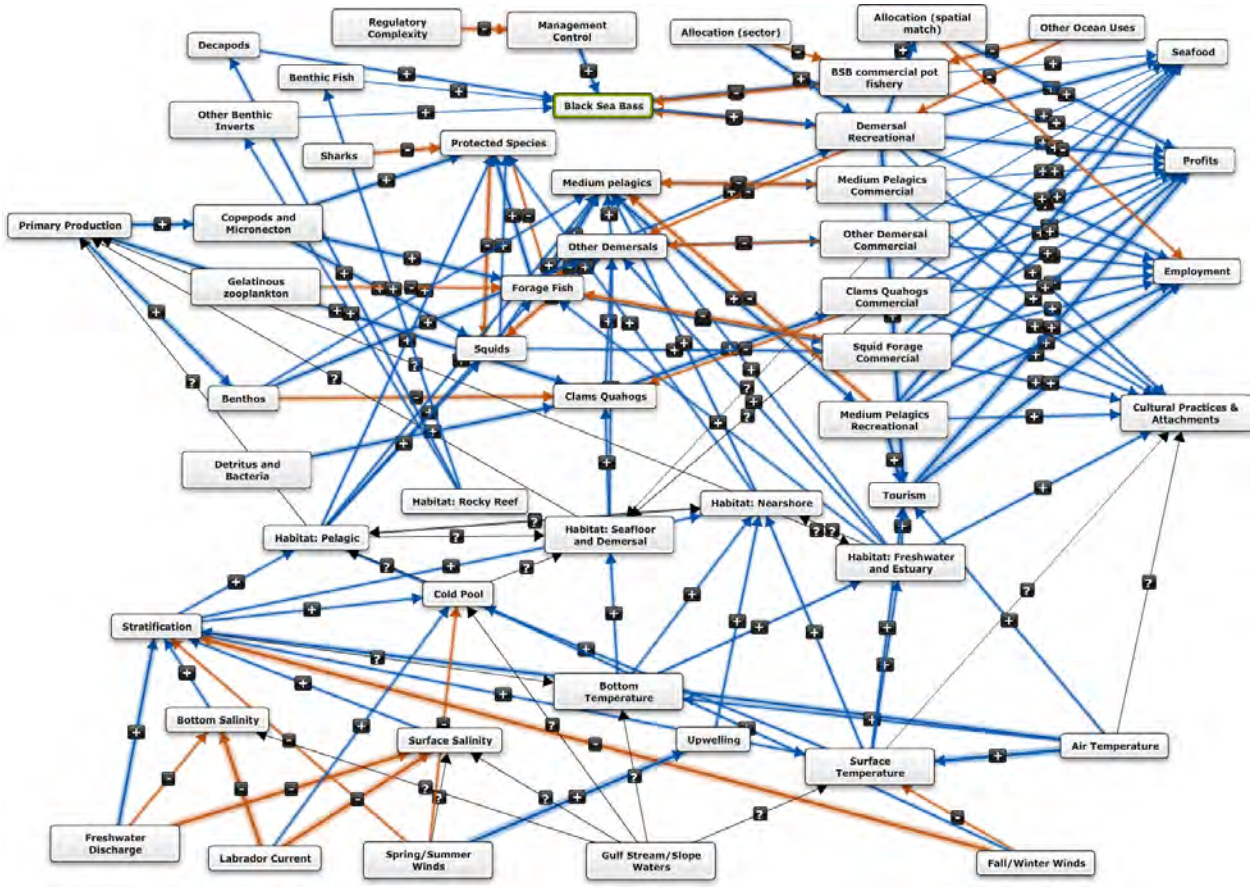

Figure 1: Example conceptual model for a species determined to be high risk: black sea bass. Note that this is an example for discussion and not a Council analysis.

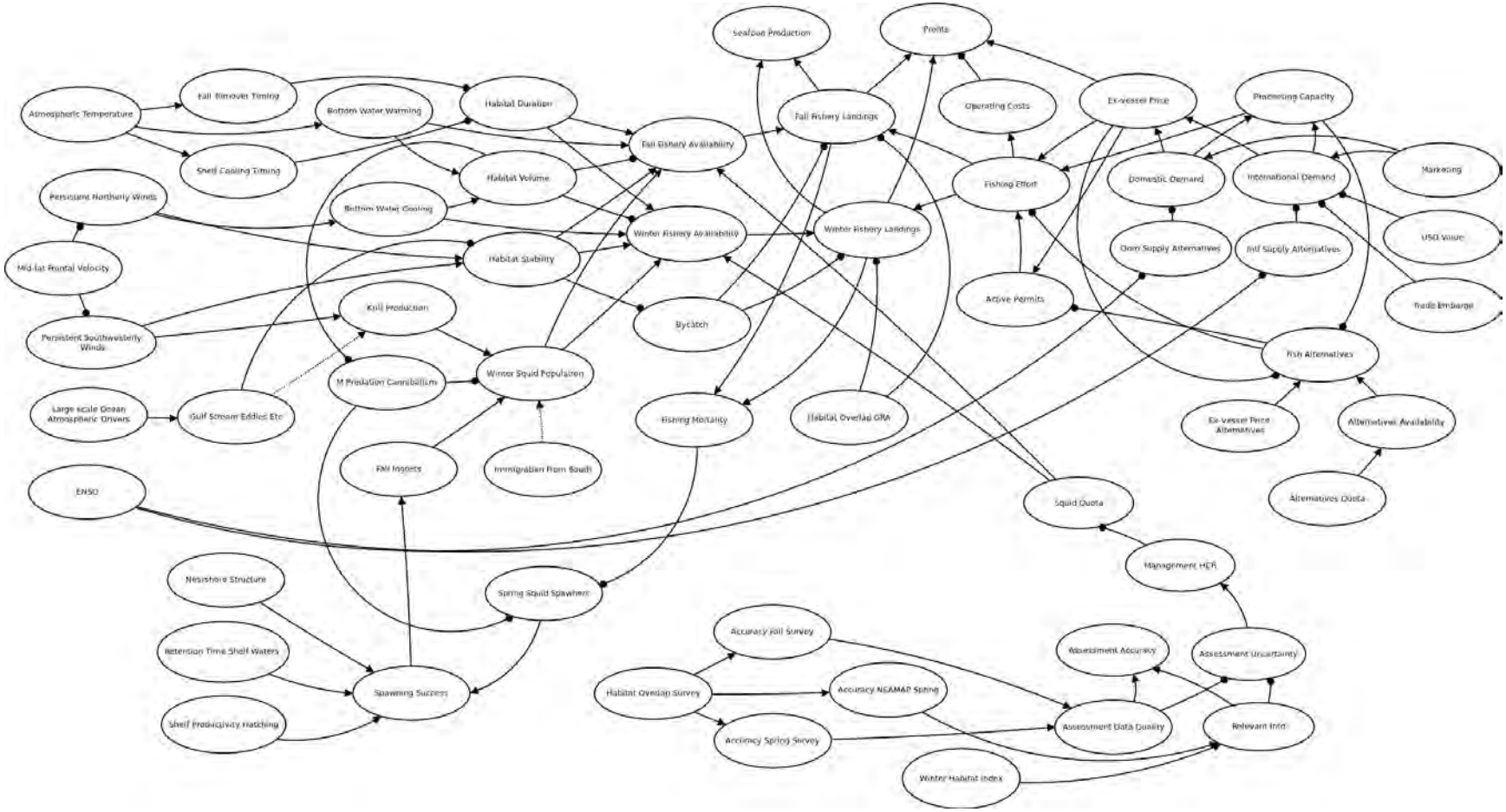

Figure 2: Example conceptual model for a fishery determined to be high risk: longfin squid. Note that this is an example for discussion and not a Council analysis.

Tables

Table 1: Risk Elements, Definitions, and Indicators Used

Element	Definition	Indicator
Ecological		
Assessment performance	Risk of not achieving OY due to analytical limitations	Current assessment method/data quality
F status	Risk of not achieving OY due to overfishing	Current F relative to reference F from assessment
B status	Risk of not achieving OY due to depleted stock	Current B relative to reference B from assessment
Food web (MAFMC Predator)	Risk of not achieving OY due to MAFMC managed species interactions	Diet composition, management measures
Food web (MAFMC Prey)	Risk of not achieving OY due to MAFMC managed species interactions	Diet composition, management measures
Food web (Protected Species Prey)	Risk of not achieving protected species objectives due to species interactions	Diet composition, management measures
Ecosystem productivity	Risk of not achieving OY due to changing system productivity	Four indicators, see text
Climate	Risk of not achieving OY due to climate vulnerability	Northeast Climate Vulnerability Assessment
Distribution shifts	Risk of not achieving OY due to climate-driven distribution shifts	Northeast Climate Vulnerability Assessment + 2 indicators
Estuarine habitat	Risk of not achieving OY due to threats to estuarine/nursery habitat	Enumerated threats + estuarine dependence
Offshore habitat	Risk of not achieving OY due to changing offshore habitat	Integrated habitat model index
Economic		
Commercial Revenue	Risk of not maximizing fishery value	Revenue in aggregate
Recreational Angler Days/Trips	Risk of not maximizing fishery value	Numbers of anglers and trips in aggregate
Commercial Fishery Resilience (Revenue Diversity)	Risk of reduced fishery business resilience	Species diversity of revenue
Commercial Fishery Resilience (Shoreside Support)	Risk of reduced fishery business resilience due to shoreside support infrastructure	Number of shoreside support businesses
Social		
Fleet Resilience	Risk of reduced fishery resilience	Number of fleets, fleet diversity
Social-Cultural	Risk of reduced community resilience	Community vulnerability, fishery engagement and reliance
Food Production		
Commercial	Risk of not optimizing seafood production	Seafood landings in aggregate
Recreational	Risk of not maintaining personal food production	Recreational landings in aggregate
Management		
Control	Risk of not achieving OY due to inadequate control	Catch compared to allocation
Interactions	Risk of not achieving OY due to interactions with species managed by other entities	Number and type of interactions with protected or non-MAFMC managed species, co-management
Other ocean uses	Risk of not achieving OY due to other human uses	Fishery overlap with energy/mining areas
Regulatory complexity	Risk of not achieving compliance due to complexity	Number of regulations by species
Discards	Risk of not minimizing bycatch to extent practicable	Standardized Bycatch Reporting
Allocation	Risk of not achieving OY due to spatial mismatch of stocks and management	Distribution shifts + number of interests

Table 2: Risk Ranking Criteria used for each Risk Element

Element	Low	Low-Moderate	Moderate-High	High
Assessment performance	Assessment model(s) passed peer review, high data quality	Assessment passed peer review but some key data and/or reference points may be lacking	*This category not used*	Assessment failed peer review or no assessment, data-limited tools applied
F status	F < Fmsy	Unknown, but weight of evidence indicates low overfishing risk	Unknown status	F > Fmsy
B status	B > Bmsy	Bmsy > B > 0.5 Bmsy, or unknown, but weight of evidence indicates low risk	Unknown status	B < 0.5 Bmsy
Food web (MAFMC Predator)	Few interactions as predators of other MAFMC managed species, or predator of other managed species in aggregate but below 50% of diet	*This category not used*	*This category not used*	Managed species highly dependent on other MAFMC managed species as prey
Food web (MAFMC Prey)	Few interactions as prey of other MAFMC managed species, or prey of other managed species but below 50% of diet	Important prey with management consideration of interaction	*This category not used*	Managed species is sole prey and/or subject to high mortality due to other MAFMC managed species
Food web (Protected Species Prey)	Few interactions with any protected species	Important prey of 1-2 protected species, or important prey of 3 or more protected species with management consideration of interaction	Important prey of 3 or more protected species	Managed species is sole prey for a protected species
Ecosystem productivity	No trends in ecosystem productivity	Trend in ecosystem productivity (1-2 measures, increase or decrease)	Trend in ecosystem productivity (3+ measures, increase or decrease)	Decreasing trend in ecosystem productivity, all measures
Climate	Low climate vulnerability ranking	Moderate climate vulnerability ranking	High climate vulnerability ranking	Very high climate vulnerability ranking
Distribution shifts	Low potential for distribution shifts	Moderate potential for distribution shifts	High potential for distribution shifts	Very high potential for distribution shifts
Estuarine habitat	Not dependent on nearshore coastal or estuarine habitat	Estuarine dependent, estuarine condition stable	Estuarine dependent, estuarine condition fair	Estuarine dependent, estuarine condition poor
Offshore habitat	No change in offshore habitat quality or quantity	Increasing variability in habitat quality or quantity	Significant long term decrease in habitat quality or quantity	Significant recent decrease in habitat quality or quantity
Commercial Revenue	No trend and low variability in revenue	Increasing or high variability in revenue	Significant long term revenue decrease	Significant recent decrease in revenue
Recreational Angler Days/Trips	No trends in angler days/trips	Increasing or high variability in angler days/trips	Significant long term decreases in angler days/trips	Significant recent decreases in angler days/trips
Commercial Fishery Resilience (Revenue Diversity)	No trend in diversity measure	Increasing or high variability in diversity measure	Significant long term downward trend in diversity measure	Significant recent downward trend in diversity measure

Table 2: Risk Ranking Criteria used for each Risk Element *(continued)*

Element	Low	Low-Moderate	Moderate-High	High
Commercial Fishery Resilience (Shoreside Support)	No trend in shoreside support businesses	Increasing or high variability in shoreside support businesses	Significant recent decrease in one measure of shoreside support businesses	Significant recent decrease in multiple measures of shoreside support businesses
Fleet Resilience	No trend in diversity measure	Increasing or high variability in diversity measure	Significant long term downward trend in diversity measure	Significant recent downward trend in diversity measure
Social-Cultural	Few (<10%) vulnerable fishery dependent communities	10-25% of fishery dependent communities with >3 high vulnerability ratings	25-50% of fishery dependent communities with >3 high vulnerability ratings	Majority (>50%) of fishery dependent communities with >3 high vulnerability ratings
Commercial	No trend or increase in seafood landings	Increasing or high variability in seafood landings	Significant long term decrease in seafood landings	Significant recent decrease in seafood landings
Recreational	No trend or increase in recreational landings	Increasing or high variability in recreational landings	Significant long term decrease in recreational landings	Significant recent decrease in recreational landings
Control	No history of overages	Small overages, but infrequent	Routine overages, but small to moderate	Routine significant overages
Interactions	No interactions with non-MAFMC managed species	Interactions with non-MAFMC managed species but infrequent, Category II fishery under MMPA; or AMs not likely triggered	AMs in non-MAFMC managed species may be triggered; or Category I fishery under MMPA (but takes less than PBR)	AMs in non-MAFMC managed species triggered; or Category I fishery under MMPA and takes above PBR
Other ocean uses	No overlap; no impact on habitat	Low-moderate overlap; minor habitat impacts but transient	Moderate-high overlap; minor habitat impacts but persistent	High overlap; other uses could seriously disrupt fishery prosecution; major permanent habitat impacts
Regulatory complexity	Simple/few regulations; rarely if ever change	Low-moderate complexity; occasional changes	Moderate-high complexity; occasional changes	High complexity; frequently changed
Discards	No significant discards	Low or episodic discard	Regular discard but managed	High discard, difficult to manage
Allocation	No recent or ongoing Council discussion about allocation	*This category not used*	*This category not used*	Recent or ongoing Council discussion about allocation

Table 3: Species level risk analysis results; l=low risk (green), lm= low-moderate risk (yellow), mh=moderate to high risk (orange), h=high risk (red)

Species	Assess	Fstatus	Bstatus	FW1Pred	FW1Prey	FW2Prey	Climate	DistShift	EstHabitat
Ocean Quahog	l	l	l	l	l	l	h	mh	l
Surfclam	l	l	l	l	l	l	mh	mh	l
Summer flounder	l	h	lm	l	l	l	lm	mh	h
Scup	l	l	l	l	l	l	lm	mh	h
Black sea bass	l	l	l	l	l	l	mh	mh	h
Atl. mackerel	l	h	h	l	l	l	lm	mh	l
Butterfish	l	l	l	l	l	l	l	h	l
Longfin squid	lm	lm	lm	l	l	lm	l	mh	l
Shortfin squid	lm	lm	lm	l	l	lm	l	h	l
Golden tilefish	l	l	lm	l	l	l	mh	l	l
Blueline tilefish	h	h	mh	l	l	l	mh	l	l
Bluefish	l	l	lm	l	l	l	l	mh	h
Spiny dogfish	lm	l	lm	l	l	l	l	h	l
Monkfish	h	lm	lm	l	l	l	l	mh	l
Unmanaged forage	na	na	na	l	lm	lm	na	na	na
Deepsea corals	na	na	na	l	l	l	na	na	na

113 <!–

Table 4: Species and sector level risk analysis results; l=low risk (green), lm= low-moderate risk (yellow), mh=moderate to high risk (orange), h=high risk (red)

Species	MgtControl	TecInteract	OceanUse	RegComplex	Discards	Allocation
Ocean Quahog-C	l	l	lm	l	l	l
Surfclam-C	l	l	lm	l	l	l
Summer flounder-R	mh	l	lm	h	h	h
Summer flounder-C	lm	mh	lm	mh	lm	h
Scup-R	l	l	lm	mh	mh	l
Scup-C	l	mh	lm	mh	mh	l
Black sea bass-R	h	l	mh	h	mh	h
Black sea bass-C	lm	lm	h	mh	lm	h
Atl. mackerel-R	l	l	l	l	l	h
Atl. mackerel-C	l	lm	mh	h	lm	h
Butterfish-C	l	lm	mh	h	mh	l
Longfin squid-C	l	mh	h	h	h	h
Shortfin squid-C	l	lm	lm	lm	l	l
Golden tilefish-R	na	l	l	l	l	l
Golden tilefish-C	l	l	l	l	l	l
Blueline tilefish-R	l	l	l	mh	l	h
Blueline tilefish-C	l	l	l	mh	l	h
Bluefish-R	lm	l	l	l	mh	h
Bluefish-C	l	l	lm	lm	lm	h
Spiny dogfish-R	l	l	l	l	l	l
Spiny dogfish-C	l	mh	mh	mh	lm	h
Unmanaged forage	na	na	na	na	na	na
Deepsea corals	na	na	mh	na	na	na

Table 5: Ecosystem level risk analysis results; l=low risk (green), lm= low-moderate risk (yellow), mh=moderate to high risk (orange), h=high risk (red)

System	EcoProd	CommRev	RecVal	FishRes1	FishRes4	FleetDiv	Social	ComFood	RecFood
Mid-Atlantic	lm	mh	h	l	mh	mh	lm	h	mh

Table 6: Risk Elements, Definitions, and Indicators put aside for future evaluation

Risk Element	Definition: Risk to what?	Indicators used
Put Aside		
Population diversity	Risk of not achieving OY due to reduced diversity	Size composition, sex ratio, genetic diversity
Ecological diveristy	Risk of not achieving OY due to reduced diversity	Fishery independent species diversity
Fishery Resilience (2)	Risk of reduced fishery business resilience due to access to capital	No current indicator avilable
Fishery Resilience (3)	Risk of reduced fishery business resilience due to insurance availabilty	No current indicator available
Fishery Resilience (5)	Risk of reduced fishery business resilience due to access to emerging markets/opportunities	Needs clarification
Commercial Employment	Risk of not optimizing employment opportunities	EOP Committee unconfident in Fisheries of US employment inicator
Recreational Employment	Risk of not optimizing employment opportunities	EOP Committee unconfident in Fisheries of US employment indicator
Seafood safety	Risk of not maintaining market access, human health	Number of public advisories by species

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

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Michael P. Luisi, Chairman | G. Warren Elliott, Vice Chairman
Christopher M. Moore, Ph.D., Executive Director

September 14, 2018

Dear NOAA Fisheries:

The Mid-Atlantic Fishery Management Council's (MAFMC) Ecosystem and Ocean Planning Committee (Committee) met via webinar on September 10, 2018 to review the draft Northeast Regional Ecosystem-Based Fishery Management (EBFM) Implementation Plan. After a lengthy discussion, the Committee offers the following comments regarding the draft Northeast Regional EBFM Implementation Plan.

- Under Guiding Principle #1, the *Develop engagement strategies to facilitate the participation of partners and stakeholders in the EBFM process* section indicates that "long-term coordination will be necessary to blend the two approaches" taken by the Mid-Atlantic and New England Councils in implementing EBFM. As noted in the document, the two Councils have taken very different approaches to implementing ecosystem considerations in their management process and using the term "blend" seems to imply one approach for both Council's is a goal of the Northeast plan. Given the highly inter-connected fisheries within the region, there is clearly a need to continue, and potentially enhance, the cooperative and collaborative management and science partnerships between the Councils, the Atlantic States Marine Fisheries Commission (ASMFC) and NMFS. There is also a need to share advancements and lessons-learned as each Council continues with the development and implementation of ecosystem considerations and approaches. However, the Committee strongly believes those efforts should remain separate and not integrated into one "blended" approach in order to meet the needs, challenges and priorities specific to each region. Therefore, the Committee suggests providing additional language or clarification at to what is intended in this section.
- The Committee notes that the Northeast Regional EBFM Implementation Plan is the only plan that combines two management Council's within one plan – all others are specific to a particular Council. Given that one regional office and one science center services both Councils, the development of one comprehensive Northeast Region Plan is likely the most effective and efficient approach; however, as the Committee notes above, it should not be done in order to develop one ecosystem approach for both Councils.
- In the same section under Guiding Principle #1, the Committee suggests including the Council's Scientific and Statistical Committees (SSC) as additional partners needed to increase the engagement between the Councils, ASMFC, NEFSC and GARFO. The SSC's play an integral role between science advice and management implementation and they consider, at least in the MAFMC SSC, ecosystem factors when determining ABC recommendations. Given the continued interest in including ecosystem Terms of Reference in benchmark stock assessments, the need for increased coordination between the SSC's and their evaluation of

ecosystem factors should be noted.

- The Committee is encouraged to see the draft document acknowledge the likely increase in interactions with species from the south Atlantic and the need for increased coordination, but there does not appear to be an Action Item or Milestone associated with this recommendation and it's not clear what current Action Item this may fall under. For example, Action Item 1a3 in Table 1 may be appropriate but it describes specific Milestones related to Ecological Production Units (EPUs) and the Northeast plan does not include EPUs south of Hatteras. The Committee recommends providing specific Action Items and/or Milestones addressing increased coordination with the South Atlantic Council.
- Under Guiding Principle #2, the *Conduct science to understand ecosystems* section focuses on NEFSC specific surveys and initiatives. The Committee suggests mentioning the availability and potential use of other important fishery dependent and independent surveys such as NEAMAP and those surveys supported by NMFS such as those covered under funds from the Interjurisdictional Fisheries Act. These surveys, in addition to NEFSC specific surveys, will be useful in advancing ecosystem science.
- Under the *Provide Ecosystem Status Reports for each Large Marine Ecosystem* section under Guiding Principle #2, the Committee suggests including some language that highlights the fact that a significant amount of data and information within the Mid-Atlantic SOE report was utilized by the Council in its development of the Mid-Atlantic Risk Assessment. Since the Risk Assessment is a continual and adaptive process, it emphasizes the need to continue the annual development of the SOE report.
- In Table 2, Roadmap and Action Item Number 2a4. The Fishery-Dependent Data Visioning project Milestone associated with this Action Item indicates this project will be finalized within the next year. The Committee notes this timeframe seems to be much sooner than previous updates on this project which indicated a 3-5 year timeframe until finalization. Some clarification on this Milestone is needed.
- In Table 3, Roadmap Action Item 3a1. The Committee believes the footnotes associated with the documents mentioned under the Milestones appear to be off by one. This footnote issue appears in other locations as well – e.g. first full paragraph on page 12 referring to the Mid-Atlantic Risk Assessment.
- In Table 3, Roadmap Action Item 3b1. The Action Item indicates factors which impact all 800+ managed species are to be considered. The Committee questions why factors that impact all 800+ managed species throughout the country would be considered within the Northeast Regional Plan. There are likely factors impacting a particular species that are not relevant or appropriate for the Northeast Region. The Committee recommends modifying the Action Item to something similar to the Southeast Region Plan that states "Ensure that factors which impact managed species are being considered".
- Under Guiding Principle #4, the *Development of Management Strategy Evaluation capabilities to better conduct ecosystem-level analyses to provide ecosystem-wide management advice* section indicates an FTE (currently spilt between two FTE's) will be responsible for Northeast Region MSE projects. The Committee suggests providing additional clarifying language regarding the role and responsibilities of this position(s). Will this position(s) be the only position/person to do all MSE work needed by the Council or will all MSE analyses be facilitated through this position? As noted in the draft document, both Councils have pending needs for MSE analyses and these demands are likely to increase in time. The Committee supports NMFS increasing their MSE capacity but don't want this FTE position to create a

bottle-neck in the development of MSE projects.

- Under the *Evaluate ecosystem-level measures of resilience* section within Guiding Principle #6, there is discussion regarding further work needed to establish social and economic related thresholds to determine ecosystem resilience. The Committee notes that it might be worth highlighting in this section that one goal or possible outcome from MAFMC's Ecosystem Approach to Fisheries Management (EAFM) guidance document and Risk Assessment initiatives are to help in the development of region/Council specific social and economic targets and thresholds.
- Related to the comment above, the Committee recommends the Milestone column associated with Roadmap Number and Action Item 6b1 in Table 6 also include continued development and refinement of the Mid-Atlantic Council Risk Assessment.
- Under the *Evaluate community well-being* section within Guiding Principle #6, it mentions the two community resilience workshops (one in New England and one in the Mid-Atlantic) GARFO conducted. The Committee suggests adding an additional sentence or two as to how the information gained from these workshops will be used in the future, particularly as it relates to tracking and understanding changes in community reliance.

On behalf of the MAFMC EOP Committee, we appreciate the opportunity to provide input on the draft Northeast Regional EBFM Implementation Plan. We look forward to the continued partnership with NMFS in support of the Council's commitment to continuing the development and implementation of its EAFM guidance document.

Sincerely,

BMP for G Warren Elliott

G. Warren Elliott, Chairman
MAFMC Ecosystem and Ocean Planning Committee

cc: C. Moore, M. Luisi, S. Michels, J. Boreman, S. Rauch, C. Werner, M. Pentony, J. Hare, B. Muffley

From: David Dow <ddow420@comcast.net>
Sent: Saturday, September 15, 2018 3:37 AM
To: Moore, Christopher
Cc: David Dow
Subject: October 2 MAFMC Discussion of an Ecosystems Approach to Fisheries Management Risk Assessment

I am a retired marine scientist from the Fisheries Lab in Woods Hole and grassroots environmental activist living on Cape Cod, Ma. I want to urge the Mid-Atlantic Fishery Management Council to strongly consider moving towards an ecosystems approach to fisheries management in order to address the shifting baseline in the marine environment and its effects on the pelagic food chain for forage species (i.e., menhaden)and predator-prey interactions for groundfish (i.e. Summer flounder) and predatory fish (i.e. black sea bass; tuna. swordfish; great white sharks; etc.). I used to serve on the NEFMC's Habitat Plan Development Team which helped develop Omnibus Amendment 2 (OHA 2) which missed an opportunity to include eutrophication; climate change and increased human uses (wind farms; US Naval training; hardening of coastal shorelines to address relative sea level rise and storm surge during extreme weather events; oil/gas exploration activities; increased ocean noise from large vessels; etc.) as factors influencing the "productive capacity" of Essential Fish Habitat (EFH). We need to better integrate EFH with fishery population dynamics models to make fishery management more efficient and cost effective the current times.

When I worked at NASA's Earth Resources Laboratory, I was engaged in the "productive capacity of wetlands" project which linked salt marsh production to shrimp yield off the coast. Dr. Joan Browder (SEFSC) and colleagues at Louisiana State University's Center for Wetland Resources published a number of peer-reviewed papers linking wetland loss to effects on offshore shrimp populations in the Gulf of Mexico. The NASA team utilized Landsat remote sensing data to estimate the biomass of salt marsh plants that could be potentially exported into coastal waters.

At the Fisheries Lab in Woods Hole (Northeast Fisheries Science Center), I participated in the EMaX (Energy Modeling and Analysis Exercise) carbon flow model for the Northeast Continental Shelf Ecosystem. This model focused on the role of forage fish in connecting plankton (grazing food chain and microbial food web) to the living marine (fish and shellfish); protected (marine mammals and sea turtles) and natural trust resources (seabirds) at the top of the food chain. We used ocean color satellite data to estimate the primary production in the ocean in the region from Chesapeake Bay to the Maine/Canada border. It turned out that we had more primary production (particulate and dissolved) than yield of LMRs/PRs/NTRs at the top, so that we added the microbial food web to the grazing food chain in order to increase the length of the food chain and thus increase community respiration. Biological oceanographers have studied carbon flow and the various environmental control factors since the late 1960's and the dominance of the microbial food web when the ocean surface waters are stratified (ammonia recycling is important) and the Spring diatom bloom as an important component of the grazing food chain (which is controlled by nitrate).

There has been dramatic increases in the nutrient levels in coastal embayments from eutrophication (nitrogen enrichment) and climate change (warming waters and increasing acidification of the sediments) which have influenced our coastal embayments adjacent to Nantucket Sound. Cape Cod residents will expend $ 4-7 billion over the next 20-30 years to reduce "N" loading from septic systems. The Gulf of Maine to the north of Cape Cod has warmed rapidly due climate-induced hydrographic changes and warmer bottom waters during the Winter/surface waters during the Summer. When I first arrived on Cape Cod in 1987, the water at the Falmouth beaches reached 70 F for a couple of days in early August, but this started in July this year and is still occurring in mid-September in Nantucket Sound (Gulf of Maine surface waters have also exceeded 70 F for extended periods).

One consequence of this is that numerous Mid-Atlantic fish
species (scup; black sea bass; menhaden; Summer flounder; great white sharks) are migrating into southern New England waters. It is encouraging that the MAFMC is holding regional hearings on Summer flounder to address this distribution shift and its consequences for management. I presume that the Atlantic States Marine Fisheries Commission is involved in this dialog and will coordinate efforts with state fisheries management agencies and the NEFMC for federal jurisdictional waters (3-200 miles). I wrote an Op-ed piece in CapeCod Today which was reprinted in the Rhode Island Saltwater Anglers Association newsletter on this management integration challenge. I also discussed this matter with one of Sen. Markey's staff.

I feel that an adaptive, ecosystems-based fisheries management approach could help integrate the effects of the shifting baseline
in the ocean with effects on wild species and their habitats to help better understand the "natural mortality" component of population dynamics models which help set the quotas and develop ways to estimate the "productive capacity" of EFH using lessons learned from the EMaX research. There are a number of marine academic researchers which explore natural capital and ecosystem services which may provide insights on how to address this problem as a complex, dynamic system. Since I have been retired for 10 years, I haven't kept up with the progress in this area. It is important to incorporate leading edge research more quickly into the fisheries management process, since things are changing more rapidly than scientists; regulators
and policy makers envisaged. It is important to maintain public confidence in fishery management, since we are utilizing a public
resource. Since I used to be the Recreational Fisheries Coordinator in the Northeast, I would like to see better data on the economic
impact of saltwater anglers on the economy of coastal communities (including economic multiplier effect). On Cape Cod we are losing
our working waterfront to tourist related development which hurts both commercial and recreational fishing.

Thanks for your consideration of this comments

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