Mid-Atlantic EAFM Risk Assessment Documentation and Results

S. Gaichas, G. DePiper, R. Seagraves, L. Colburn, A. Loftus, M. Sabo, B. Muffley

August 17, 2018

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.

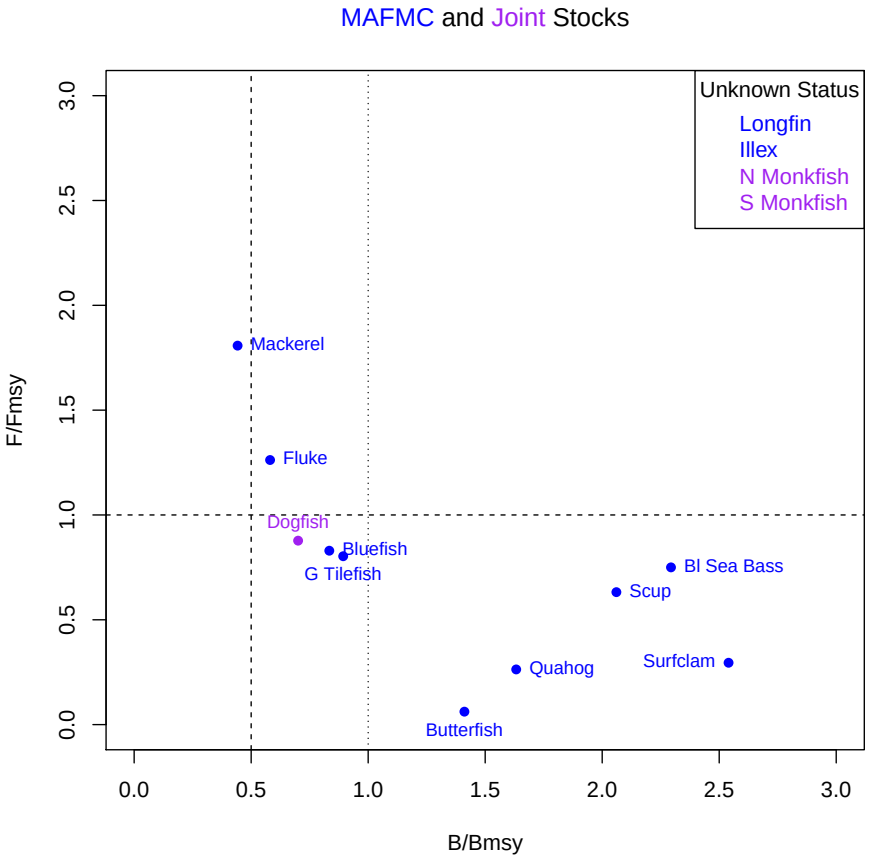

Figure 1: Summary of single species status for MAFMC stocks

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.

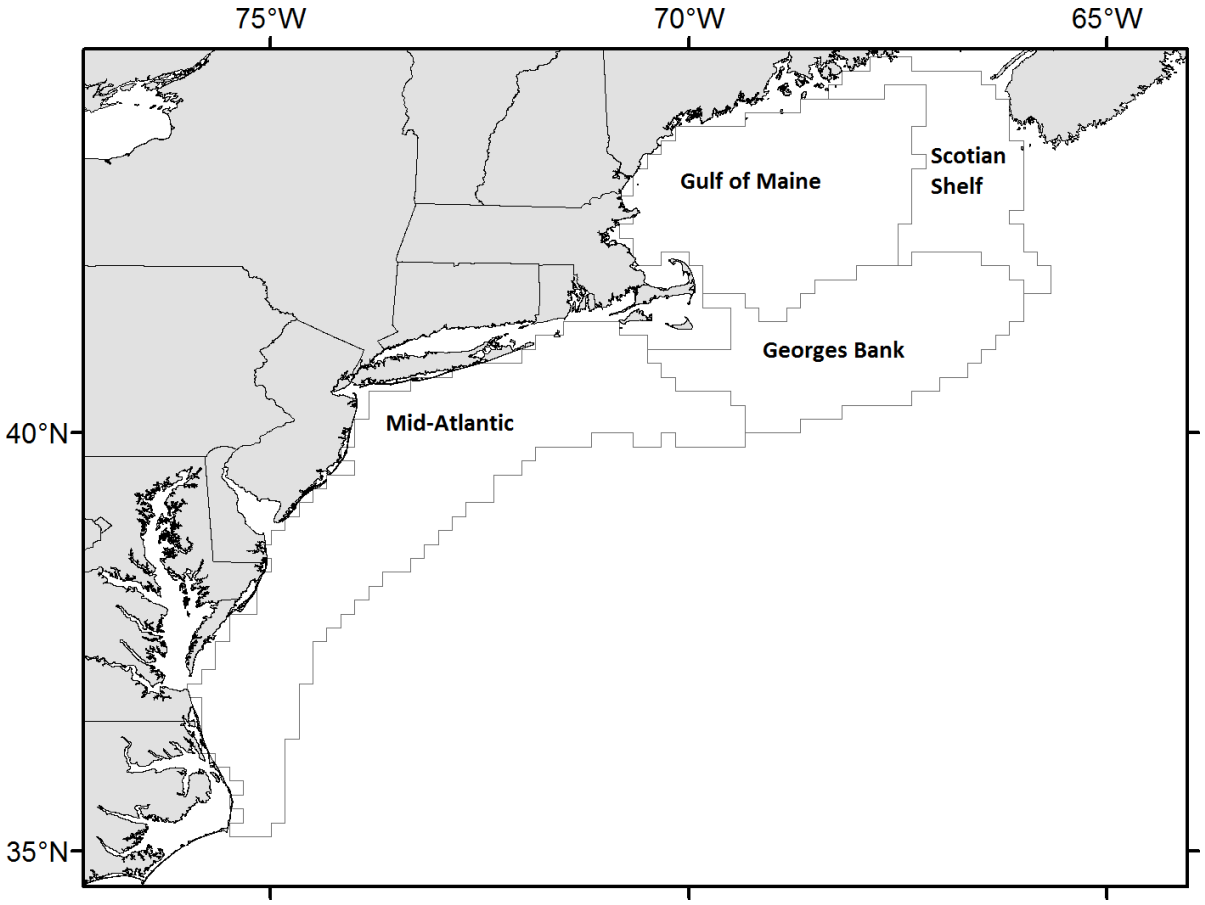

Figure 2: Northeast US Ecosystem Production units.

Primary production

Primary production has fluctuated recently with current conditions near average.

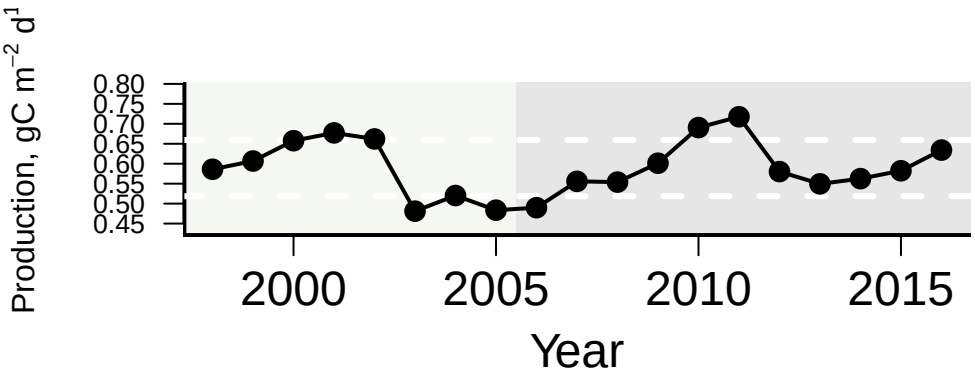

Figure 3: Primary production

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.

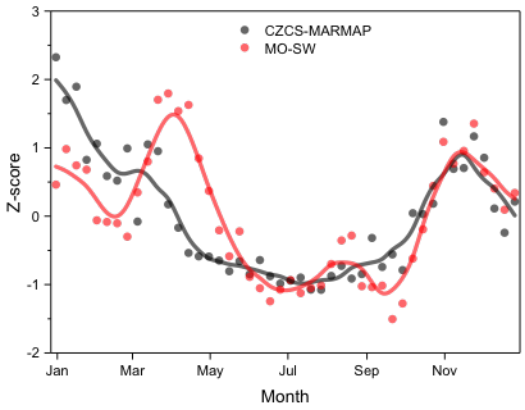

Figure 4: Comparison of 1970-80s annual primary productivity cycle (black) with 1997-present (orange)

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.

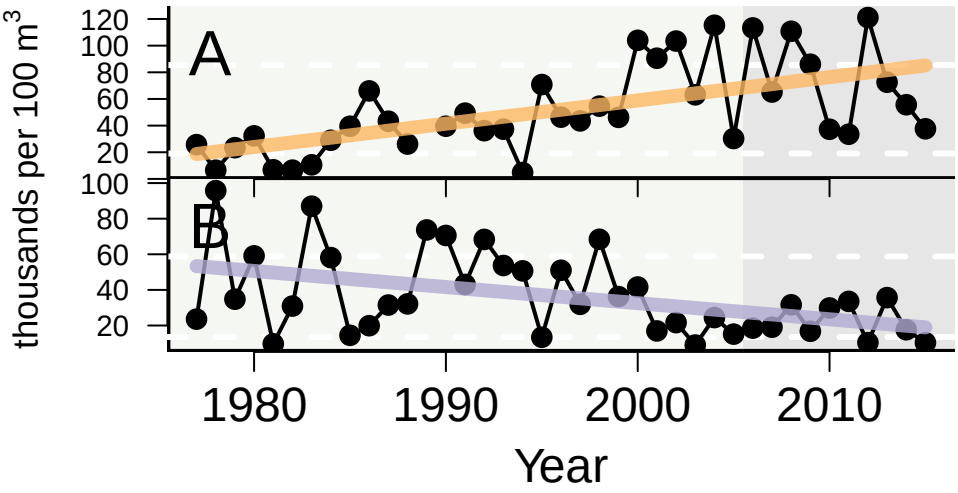

Figure 5: A: Centropages typicus spring, B: Centropages typicus fall

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.

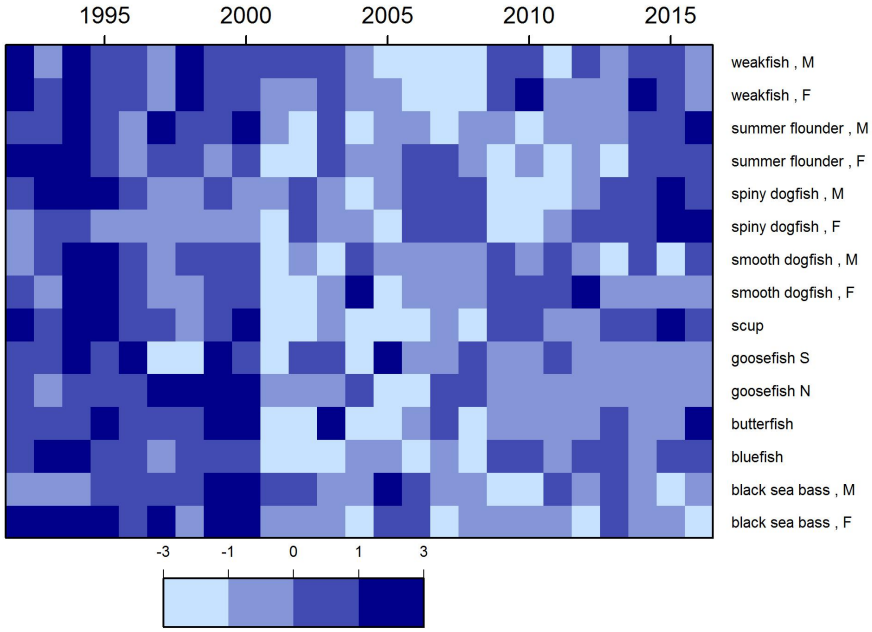

Figure 6: Fish Condition (weight/length)

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.

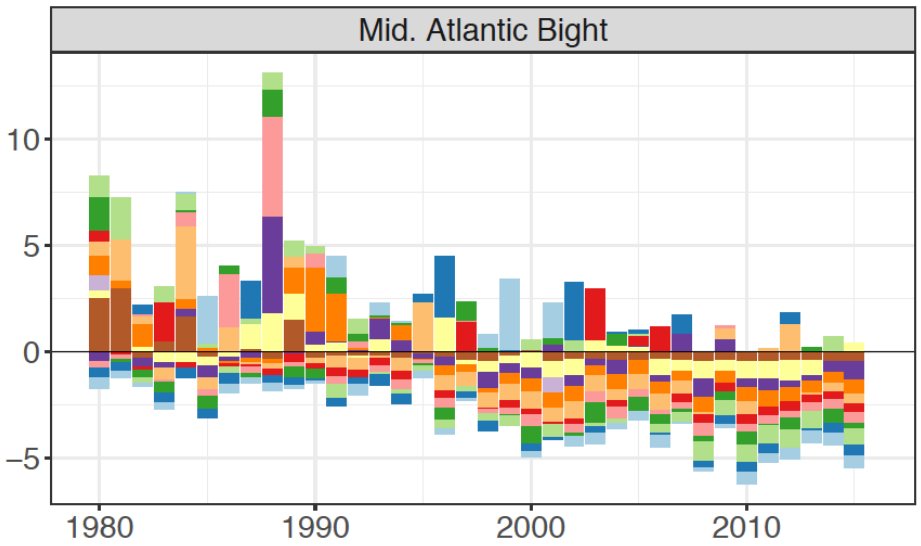

Figure 7: Fish productivity: Anomalies of recruit abundance per spawner biomass for species in the MAB. Annual anomalies shown are the average of spring and fall anomalies.

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).

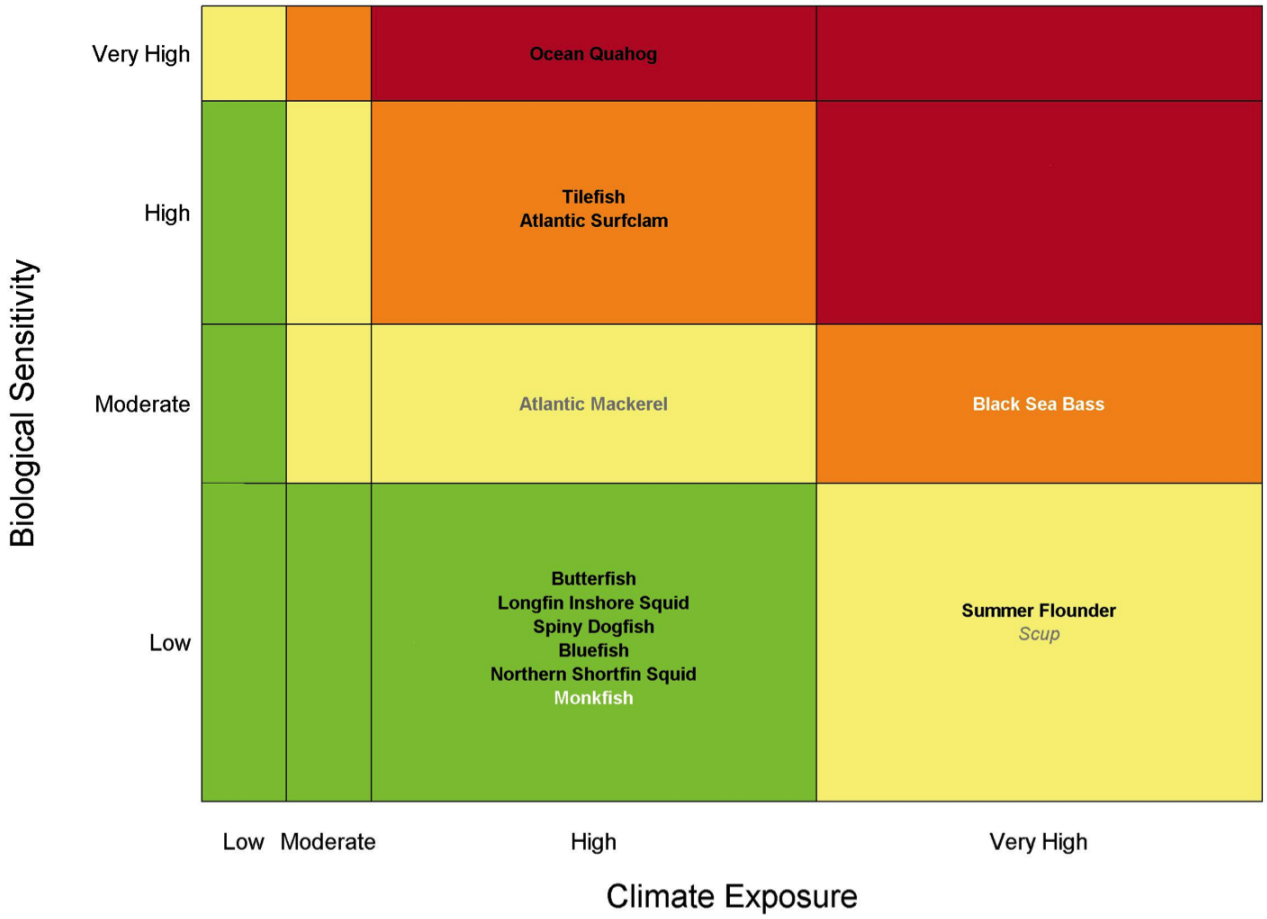

Figure 8: Results of Northeast Climate Vulnerability Analysis (Hare et al. 2016) for Mid-Atlantic species

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.

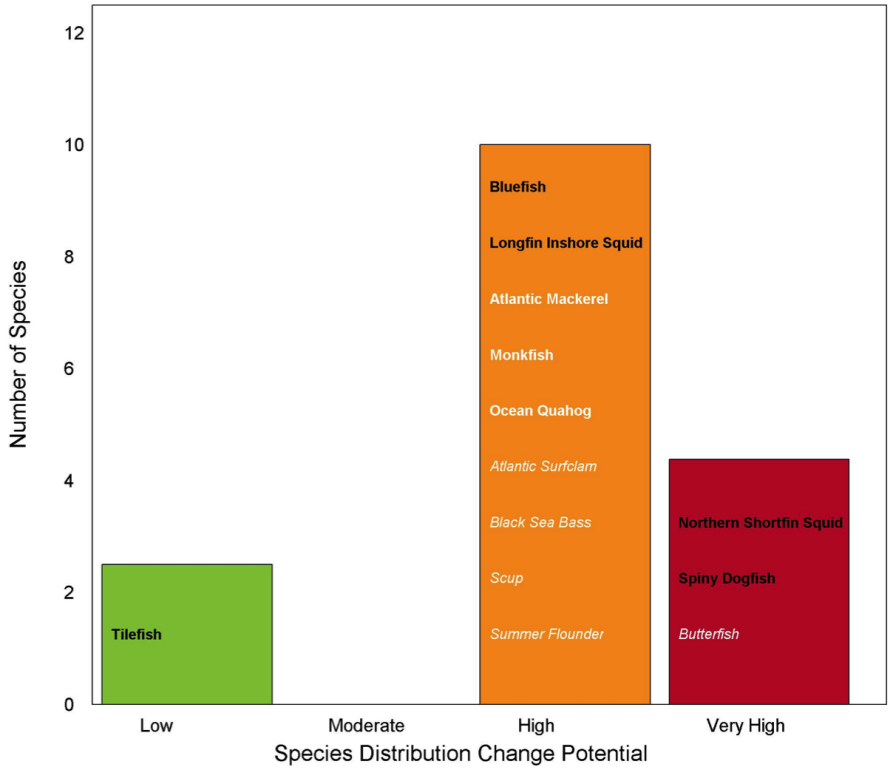

Figure 9: Results of Northeast Climate Vulnerability Analysis (Hare et al. 2016) for Mid-Atlantic species distribution shift risk

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.

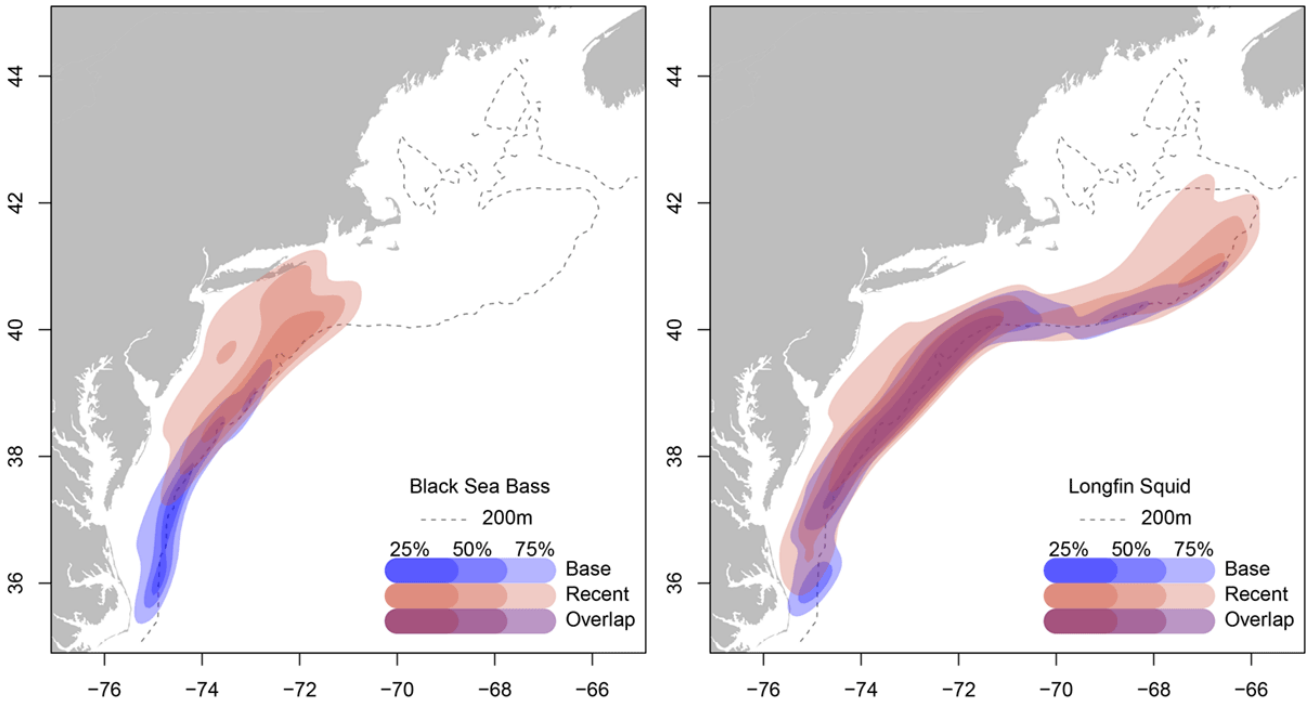

Figure 10: Shifts in species distribution, 1970s (blue), recent (red) and overlap (purple)

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.

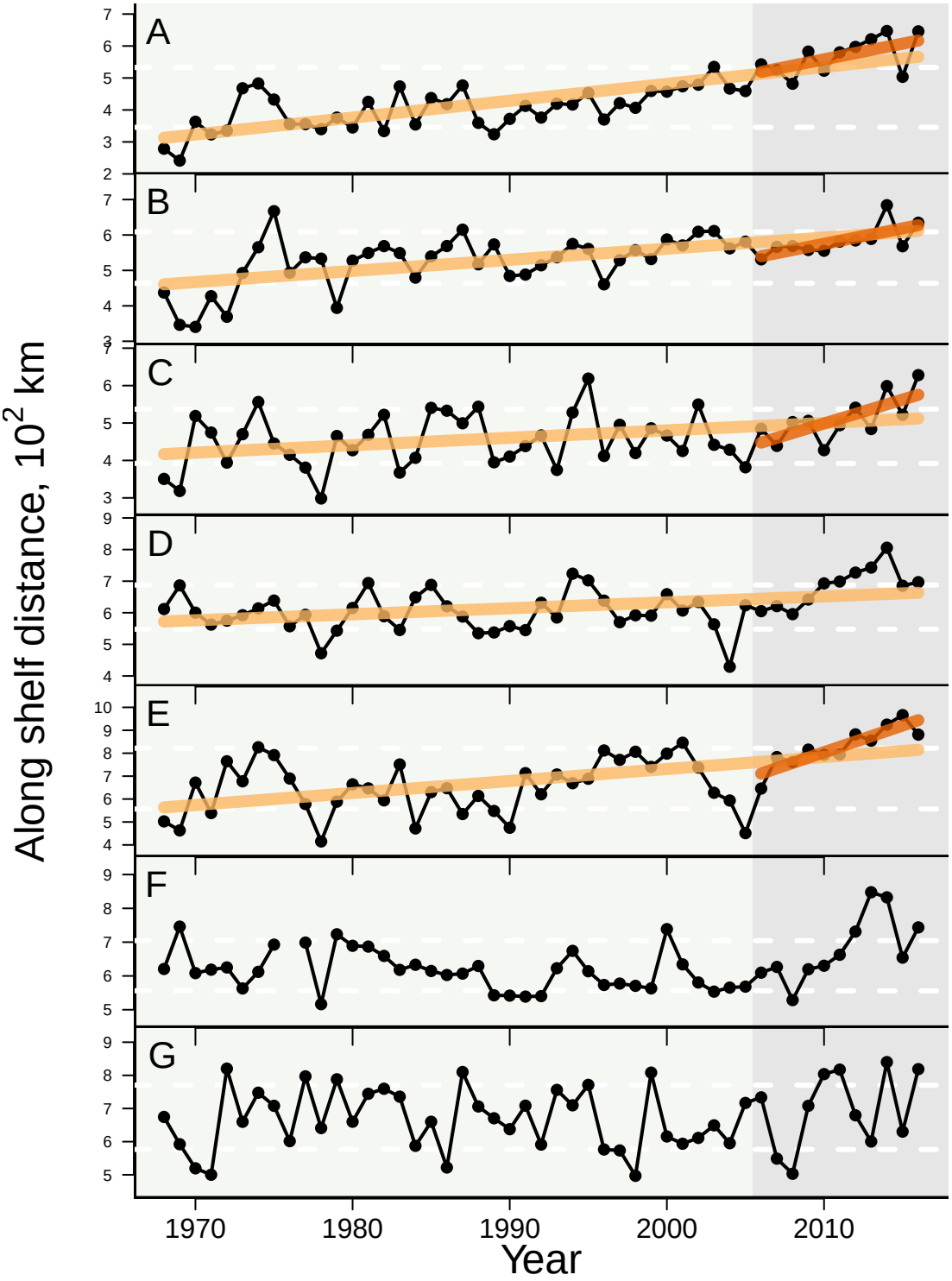

Figure 11: Shifts in species distribution over time; A: Black sea bass, B: Summer flounder, C: Scup, D: Butterfish, E: Atlantic mackerel, F: Longfin squid, G: Shortfin squid

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.

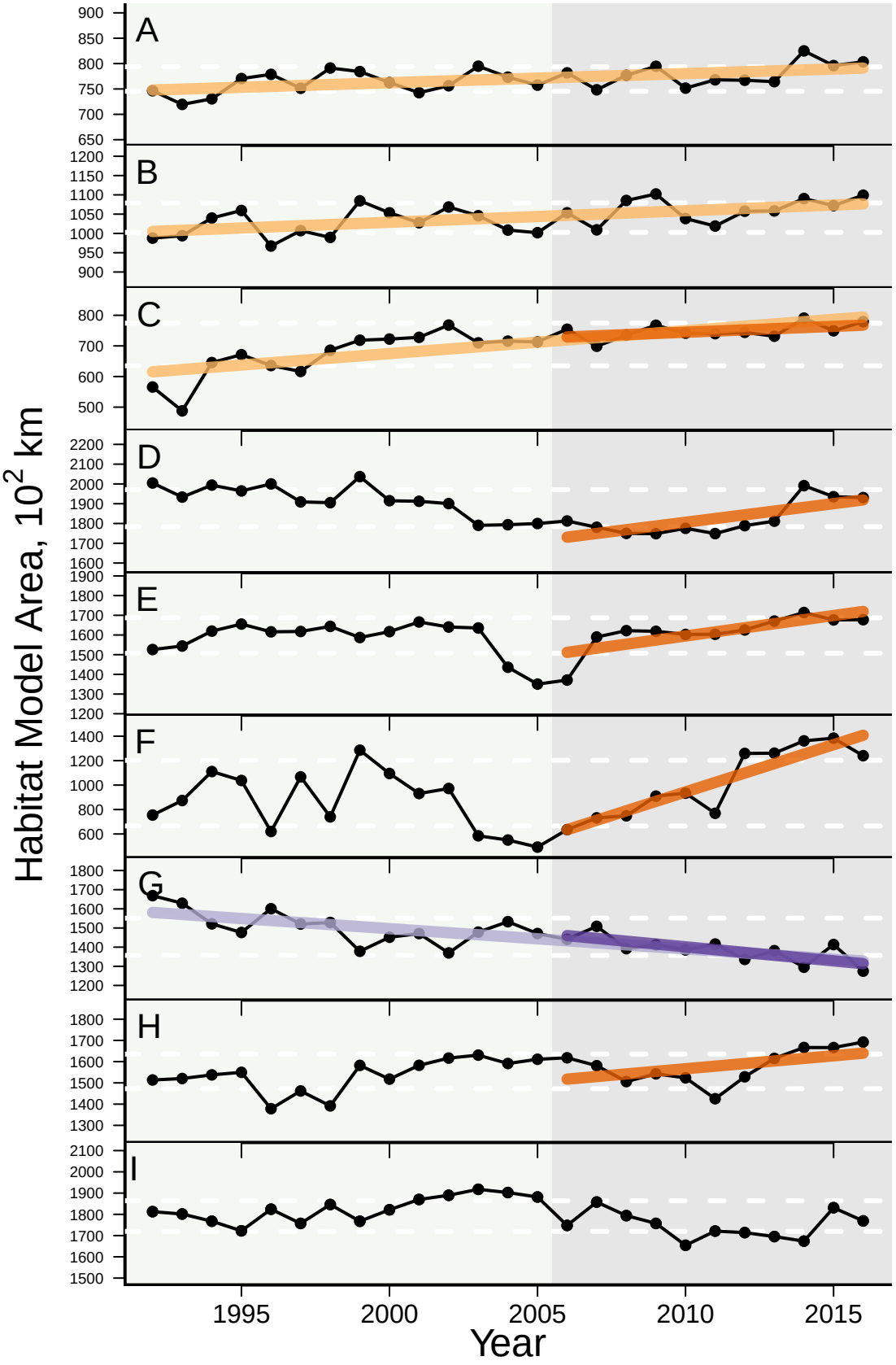

Figure 12: Shifts in modeled species fall habitat area over time; A: Black sea bass, B: Summer flounder, C: Scup, D: Butterfish, E: Atlantic mackerel, F: Longfin squid, G: Shortfin squid, H: Dogfish, I: Goosefish

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).

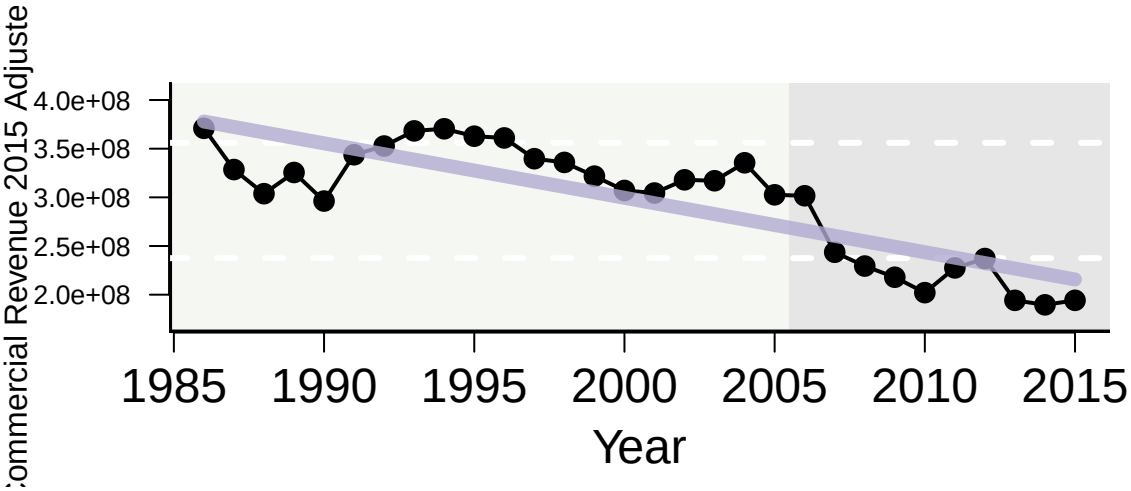

Figure 13: Aggregate Mid-Atlantic managed species revenue

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.

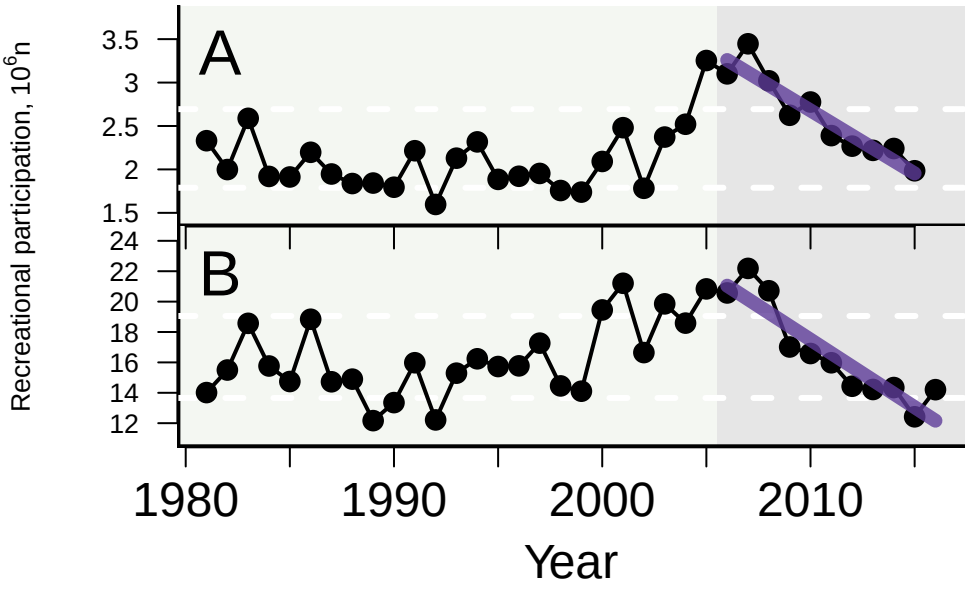

Figure 14: A: number of anglers, B: number of trips

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.

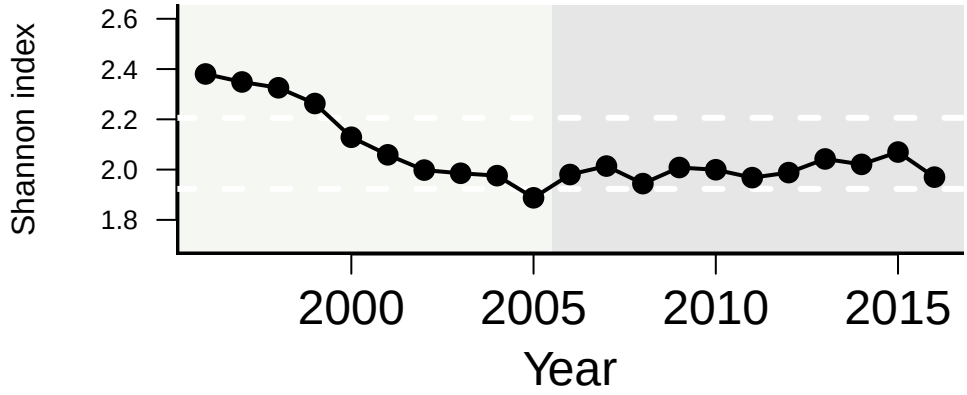

Figure 15: Diversity in species revenue

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.

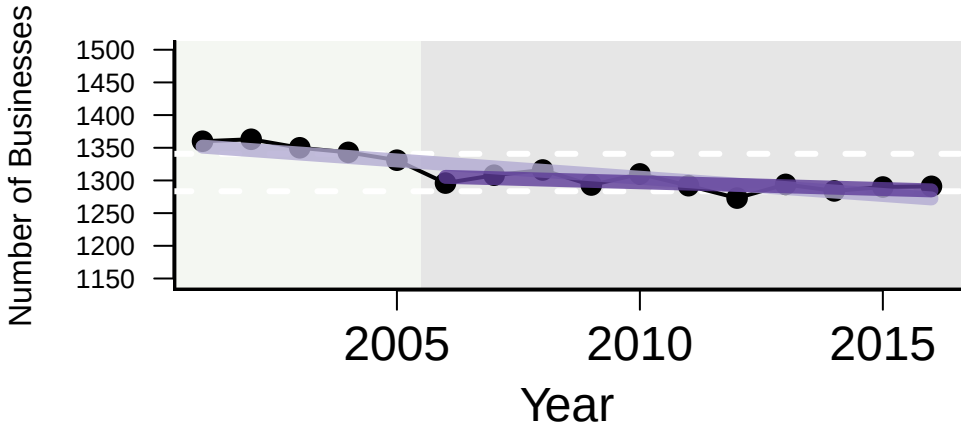

Figure 16: Shoreside support businesses: Number of Companies

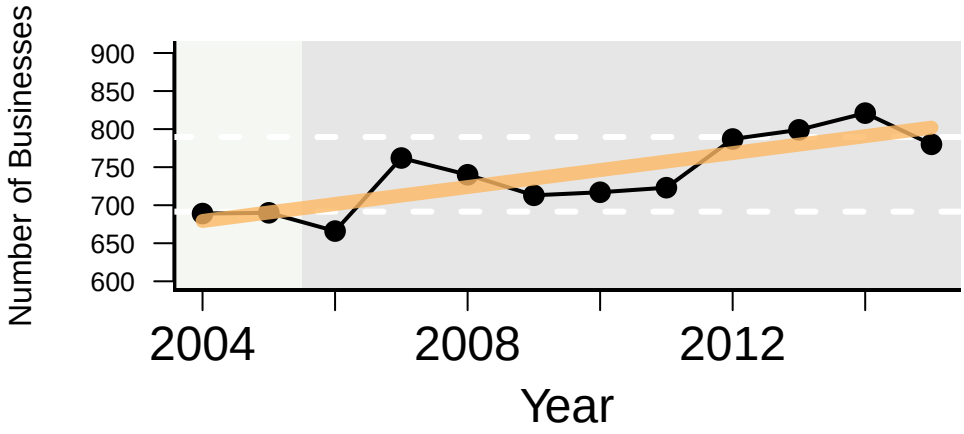

Figure 17: Shoreside support businesses: Number of Nonemployer entities

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.

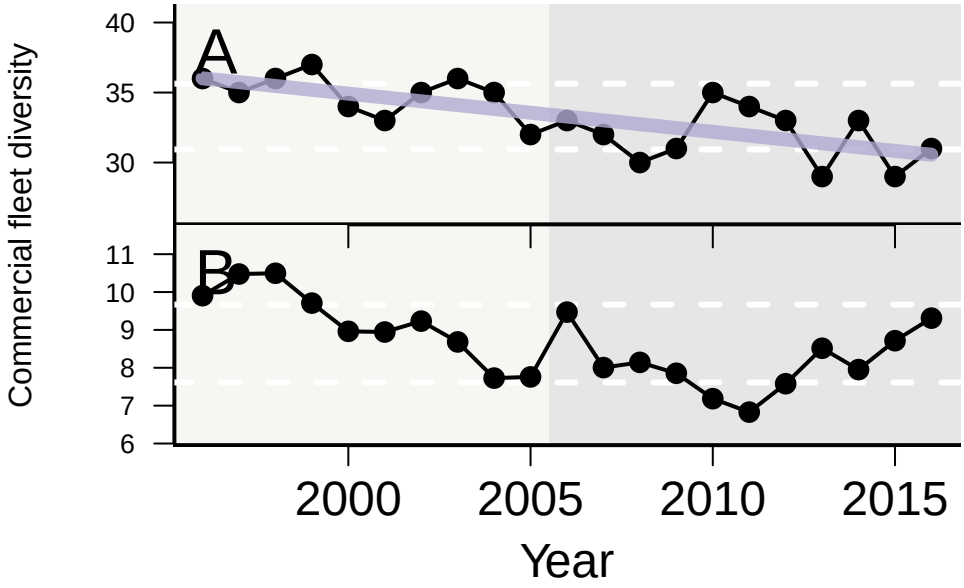

Figure 18: A: fleet count, B: average fleet diversity

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.

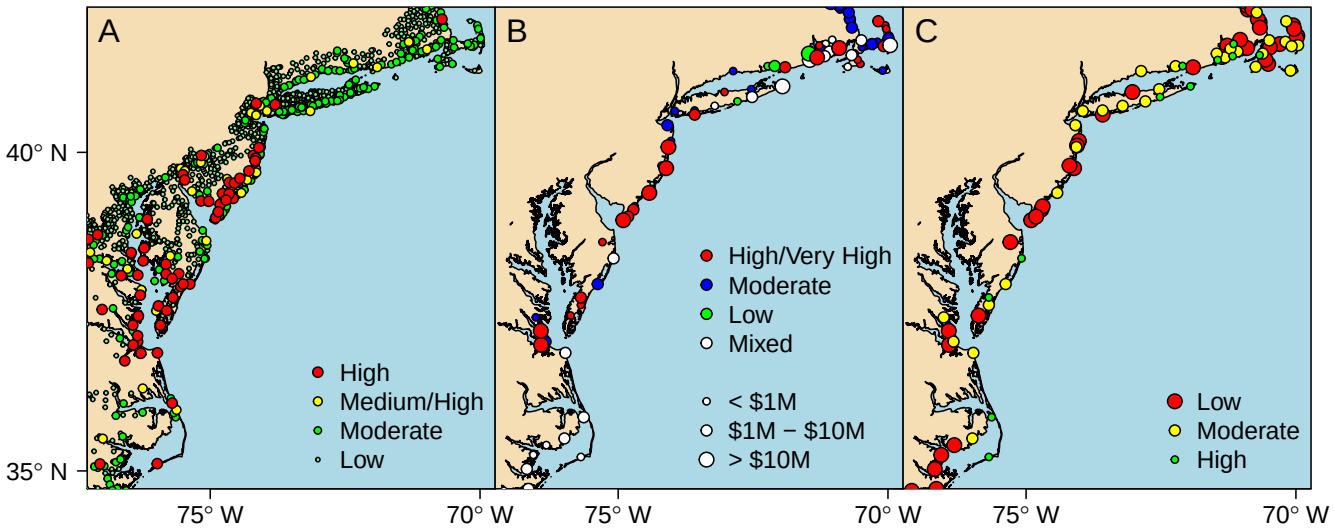

Figure 19: Risks from sea level rise (A), reliance on climate-vulnerable species (B), and catch diversity (C)

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.

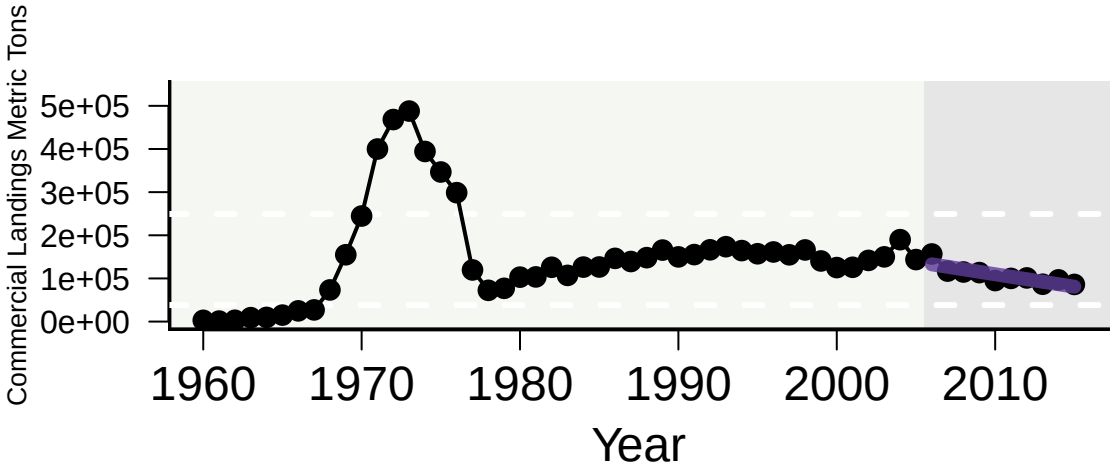

Figure 20: Aggregate Mid-Atlantic managed species landings

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.

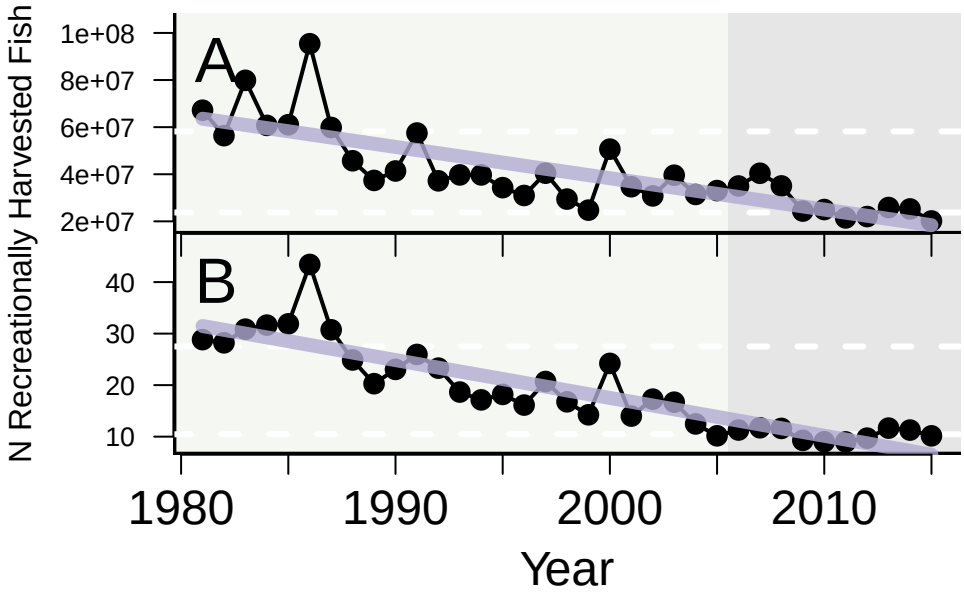

Figure 21: A: Total recreational harvest, B: Harvest per angler

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

References

Able, K.W. 2005. A re-examination of fish estuarine dependence: Evidence for connectivity between estuarine and ocean habitats. Estuarine, Coastal and Shelf Science **64**(1): 5–17. doi:10.1016/j.ecss.2005.02.002.

Barrett, R., Camphuysen, K., Anker-Nilssen, T., Chardine, J., Furness, R., Garthe, S., Hu¨ppop, O., Leopold, M., Montevecchi, W., and Veit, R. 2007. Diet studies of seabirds: A review and recommendations. ICES Journal of Marine Science **64**: 1675–1691.

Bowser, A., Diamond, A., and Addison, J. 2013. From puffins to plankton: A DNA-based analysis of a seabird food chain in the northern Gulf of Maine. PLoS One **8:e83152**.

Burke, V., Morreale, S., and Standora, E. 1994. Diet of the Kemps ridley sea turtle, Lepidochelys kempii, in New York waters. Fishery Bulletin **92**: 26–32.

Burke, V., Standora, E., and Morreale, S. 1993. Diet of Juvenile Kemp's Ridley and Loggerhead Sea Turtles from Long Island, New York. Copeia **1993**: 1176–1180.

Colburn, L.L., Jepson, M., Weng, C., Seara, T., Weiss, J., and Hare, J.A. 2016. Indicators of climate change and social vulnerability in fishing dependent communities along the Eastern and Gulf Coasts of the United States. Marine Policy **74**: 323–333. doi:10.1016/j.marpol.2016.04.030.

Gaichas, S., Seagraves, R., Coakley, J., DePiper, G., Guida, V., Hare, J., Rago, P., and Wilberg, M. 2016. A Framework for Incorporating Species, Fleet, Habitat, and Climate Interactions into Fishery Management. Frontiers in Marine Science **3**(105). doi:10.3389/fmars.2016.00105.

Gannon, D.P., Read, A.J., Craddock, J.E., and Mead, J.G. 1997. Stomach contents of long-finned pilot whales (Globicephala melas) stranted on the U.S. Mid-Atlantic coast. Marine Mammal Science **13**(3): 405–418. Available from https://www.greateratlantic.fisheries.noaa.gov/prot_res/atgtrp/ai/bgl/3.pdf [accessed 17 November 2017].

Hare, J.A., Morrison, W.E., Nelson, M.W., Stachura, M.M., Teeters, E.J., Griffis, R.B., Alexander, M.A., Scott, J.D., Alade, L., Bell, R.J., Chute, A.S., Curti, K.L., Curtis, T.H., Kircheis, D., Kocik, J.F., Lucey, S.M., McCandless, C.T., Milke, L.M., Richardson, D.E., Robillard, E., Walsh, H.J., McManus, M.C., Marancik, K.E., and Griswold, C.A. 2016. A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE **11**(2): e0146756. doi:10.1371/journal.pone.0146756.

Jepson, M., and Colburn, L.L. 2013. Development of Social Indicators of Fishing Community Vulnerability and Resilience in the US Southeast and Northeast Regions. NOAA Technical Memorandum NMFS-F/SPO-129 (US Dept Commerce, 2013). Available from http://www.nmfs.noaa.gov/sfa/management/councils/training/2014/r_h3_fishing_community_vulnerability.pdf [accessed 25 September 2015].

Johnson, A., Richards, A., Cullen, D.W., and Sutherland, S.J. 2008. Growth, reproduction, and feeding of large monkfish, Lophius americanus. ICES Journal of Marine Science **65**: 1306–1315. Available from https://www.nefsc.noaa.gov/read/popdy/monkfish/Publications/ICES%20J%202008%20Johnson%

20et%20al.pdf [accessed 26 September 2017].

Johnson, J., Dropkin, D., Warkentine, B., Rachlin, J., and Andrews, W. 1997. Food Habits of Atlantic Sturgeon off the Central New Jersey Coast. Transactions of the American Fisheries Society **126**: 166–170.

McClellan, C., and Read, A. 2007. Complexity and variation in loggerhead sea turtle life history. Biological Letters **3**: 592–594.

NMFS. 2017. Fisheries Economics of the United States, 2015. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-F/SPO-170.

Perry, M.C., Olsen, G.H., Richards, A., and Osenton, P.C. 2013. Predation on Dovekies by Goosefish over Deep Water in the Northwest Atlantic Ocean. Northeastern Naturalist **20**(1): 148–154. Available from https://www.eaglehill.us/NENAonline/articles/NENA-20-1/20-Perry.shtml [accessed 26 September 2017].

Powers, K. 1983. Pelagic distributions of marine birds off the Northreastern United States. NOAA Technical Memorandum NMFS-F/NEC 27. Woods Hole, MA.

Powers, K., and Backus, E. 1987. Energy transfer to seabirds. *In* Georges Bank. MIT Press, Cambridge, MA. pp. 372–374.

Powers, K., and Brown, R. 1987. Seabirds. *In* Georges Bank. MIT Press, Cambridge, MA. pp. 359–371.

Savoy, T. 2007. Prey eaten by Atlantic sturgeon in Connecticut waters. Pages 157-166 in J. Munro, D. Hatin, J. E. Hightower, K. McKown, K. J. Sulak, A. W. Kahnle, and F. Caron, editors. Anadromous sturgeons: Habitats, threats, and management. American Fisheries Society, Symposium 56. American Fisheries Society, Bethesda, MD.

Schneider, D., and Heinemann, D. 1996. The state of marine bird populations from Cape Hatteras to the Gulf of Maine. *In* The Northeast Shelf Ecosystem: Assessment, Sustainability, and Management. Blackwell Science, Cambridge, MA. pp. 197–216.

Seney, E., and Musick, J. 2007. Historical Diet Analysis of Loggerhead Sea Turtles (Caretta caretta) in Virginia. Copeia **2007**: 478–489.

Shoop, C., and Kenney, R. 1992. Seasonal Distributions and Abundances of Loggerhead and Leatherback Sea Turtles in Waters of the Northeastern United States. Herpetological Monographs **6**: 43–67.

Smith, B.E., and Link, J.S. 2010. The Trophic Dynamics of 50 Finfish and 2 Squid Species on the Northeast US Continental Shelf. NOAA Technichal Memorandum NMFS-NE-216. National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. Available from http://www.nefsc.noaa.gov/publications/tm/tm216/ [accessed 26 April 2016].

Smith, L.A., Link, J.S., Cadrin, S.X., and Palka, D.L. 2015. Consumption by marine mammals on the Northeast U.S. continental shelf. Ecological Applications **25**(2): 373–389. doi:10.1890/13-1656.1.

US EPA. 2012. National Coastal Condition Report IV, EPA-842-R-10-003. United States Environmental Protection Agency, Office of Research; Development/Office of Water, Washington, DC. Available from http://www.epa.gov/nccr.

Yue, S., Pilon, P., Phinney, B., and Cavadias, G. 2002. The influence of autocorrelation on the ability to detect trend in hydrological series. Hydrological Processes **16**(9): 1807–1829. doi:10.1002/hyp.1095.