2021 State of the Ecosystem

Mid-Atlantic

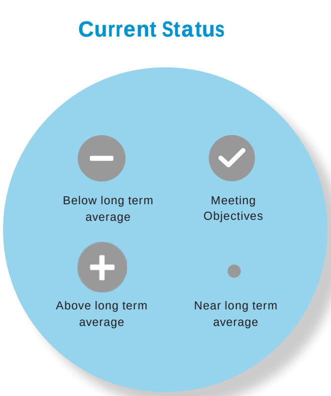
NOAA FISHERIES

Performance Relative to Fishery Management Objectives

Trends and status of indicators related to broad, ecosystem-level fishery management objectives, with implications for the Mid-Atlantic Fishery Management Council (MAFMC)

OBJECTIVE (INDICATOR)	Seafood production (total and MAFMC managed landings)	Commercial profits (MAFMC managed revenue)	Recreational opportunities (effort and fleet diversity)
TREND			Effort / Fleet diversity
CURRENT STATUS			Effort / Fleet diversity
IMPLICATIONS	Surfclam/ocean quahog landings driving commercial landings decline; likely market driven. Recreational harvest is declining due to different drivers. Overfishing does not seem to be the driver as ecosystem overfishing appears unlikely, most stocks are not overfished, and system biomass trends are stable. Recommend monitoring climate indicators as they continue trending toward uncharted territory, which affects stock distributions and will generate other ecosystem changes. Should also monitor the declining fishery engagement.	Primarily surfclams/ocean quahogs revenue driving patterns. Recent declines in prices contributed to falling revenue as quantities landed did not increase enough to overcome declining prices. Falling prices were likely due to market dynamics. Monitor climate risks to surfclams and ocean quahogs.	Recreational effort is near long-term average, but fleet diversity is decreasing due to a shift away from party/charter to shore-based fishing, decreasing the range of recreational fishing opportunities. Shore-based anglers will have access to different species/sizes of fish than vessel-based anglers.

OBJECTIVE (INDICATOR)	Stability (fishery and ecosystem diversity maintained over time)	Social vulnerability (community fishery engagement, reliance, and vulnerability)	Protected species (coastwide bycatch, population numbers, mortalities)
TREND	Fishery / Ecosystem	Fewer highly engaged communities (2020 report)	Bycatch / Population NARW
CURRENT STATUS	Fishery / Ecosystem	Range of individual community status shown as baseline	Bycatch / Population NARW
IMPLICATIONS	Fishery: Commercial fleet diversity metrics suggests stable capacity to respond to the current range of fishing opportunities. Recreational species catch diversity has been maintained by a different set of species over time. Ecosystem: While larval and adult fish diversity indices are stable, a few warm-southern larval species are becoming more dominant. Increasing zooplankton diversity is driven by declining dominance of an important species, which warrants continued monitoring.	Highlighted communities may be vulnerable to changes in fishing patterns due to regulations and/or climate change. When any of these communities are also experiencing social vulnerability, they may have lower ability to successfully respond to change. These indicators may also point to communities that are vulnerable to environmental justice issues.	Bycatch trends are related to fishery management, shifts in population distribution combined with fishery shifts, and population increase for seals. Population drivers for North Atlantic Right Whales (NARW) include combined fishery interactions/ship strikes, distribution shifts, and copepod availability. Unusual mortality events continue for 3 large whale species, harbor and gray seals.

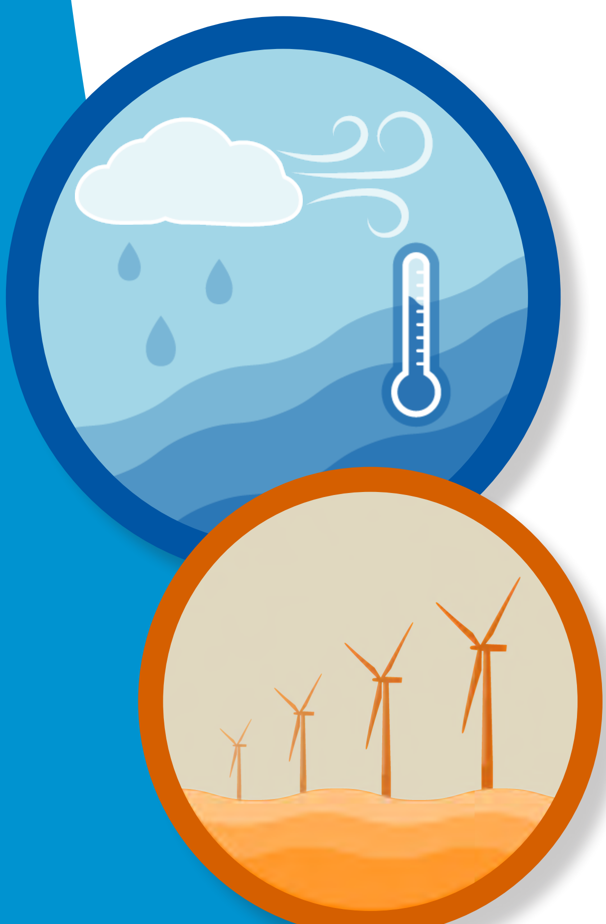


Risks to Meeting Fishery Management Objectives

Climate and Ecosystem Productivity Risks

Climate change, most notably ocean warming, continues in the Mid-Atlantic and is affecting the ecosystem in various ways:

- Surfclams and ocean quahogs drive trends in Mid-Atlantic commercial revenue, but are vulnerable because of their sensitivity to warming ocean temperatures and ocean acidification. New observations show that acidification in surfclam summer habitat is approaching, but not yet at, levels affecting surf clam growth.
- Warmer-than-average 2020 winter water temperatures in Chesapeake Bay likely helped blue crabs, but hurt striped bass numbers.
- New habitat climate vulnerability analysis links black sea bass, scup, and summer flounder to several highly vulnerable nearshore habitats from salt marsh through shallow estuarine and marine reefs.



- The Mid-Atlantic had frequent ocean heatwaves in 2020.
- Increased primary productivity in summer continues, but is from smaller species that are less likely to increase fish productivity.
- Temperature and zooplankton changes impact fish condition for different species, impacts to fisheries and markets are under investigation.
- Apex predator populations are stable (sharks) to increasing (gray seals).

Other Ocean Uses: Offshore Wind Risks

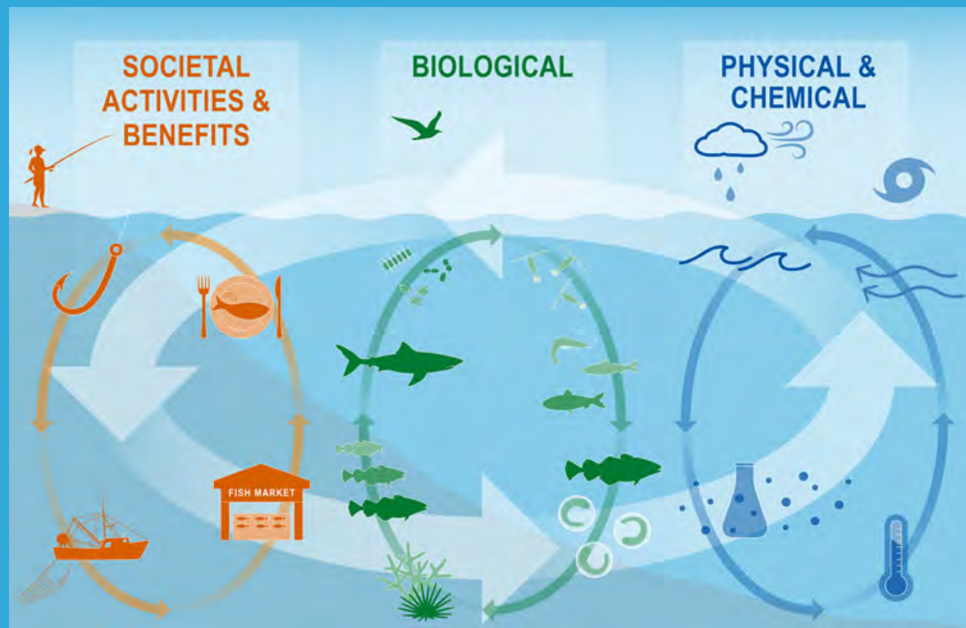
More than 20 offshore wind development projects are proposed for construction over the next decade in the Northeast, covering more than 1.7 million acres by 2030. The development of multiple offshore wind sites in the Mid-Atlantic pose a number of risks and impacts to fisheries including:

- If all sites are developed, 2-24% of total average revenue could be displaced for major Mid-Atlantic species in lease areas.
- Displaced fishing effort can alter fishing methods, which can in turn change habitat, species (managed and protected), and fleet interactions.
- Right whales may be displaced, and altered local oceanography could affect distribution of their zooplankton prey.
- Current plans for rapid buildout in a patchwork of areas spreads the impacts differentially throughout the region.
- Scientific surveys collecting data for ocean and ecosystem conditions, fish, and protected species will be altered, potentially increasing uncertainty for management decision-making.

COVID-19 affected both fisheries and data collection in 2020 (see the NOAA Fisheries economic assessment of COVID-19 effects on the U.S. fishing and seafood industry report). We will continue to evaluate the impacts in the Northeast for future SOE reports.

Characterizing Ecosystem Change

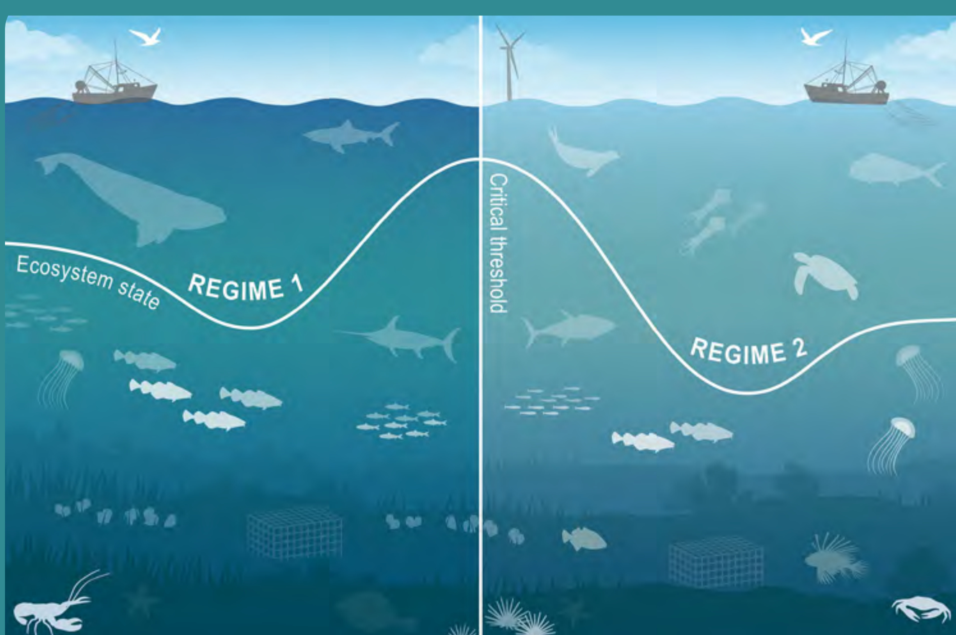
Multiple System Drivers



The Northeast shelf ecosystem is changing, which is affecting the services that the ecosystem provides. To illustrate how multiple factors are driving change in this complex ecosystem we are using three overarching concepts: multiple system drivers, regime shifts, and ecosystem reorganization. Societal, biological, physical and chemical factors comprise the **multiple system drivers** that influence marine ecosystems through a variety of different pathways.

Regime Shift

These drivers affect fishery management objectives such as seafood production and recreational opportunities, as well as other ecosystem services we derive from the ocean. Changes in the multiple drivers can lead to **regime shifts** — large, abrupt and persistent changes in the structure and function of an ecosystem. Regime shifts and changes in how the multiple system drivers interact can result in **ecosystem reorganization** as species and humans respond and adapt to the new environment.



Introduction

About This Report

This report is for the Mid-Atlantic Fishery Management Council (MAFMC). The purpose of this report is to synthesize ecosystem information to better meet fishery management objectives, and to update the MAFMC's Ecosystem Approach to Fishery Management (EAFM) risk assessment. The major messages of the report are synthesized on pages 1 and 2, and synthesis themes are illustrated on page 3. The information in this report is organized into two sections; performance measured against ecosystem-level management objectives (Table 1), and potential risks to meeting fishery management objectives (climate change and other ocean uses).

Report structure

The two main sections contain subsections for each management objective or potential risk. Within each subsection, we first review indicator trends, and the status of the most recent year relative to a threshold (if available) or relative to the long-term average. Second, we synthesize results of other indicators and information to outline potential implications for management (i.e., connecting indicator(s) status to management and why an indicator(s) is important). For example, if there are multiple drivers related to an indicator trend, which drivers may be more or less supported by current information, and which, if any, can be affected by management action? Similarly, which risk indicators warrant continued monitoring to evaluate whether regime shifts or ecosystem reorganization are likely? We emphasize that these implications are intended to represent testable hypotheses at present, rather than "answers," because the science behind these indicators and syntheses continues to develop.

A glossary of terms[1], detailed technical methods documentation[2] and indicator data[3] are available online. The details of standard figure formatting (Fig. 51a), categorization of fish and invertebrate species into feeding groups (Table 2), and definitions of ecological production units (EPUs, including the Mid-Atlantic Bight, MAB; Fig. 51b) are provided at the end of the document.

Table 1: Ecosystem-scale fishery management objectives in the Mid-Atlantic Bight

Objective Categories	Indicators reported here
Provisioning and Cultural Services	
Seafood Production	Landings; commercial total and by feeding guild; recreational harvest
Profits	Revenue decomposed to price and volume
Recreation	Days fished; recreational fleet diversity
Stability	Diversity indices (fishery and ecosystem)
Social & Cultural	Community engagement/reliance status
Protected Species	Bycatch; population (adult and juvenile) numbers, mortalities
Supporting and Regulating Services	
Biomass	Biomass or abundance by feeding guild from surveys
Productivity	Condition and recruitment of managed species, Primary productivity
Trophic structure	Relative biomass of feeding guilds, Zooplankton
Habitat	Estuarine and offshore habitat conditions

Performance relative to fishery management objectives

In this section, we examine indicators related to broad, ecosystem-level fishery management objectives. We also provide hypotheses on the implications of these trends—*why* we are seeing them, what's driving them, and potential or observed regime shifts or changes in ecosystem structure. Identifying multiple drivers, regime shifts, and potential changes to ecosystem structure, as well as identifying the most vulnerable resources, can help managers determine whether we can do anything differently to meet objectives and how to prioritize for upcoming issues/risks.

[1] https://noaa-edab.github.io/tech-doc/glossary.html
[2] https://NOAA-EDAB.github.io/tech-doc
[3] https://github.com/NOAA-EDAB/ecodata

Seafood Production

Indicators: Landings; total and by feeding guild

All seafood landed by commercial fisheries (total landings) and MAFMC's managed species landings (a subset of the total) continue to trend downward in the MAB (Fig. 1). The downward trend is most significant in the benthos (clams) group (Fig. 2).

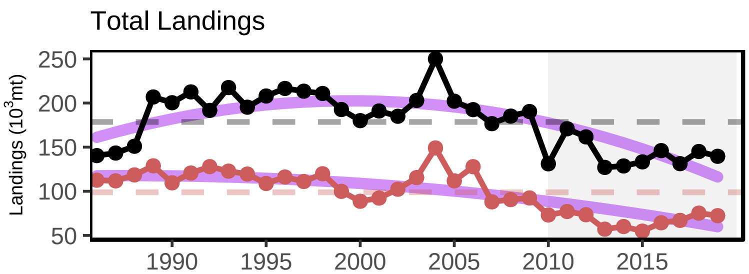


Figure 1: Total commercial seafood landings (black) and Mid-Atlantic managed seafood landings (red).

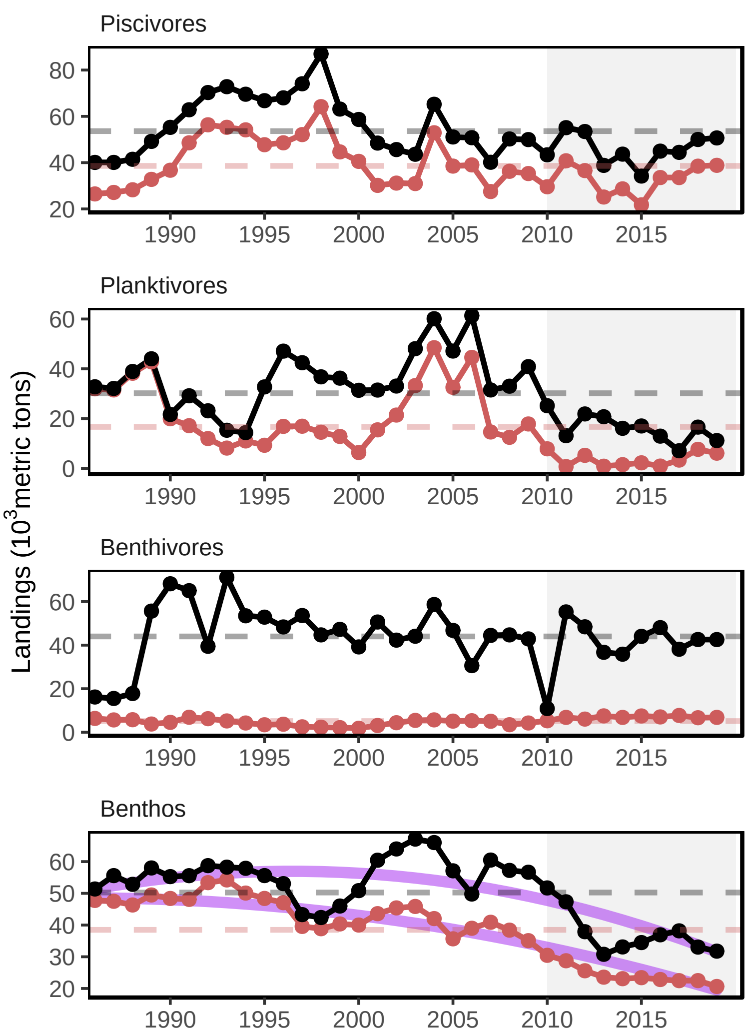


Figure 2: Total commercial landings (black) and MAFMC managed species landings (red) by feeding guild.

Total recreational harvest (retained fish presumed to be eaten) is also down in the MAB (Fig. 3).

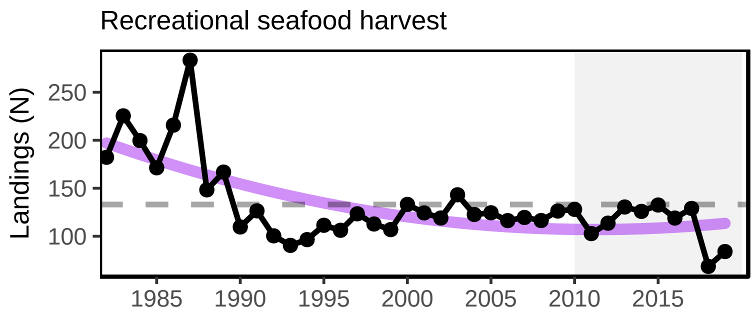


Figure 3: Total recreational seafood harvest (millions of fish) in the Mid-Atlantic region.

Recreational shark landings show an increase in pelagic sharks over the past decade, with a sharp decrease in 2018 and 2019 (Fig 4). This is likely influenced by regulatory changes implemented in 2018 intended to rebuild shortfin mako stocks.

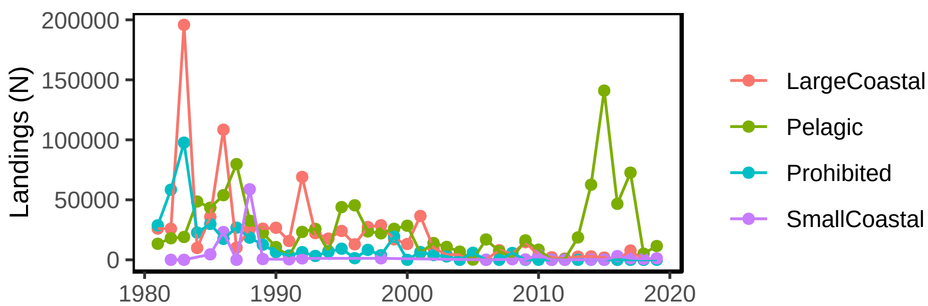


Figure 4: Recreational shark landings from Large Pelagics Survey.

Aquaculture production is not yet included in total seafood landings, but we are working toward including it in future reports. Available aquaculture production of oysters for a subset of Mid-Atlantic states is trending upward.[4]

Implications

Declining commercial and recreational landings can be driven by many interacting factors, including combinations of ecosystem and stock production, management actions, market conditions, and environmental change. While we cannot evaluate all possible drivers at present, here we evaluate the extent to which ecosystem overfishing (total landings exceeding ecosystem productive capacity), stock status, and system biomass trends may play a role.

Ecosystem Overfishing Indices Thresholds for ecosystem-level overfishing based on system production characteristics have been proposed [1], and are applied here for the MAB. The proposed ecosystem overfishing thresholds are calculated based on *total catch* while our preliminary indicators are based on *commercial landings*. Therefore, our current indicators are underestimated compared with the proposed thresholds. In future reports we may be able to include commercial discards and recreational removals to evaluate total catch.

Based on either the ratio of total landings to total primary production (Fogarty Index, Fig. 5), or total landings per unit area (Ryther Index, Fig. 6), MAB landings are at or below the proposed thresholds, so ecosystem overfishing is unlikely to be a major factor driving decreased landings.

[4] https://noaa-edab.github.io/ecodata/human_dimensions_MAB#Commercial; "Oyster Aquaculture" tab

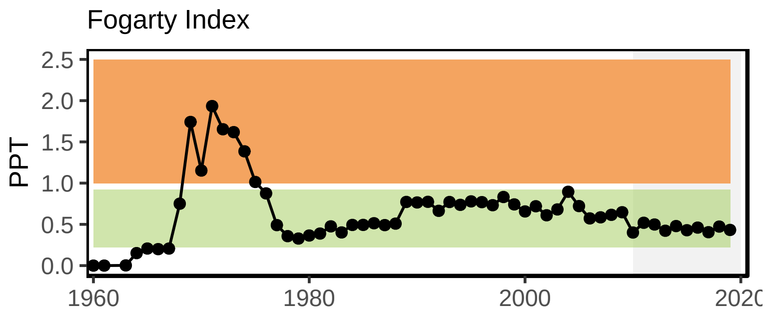


Figure 5: Fogarty Index; the ratio of total landings to total primary production in the MAB. Link and Watson (2019) give an optimal range (green shading) of the Fogarty ratio of 0.22 to 0.92 parts per thousand (PPT). Previous work suggested that index values exceeding 1 to 2 PPT (orange shading) led to ecosystem tipping points.

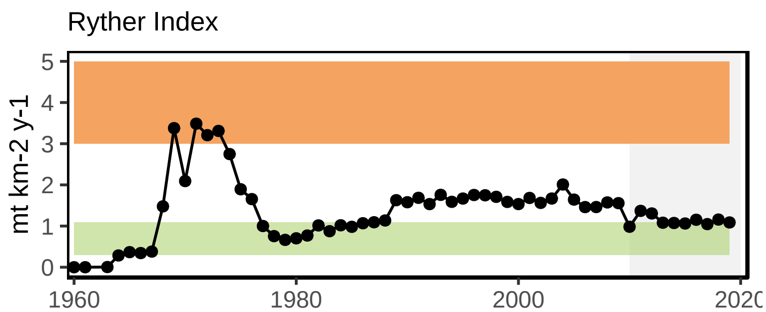


Figure 6: Ryther index; total landings presented on a unit area basis for the MAB. Theoretical estimates (Link and Watson, 2019) imply the index should range from 0.3 - 1.1 mt per sq km annually (green shading) with a limit of 3 mt per sq km annually, above which tipping points could occur in fished ecosystems (orange shading). Expected system-wide MSYs can be in the range of 1 to 3 mt per sq km (unshaded).

The amount of potential yield we can expect from a marine ecosystem depends on the amount of production entering at the base of the food web, primarily in the form of phytoplankton; the pathways this energy follows to reach harvested species; the efficiency of transfer of energy at each step in the food web; and the fraction of this production that is removed by the fisheries. The fraction of production removed by fisheries has declined since the late 1990s (Fig. 7). The overall trend is largely driven by the decrease in landings with an increase in primary production over the same period. Current fisheries remove a lower proportion of the ecosystem's primary production now than in the 1970s, when the Fogarty and Ryther indices suggest that ecosystem overfishing may have occurred.

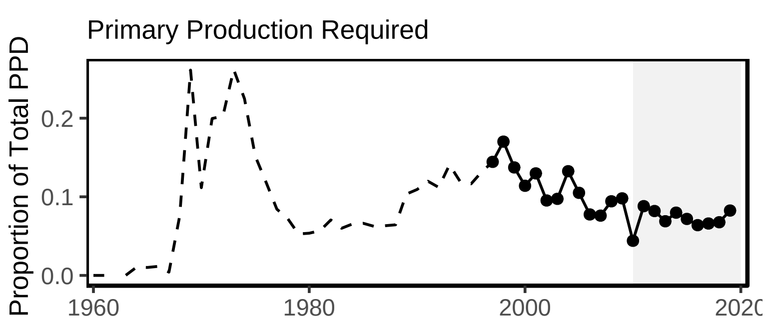


Figure 7: Primary production required to support MAB commercial landings. Included are the top species accounting for 80% of the landings in each year, with 15% transfer efficiency assumed between trophic levels. PPD is total primary production. The solid line is based on satellite-derived PPD and the dashed line is based on primary production reconstructed using the mean of satellite-derived PPD from 1998-2010.

Stock Status Single species management objectives of maintaining biomass above minimum thresholds and fishing mortality below limits are being met for all but two MAFMC managed species, though the status of six stocks is unknown (Fig. 8). Therefore, stock status and associated management constraints are unlikely to be driving decreased landings. To better address the role of management in future reports, we could examine how the total allowable catch (TAC) and the percentage of the TAC taken for each species has changed through time.

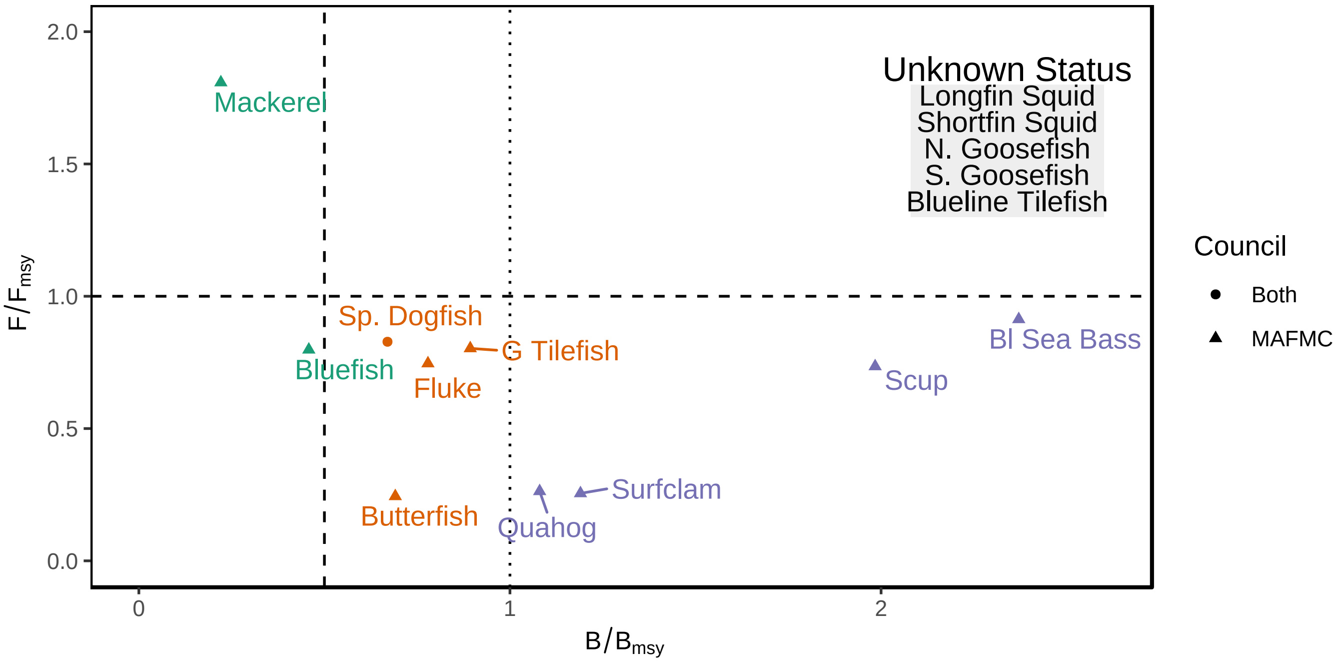


Figure 8: Summary of single species status for MAFMC and jointly federally managed stocks (Goosefish and Spiny dogfish). Stocks in green are below the biomass threshold (overfished), stocks in orange are above the biomass threshold but below the biomass target, and stocks in purple are above the biomass target. Only one stock, Atlantic mackerel, has fishing mortality above the limit (subject to overfishing).

System Biomass Although aggregate biomass trends derived from scientific resource surveys are mostly stable in the MAB, spring piscivores and fall benthos show long-term increases (Fig. 9). The NEAMAP Fall 2020 survey was completed and is included here; NEFSC surveys were not completed in 2020. While managed species make up varying proportions of aggregate biomass, trends in landings are not mirroring shifts in the overall trophic structure of survey-sampled fish and invertebrates. Therefore, major shifts in feeding guilds or ecosystem trophic structure are unlikely to be driving the decline in landings.

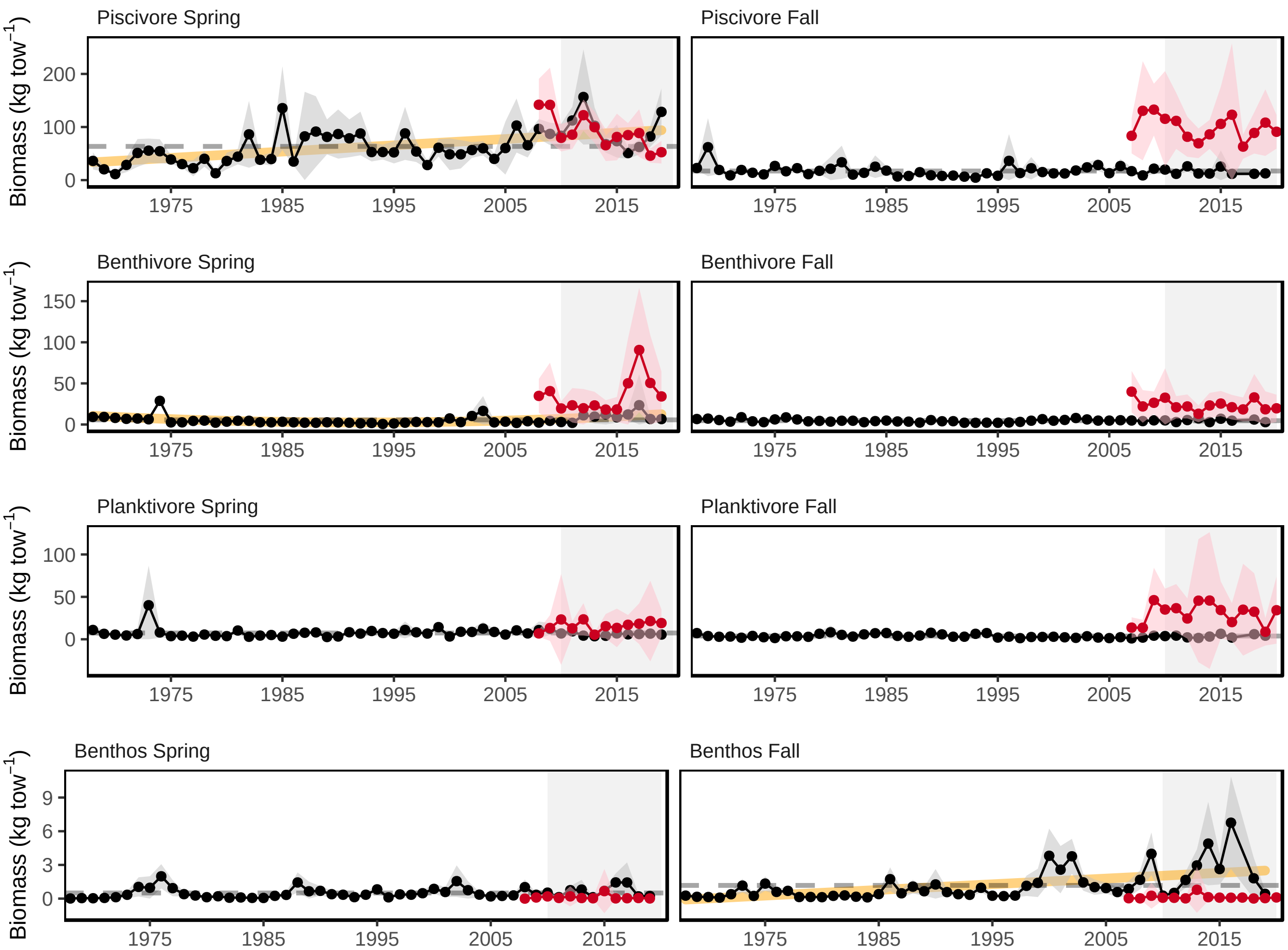


Figure 9: Spring (left) and fall (right) surveyed biomass in the Mid-Atlantic Bight. Data from the NEFSC Bottom Trawl Survey are shown in black, with NEAMAP shown in red. The shaded area around each annual mean represents 2 standard deviations from the mean.

Effect on Seafood Production Because ecosystem overfishing seems unlikely, stock status is mostly acceptable, and aggregate biomass trends appear stable, the decline in commercial landings is most likely driven by market dynamics affecting the landings of surfclams and ocean quahogs, as landings have been below quotas for these species.

Climate change also seems to be shifting the distribution of surfclams and ocean quahogs, resulting in areas with overlapping distributions and increased mixed landings. Given the regulations governing mixed landings, this could become problematic in the future and is currently being evaluated by the Council.

The decline in recreational seafood landings stems from other drivers. Some of the decline, such as that for recreational shark landings, is driven by management intended to reduce fishing mortality on mako sharks. However, NOAA Fisheries' Marine Recreational Information Program survey methodology was updated in 2018, so it is unclear whether the record-low landings for species other than sharks in 2018 are driven by changes in fishing behavior or the change in the survey methodology.

Other environmental changes require monitoring as they may become important drivers of landings in the future:

- Climate is trending into uncharted territory. Globally, 2020 was tied with the warmest year on record[5] with regional marine heatwaves apparent (see Climate Risks section).

[5] https://www.nasa.gov/press-release/2020-tied-for-warmest-year-on-record-nasa-analysis-shows

- Stocks are shifting distribution, moving towards the northeast and into deeper waters throughout the Northeast US Large Marine Ecosystem (Fig. 10).

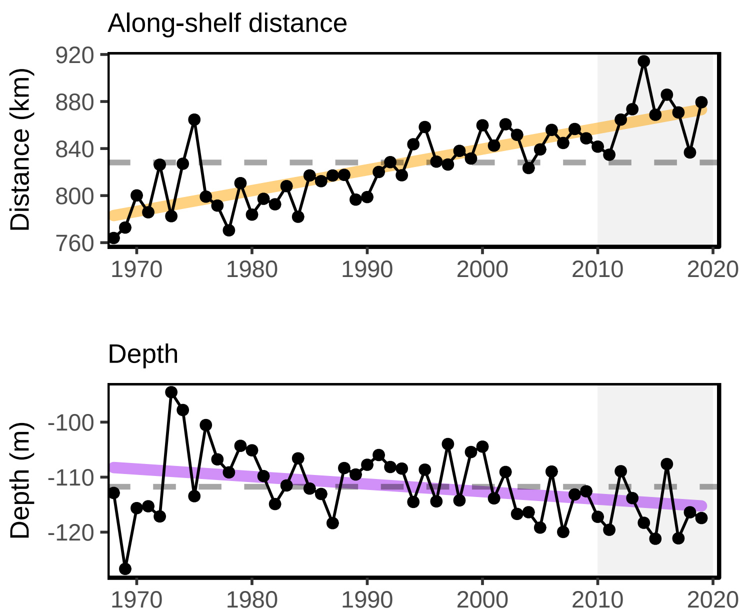


Figure 10: Aggregate species distribution metrics for species in the Northeast Large Marine Ecosystem.

- Some ecosystem composition and production changes have been observed (see Stability section).
- Fishing engagement has declined in some communities (see Social Vulnerability section).

Commercial Profits

Indicators: revenue (a proxy for profits), with price and volume components

Total commercial revenue (black) has increased over the long term, but the trend may be reversing, with recent total revenue below the long-term average (Fig. 11). The MAFMC-managed species revenue (red) has continued its downward trend, with recent years near a time-series low.

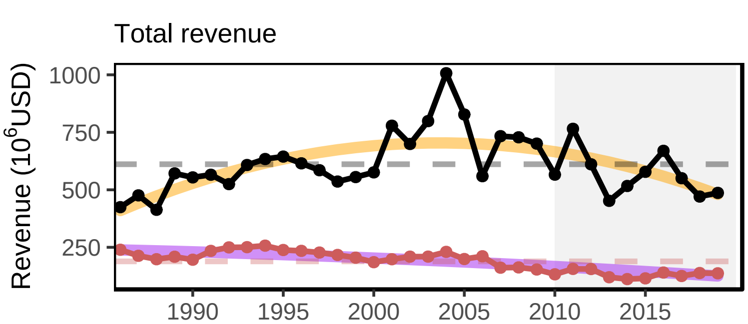


Figure 11: Total revenue for the region (black) and revenue from MAFMC managed species (red).

Revenue earned by harvesting resources is a function of both the quantity landed of each species and the prices paid for landings. Beyond monitoring yearly changes in revenue, it is even more valuable to determine what drives these changes: harvest levels, the mix of species landed, price changes, or a combination of these. The Bennet Indicator decomposes revenue change into two parts, one driven by changing quantities (volumes), and a second driven by changing prices.

Total revenue trends, decomposed to price and volume indicators (Fig. 12), mirror price and volume indicator trends for the benthos (clams; orange in Fig. 13) group, especially over the past decade.

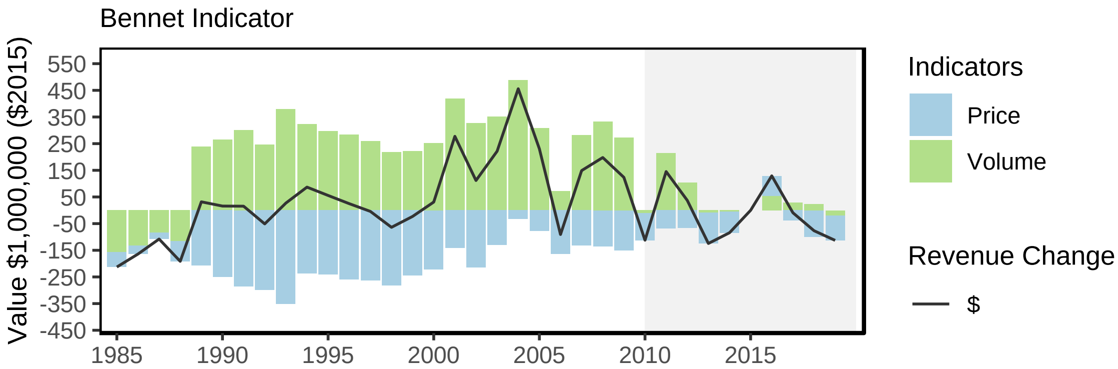


Figure 12: Revenue change from the 2015 values in dollars (black), Price (PI), and Volume Indicators (VI) for commercial landings in the Mid-Atlantic Bight.

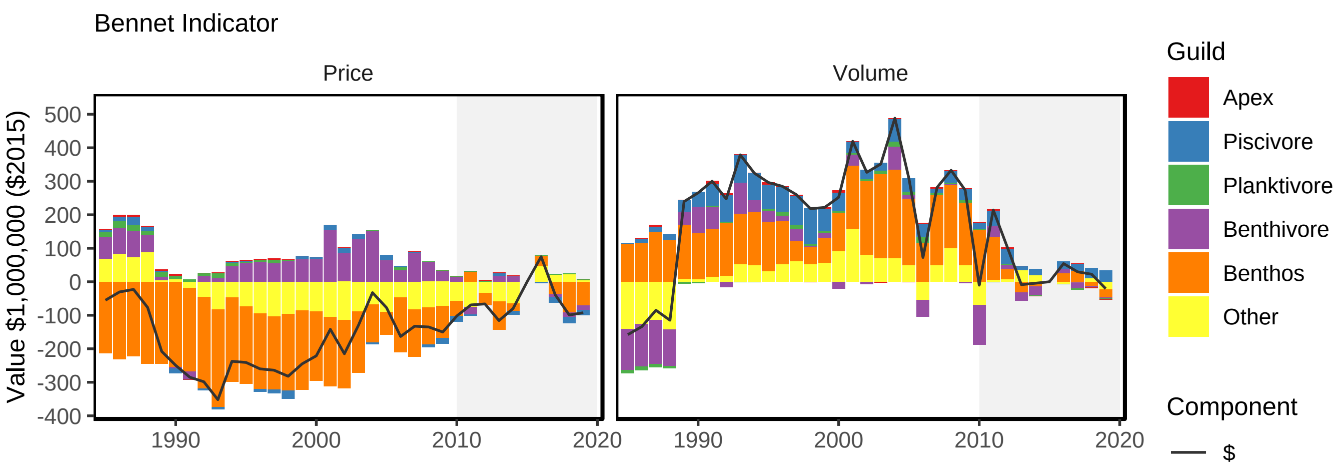


Figure 13: Total component value in dollars (black) for commercial landings in the Mid-Atlantic Bight.

Implications

The Bennet indicator demonstrates that increasing total revenue early in the time series is due to increasing quantities landed, which offset declining prices. Recent declines in prices contributed to falling revenue as quantities landed did not increase enough to counteract declining prices.

Changes in other indicators, particularly those driving landings and those related to climate change, require monitoring as they may become important drivers of revenue in the future; for example:

- Surfclams and ocean quahogs are sensitive to warming ocean temperatures and ocean acidification.
- Acidification levels in surfclam summer habitat are approaching, but not yet at, levels affecting surfclam growth (see Climate Risks section).

Recreational Opportunities

Indicators: Angler trips, fleet diversity

Recreational effort (angler trips) has no significant long term trend, with current effort near the long-term average (Fig. 14). However, recreational fleet diversity has declined over the long term (Fig. 15).

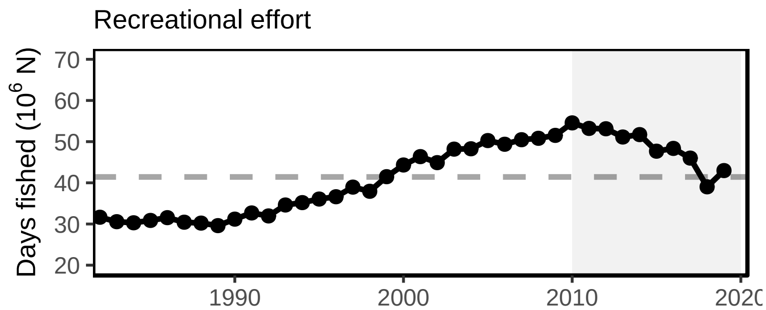


Figure 14: Recreational effort in the Mid-Atlantic.

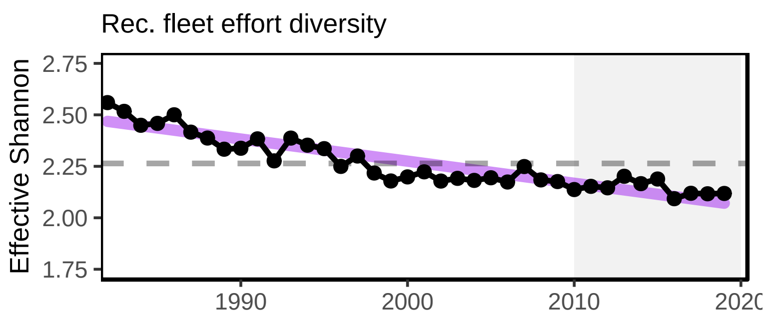


Figure 15: Recreational fleet effort diversity in the Mid-Atlantic.

Implications

The absence of a long-term trend in recreational effort suggests relative stability in the overall number of recreational opportunities in the MAB. However, the decline in recreational fleet diversity suggests a potentially reduced range of opportunities.

The downward effort diversity trend is driven by party/charter contraction (from a high of 24% of angler trips to 7% currently), and a shift toward shorebased angling. Effort in private boats remained stable between 36-37% of angler trips across the entire series.

Changes in recreational fleet diversity can be considered when managers seek options to maintain recreational opportunities. Shore anglers will have access to different species than vessel-based anglers, and when the same species, typically smaller fish. Many states have developed shore-based regulations where the minimum size is lower than in other areas and sectors to maintain opportunities in the shore angling sector.

Stability

Indicators: fishery fleet and catch diversity, ecological component diversity

While there are many potential metrics of stability, we use diversity indices as a first check to evaluate overall stability in fisheries and ecosystems. In general, diversity that remains constant over time suggests a similar capacity to respond to change over time. A significant change in diversity over time does not necessarily indicate a problem or an improvement, but does indicate a need for further investigation. We examine commercial and recreational fleet and species catch diversity, and diversity in zooplankton, larval, and adult fish.

Fishery Diversity Diversity estimates have been developed for fleets and species landed by commercial vessels with Mid-Atlantic permits. A fleet is defined here as the combination of gear type (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). Commercial fishery fleet count and fleet diversity have been stable over time in the MAB, with current values near the long-term average (Fig. 16). This indicates similar commercial fleet composition and species targeting opportunities over time.

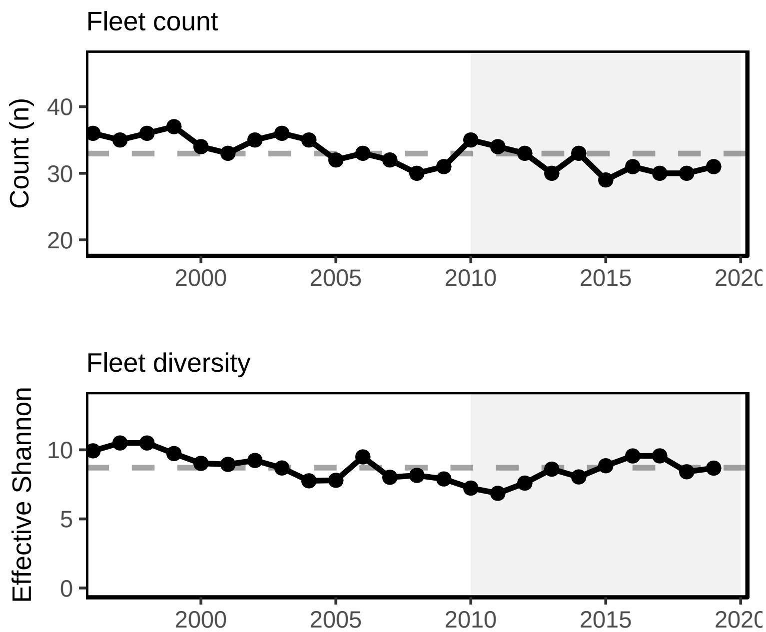


Figure 16: Fleet diversity and fleet count in the Mid-Atlantic.

Commercial fisheries are relying on fewer species relative to the mid-90s, but current species revenue diversity has been consistent since then and is currently near the long term average (Fig. 17).

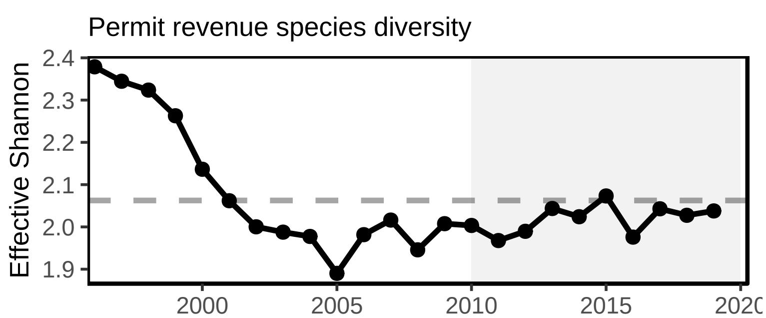


Figure 17: Species revenue diversity in the Mid-Atlantic.

As noted above recreational fleet effort diversity is unstable (declining; Fig. 15). However, recreational species catch diversity is stable and has been at or above the long term average in 7 of the last 10 years (Fig. 18).

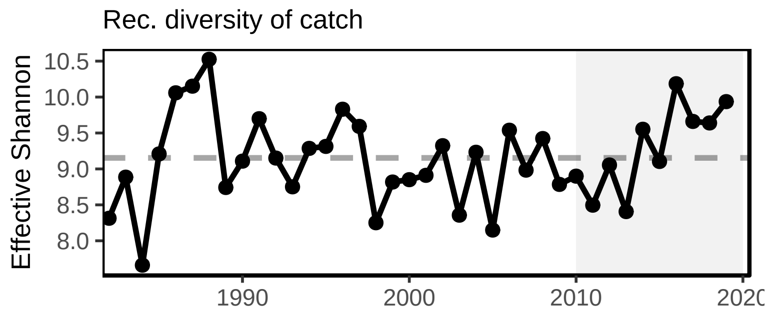


Figure 18: Diversity of recreational catch in the Mid-Atlantic.

Ecological Diversity Ecological diversity indices show mixed trends. Zooplankton diversity is increasing in the MAB (Fig. 19). Adult fish diversity is measured as the expected number of species in a standard number of individuals sampled from the NEFSC bottom trawl survey. There is no vessel correction for this metric, so indices collected aboard the research vessel Albatross IV (up to 2008) and research vessel Bigelow (2009-present) are calculated separately. Larval fish and adult fish diversity indices are stable over time, with current values near the long-term average (Figs. 20, 21).

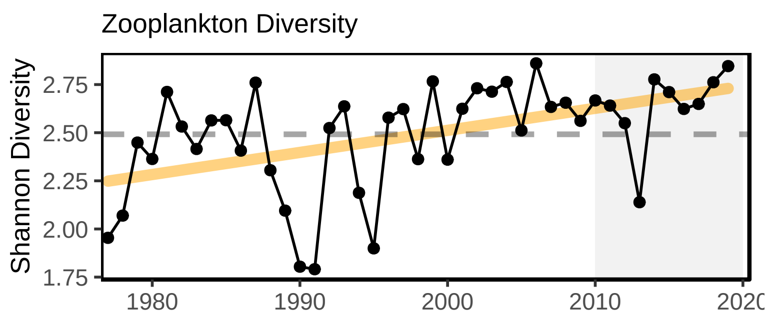


Figure 19: Zooplankton diversity in the Mid-Atlantic Bight, based on Shannon diversity index.

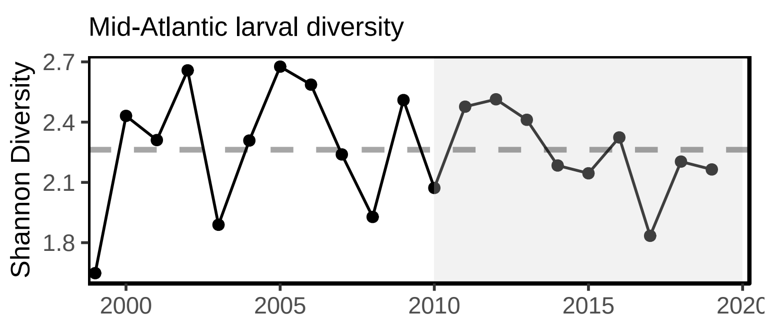


Figure 20: Larval fish diversity in the Mid-Atlantic Bight, based on Shannon diversity index.

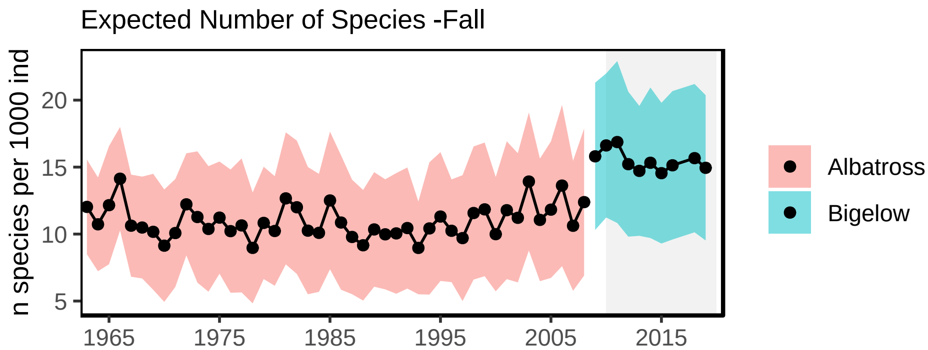


Figure 21: Adult fish diversity the Mid-Atlantic Bight, based on expected number of species.

Implications

Fleet diversity indices are used by the MAFMC to evaluate stability objectives as well as risks to fishery resilience and maintaining equity in access to fishery resources [2].

Stability in commercial fleet diversity metrics suggests stable capacity to respond to the current range of fishing opportunities.

Declining recreational fleet effort diversity, as noted above, indicates that the party/charter boat sector continues to contract, with shoreside angling becoming more important, as a percentage of recreational days fished.

Stability in recreational species catch diversity has been maintained by a different set of species over time. A recent increase in Atlantic States Marine Fisheries Commission (ASMFC) and South Atlantic Fishery Management Council (SAFMC) managed species in recreational catch is helping to maintain diversity in the same range that MAFMC and New England Fishery Management Council (NEFMC) species supported in the 1990s.

Ecological diversity indices can provide insight into ecosystem structure. Changes in ecological diversity over time may indicate altered ecosystem structure with implications for fishery productivity and management [3].

Increasing zooplankton diversity is driven by the declining dominance of the calanoid copepod *Centropages typicus*, with a similar composition of other zooplankton species.

Stable larval and adult fish diversity indicates the same overall number and evenness over time, but doesn't rule out species substitutions (e.g., warm-water replacing cold-water). While larval fish diversity is near the long-term mean, the dominance of a few warm-water taxa has increased. Stable but variable larval diversity can indicate interannual changes in a dominant species.

In the MAB, existing diversity indicators suggest overall stability in the fisheries and ecosystem components examined. However, declining recreational fleet diversity suggests a potential loss in the range of recreational fishing opportunities, and increasing zooplankton diversity is due to the declining dominance of an important species, suggesting change in the zooplankton community that warrants continued monitoring to determine if managed species are affected.

Social Vulnerability

Indicators: Social vulnerability in commercial and recreational fishing communities

Social vulnerability measures social factors that shape a community's ability to adapt to change and does not consider gentrification pressure (see detailed definitions). Communities that ranked medium-high or above for one or more of the following indicators: poverty, population composition, personal disruption, or labor force structure, are highlighted in red.

Commercial fishery engagement measures the number of permits, dealers, and landings in a community, while reliance expresses these numbers based on the level of fishing activity relative to the total population of a community. In 2020, we reported that the number of highly engaged Mid-Atlantic commercial fishing communities had declined over time, and engagement scores had also declined in medium-highly engaged communities. Here we focus on the top ten most engaged, and top ten most reliant commercial fishing communities and their associated social vulnerability (Fig. 22). Barnegat Light and Cape May, NJ, and Reedville, VA are highly engaged and reliant with medium-high to high social vulnerability.

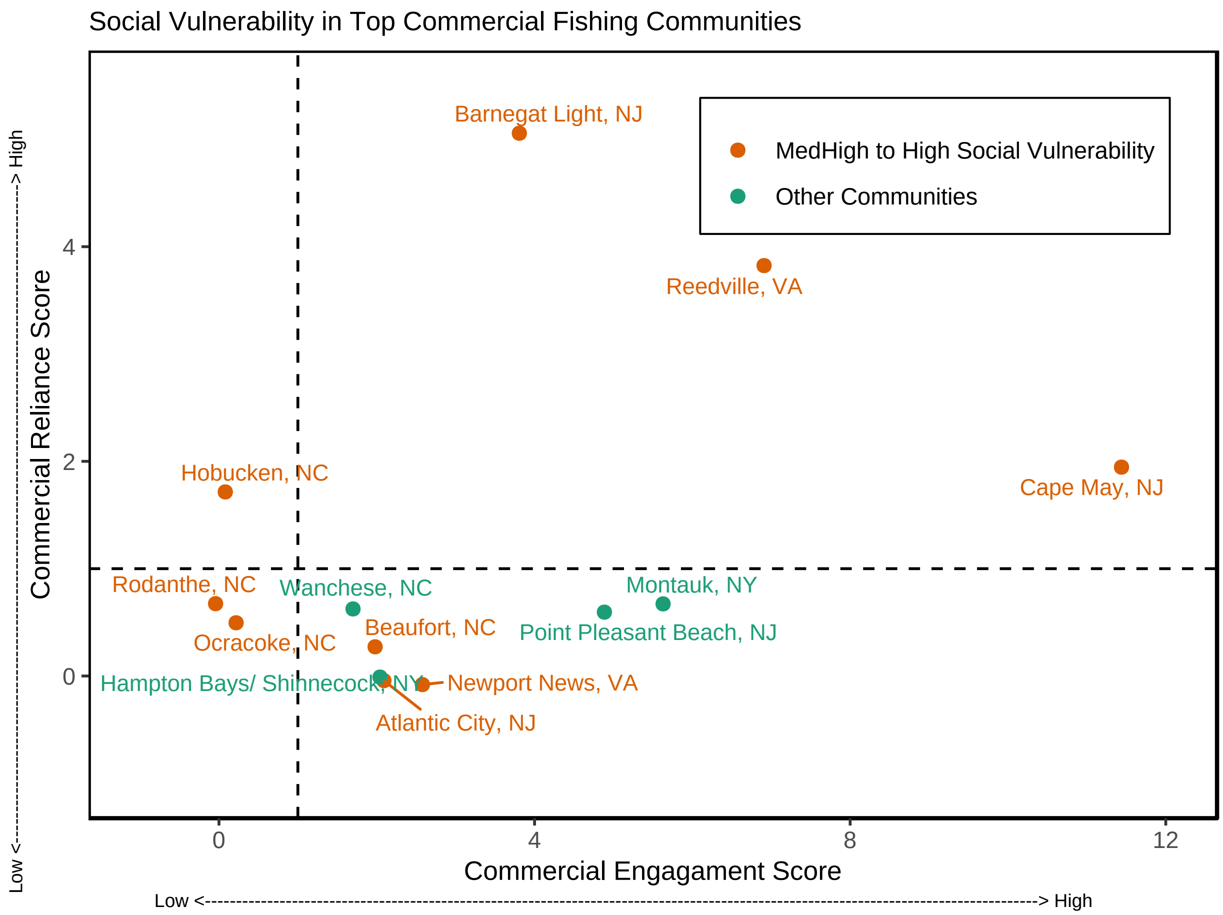


Figure 22: Commercial engagement, reliance, and social vulnerability for the top commercial fishing communities in the Mid-Atlantic.

Recreational fishery engagement measures shore, private vessel, and for-hire fishing activity while reliance expresses these numbers based on fishing effort relative to the population of a community. Of the nine recreational communities that are most engaged and reliant, Avon, Ocracoke and Hatteras, NC and Barnegat Light and Cape May, NJ scored medium-high or above for social vulnerability (Fig. 23).

Both commercial and recreational fishing are important activities in Montauk, NY; Barnegat Light, Cape May, and Point Pleasant Beach, NJ; and Ocracoke and Rodanthe, NC, meaning some of these communities may be impacted simultaneously by commercial and recreational regulatory changes. Of these communities, three scored medium-high or above for social vulnerability.

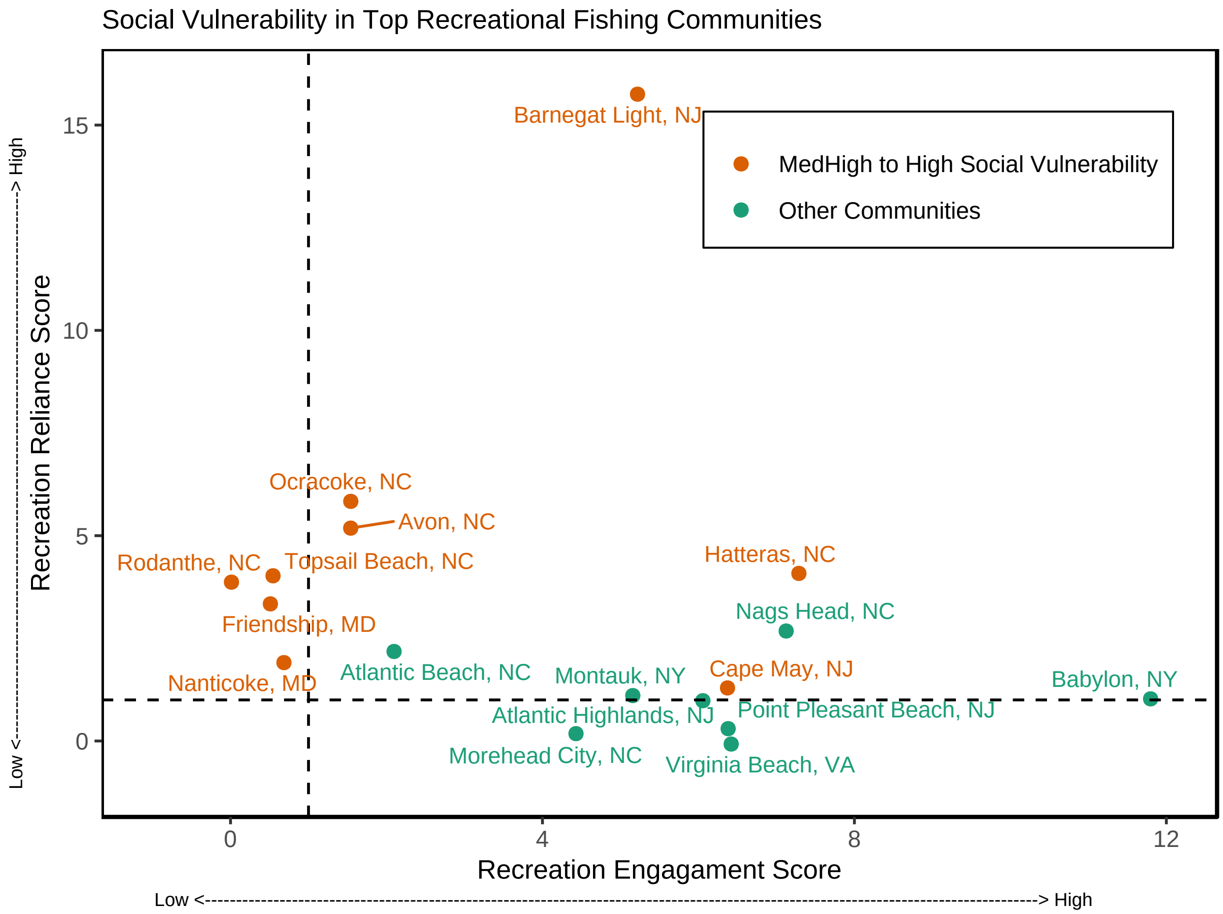


Figure 23: Recreational engagement, reliance, and social vulnerability for the top recreational fishing communities in the Mid-Atlantic.

Implications

These plots provide a snapshot of the relationship between social vulnerability and the most highly engaged and most highly reliant commercial and recreational fishing communities in the Mid-Atlantic. Similar plots are used to inform the annual California Current Ecosystem Status Report. These communities may be vulnerable to changes in fishing patterns due to regulations and/or climate change. When any of these communities are also experiencing social vulnerability, they may have lower ability to successfully respond to change. These indicators may also point to communities that are vulnerable to environmental justice issues. Additional analysis related to ecosystem shifts and National Standard 8 of the Magnuson-Stevens Act is ongoing.

Protected Species

Protected species include marine mammals protected under the Marine Mammal Protection Act, endangered and threatened species protected under the Endangered Species Act, and migratory birds protected under the Migratory Bird Treaty Act. In the Northeast U.S., endangered/threatened species include Atlantic salmon, Atlantic and shortnose sturgeon, all sea turtle species, and five baleen whales. Fishery management objectives for protected species generally focus on reducing threats and on habitat conservation/restoration. Here we report on the status of these actions as well as indicating the potential for future interactions driven by observed and predicted ecosystem changes in the Northeast U.S. region. Protected species objectives include managing bycatch to remain below potential biological removal (PBR) thresholds, recovering endangered populations, and monitoring unusual mortality events (UMEs).

Indicators: bycatch, population (adult and juvenile) numbers, mortalities

Average indices for both harbor porpoise (Fig. 24) and gray seal bycatch (Fig. 25) are below current PBR thresholds, meeting management objectives. However, the 2019 bycatch estimate for gray seals was highest in the time series.

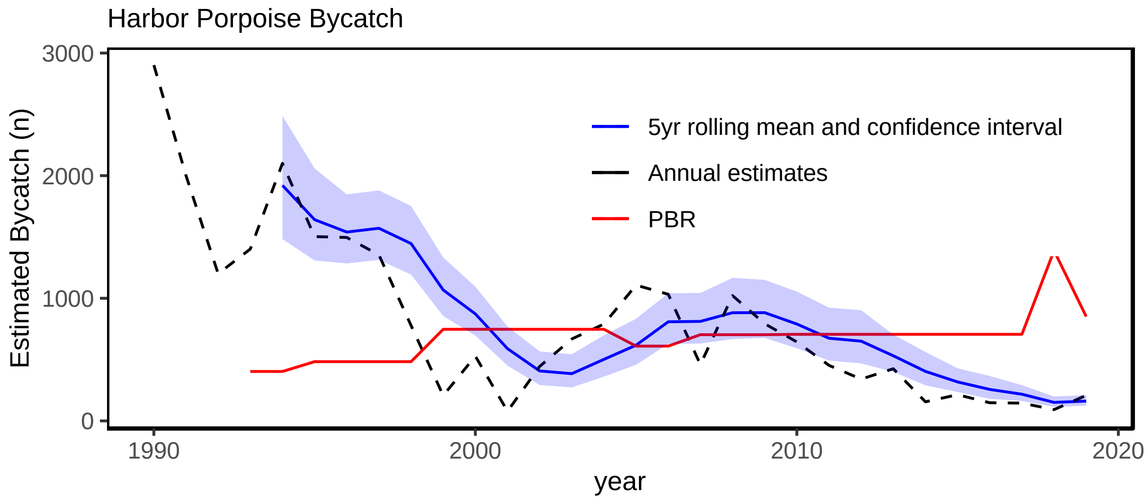


Figure 24: Harbor porpoise average bycatch estimate for Mid-Atlantic and New England fisheries (blue) and the potential biological removal (red). 2019 estimates are preliminary.

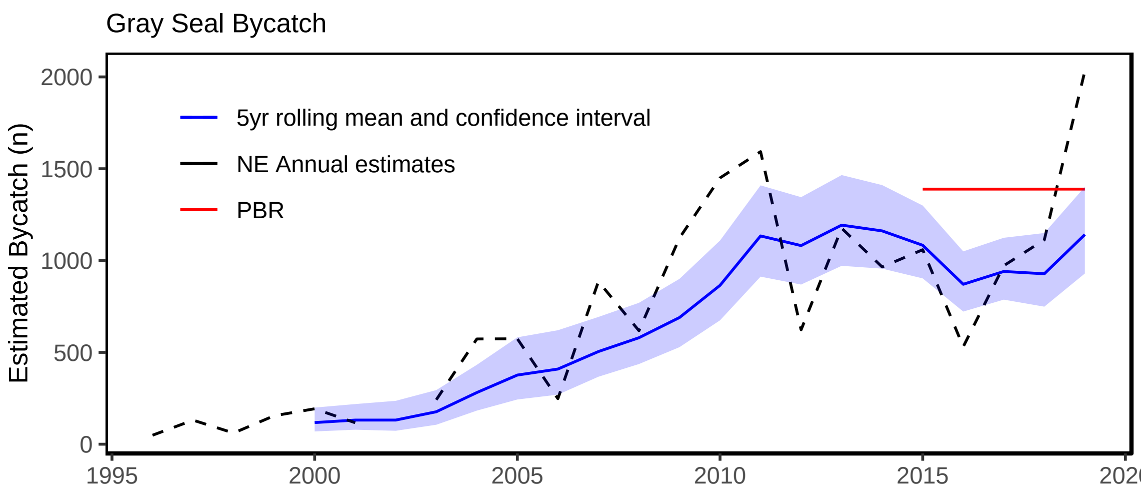


Figure 25: Gray Seal average bycatch estimate for New England gillnet fisheries (blue) and and the potential biological removal (red). 2019 estimates are preliminary.

The North Atlantic right whale population was on a recovery trajectory until 2010, but has since declined (Fig. 26). Reduced survival rates of adult females and diverging abundance trends between sexes have also been observed. It is estimated that there are only about 100 adult females remaining in the population.

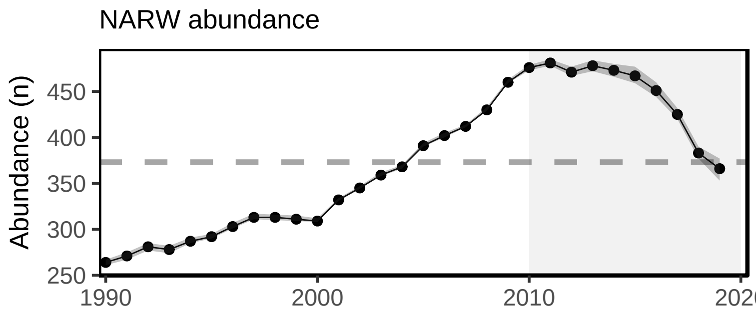


Figure 26: Estimated North Atlanic right whale abundance on the Northeast Shelf.

North Atlantic right whale calf counts have also been declining (Fig. 27). In 2018 there were zero observed new calves, and a drop in annual calves roughly mirrors the abundance decline, however seven new calves were born in 2019. Preliminary 2020 observations of 12 calves have been recorded as of January 2021.

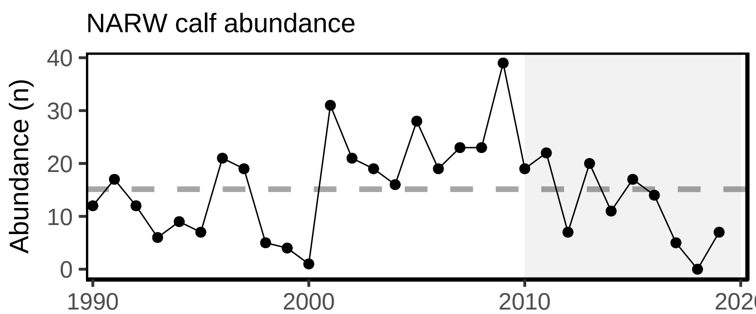


Figure 27: Number of North Atlantic right whale calf births, 1990 - 2019.

This year, four Unusual Mortality Events (UMEs) continued, three for large whales (North Atlantic right whales, humpback whales, and minke whales) and one for gray and harbor seals.

Since 2017, the total UME right whale mortalities includes 32 dead stranded whales, 11 in the US and 21 in Canada. When alive but seriously injured whales (14) are taken into account, 46 individual whales are included in the UME. During 2020, two mortalities were documented, however, recent research suggests that many mortalities go unobserved and the true number of mortalities are about three times the count of the observed mortalities [4]. The primary cause of death is “human interaction” from entanglements or vessel strikes.

Coastal bottlenose dolphin stocks off North Carolina and Virginia are listed as depleted, so a take reduction team met in 2019 and has been evaluating and implementing some of the team’s consensus recommendations.

Also, a UME for both gray and harbor seals was declared in 2018 due to a high number of mortalities thought to be caused by phocine distemper virus.

Implications

Bycatch management measures have been implemented to maintain bycatch below Potential Biological Removal (PBR) thresholds. The downward trend in harbor porpoise bycatch can also be due to a decrease in harbor porpoise abundance in US waters, reducing their overlap with fisheries, and a decrease in gillnet effort. The increasing trend in gray seal bycatch may be related to an increase in the gray seal population (U.S. pup counts).

The number of gray seals in U.S. waters has risen dramatically in the last three decades. Based on a survey conducted in 2016, the size of the gray seal population in the U.S. during the breeding season was approximately 27,000 animals, while in Canada the population was estimated to be roughly 425,000. A survey conducted in 2021 in both countries will provide updated estimates of abundance. The population in Canada is increasing at roughly 4% per year, and contributing to rates of increase in the U.S., where the number of pupping sites has increased from 1 in 1988 to 9 in 2019. Mean rates of increase in the number of pups born at various times since 1988 at four of the more data-rich pupping sites (Muskeget, Monomoy, Seal, and Green Islands) ranged from no change on Green Island to high rates increase on the other three islands, with a maximum increase of 26.3% (95%CI: 21.6 - 31.4%; [5] and see Figure in New England SOE report). These high rates of increase provide further support for the hypothesis that seals from Canada are continually supplementing the breeding population in U.S. waters.

Strong evidence exists to suggest that interactions between right whales and the offshore lobster gear in the U.S. and snow crab gear in Canada is contributing substantially to the decline of the species. Further, right whale distribution has changed since 2010. New research suggests that recent climate driven changes in ocean circulation have resulted in right whale distribution changes driven by increased warm water influx through the Northeast Channel, which has reduced the primary right whale prey (*Calanus finmarchicus*) in the central and eastern portions of the Gulf of Maine [6–8].

The UMEs are under investigation and are likely the result of multiple drivers. For all three large whale UMEs, human interaction appears to have contributed to increased mortalities, although investigations are not complete. An investigation into the cause of the seal UME so far suggests phocine distemper virus as a potential cause.

A marine mammal climate vulnerability assessment is currently underway for Atlantic and Gulf of Mexico populations and will be reported on in future versions of this report.

Risks to meeting fishery management objectives

Climate and Ecosystem Productivity

Climate Change Indicators: ocean currents, temperature, heatwaves, acidification

Regional ocean current indicators remain at unprecedented levels. In 2019, the Gulf Stream was at its most northern position since 1993 (Fig. 28). A more northerly Gulf Stream position is associated with warmer ocean temperature on the Northeast US shelf [9], a higher proportion of Warm Slope Water in the Northeast Channel, and increased sea surface height along the U.S. east coast [10].

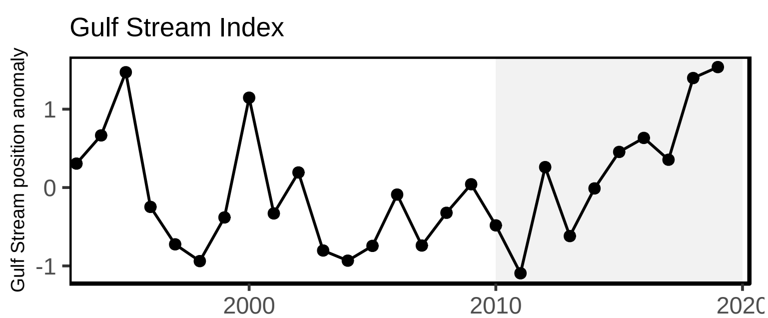


Figure 28: Index representing changes in the location of the Gulf Stream north wall. Positive values represent a more northerly Gulf Stream position.

In 2019, we also observed the second lowest proportion of Labrador Slope Water entering the Gulf of Maine since 1978 (Fig. 29). The changing proportions of source water affect the temperature, salinity, and nutrient inputs to the Gulf of Maine ecosystem.

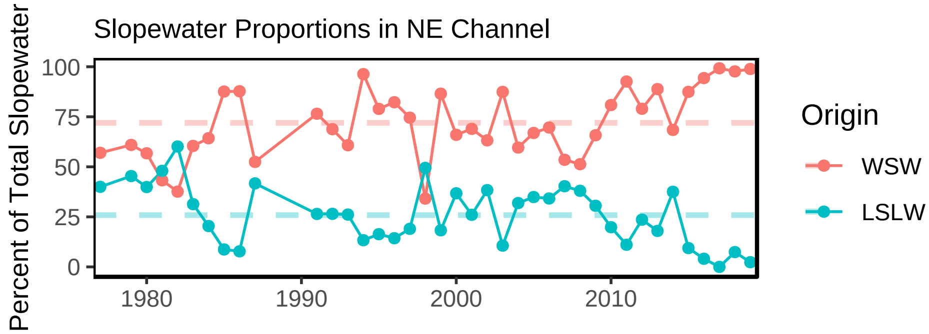


Figure 29: Proportion of Warm Slope Water (WSW) and Labrador Slope Water (LSLW) entering the GOM through the Northeast Channel.

Ocean temperatures continue to warm at both the bottom (Fig. 30) and the surface (Fig. 31). Warming is not seasonally uniform, however: spring 2020 was cooler than average on portions of the shelf.

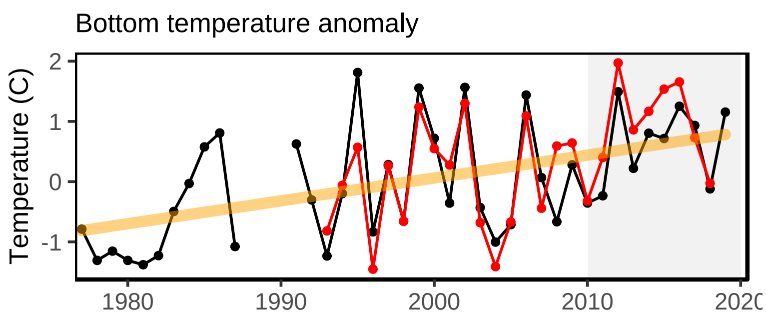


Figure 30: Annual bottom temperature in the Mid-Atlantic Bight. (black = in situ observations, red = observations assimilated by ocean model for comparison)

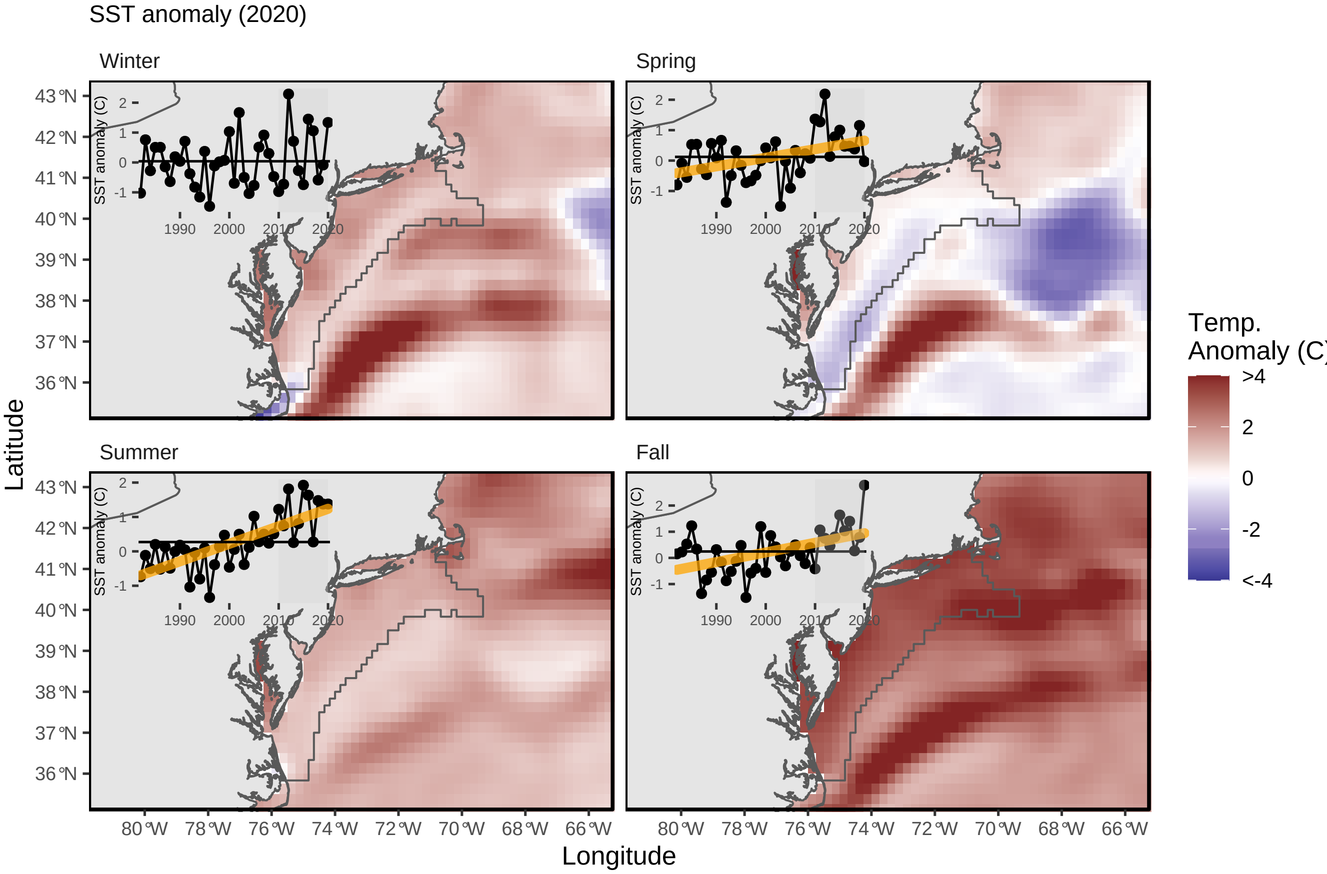


Figure 31: MAB seasonal sea surface temperature (SST) time series overlaid onto 2020 seasonal spatial anomalies.

The Chesapeake Bay also experienced a warmer-than-average winter and a cooler-than-average spring in 2020, relative to the previous decade. Water temperatures returned to average during the summer and were slightly above average from October through December, as measured by both satellites and bouys (Fig. 32).

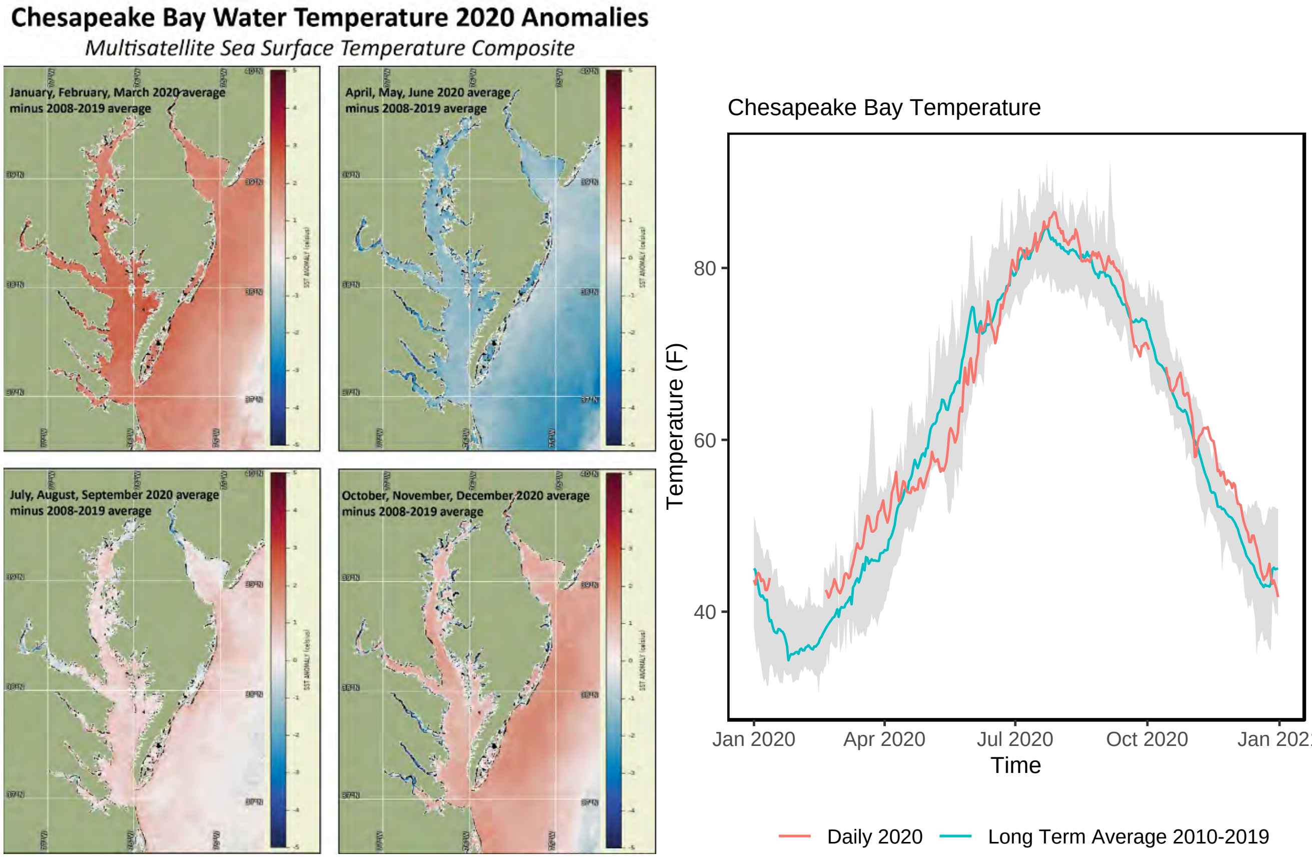


Figure 32: Left panel: Chesapeake Bay sea surface temperature (SST) seasonal spatial anomalies for 2020, from NOAA multisatellite SST composite. Positive values (red) above 2008-2019 average; negative values (blue) below 2008-2019 average. A) Jan, Feb, Mar; B) Apr, May, Jun; C) Jul, Aug, Sep; D) Oct, Nov, Dec. Right panel: NOAA Chesapeake Bay Interpretive Buoy System Gooses Reef bouy sea water temperature; Blue = 2020, red = Long term average 2010-2019.

A marine heatwave is a warming event that lasts for five or more days with sea surface temperatures above the 90th percentile of the historical daily climatology (1982-2011) [11]. The MAB experienced frequent ocean heatwaves of moderate intensity in 2020 that extended well into December (Fig. 33), similar to warming observed in Chesapeake Bay (Fig. 32).

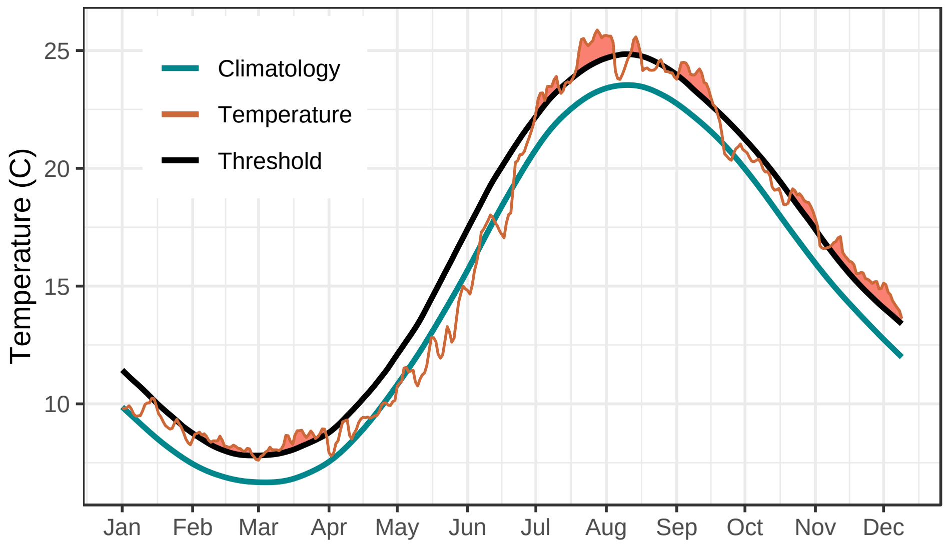


Figure 33: Marine heatwave events (red) in the Mid-Atlantic occuring in 2020.

Changes in ocean temperature and circulation alter habitat features such as the cold pool, a 20–60 m thick band of cold, relatively uniform near-bottom water that persists from spring to fall over the mid-shelf and outer shelf of the Middle Atlantic Bight (MAB) and Southern Flank of Georges Bank [12]. The cold pool plays an essential role in the structuring of the MAB ecosystem. It is a reservoir of nutrients that feeds phytoplankton productivity, is essential fish spawning and nursery habitat, and affects fish distribution and behavior [12]. The average temperature of the cold pool has been getting warmer over time [13]). These changes can affect distribution and migration timing for species that depend on the cold pool habitat. The area of the MAB cold pool was near average in 2018 (Fig. 34), the last complete year of the dataset. The size of the cold pool varies annually, with the smallest sizes associated with record-warm years (e.g. 2012). The cold pool temperature shows a similar variation as its extent, both of which are strongly impacted by each early spring setting in temperature on the shelf.

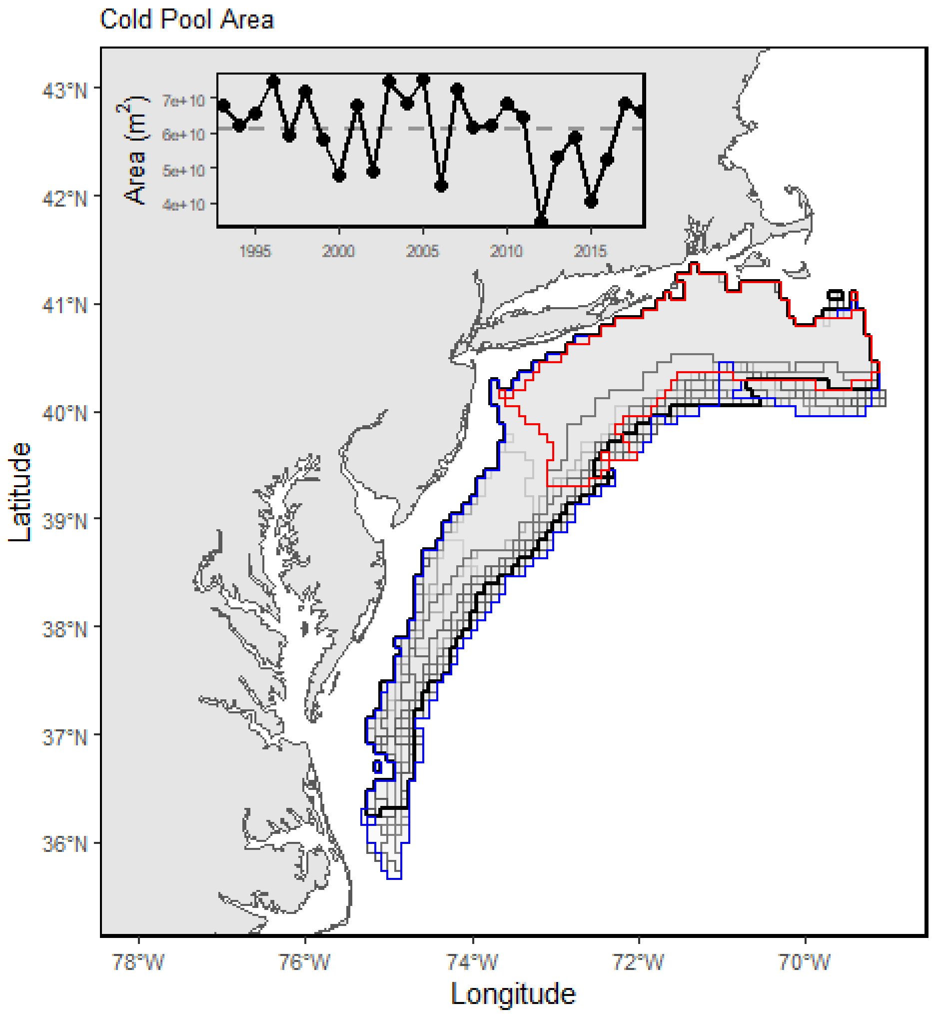


Figure 34: Map of cold pool area. Time series of cold pool spatial extent from1993-2018. Black = 2018 (Last year in time series), Red = 2012 Minimum area, Blue = 2005 Maximum area.

New glider-based observations revealed areas of low pH (7.8) during summer in Mid-Atlantic habitats occupied by Atlantic surfclams and sea scallops (Fig. 35) [14]. This seasonal pH minimum is associated with cold-pool subsurface and bottom water, which is cut off from mixing with surface water by strong stratification. However, seawater pH in shelf waters increased during the fall mixing period due to the influence of a slope water mass characterized by warm, salty, highly alkaline seawater. Lower pH in nearshore waters is likely associated with freshwater input.

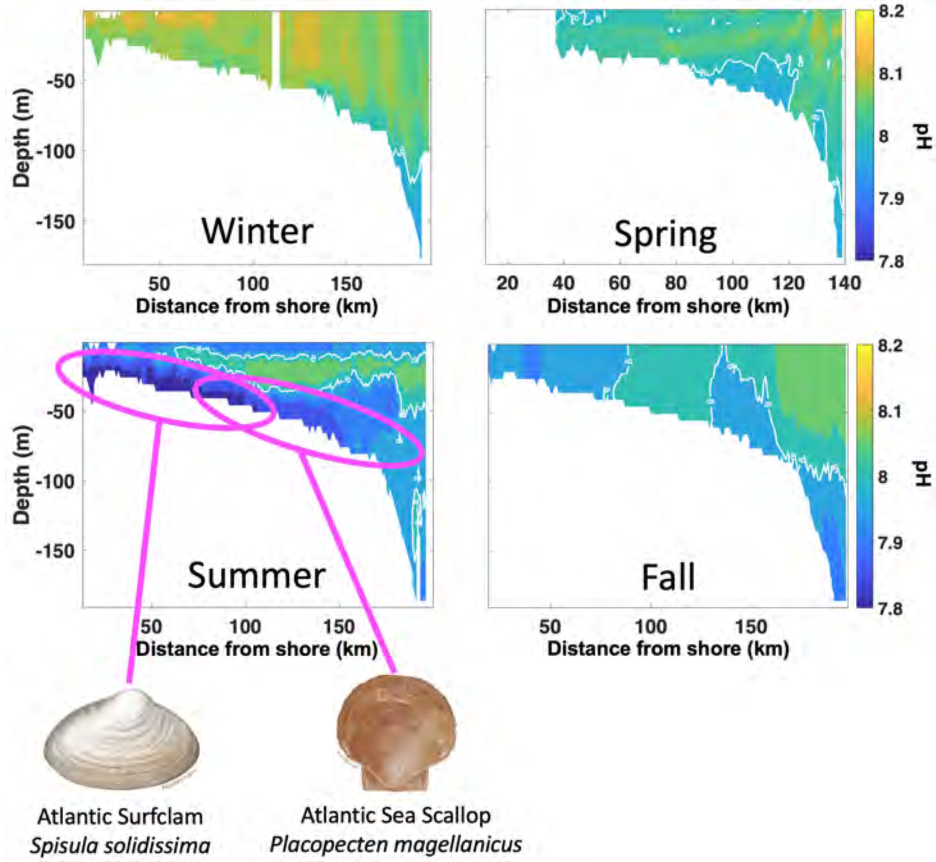


Figure 35: Seasonal glider-based pH observations on the Mid-Atlantic Bight shelf (New Jersey cross-shelf transect) in relation to Atlantic surfclam and Atlantic sea scallop habitats (modified from Wright-Fairbanks et al. 2020).

Ecosystem Productivity Indicators: primary production, zooplankton, forage fish, fish condition

Increased temperatures, as reported above, can increase the rate of photosynthesis by phytoplankton (i.e. primary productivity). Annual primary production has increased over time, primarily driven by increased productivity in the summer months (Figs. 36, 37).

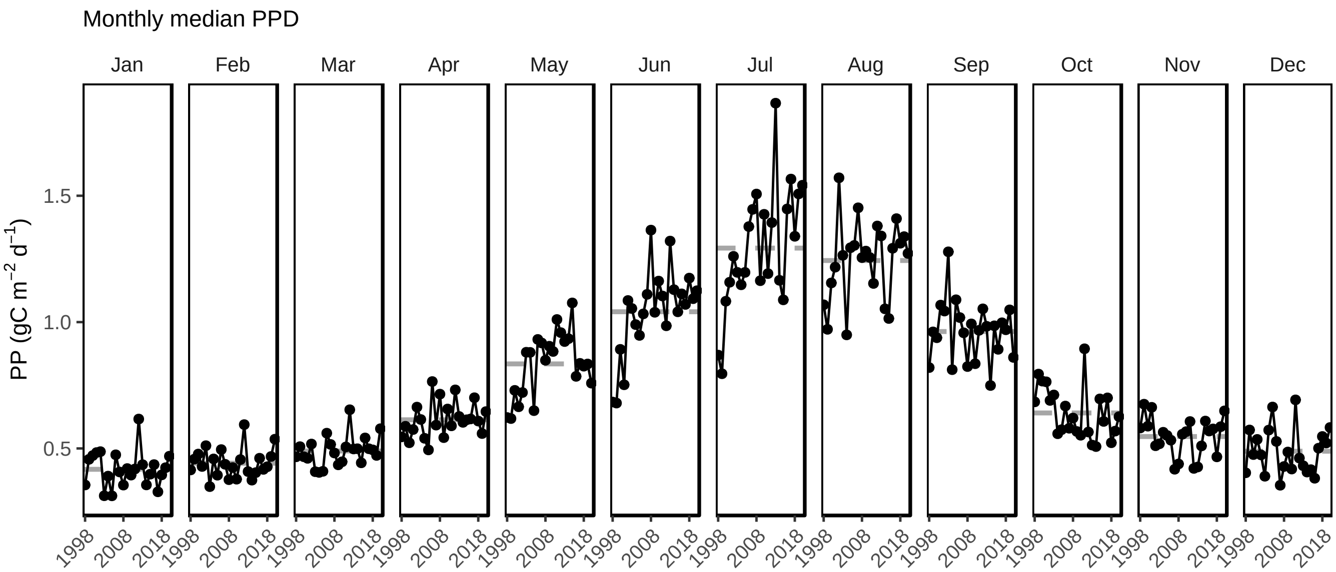


Figure 36: Monthly primary production trends show the annual cycle (i.e. the peak during the summer months) and the changes over time for each month.

Larger-than-average phytoplankton blooms were observed from late fall into winter in 2020 (Fig. 37).

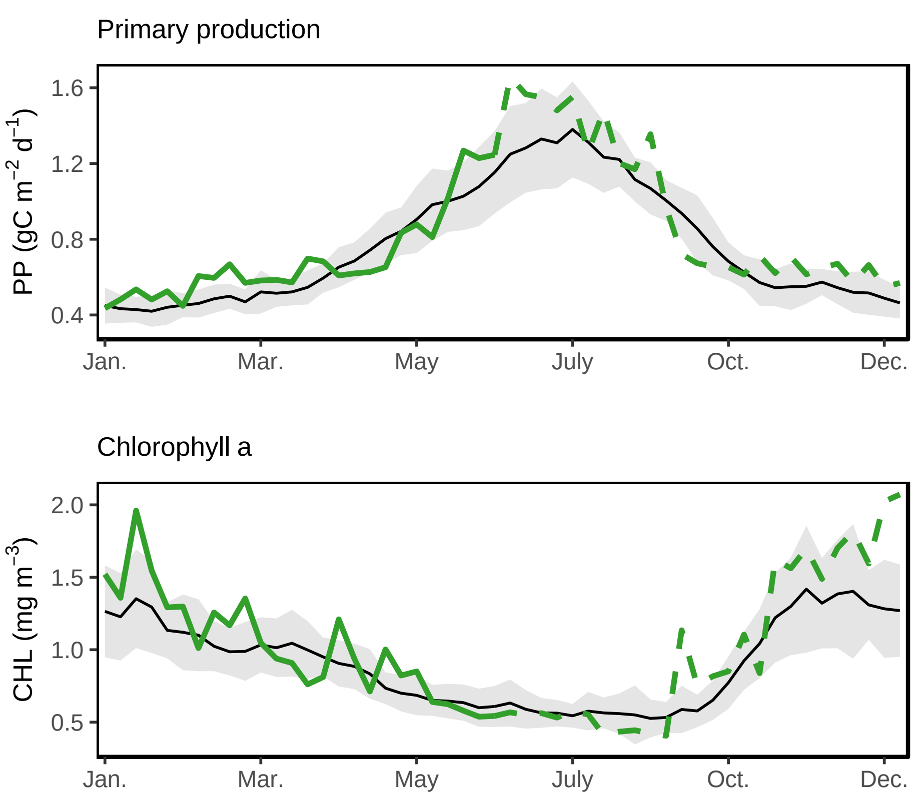


Figure 37: Weekly chlorophyll concentrations and primary productivity in the Mid-Atlantic are shown for by the colored line for 2020 (dashed portion indicates preliminary data from a new satellite source). The long-term mean is shown in black and shading indicates +/- 1 sample SD.

Climatology of seasonal phytoplankton size fractions confirms that the phytoplankton community in the summer is dominated by smaller (pico and nano) size classes (Fig. 38). This implies less efficient transfer of primary production to higher trophic levels.

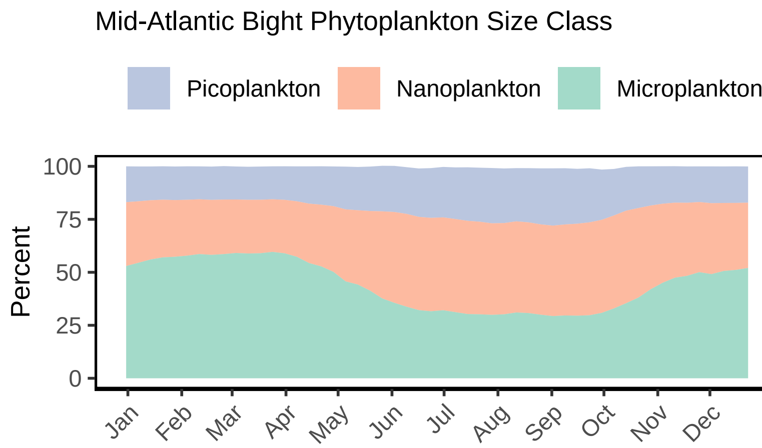


Figure 38: The annual climatology (1998-2019) percent composition of the phytoplankton size classes in the Mid-Atlantic bight based on satellite observations.

Trends in gelatinous zooplankton and krill are the same across ecological production units (EPUs) as last year (data were updated to 2019; Fig. 39). There has been a long term increase in both groups on Georges Bank and for krill in the Gulf of Maine as well.

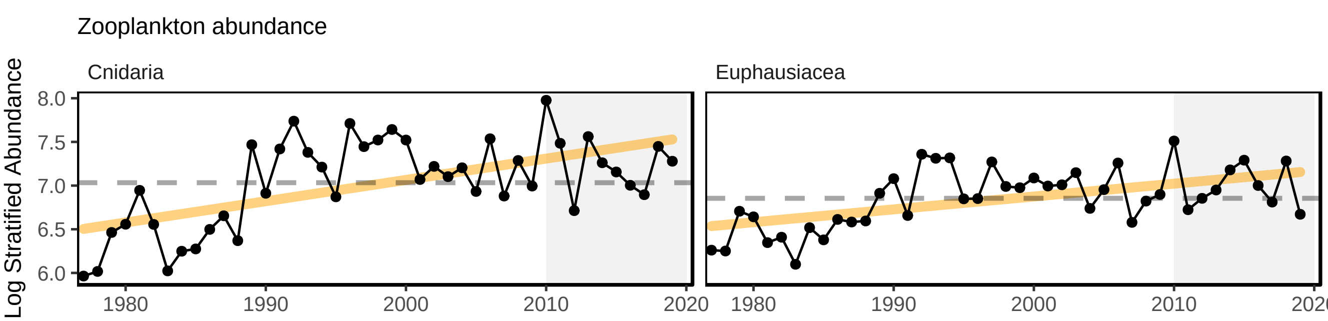


Figure 39: Stratified abundance of cnidarians and euphausiids in Mid-Atlantic Bight.

Larger zooplankton (i.e. *Calanus finmarchicus*) had above average abundance in 2018-2019, while smaller-bodied copepods were near or below average (Fig. 40).

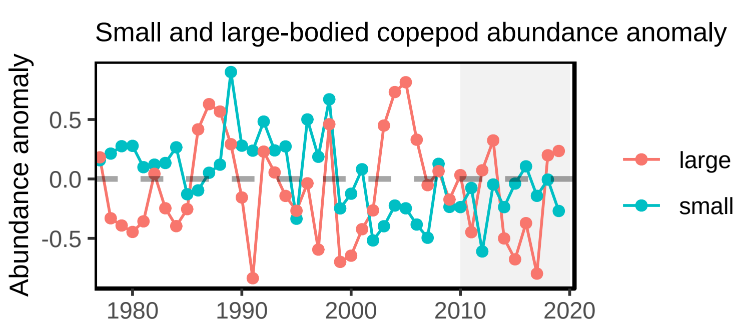


Figure 40: Large (red) and small-bodied (blue) copepod abundance in the Mid-Atlantic Bight.

An index of aggregate zooplankton and forage fish fluctuations (forage anomaly) constructed from zooplankton and ichthyoplankton data has no apparent trend in MAB, but appears to be more variable since 2010 (Fig. 41). Changes in environmental conditions, lower tropic levels, and diversity of the plankton community are potentially impacting the prey of zooplankton and ichthyoplankton, which may affect this index.

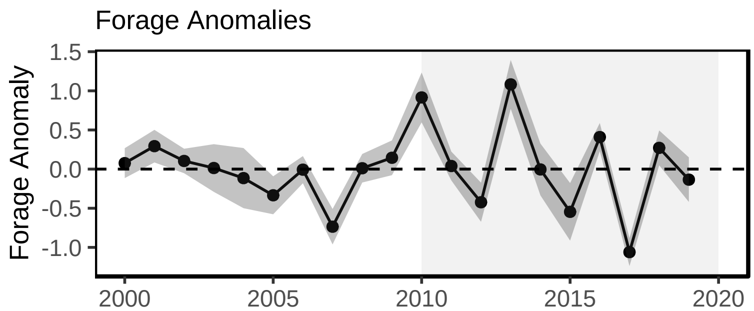


Figure 41: Changes from 2000-2019 average abundance for an aggregate of 13 zooplankton and 16 ichthyoplankton groups sampled on NEFSC ECOMON surveys.

Nutritional value (energy content) of juvenile and adult forage fishes as prey is related to both environmental conditions, fish growth and reproductive cycles. Forage energy density measurements from NEFSC trawl surveys 2017-2019 are building toward a time series to evaluate trends (Fig. 42). New 2019 measurements were consistent with last year's report: the energy density of Atlantic herring was almost half the value (5.69 +/- 0.07 kJ/g wet weight) reported in earlier studies (10.6-9.4 kJ/ g wet weight). Silver hake, sandlance, longfin squid (*Loligo* below) and shortfin squid (*Illex* below) were also lower than previous estimates [15,16]. Energy density of alewife, butterfish and Atlantic mackerel varies seasonally, with seasonal estimates both higher and lower than estimates from previous decades.

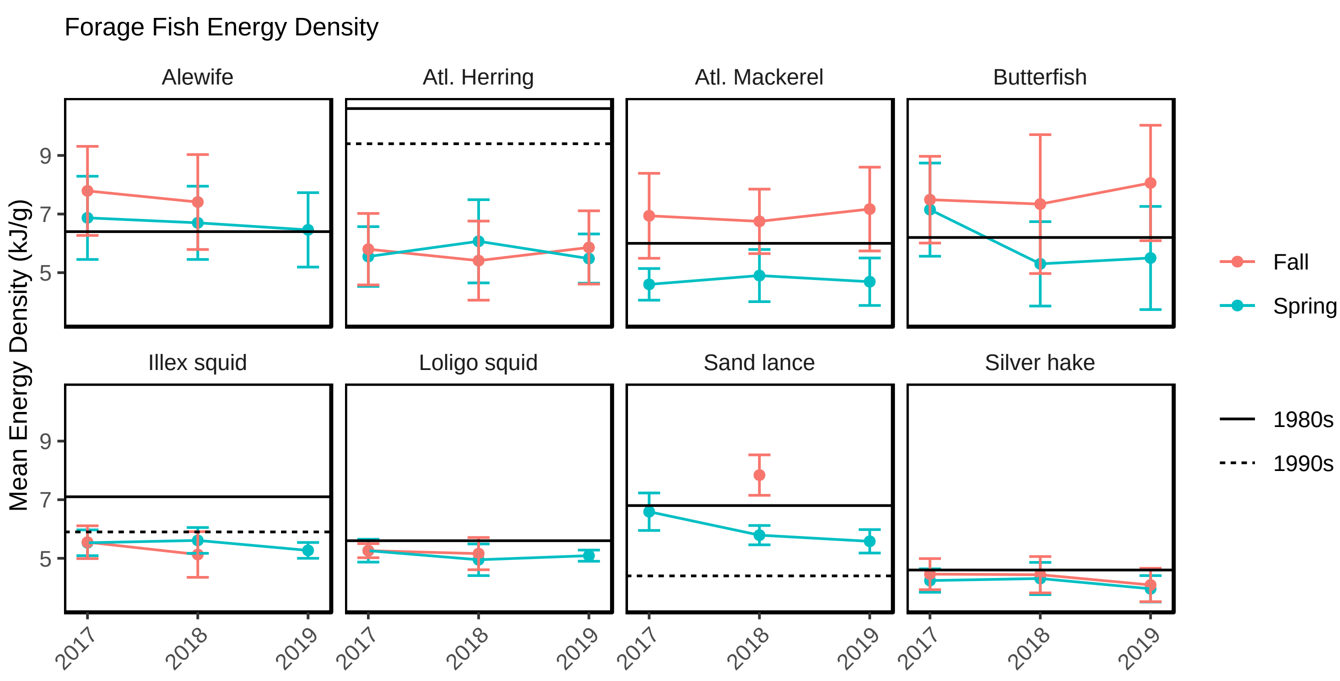


Figure 42: Forage fish mean energy density mean and standard deviation by season and year, compared with 1980s (Steimle and Terranove 1985) and 1990s (Lawson et al. 1998) values.

The health and well being of individual fish can be related to body shape condition indices (i.e. weight at a given length) such as relative condition index, which is the ratio of observed weight to predicted weight based on length [17]. Heavier and fatter fish at a given length have higher relative condition which is expected to influence growth, reproductive output and survival. A pattern of generally good condition was observed across many MAB species prior to 2000, followed by a period of generally poor condition from 2001-2010, with a mix of good and poor condition 2011-2019 (Fig. 43). While there were no new data to update the condition indicator this year, preliminary results of synthetic analyses described in the Implications section show that changes in fishing pressure, population size, temperature, and zooplankton influence the condition of different fish species. Potential links between fish condition, fisheries, and markets are under investigation.

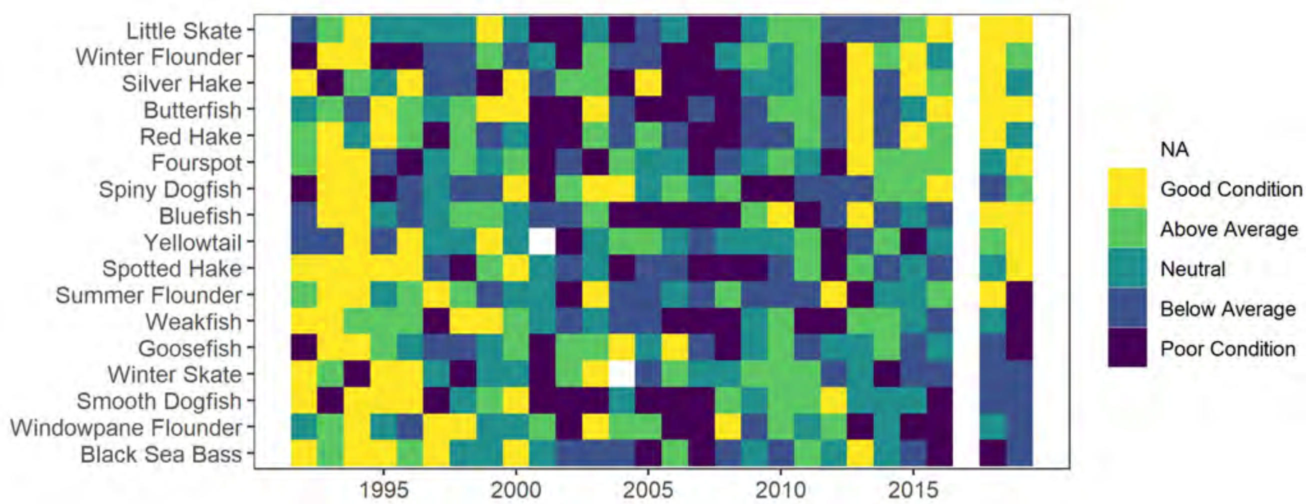


Figure 43: Condition factor for fish species in the MAB based on fall NEFSC bottom trawl survey data. MAB data are missing for 2017 due to survey delays, and no survey was conducted in 2020.

Ecosystem Structure Indicators: distribution shifts, diversity, predators

As noted in the Landings Implications section above, stocks are shifting distribution throughout the region. In aggregate, fish stocks are moving northeast along the shelf and into deeper waters.

Zooplankton diversity is increasing in the MAB, while larval fish and adult fish diversity indices are stable over time with current values near the long-term average (see Diversity Indicators section, above).

New indicators for shark populations, combined with information on gray seals (see Protected Species Implications section, above), suggests predator populations range from stable (sharks, Figs. 44, 45) to increasing (seals) in the MAB. Stable predator populations suggest stable predation pressure on managed species, but increasing predator populations may reflect increasing predation pressure.

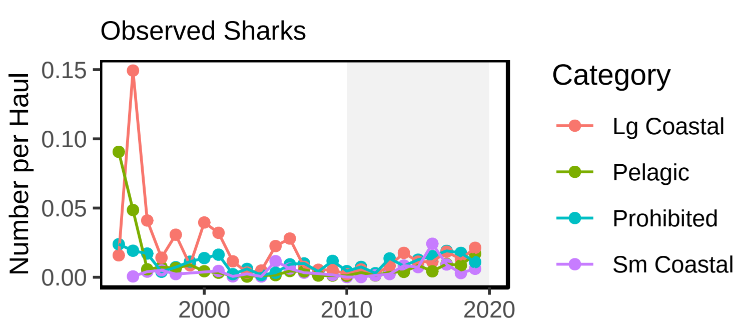


Figure 44: Estimated number of sharks per unit effort from Northeast Fisheries Observer Program data.

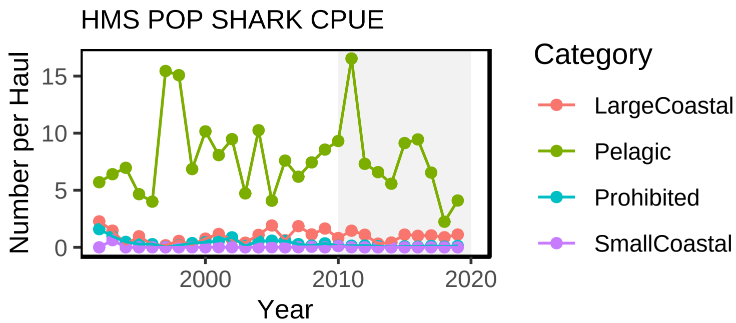


Figure 45: Estimated number of sharks per unit effort from Highly Migratory Species Pelagic Observer Program data.

As noted in the Protected Species section, gray seal populations are increasing. Harbor and gray seals occupying New England waters are generalist predators that consume more than 30 different prey species. An evaluation of hard parts found in seal stomachs showed that harbor and gray seals predominantly exploit abundant demersal fish species (i.e. red, white and silver hake). Other relatively abundant prey species found in hard-part remains include sand lance, yellowtail flounder, four-spotted flounder, Gulf-stream flounder, haddock, herring, redfish, and squids.

A recent stable isotope study utilizing gray seal scat samples obtained from Massachusetts habitats showed individual gray seals can specialize on particular prey. It also found that gray seals vary their diet seasonally, focusing on demersal inshore species prior to the spring molt, and offshore species such as sand lance after molting. DNA studies on gray seal diet in Gulf of Maine and Massachusetts waters found spiny dogfish and Jonah crab present in gray seal scat samples. Skate and crab remains were also found in gray seal stomach remains. In contrast to direct feeding, it is uncertain if the presence of skates and crabs is due to secondary consumption or scavenging.

Habitat Climate Vulnerability

A recent habitat climate vulnerability analysis links black sea bass, scup, and summer flounder to several highly vulnerable nearshore habitats from salt marsh through shallow estuarine and marine reefs. Details on highly vulnerable habitats with linkages to a variety of species, including which life stages have different levels of dependence on a particular habitat, are available in a detailed table.[6]

Implications

Links between climate change and managed species Estuarine and nearshore habitats support many life stages of state and federally-managed species, and are highly vulnerable to climate change. Below we highlight how recently observed habitat changes affect several key managed species in Chesapeake Bay and in both nearshore and offshore waters of the MAB. Overall, multiple drivers interact differently for each species, producing a range of population impacts.

Striped bass and blue crabs The warmer than average winter may have affected key Chesapeake Bay fishery resources during a critical period. Results of the Maryland juvenile striped bass survey, conducted by the Maryland Department of Natural Resources (MDNR), showed low recruitment success in 2020, about fivefold below the long-term average. This low recruitment event may have been caused by a mismatch in striped bass larval and prey abundance due to the warm winter conditions, resulting in reduced larval survival. Warm winters typically trigger early phytoplankton and zooplankton blooms, including key copepod prey, which die before striped bass larvae are present in the tributary [18].

In addition to winter water temperature, survival of early life stages of striped bass in the Chesapeake Bay is strongly correlated with freshwater flow [18–20]. High-flow regimes push zooplankton prey downstream, where they get trapped with striped bass larvae in the estuarine turbidity maximum. In low-flow years, such as 2020, zooplankton prey are less likely to match up with striped bass larvae in space and time, reducing striped bass larval survival and

[6] https://noaa-edab.github.io/ecodata/Hab_table

recruitment success. The combined effects of warm winter temperatures and low flow in 2020 may be the primary cause of the low recruitment observed by the MDNR juvenile striped bass survey.

Conversely, warmer winter temperatures may have reduced overwintering mortality of Chesapeake Bay blue crabs. Calculations done by MDNR based on data from the annual bay-wide winter dredge survey indicate that blue crabs experienced the lowest overwintering mortality ever observed (2020 Chesapeake Bay Blue Crab Advisory Report). Previous studies have demonstrated the correlation between winter water temperature and blue crab survival in the Chesapeake Bay [21–23].

American oyster Increased salinity in the Chesapeake Bay often results in high juvenile oyster abundance [24]. In Maryland, the 2020 MDNR fall oyster survey documented above-average spatsets along the Eastern Shore as expected, given the high salinity. However, the Western Shore did not fare as well, suggesting that local environmental conditions are also important.

Summer flounder The NEAMAP survey saw a doubling of summer flounder catch in the near coastal waters in 2020 relative to 2019. It is more likely that environmental conditions made summer flounder more available in nearshore habitats and less likely that the population doubled between 2019 and 2020, but this remains to be confirmed and investigated along with habitat-specific information. In upcoming reports, we plan to integrate information on federally managed species in both Chesapeaky Bay (ChesMMAP) and NEAMAP surveys with nearshore environmental information to highlight interactions in these important habitats.

Surfclam Ocean acidification also has different implications, depending on the species and life stage. Recent lab studies have found that surfclams exhibited metabolic depression in a pH range of 7.46-7.28 [25]. In other bivalve species, metabolic depression happened between pH 7.38 and 7.14 for blue mussels [26] and around pH 7.1 for Pacific oysters [27]. At pH of 7.51, short term experiments indicated that surfclams were selecting particles differently, which may have long term implications for growth [25]. Computer models would help in determining the long term implications of growth on surfclam populations. Data from about one year of observations (2018-2019) show that seasonal ocean pH has not yet reached the metabolic depression threshold observed for surfclams in lab studies so far; however, thresholds at different life stages, specifically larval stages that are typically more vulnerable to ocean acidification, have not yet been determined.

Heatwave impacts Marine heatwaves measure not just temperature, but how long the ecosystem is subjected to the high temperature. They are driven by both atmospheric and oceanographic factors and can have dramatic impacts on marine ecosystems. Marine heatwaves are measured in terms of intensity (water temperature) and duration (the cumulative number of degree days) using satellite measurements of daily sea surface temperature. Plotted below are maximum intensity and cumulative intensity, which is intensity times duration.

The MAB had multiple marine heatwaves in 2020 (Fig. 33). Although the individual maximum intensity heatwave on July 28 was near intensity average (for a heatwave), the combination of multiple heatwaves led to the third highest cumulative heatwave intensity on record in 2020 (Fig. 46). The strongest heatwaves on record in the Middle Atlantic Bight occurred in the winter of 2012 in terms of maximum intensity (+5.13 °C above average) and in the winter/summer of 2012 in terms of cumulative intensity (515 °C-days). 2012 is still the warmest year on record in the Northeast US LME. Recent papers published on the impacts of the 2012 heatwave give insight into the implications of marine heatwaves. Lobster was impacted as well as the timing of fishing and markets [28]. Other more southern warm water species have been observed in the MAB, including reports in 2020 of Cobia in the waters off of Rhode Island.

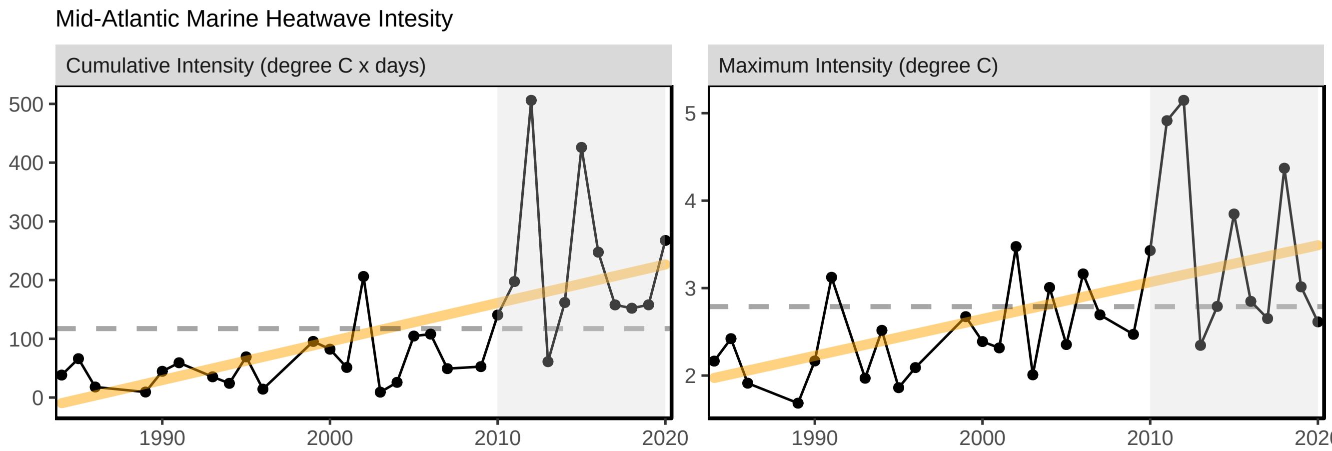


Figure 46: Marine heatwave cumulative intesity (left) and maximum intensity (right) in the Mid-Atlantic Bight.

Distribution shift impacts Trends for a suite of 48 commercially or ecologically important fish species along the entire Northeast Shelf continue to show movement towards the northeast and generally into deeper water (Fig. 10). We hope to expand this analysis beyond fish. Marine mammal distribution maps are available online[7]; updated maps and trends are currently being developed.

Shifting species distributions alter both species interactions and fishery interactions. In particular, shifting species distributions can alter expected management outcomes from spatial allocations and bycatch measures based on historical fish and protected species distributions.

Ecosystem productivity change impacts Climate and associated changes in the physical environment affect ecosystem productivity, with warming waters increasing the rate of photosynthesis at the base of the food web. However, increased summer production in the MAB may not translate to increased fish biomass because smaller phytoplankton dominate in this season.

While krill and large gelatinous zooplankton are increasing over time, smaller zooplankton are periodically shifting abundance between the larger, more nutritious Calanus finmarchicus and smaller bodied copepods with no apparent overall trend. Forage species are difficult to survey, but a new index that includes ichthyoplankton suggests high interannual variability in abundance of larval fish and zooplankton prey. The nutritional content of larger bodied forage fish and squid changes seasonally in response to ecosystem conditions, with apparent declines in energy density for Atlantic herring and *Illex* squid relative to the 1980s, but similar energy density for other forage species. Some of these factors are now being linked to the relative condition of managed fish.

Environmental drivers of fish condition Generalized Additive Models (GAMs) were used to test how measures of fishing pressure, stock abundance, and individual environmental variables performed in explaining the changes of fish condition (fatness) over time. Some species such as Acadian redfish, butterfish and winter flounder were more affected by fishing pressure and stock size, whereas other species such as weakfish, windowpane flounder, and American plaice may be more affected by local bottom temperatures and zooplankton.

These relationships can potentially provide insights on which species may be more vulnerable to environmental changes such as climate change, as well as what biomass changes may be expected from certain species given current environmental conditions.

Correlations were examined between environmental drivers, and as expected there were strong temperature correlations between seasons as well as correlations between temperature and zooplankton indices. Planned future work includes building full GAM models for each fish species, and linking fish condition to socio-economic models to assess whether fish condition impacts the market value generated by that species.

[7] https://www.nefsc.noaa.gov/AMAPPSviewer/

Potential economic impacts of fish condition Economic theory and empirical analyses have highlighted that many factors can affect the price of fish, including the total quantity of fish in the market (sometimes including internationally), increased demand around holidays, time the fish was in storage, and other issues that either affect the quality of the fish or the amount of fish available for purchase. We plan on empirically exploring whether fish condition is a quality metric that drives fish prices. Understanding the socio-economic impact of fish condition will help us more holistically understand the impacts of condition change on society, if any.

Other Ocean Uses: Offshore Wind

Indicators: development timeline, revenue in lease areas, survey overlap

More than 20 offshore wind development projects are proposed for construction over the next decade in the Northeast (projects & construction timelines based on Table E-4 of South Fork Wind Farm Draft Environmental Impact Statement). Offshore wind areas may cover more than 1.7 million acres by 2030 (Fig. 47). Just over 1,900 foundations and more than 3,000 miles of inter-array and offshore export cables are proposed to date. Each proposed project has a two-year construction timeline [29]. Based on current timelines, the areas affected would be spread out such that it is unlikely that any one particular area would experience full development at one time.

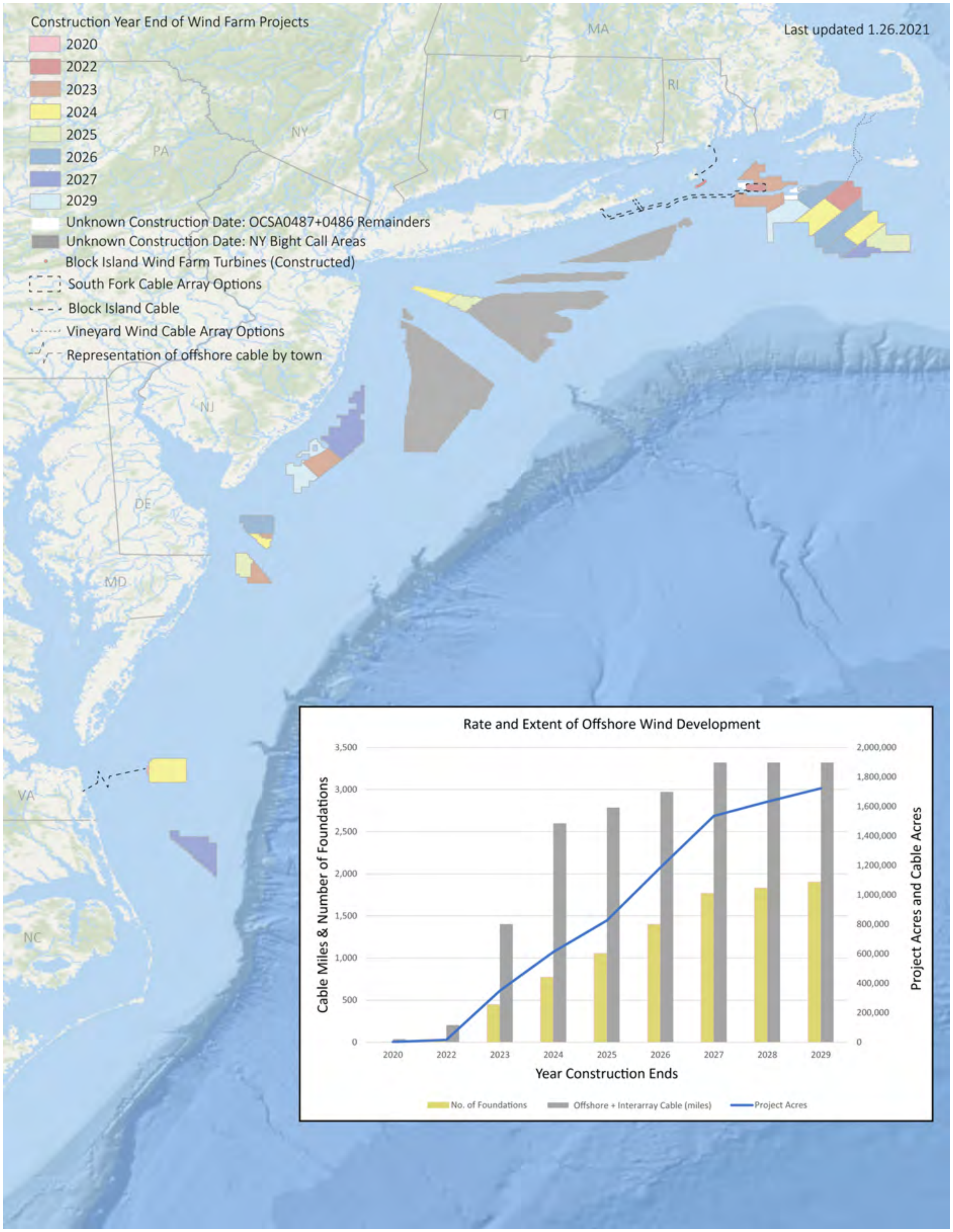


Figure 47: All Northeast Project areas by year construction ends (each project has 2 year construction period). Data for cumulative project areas, number of foundations, offshore cable area (acres) and offshore cable and interarray cable (mile) are displayed in the graph.

Based on vessel logbook data, average commercial fishery revenue from trips in the proposed offshore wind lease areas and the New York Bight Call Areas represented 2-24% of the total average revenue for each MAFMC managed fishery from 2008-2018 (Fig. 48).

The surfclam/ocean quahog fishery was the most affected fishery, with a maximum of 31% of annual fishery revenue occurring within potential wind lease areas during this period. The golden and blueline tilefish fisheries and spiny dogfish fishery were the least affected, at 3-4% maximum annual revenue affected, respectively. A maximum of 11% of the annual monkfish revenues were affected by these areas, with similar effects for the bluefish (10%), summer flounder/scup/black sea bass (9%), and mackerel/squid/butterfish (8%) fisheries. The New York Bight Call Areas represented only 1-5% of total average fishery revenue from any fishery during 2008-2018, with the surfclam/ocean quahog fishery most affected.

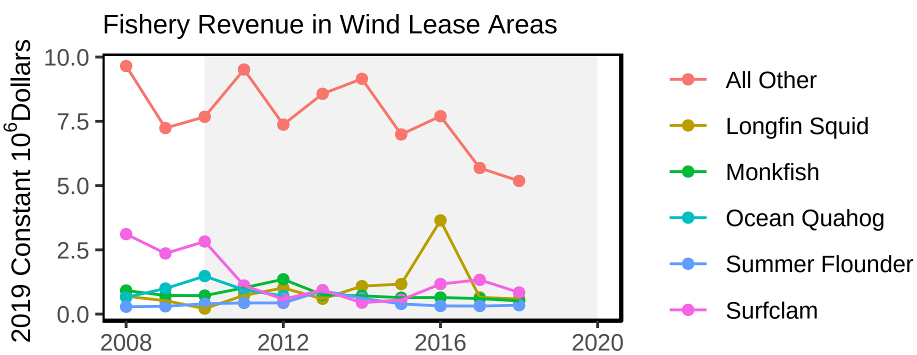


Figure 48: Wind energy revenue in the Mid-Atlantic

Proposed wind energy project areas and NY Bight Call Areas interact with the region's federal scientific surveys (Fig. 49). The total survey area overlap ranges from 1-14% across ecosystem, shellfish, fish, shark, and protected species surveys. For example, the sea scallop survey will have significant overlap (up to 96% of individual strata) while the bottom trawl survey will have up to 60% overlap. Additionally, up to 50% of the southern New England North Atlantic right whale survey's area overlaps with proposed project areas.

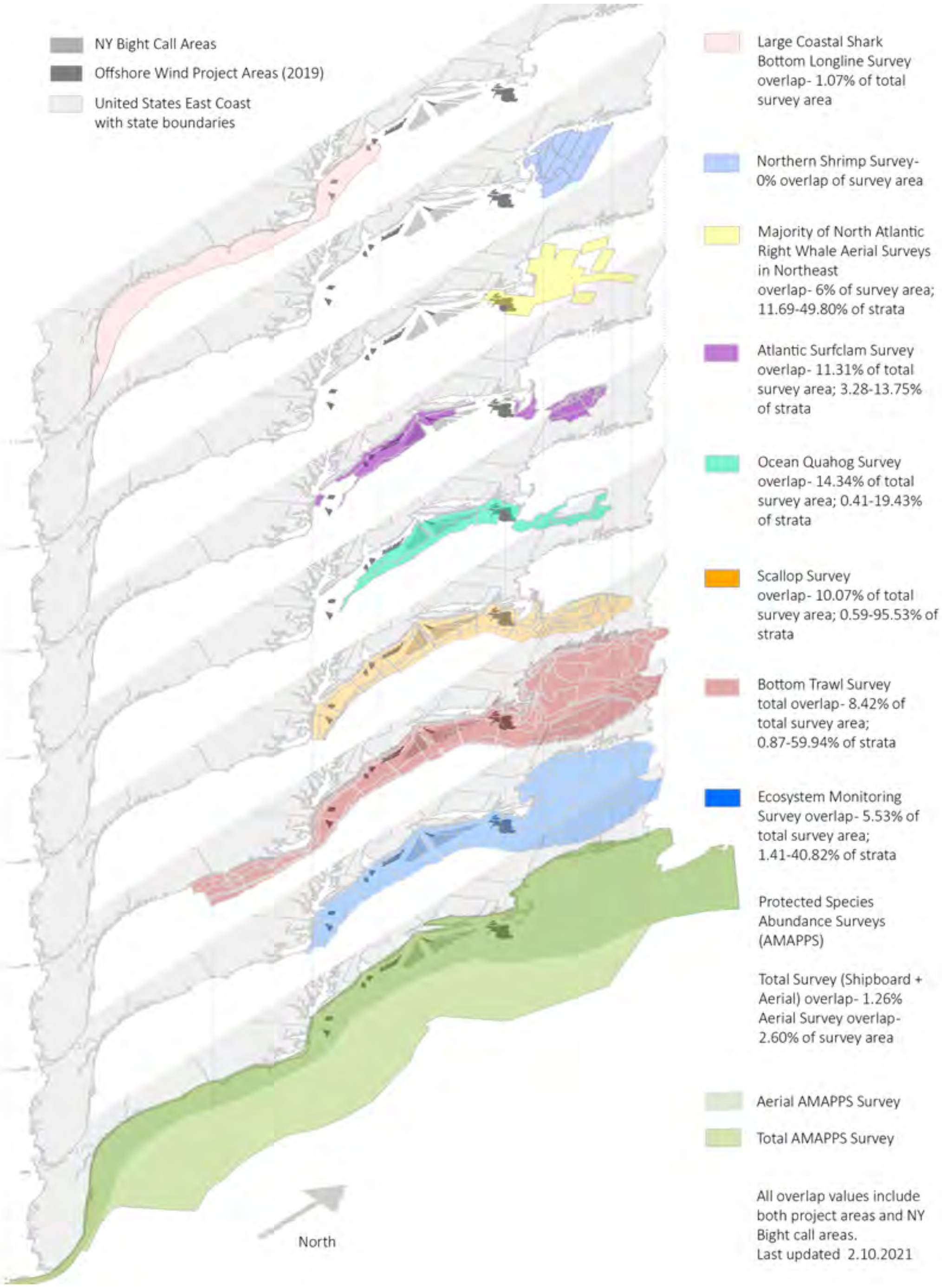


Figure 49: Interaction of Greater Atlantic Fisheries Scientific Surveys and Offshore Wind Development

Implications

Current plans for rapid buildout of offshore wind in a patchwork of areas spreads the impacts differentially throughout the region (Fig. 50).

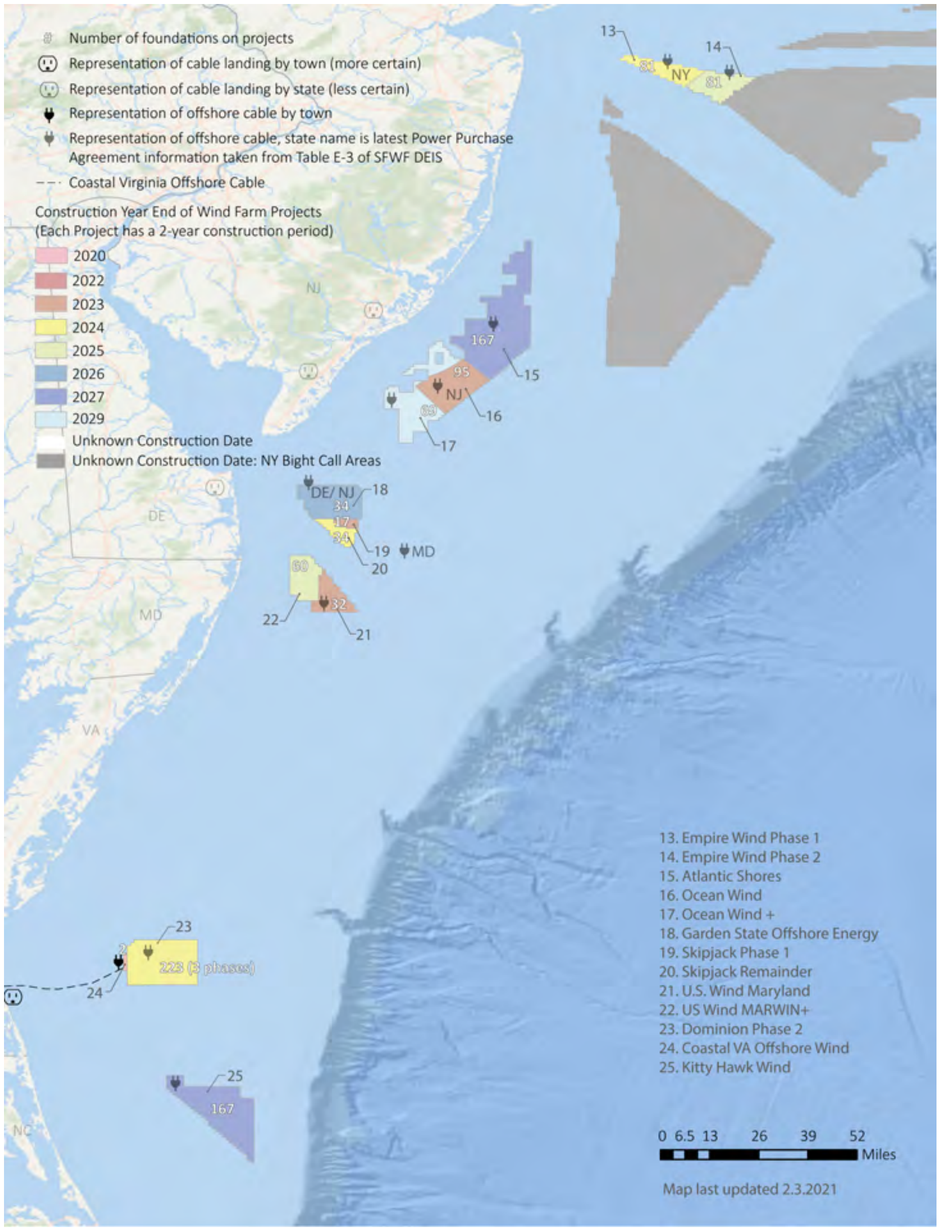


Figure 50: Zoomed in areas with name of Project, number of foundations within each project area and the states that have declared power purchase agreements.

2-24% of total average revenue for major Mid-Atlantic commerical species in lease areas could be displaced if all sites are developed. Displaced fishing effort can alter fishing methods, which can in turn change habitat, species (managed and protected), and fleet interactions.

Right whales may be displaced, and altered local oceanography could affect distribution of their zooplankton prey.

Scientific data collection surveys for ocean and ecosystem conditions, fish, and protected species will be altered, potentially increasing uncertainty for management decision making.

Contributors

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Document Orientation

The figure format is illustrated in Fig 51a. Trend lines are shown when slope is significantly different from 0 at the p < 0.05 level. An orange line signifies an overall positive trend, and purple signifies a negative trend. To minimize bias introduced by small sample size, no trend is fit for < 30 year time series. Dashed lines represent mean values of time series unless the indicator is an anomaly, in which case the dashed line is equal to 0. Shaded regions indicate the past ten years. If there are no new data for 2018, the shaded region will still cover this time period. The spatial scale of indicators is either coastwide, Mid-Atlantic states (New York, New Jersey, Delaware, Maryland, Virginia, North Carolina), or at the Mid-Atlantic Bight (MAB) Ecosystem Production Unit (EPU, Fig. 51b) level.

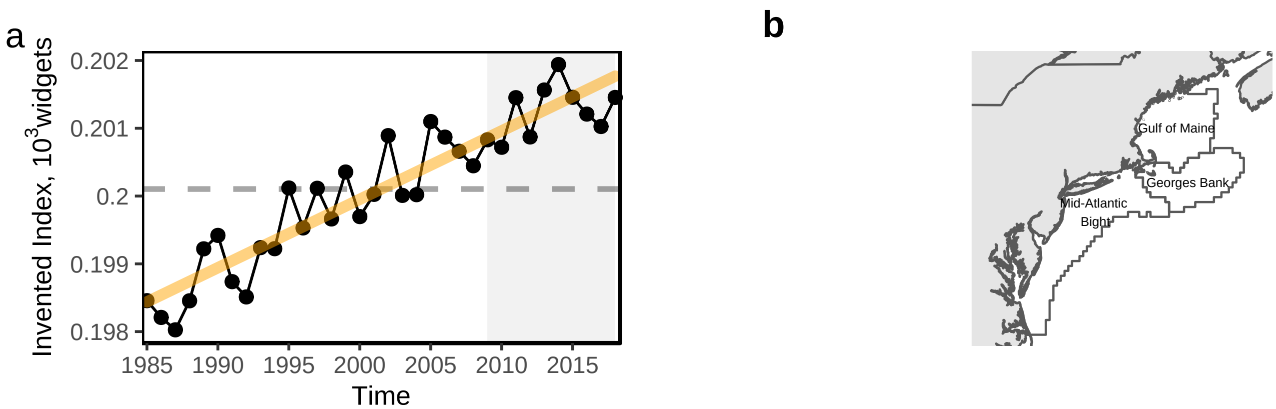

Figure 51: Document orientation. a. Key to figures. b.The Northeast Large Marine Ecosystem.

Fish and invertebrates are aggregated into similar feeding categories (Table 2) to evaluate ecosystem level trends in predators and prey.

Table 2: Feeding guilds and management bodies.

Guild	MAFMC	Joint	NEFMC	State or Other
Apex Predator	NA	NA	NA	bluefin tuna, shark uncl, swordfish, yellowfin tuna
Piscivore	bluefish, longfin squid, northern shortfin squid, summer flounder	goosefish, spiny dogfish	acadian redfish, atlantic cod, atlantic halibut, clearnose skate, little skate, offshore hake, pollock, red hake, silver hake, smooth skate, thorny skate, white hake, winter skate	fourspot flounder, john dory, sea raven, striped bass, weakfish, windowpane
Planktivore	atlantic mackerel, butterfish	NA	atlantic herring	alewife, american shad, blackbelly rosefish, blueback herring, cusk, longhorn sculpin, lumpfish, menhaden, northern sand lance, northern searobin, sculpin uncl
Benthivore	black sea bass, scup, tilefish	NA	american plaice, barndoor skate, crab,red deepsea, haddock, ocean pout, rosette skate, winter flounder, witch flounder, yellowtail flounder	american lobster, atlantic wolffish, blue crab, cancer crab uncl, chain dogfish, cunner, jonah crab, lady crab, smooth dogfish, spider crab uncl, squid cuttlefish and octopod uncl, striped searobin, tautog
Benthos	atlantic surfclam, ocean quahog	NA	sea scallop	blue mussel, channeled whelk, sea cucumber, sea urchin and sand dollar uncl, sea urchins, snails(conchs)

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543-1026

22 March, 2021

Mid-Atlantic Fishery Management Council
800 North State Street, Suite 201
Dover, DE 19901
Scientific and Statistical Committee

To the Council,

In this memo we list the comments and requests received on the 2019 and 2020 State of the Ecosystem (SOE) reports, and how we responded to those requests. We include comments from both Councils because adjustments to the report were made in response to both. We welcome comments on whether this memo is useful and how to improve it for future SOE reporting.

The attached document includes a table where we summarize all comments and requests with sources. The Progress column briefly summarizes how we responded, with a more detailed response in the numbered Memo Section. In the Progress column, "SOE" indicates a change included in the report(s). In each detailed response, we refer to SOE pages where changes are found or describe information that was not sufficiently developed to include in the 2021 SOE in an effort to solicit feedback on how best to develop indicators for future reports.

We welcome comments on the entire SOE report as well as information included in this memo, and look forward to feedback from the SSC and Council.

Sincerely,

Sarah Gaichas, PhD
Research Fishery Biologist
Ecosystem Dynamics and
Assessment Branch
Northeast Fisheries Science Center

encl: State of the Ecosystem 2021: Request Tracking Memo

cc: Jon Hare

State of the Ecosystem 2021: Request Tracking Memo

March 18, 2021

Introduction

In the table below we summarize all comments and requests with sources. The Progress column briefly summarizes how we responded, with a more detailed response in the numbered Memo Section. In the Progress column, "SOE" indicates a change included in the State of the Ecosystem (SOE) report(s).

Request	Year	Source	Progress	Memo Section
Report card and summary visualizations	2019	Both Councils	SOE new report card table and summary visualizaitions of synthesis themes	1
Ecosystem Overfishing indicators (Link and Watson, 2019)	2020	Both Councils	SOE two ecosystem overfishing indicators included	2
Primary production required, interpretation of decline?	2020	Both Councils	SOE indicator reworked along with Link and Watson metrics	3
Climate Change context	2020	NEFMC	SOE reorganized; Risks section added emphasizing climate change	4
Clarify language (e.g., primary production required)	2020	Both Councils	SOE edited by Research Communications Branch; glossary included	5
Copy Editing	2020	Both Councils	SOE edited by Research Communications Branch	6
Ocean Acidification	2020	NEFMC	SOE indicator added with in-situ data linked to preliminary lab work on thresholds	7
Include examples of High/Low engaged ports	2020	NEFMC	SOE indicator reworked to show individual ports and social vulnerability	8
Expand wind lease area and habitat overlap	2020	MAFMC	SOE indicator expanded to rank species with habitat in wind lease areas by landings in wind lease areas	9
Expand cold pool index	2020	MAFMC	SOE indicator expanded with modeled data to include area and other attributes	10
Seperate Bigelow/Albatross catch diversity metric	2020	MAFMC	SOE indicator added	11
Shark abundance and catch indicators	2020	MAFMC	SOE multiple shark indicators added	12
Uncertainty estimates	2020	MAFMC	SOE included for subset of indicators	13
Bycatch index	2020	NEFMC	SOE added seal bycatch indicator, retained harbor porpoise indicator	14
Marine Mammal consumption	2019	MAFMC	SOE added discussion of seal diets, memo no new consumption ests since Smith et al but could be in the future once work is complete	15
Estuarine Water Quality	2020	NEFMC	SOE Chesapeake indicators updated and expanded	16
Forage abundance	2019	MAFMC	SOE forage anomaly indicator added	17
Linking Condition	2020	MAFMC	in progress; not ready for 2021	18
Avg weight of diet components by feeding group	2019	Internal	in progress; part of fish condition	19
Mean stomach weight across feeding guilds	2019	MAFMC	in progress; stomach fullness analysis started–species level	20
Shellfish growth/distribution linked to climate (system productivity)	2019	MAFMC	in progress; project with R Mann student to start 2021	21

(continued)

Request	Year	Source	Progress	Memo Section
Cumulative weather index	2020	MAFMC	in progress; data gathered for prototype	22
Management complexity	2019	MAFMC	in progress; student work needs further analysis, no further work in 2020	23
VAST and uncertainty	2020	Both Councils	in progress; not ready for 2021	24
Seal index	2020	MAFMC	in progress; not ready for 2021	25
Incorporate social sciences survey from council	2020	NEFMC	unable to start in 2020	26
Young of Year index from multiple surveys	2019	MAFMC	unable to start in 2020	27
Biomass of spp not included in BTS	2020	MAFMC	unable to start in 2020	28
Estuarine condition relative to power plants and temp	2019	MAFMC	unable to start in 2020	29
Inflection points for indicators	2019	Both Councils	unable to start in 2020	30
Reduce indicator dimensionality with multivariate statistics	2020	NEFMC	unable to start in 2020	31
Breakpoints	2020	NEFMC	unable to start in 2020	32
Re-evaluate EPUs	2020	NEFMC	unable to start in 2020	33

Responses to comments

1 Report card and summary visualizations

Both Councils requested a "report card" style summary section with visualizations in 2019. We introduced a 2 page summary format in 2020 with a bulleted list of results on the first page and visualizations on the second. This year, the report was reorganized to more clearly link indicators with fishery management objectives and to better synthesize results across indicators, so the summary section was restructured accordingly. The 2021 summary pages include:

1. a report card style table summarizing status and trends of indicators linked to management objectives, combined with brief descriptions of implications for management synthesizing across multiple indicators in the report;

2. a bulleted list highlighting risks to meeting fishery management objectives, including those from climate change and those from wind energy development; and

3. visualizations of ecosystem synthesis themes integrated in the report, including multiple drivers of change, regime shifts, and ecosystem reorganization.

We welcome feedback on these revisions and suggestions for further refinements to make this summary more useful.

2 Ecosystem Overfishing indicators (Link and Watson, 2019)

Both Councils have requested more information on ecosystem thresholds and inflection points. This year we have calculated two ecosystem overfishing indicators with proposed thresholds [1] for each ecological production unit (EPU) on the northeast US shelf. We note the caveats with this analysis and request feedback on how the Councils would like to move forward with these indicators in the future:

1. The proposed ecosystem overfishing thresholds are calculated based on *total catch* while our preliminary indicators are based on *commercial landings*. Therefore, our current indicators are underestimated compared with the proposed thresholds. It is possible to add commercial discards and recreational landings and dead discards in the future, or to calculate how much additional catch is required to exceed a threshold.

2. The proposed ecosystem overfishing thresholds are based on a global analysis. The indices define ecosystem productivity in different ways. The Ryther Index is effectively based on fishery removals relative to global primary productivity per unit area, while the Fogarty Index is based on fishery removals relative to regional primary productivity [1]. The study authors "recommend that the indices proposed here be used cognizant of other potential sources of productivity and that are relevant to the scale at which fisheries management mostly occurs."

Our implementation of these indicators is fully documented in an R package `eofindices`, where a disucssion of technical details including the 2021 calculations and potential future work are also provided. We welcome suggestions for further analysis that would be most useful for the Councils to evaluate and potentially use these ecosystem overfishing indices.

3 Primary production required, interpretation of decline?

Both Councils were interested in further interpretation of the decline in the fraction of primary production required to support commercial landings presented in the 2020 reports. For 2021, this indicator was extended back in time by reconstructing total primary production prior to the satellite era using the mean of 1998-2010 as values for pre 1998 (Fig. 1). This gives a fuller context of the demand that much higher historical landings placed on ecosystem productivity relative to current landings.

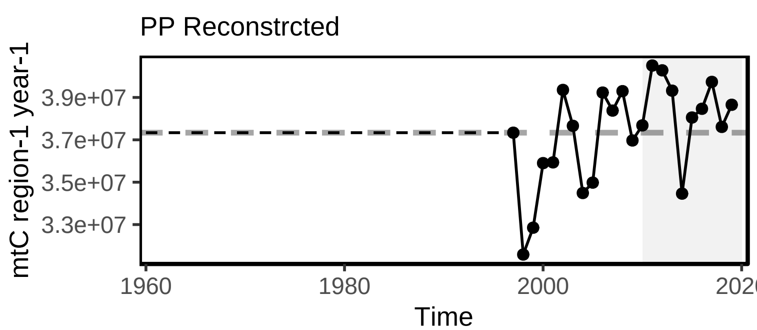

Figure 1: Primary production reconstructed (dashed line) using the mean of satellite-derived values from 1998-2010 (points); example for the Mid-Atlantic Bight.

It is also interpreted in the context of the ecosystem overfishing indicators introduced this year, which suggest when ecosystem overfishing may have ocurred over the past 50 years. In the SOE, we note that fisheries catches are sustained by a lower proportion of the ecosystem's primary production now than in the past, particularly when compared with the 1970s when the Fogarty and Ryther indices suggest that ecosystem overfishing may have occurred in the MAB and on GB. We also note that landings are generally declining while primary production remains steady or increasing across the EPUs. A full set of plots to help interpret the primary production required and ecosystem overfishing indices (including mean trophic level, which species are included in the landings, and the primary production time series) are available online. We welcome suggestions to include additional plots or conduct analyses to improve interpretation of these indices for the Councils.

4 Climate Change context

The NE SSC was interested in more explicitly addressing climate change in the reports. As described above, we have now reorganized the report into two major sections. The second section outlines risk to meeting fishery management objectives, with climate change representing the first major risk category (the other is offshore wind energy development). Climate risks to meeting fishery management objectives are also explicitly indicated and cross-referenced in the first section on performance against management objectives. We welcome feedback on this structural revision.

Climate forecasts at scales relevant to fishery management (months to years) are in progress, with at least one paper on statistical bottom temperature forecasts in review at present. We plan to include more of this information in future reports as the science becomes available, and welcome guidance on which forecast variables might be most useful to the Councils.

5 Clarify language (e.g., primary production required)

Both Councils asked for clarification of several terms, including "primary production required," and "fishery engagement." The NE SSC suggested adding a glossary to improve clarity. We have added an online glossary (https://noaa-edab.github.io/tech-doc/glossary.html) which is linked from the report to explain many terms. The Northeast Fisheries Science Center Research Communications Branch (NEFSC RCB) also reviewed the draft document to streamline language, and brief text was added to explain the information used in each indicator.

6 Copy Editing

The NE SSC pointed out copy editing errors in the document. The NEFSC RCB copy edited a draft version of the 2021 document. We are working to further integrate RCB copy editing into our production process in the future.

7 Ocean Acidification

Last year we reported on work in progress related to Ocean Acidification (OA), including:

- Aleck Wang (WHOI) and Chris Melrose (NEFSC) are working on climatology of spatial and seasonal patterns of carbonate chemistry parameters on the Northeast U.S. Continental Shelf, which will form a critical baseline for future OA indicators.
- Grace Saba (Rutgers) is the lead PI on a new project which is using gliders to characterize OA conditions and to validate/improve OA models for the region.
- There is ongoing experimental work being conducted at the NEFSC Milford lab that we could include if the information is relevant

Both Councils, and in particular the NE SSC, were interested in including this work as it becomes available. This year we included the data from gliders characterizing seasonal OA conditions on the Mid-Atlantic shelf (p. 25-26 MAFMC and Fig. 2), and compared the observed OA conditions with preliminary lab results on pH thresholds where surfclam growth may be impacted (p. 32 MAFMC).

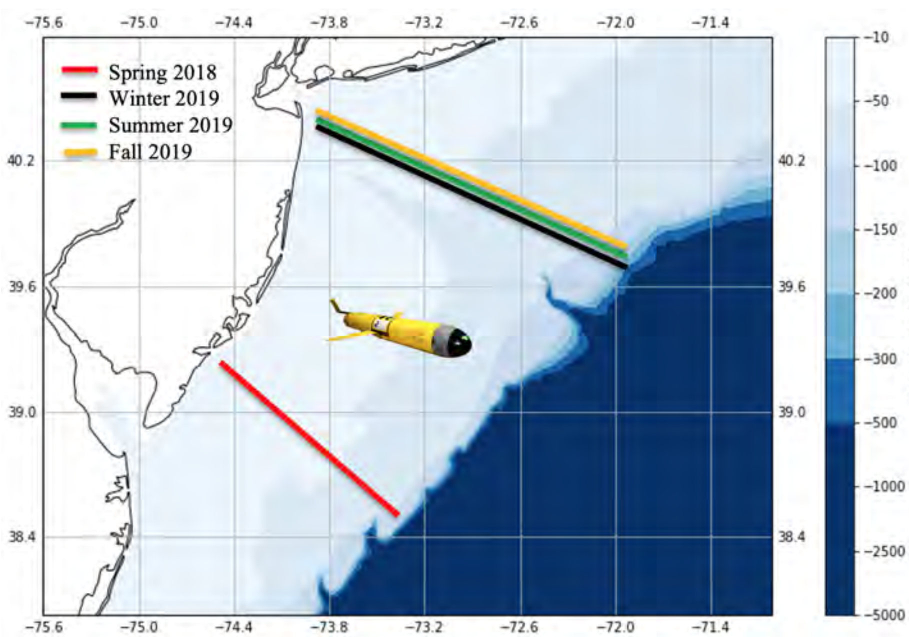

Figure 2: Locations and timing of glider-based pH transects on the Mid-Atlantic shelf.

We will continue to update OA information as it becomes available.

8 Include examples of High/Low engaged ports

Both Councils were interested in more information on fishery engagement trends, including clearer definitions of engagement and reliance, and the NE SSC requested examples of engagement scores at the fishing community level. Fishery engagement, reliance, and social vulnerability are briefly defined in the SOE text and glossary, with a link to the NMFS webpage defining all of these indicators and a maps with information for all communities.

A new presentation of individual community status with respect to engagement, reliance, and social vulnerability for both commercial and recreational fisheries was included as a baseline (p. 15-17 MAFMC and p. 19 NEFMC), to be updated in future years so that Councils may keep track of changes in community status.

9 Expand wind lease area and habitat overlap

The Mid-Atlantic Council and SSC remain interested in the potential effects of offshore wind development on ecosystems and fishery management, and asked to see expanded consideration of information beyond the NEFSC bottom trawl survey. This year offshore wind development indicators are highlighted in the new SOE section on risks to meeting fishery management objectives. The MA SSC expressed interest in an indicator of fishery revenue within wind lease areas, which has been provided this year with a focus on Council-managed species in each SOE report (p. 36 MAFMC and p. 36 NEFMC). Information on overlap of scientific surveys for ocean physics, low trophic levels, shellfish, fish, and protected species with wind lease areas is also provided in each report (p. 37 MAFMC and p. 38 NEFMC). Detailed maps highlighting the timing and type of potential development are also included. The wind energy area and habitat overlap information presented in 2020 could not be updated as there were no new NEFSC bottom trawl surveys, but the table is retained online as supplementary informtion.

During the production process, new information summarizing seabird, cetatean, and turtle "hotspots" with respect to wind lease areas was submitted by Timothy White (BOEM). We present that information here for feedback to determine if this should be refined and included in future SOE reports. Hotspot richness was defined as the sum of the number of persistent hotspots across taxa. Tim calculated individual persistent hotspots for about 60 different species (whales, seabirds, and sea turtles), then summed the individual hotspots across each grid cell to calculate hotspot richness, as shown on the map. A cell with a hotspot richness value of 8 represents 8 species-specific hotspots. All the wind energy areas intersect hotspots, and all values greater than 1 represent multi-species persistent hotspots (Fig. 3). Visualizations of hotspots for cetaceans, seabirds, and turtles separately are also available.

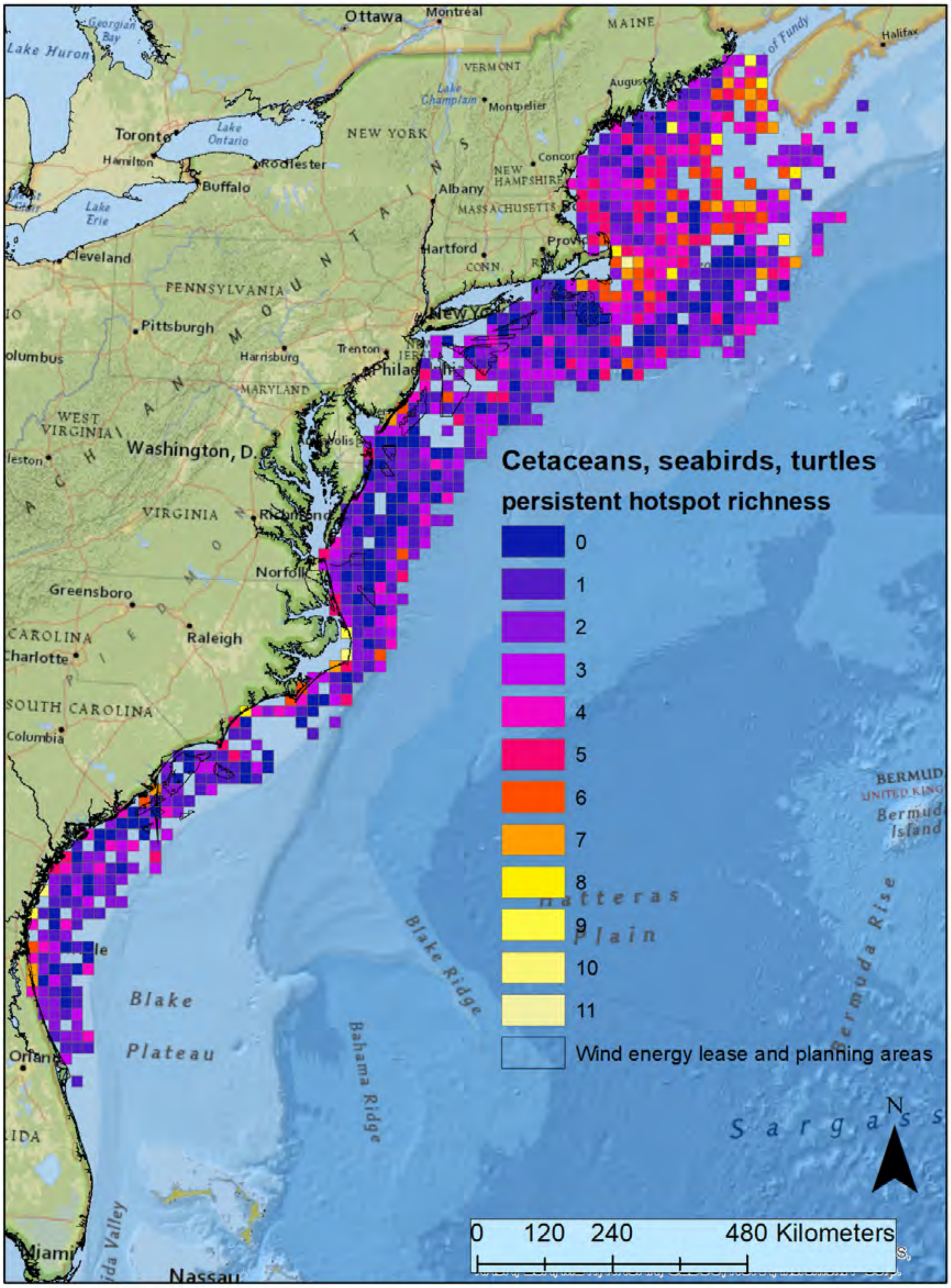

Figure 3: Overlap of whale, seabird, and turtle hotspots with wind lease areas.

We welcome further discussion on the expanded offshore wind development section, and suggestions for further indicator development that is most beneficial to the Councils.

10 Expand cold pool index

The MA SSC was interested in an expanded cold pool index, in particular with respect to timing of stratification and its breakdown in the fall. This year we introduced new cold pool metrics based on the GLORYS12V1 dataset, which is an global ocean reanalysis model for the ocean physics with 8 km resolution and 50 depth layers. In prior years, bottom temperature observations from the surveys were used to define the cold pool index. The advantage of the modeled product is the improved spatial and temporal resolution compared to the survey data. The vertical layers of the model will also allow us to examine stratification and mixing indices in future reports. One limitation, however, is the time series is shorter and there is a lag in the availability of the more recent data; current availaility is January 1993-June 2019.

In the SOE we visualize changes in cold pool area using this dataset to allow the Council to see how this dynamic habitat varies annually and in response to the temperature indicators we report. While we considered this to be an intuitive initial presentation, there are many other possible cold pool metrics that could be reported from this dataset. For example, time series of four additional metrics are available in the SOE dataset, `ecodata` (Fig. 4):

1. Name: T_mean; Definition: yearly-mean cold pool temperature distribution; Units: degrees C.
2. Name: T_min; Definition: yearly-min cold pool temperature distribution; Units: degrees C.
3. Name: T_peak; Definition: spatial cold pool temperature distribution at the peak day 140; Units: degrees C.
4. Name: V_max; Definition: yearly-max cold pool vertical distribution relative to depth; Units: meter/meter.

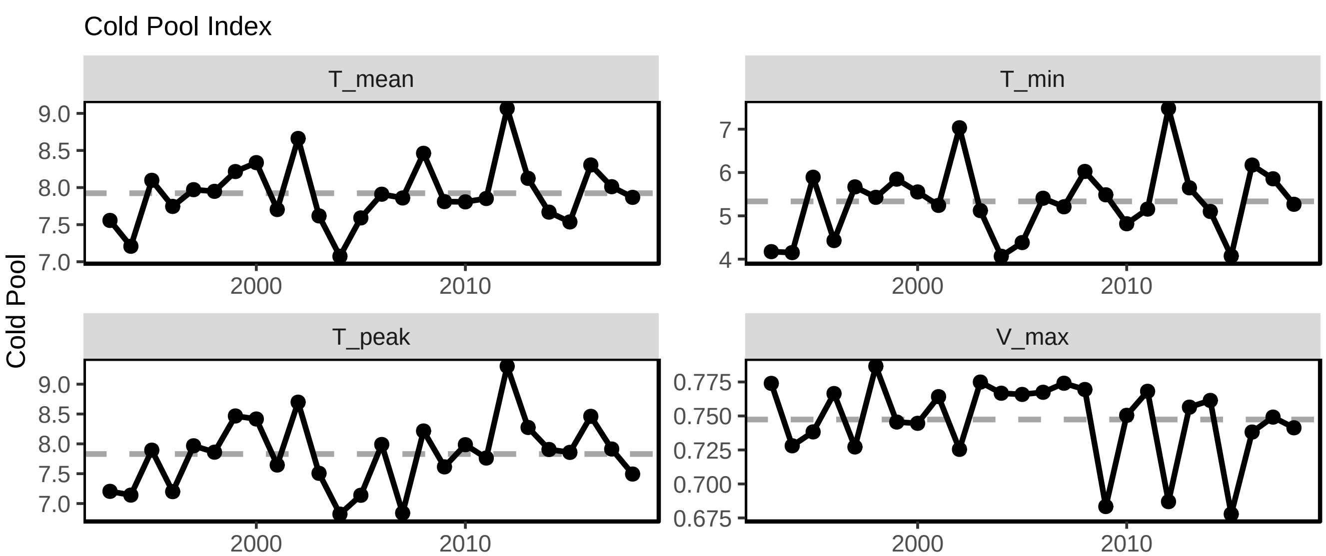

Figure 4: Mid-Atlantic cold pool metrics from the GLORYS reanalysis dataset, as defined in text above.

We welcome feedback on whether using this reanalysis dataset is preferable to the prior observation-based cold pool index. Dynamics of the cold pool have been described in detail using model-based information [2]. If this dataset seems promising, we seek suggestions on metrics the SSC would like to see from this dataset and how to present this information so that it is most useful to the Council.

11 Seperate Bigelow/Albatross catch diversity metric

The NE SSC requested a species diversity metric based on NEFSC trawl survey data. We had included such a metric in past reports (2017), but were concerned that apparent differences in diversity prior to and after 2008 may be driven by differences in survey vessels. While species-specific cpue and sizes have calibration coefficents between survey vessels, the number of species captured by the vessels has no known calibration coefficient.

After discussion with both SSCs in 2020, we calculated NEFSC trawl survey diversity metrics separately for the Albatross and Bigelow survey vessel time series. In each 2021 SOE we report the expected number of species per 1000 individuals sampled for each EPU in the fall, with uncertainty (p. 15 MAFMC and p. 18 NEFMC). Distinguising potential vessel effects from trends in diversity should be facilitated by this presentation. Plots for spring, as well as comparisons with Shannon diversity metrics combining both vessel time series as originally calculated, are available online (https://noaa-edab.github.io/ecodata/macrofauna_NE#Survey_Shannon_Diversity, https://noaa-edab.github.io/ecodata/macrofauna_MAB#Survey_Shannon_Diversity). We welcome further discussion to refine this and other diversity indices.

12 Shark abundance and catch indicators

The MAFMC requested information on biomass of sharks, as fishermen had reported encountering more blacktip, spinner, and sandbar sharks each summer. Both Councils have been interested in expanding data sources beyond the NEFSC bottom trawl survey for improved understanding of ecosystem dynammics. We were able to obtain commercial landings (Fig. 5), recreational landings (SOE p. 6 MAFMC and p. 8 NEFMC), and CPUE data (SOE p. 31 MAFMC and p. 34 NEFMC) from the Highly Migratory Species (HMS) group at NMFS Headquarters as well as bycatch information from the NEFSC Observer Program (SOE p. 30 MAFMC and p. 34 NEFMC).

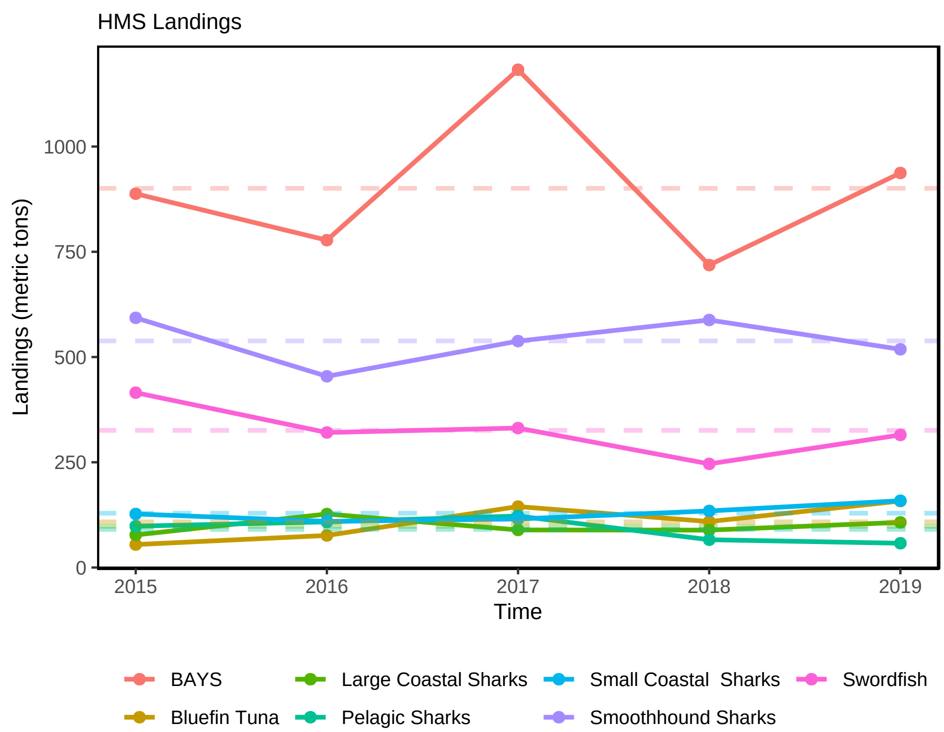

Figure 5: Highly Migratory Species (HMS) landings; groups include “Bluefin Tuna”, “BAYS”, “Swordfish”, “Large Coastal Sharks”, “Small Coastal Sharks”, “Pelagic Sharks”, “Smoothhound Sharks”. “BAYS” includes bigeye, albacore, yellowfin and skipjack tunas. “Large Coastal Sharks” includes blacktip, bull, great hammerhead, scalloped hammerhead, smooth hammerhead, lemon, nurse, sandbar, silky, spinner, and tiger sharks. “Small Coastal Sharks” includes Atlantic sharpnose, blacknose, bonnethead, finetooth sharks. “Pelagic Sharks” includes blue, porbeagle, shortfin mako, and thresher sharks. “Smoothhound Sharks” includes smooth dogfish shark.

In addition, commercial revenue from HMS (Fig. 6) and information on CPUE (bycatch) of many other species (Table 2) is available.

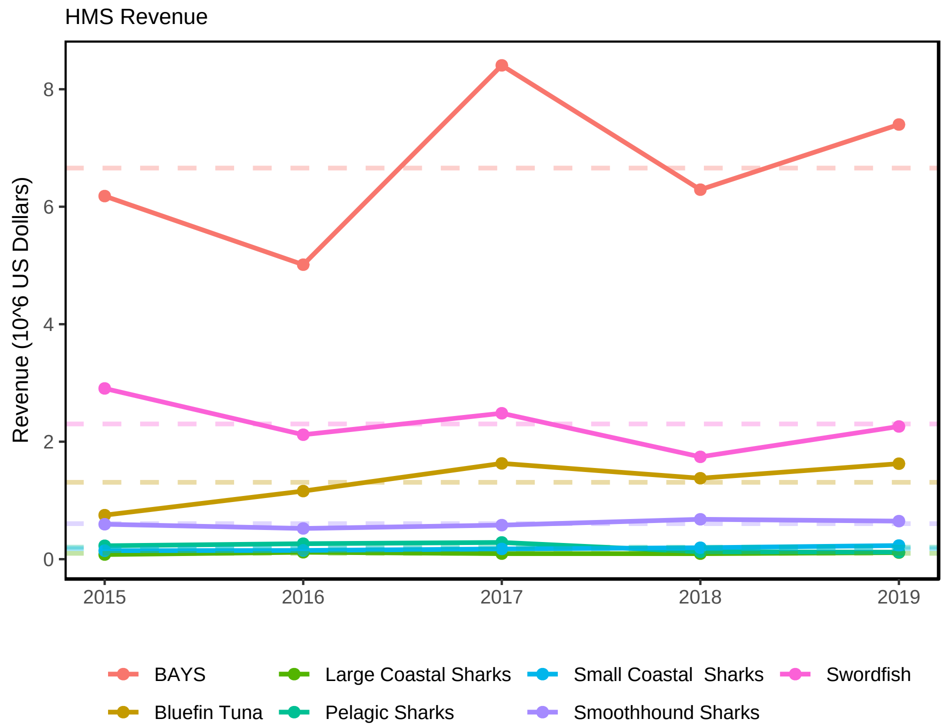

Figure 6: HMS revenue, groups are the same as previous figure.

Table 2: Species with CPUE available from HMS fishery observations.

Species	Species, continued
AMBERJACK	SHARK HAMMERHEAD SMOOTH
BARRACUDA	SHARK MAKO
BLUEFISH	SHARK MAKO LONGFIN
BONITO	SHARK MAKO SHORTFIN
CIGARFISH	SHARK NIGHT
COBIA	SHARK OCEANIC WHITETIP
DOLPHIN ATLANTIC SPOTTED	SHARK PORBEAGLE
DOLPHIN BOTTLENOSE	SHARK REQUIEM
DOLPHIN COMMON	SHARK SAND TIGER
DOLPHIN FISH	SHARK SANDBAR
DOLPHIN PANTROPICAL SPOTTED	SHARK SILKY
DOLPHIN RISSOS	SHARK SPINNER
ESCOLAR (SMOOTH SKIN)	SHARK THRESHER
GANNET NORTHERN	SHARK THRESHER BIGEYE
GULL	SHARK THRESHER COMMON
GULL GREAT BLACK BACKED	SHARK TIGER
GULL HERRING	SHEARWATER
JACK	SHEARWATER CORY'S
LANCETFISH	SHEARWATER GREATER
LITTLE TUNNY	SKATES/RAYS
MACKERAL SNAKE	SPEARFISH
MACKEREL KING	SPEARFISH LONGBILL
MANTA RAY	SPEARFISH ROUNDSCALE
MARINE FINFISH	SQUID
MARLIN BLUE	STORM PETREL
MARLIN WHITE	SUNFISH
OILFISH (ROUGH SKIN)	SUNFISH OCEAN
OPAH	SUNFISH SHARPTIAL
PELAGIC STINGRAY	SWORDFISH
POMFRET	TUNA ALBACORE
PUFFER	TUNA BIGEYE
REMORA	TUNA BLACKFIN
SAILFISH ATLANTIC	TUNA BLUEFIN
SHARK	TUNA SKIPJACK
SHARK ATLANTIC SHARPNOSE	TUNA YELLOWFIN
SHARK BIGNOSE	TURTLE GREEN
SHARK BLACKNOSE	TURTLE HAWKSBILL
SHARK BLACKTIP	TURTLE KEMP'S RIDLEY
SHARK BLUE	TURTLE LEATHERBACK
SHARK BULL	TURTLE LOGGERHEAD
SHARK CROCODILE	UNCODED ANIMAL
SHARK DOGFISH	UNKNOWN
SHARK DOGFISH SMOOTH	WAHOO
SHARK DOGFISH SPINEY	WHALE BEAKED
SHARK DUSKY	WHALE PILOT
SHARK FINETOOTH	WHALE PILOT LONGFIN
SHARK HAMMERHEAD	WHALE PILOT SHORTFIN
SHARK HAMMERHEAD GREAT	WHALE SPERM PYGMY
SHARK HAMMERHEAD SCALLOPED	WHITE MARLIN / R.S. SPEARFISH

With these new contributions, we can potentially include more information on performance relative to management objectives for HMS, such as a Kobe plot similar to the one presented for Council-managed species. We welcome feedback on what additional information on HMS would be most useful to the Councils in future SOE reports.

13 Uncertainty estimates

Both Councils asked for uncertainty estimates to be included with indicators. Uncertainty estimates are now included for all survey biomass indices (see also Section 23), survey diversity (expected number of species), harbor porpoise and gray seal bycatch, North Atlantic right whale abundance, forage anomaly, and forage fish energy density indicators. We continue to work towards including uncertainty estiamtes for as many indicators as possible. We welcome feedback from the Councils on which indicators are highest priority for the estimation and visualization of uncertainty.

14 Bycatch index

The NEFMC was interested in additional bycatch indices. This year we added an index of gray seal bycatch to both SOE reports (p. 18 MAFMC and p.21 NEFMC). We have also added observer information on bycatch of sharks in Northeast US fisheries and additional information is available on catch and bycatch of multiple species in pelagic fisheries (see Section 12). We welcome suggestions for which species bycatch indices to prioritize in future reports.

15 Marine Mammal consumption

The MAFMC has continued interest in estimates of marine mammal consumption. While there have been no updated reports of total marine mammal consumption for the US Northeast Shelf ecosystem since 2015 [3], new diet studies are in progress. We included updated information on seal diets in both SOE reports (p. 31 MAFMC and p. 34 NEFMC). Once completed, these diet studies combined with mammal population estimates (see Section 24) could be used to update marine mammal consumption estimates.

16 Estuarine Water Quality

Both Councils have been interested in estuarine water quality. While the Chesapeake Bay water quality index reported previously is updated on a 3-year basis, so no update was available this year, we included more information on Chesapeake Bay conditions and impacts to managed species in the MAFMC SOE (p. 22-23, p. 31) as well as in the MAFMC EAFM risk assessment update. In addition a new indicator catalog (currently in progress) will contain more in-depth information on temperature, salinity, dissolved oxygen, and submerged aquatic vegetation submitted by the NOAA Chesapeake Bay Office. There are plans to expand this contribution in the future to include more MAFMC managed species, and to use the online catalog as a repository for detailed information in support of the SOE.

The NE SSC was interested in estuarine water quality in the New England region; and we have been in discussion with multiple organizations working in coastal and estuarine systems to incorporate more information. However we had inadequate resources develop New England estuarine water quality indicators in 2020.

17 Forage abundance

The MAFMC has requested integrated indicators of small pelagic fish and forage abundance for several years. In addition to the trawl survey-based information on planktivores included in the document, this year we have added a new forage anomaly indicator based on combined zooplankton and ichthyoplankton data (p. 28-29 MAFMC and p. 32 NEFMC). We welcome feedback on this new indicator, including taxa currently included (Table 3).

Table 3: Groups included in the zooplankton and ichthyoplankton-based forage anomaly indicator

Group	Category	Taxa Included
Calanus finmarchicus	Zooplankton	Calanus finmarchicus
Large Calanoid Copepods	Zooplankton	Calanus spp., Calanus minor, Eucalanus spp., Metridia lucens
Small Calanoid Copepods	Zooplankton	Small Calanoid Copepods less than 1.6 mm Prosome length
Cyclopoid Copepods	Zooplankton	Cyclopoid Copepods
Krill	Zooplankton	Euphausiacea
Mysid	Zooplankton	Mysidacea
Hyperiidea	Zooplankton	Hyperiidea Amphipods
Gammaridea	Zooplankton	Gammaridea Amphipods
Pteropod	Zooplankton	Pteropoda
Larvaceans	Zooplankton	Appendicularia
Cnidaria	Zooplankton	Cnidaria
Ctenophore	Zooplankton	Ctenophora
Salp	Zooplankton	Thaliacea
Unmanaged Clupeids	Ichthyoplankton	Clupeidae
Managed Clupeids	Ichthyoplankton	Clupeidae- Atlantic herring, Atlantic menaden, Alosa spp.
Anchovies	Ichthyoplankton	Engraulidae
Sandlance	Ichthyoplankton	Ammodytidae
Bristlemouths and hatchetfishes	Ichthyoplankton	Stomiiformes
Lanternfish	Ichthyoplankton	Myctophidae
Rocklings	Ichthyoplankton	Lotidae
Codlets	Ichthyoplankton	Bregmacerotidae
Cuskeels	Ichthyoplankton	Ophidiidae
Cod, Haddock, Pollock	Ichthyoplankton	Gadidae- Atlantic cod, Haddock, Pollock
Urophycis Hakes	Ichthyoplankton	Phycidae- Urophycis spp., Red hake, White hake, Spotted hake
Merluccius Hakes	Ichthyoplankton	Merlucciidae- Merluccius spp., Silver hake, Offshore hake
Mackerels	Ichthyoplankton	Scombridae
Butterfishes	Ichthyoplankton	Stromateidae
Unmanaged Flounders	Ichthyoplankton	Pleuronectiformes- Citharichthys, Etropus, Syacium, Bothus, Hippoglossina, Trichopsetta
Managed Flounders	Ichthyoplankton	Pleuronectiformes- Paralichthys, Pseudopleuronectes, Hippoglossoides, Hippoglossus, Limanda, Glyptocephalus

Forage energy content is another important consideration which may affect predators as much as fluctuations in abundance. We have updated information on forage fish energy content based on NEFSC bottom trawl surveys in the SOE reports (p. 29 MAFMC and p. 32 NEFMC) which highlights the potential for seasonal and interannual variability in energy content.

The MAFMC asked whether Atlantic menhaden could be evaluated for energy content. We agree that it would be useful to look at energy content of menhaden, but they are not included at present because they are not caught reliably in NEFSC bottom trawl surveys. Menhaden are much higher in the water column and/or inshore of NEFSC surveys. Any other source of data would need to maintain the rapid processing and freezing methods applied on the NEFSC survey vessel to allow accurate estimation of % dry weight.

18 Linking Condition

Both Councils were interested in more quantitative analysis linking environmental indicators, managed fish indicators, and fishery indicators to facilitate use of this information in management. Considerable progress has been made on linking environmental indicators to fish condition for multiple species, with an overview of preliminary Generalized

Additive Modeling (GAM) results described in the SOE. The NE SSC commented that overall (total) biomass could be included in the analysis of fish condition; this has been included in the analysis, as well as local abundance and local biomass (Fig. 7).

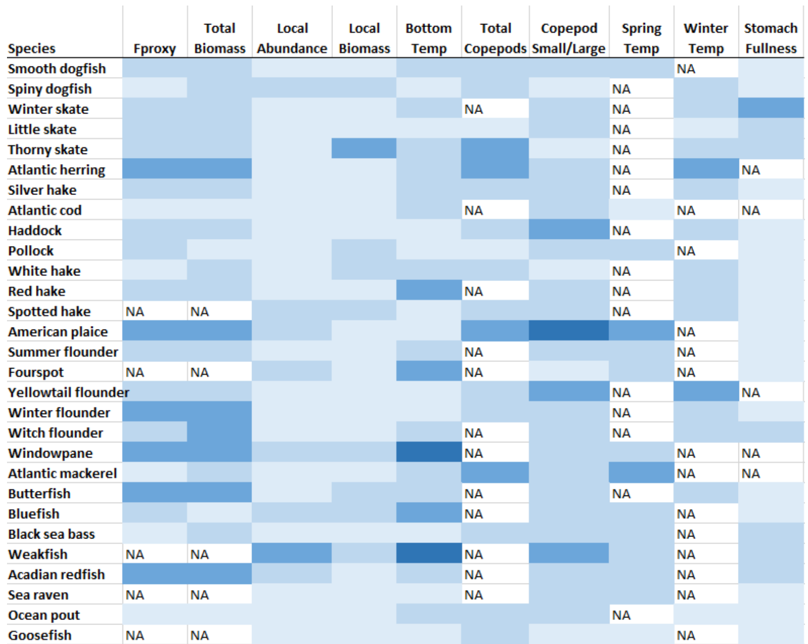

Figure 7: Preliminary results: GAM fish condition deviance explained by environmental variables, with darker cells indicating more important variables for that species.

Correlations between the potential drivers of condition are also being explored. Indices that are correlated (R>0.3, dark cells in Fig. 8) will not be used together in future full GAM analyses.

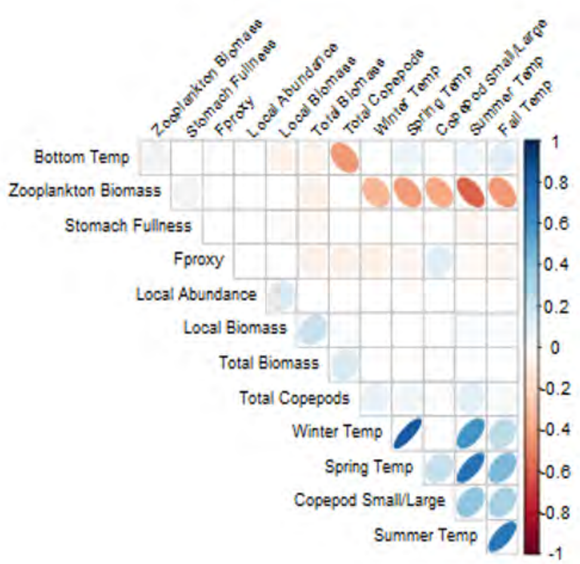

Figure 8: Preliminary results: correlations between potential environmental drivers of fish condition.

The MA SSC commented that indices of growth (weight at age) used in stock assessments could also be included in the analysis, and that methods such as Gaussian network modeling may be appropriate. The fish condition working group explored GAM analyses to link environmental indices to weights at age for managed fish species, but there were diagnostic issues that were not present in the condition analyses. The fish condition working group is continuing to make improvements to the GAM analyses, exploring options for indices of growth to integrate this information into future analyses. Similarly, modeling approaches in addition to GAMs are under investigation. Another component of the project evaluating potential links between fish condition and market prices is also ongoing.

19 Avg weight of diet components by feeding group

This information is being examined as part of the fish condition links project described above. However, we had insufficient resources to develop an independent indicator for the SOE in 2020.

20 Mean stomach weight across feeding guilds

This information is being examined as part of the fish condition links project described above. However, we had insufficient resources to develop an independent indicator for the SOE in 2020.

21 Shellfish growth/distribution linked to climate (system productivity)

The MAFMC requested that we investigate how shellfish growth and distribution information could be linked to climate indicators and possibly ecosystem productivity. We are working with Dr. Roger Mann who has obtained NSF INTERN funding for his student Alexis Hollander to spend up to 6 months at NEFSC working on shellfish growth, and to facilitate integration of SOE climate indicators with this work. This work should proceed later in 2021 or whenever in-person work is feasible.

22 Cumulative weather index

The MAFMC requested that we include information on weather that might affect recreational or commercial fishing effort. We are partnering with the National Weather Service (NWS) to provide this type of information. A preliminary index was developed based on Small craft/Gale warnings from the NWS Boston forecast office for the area off Cape Cod (Table 4).

Table 4: Gales = winds >=34 knots (usually associated with a coastal storm); Storm = winds >=48 knots

Year	Gale.Warnings	Storm.Warnings
2008	61	8
2009	49	11
2010	47	6
2011	48	5
2012	30	8
2013	43	6
2014	36	7
2015	80	3
2016	55	8
2017	52	15
2018	60	14
2019	57	8

We seek feedback from the Council on the utility of this information to further develop an indicator for future SOE reports. Is monthly data more useful than annual as above? Would seasonal aggregates be useful? Is there a certain wind speed where vessels alter effort? We look forward to further integration of NWS information for our region.

23 Management complexity

The MAFMC asked for indicators of management complexity for use in the EAFM risk assessment. An NEFSC summer student started work on this in 2018, but we have lacked capacity to finish the project since then. If resources allow we will continue the project, and guidance for further indicator developmet is welcome.

24 VAST and uncertainty

Both Councils were interested in model-based estimates of aggregate fish biomass and uncertainty based on preliminary results presented in 2020. We experimented with a model-based estimate of uncertainty for survey biomass which accounts for both spatial and temporal sources (VAST; [4]). Although the surveys were not completed this year, work on model-based estimates continues and may be presented next year.

25 Seal index

The MA SSC requested indices of abundance for seals rather than the narrative supplied in 2020. Analysis and review is in progress to update abundance and possibly assess trends in US waters for harbor and gray seals; however, these estimates were not available for the 2021 SOE. New information on increasing numbers of gray seal pups born at US pupping sites has been added to the narrative for both SOE reports [5]. A plot visualizing pup rates of increase has been added to the NEFMC SOE (p. 23), as it is most relevant to the Gulf of Maine.

A detailed stock assessment for Canadian Northwest Atlantic gray seals was published in 2017 and is available online. As noted in the SOE, the Candian population is likely supplementing the US population, and seals range widely, so distinguishing trends within US waters or individual EPUs is complex. However, a gray seal survey is in progress for 2021, and updated information will be included as it is available.

As noted by the MA SSC, seals are important predators in the ecosystem, so we have included additional updates on seal diet studies in progress, and have moved the discussion of seals as predators into a more general discussion of predator trends in the SOE along with information added for sharks.

26 Incorporate social sciences survey from council

The NE SSC was interested in reviewing information on the perception and use of social science information from an NEFMC survey. We had insufficient resources to address this in 2020. We welcome input from the New England Council and staff on how best to incorporate this information in future reports.

27 Young of Year index from multiple surveys

The MA SSC was interested in a young of year index from multiple surveys. In past reports we have included the fish productivity index, which calculates the number of small fish per biomass of large fish of the same species from NEFSC surveys. This index is based only on the NEFSC bottom trawl survey, which was not completed in 2020, so the index was not updated; we retain last year's indices online for reference (MAB, GB and GOM). We recognize that this is not strictly a young of year index, and it is from a single survey.

We had insufficient resources to address this in 2020.

28 Biomass of species not included in bottom trawl surveys

We included information on sharks this year (Section 12), and data streams for many other species not captured by bottom trawl surveys (BTS) are under investigation. However, we had insufficient resources to address this fully in 2020.

29 Estuarine condition relative to power plants and temp

We had insufficient resources to address this in 2020.

30 Inflection points for indicators

While this could not be addressed for individual indicators in 2020, we did include new Ecosystem Overfishing indicators with proposed thresholds (see Section 2, Ecosystem Overfishing indicators). We welcome suggestions for which additional indicators or groups of indicators should be prioritized for inflection point/threshold analysis in upcoming years.

31 Reduce indicator dimensionality with multivariate statistics

The NE SSC suggested statistical analysis to reduce the number of indicators and remove redundant indicators in the report. Some work has been initiated on this in past years, but we had insufficient resources to complete this in 2020.

32 Breakpoints

While this could not be addressed for individual indicators in 2020, our newly introduced regime shifts synthesis theme will be explored further in upcoming years. We welcome suggestions for which individual indicators or groups of indicators should be prioritized for regime shift analysis in upcoming years.

33 Re-evaluate EPUs

Initial planning for re-evaluating Northeast US Shelf ecological production units has started, but we had insufficient resources to begin the project in 2020.

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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[1], and revised the document in February 2019[2]. 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 [1]. 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 [2]. 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 updates the Mid-Atlantic Council's initial EAFM risk assessment [3] with indicators from the 2021 State of the Ecosystem report and with new analyses by Council Staff for the Management elements. The risk assessment was designed to 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.

Many risk rankings are unchanged based on the updated indicators for 2021 and the Council's risk criteria. Below, we highlight only the elements where updated information has changed the perception of risk. In addition, we present new indicators based on Council feedback on the original risk analysis that the Council may wish to include in future updates to the EAFM risk assessment.

[1] http://www.mafmc.org/s/EAFM_Guidance-Doc_2017-02-07.pdf

[2] http://www.mafmc.org/s/EAFM-Doc-Revised-2019-02-08.pdf

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

Changes from 2020: Ecological risk elements

Decreased Risk: 0

No indicators for existing ecological elements have changed enough to warrant decreased risk rankings according to the Council risk critiera.

Increased Risk: 1

Butterfish biomass (B) status has changed from low risk (B > Bmsy) to low-moderate risk (Bmsy > B > 0.5Bmsy) based on the new benchmark assessment (Table 3).

Update on Chesapeake Bay water quality

Many important MAFMC managed species use estuarine habitats as nurseries or are considered estuarine and nearshore coastal-dependent (summer flounder, scup, black sea bass, and bluefish), and interact with other important estuarine-dependent species (e.g., striped bass and menhaden). In 2019, we reported on improving water quality in Chesapeake Bay, and suggested that the Council could reconsider high risk ratings for estuarine-dependent species if this trend continues.

However, as reported in the 2020 SOE, the Chesapeake Bay experienced below average salinity in 2019, caused by the highest precipitation levels ever recorded for the watershed throughout 2018 and 2019.

In 2020, Chesapeake Bay experienced a warmer than average winter, followed by a cooler than average spring, with potential impacts to striped bass and blue crabs as noted in the 2021 SOE. Observations from the NOAA CBIBS buoys indicated higher-than-average salinity throughout 2020, particularly in the upper Chesapeake Bay (Gooses Reef), suggesting that the region experienced less precipitation than usual.

A dissolved oxygen model operated by the Virginia Institute of Marine Science (VIMS) and Anchor QEA (www.vims.edu/hypoxia) estimated that the overall severity and duration of hypoxia in the Chesapeake Bay was lower and shorter in 2020 compared to most recent years. A smaller-than-average spring freshet, which resulted in above-average salinity in the Bay, also might have decreased surface runoff and nutrient concentrations. Reduced nutrient inputs and cool spring temperatures likely contributed to reduced hypoxia in 2020. Information on submerged aquatic vegetation (SAV) collected in 2020 has not yet been processed, but may be included in upcoming SOE reports.

It is unclear how these annual updates in Chesapeake Bay temperature, salinity, dissolved oxygen, and SAV will affect the overall water quality indicator (which was not updated for the 2020 or 2021 report because it requires multiple years to update). The new information below suggests that high risk for estuarine-dependent species is still warranted. However, direct links between estuarine habitat conditions and population attributes for managed species (as reported for Chesapeake Bay striped bass and blue crabs) could be incorporated into future risk assessments as the science continues to develop.

Update on Climate risks

New information has been added to the SOE that could be used to update species-specific Climate risk rankings in the future. Risks to species productivity (and therefore to achieving OY) due to projected climate change in the Northeast US were evaluated in a comprehensive assessment [4]. 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.

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.

The 2021 SOE includes multiple climate indicators including surface and bottom water temperature, marine heat waves, cold pool area, and new information on ocean acidification measurements. Combined with species sensitivity information from lab work, these indicators could be used to further clarify climate risks to managed species.

For example, new glider-based observations revealed areas of low pH (7.8) during summer in Mid-Atlantic habitats occupied by Atlantic surfclams and sea scallops (Fig. 1) [5]. This seasonal pH minimum is associated with cold-pool subsurface and bottom water, which is cut off from mixing with surface water by strong stratification. However, seawater pH in shelf waters increased during the fall mixing period due to the influence of a slope water mass characterized by warm, salty, highly alkaline seawater. Lower pH in nearshore waters is likely associated with freshwater input.

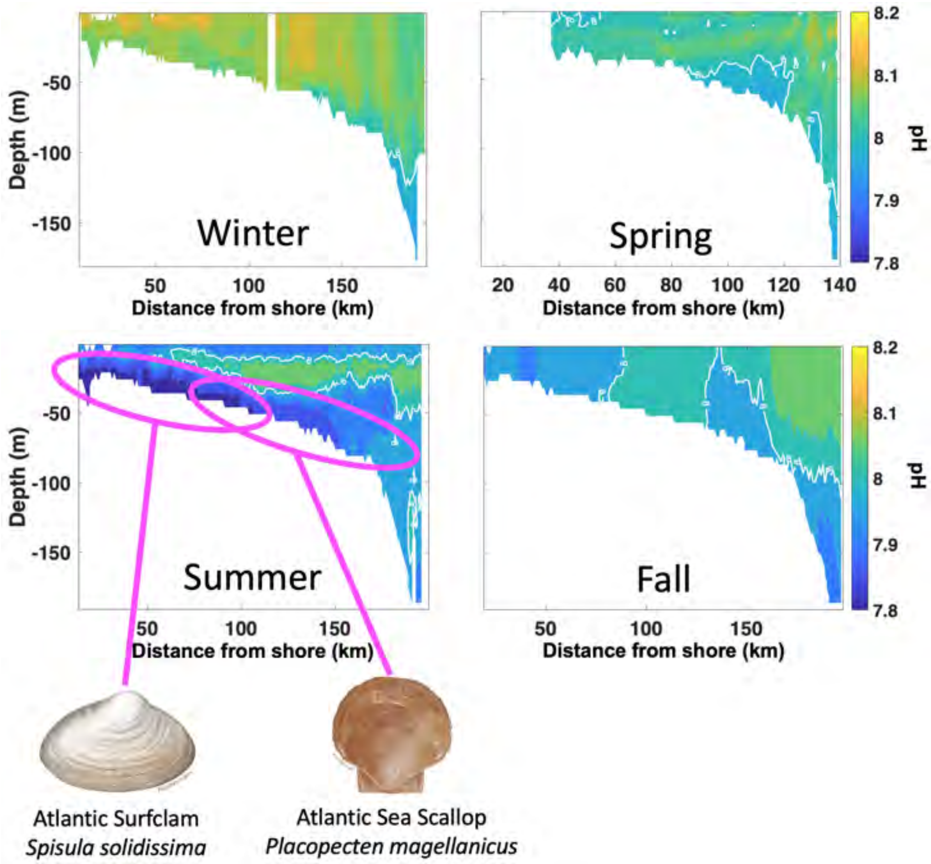

Figure 1: Seasonal glider-based pH observations on the Mid-Atlantic Bight shelf (New Jersey cross-shelf transect) in relation to Atlantic surfclam and Atlantic sea scallop habitats (modified from Wright-Fairbanks et al. 2020).

Surclams were ranked high vulnerability in the Northeast Fish and Shellfish Climate Vulnerability Assessment (FCVA) completed in 2016 [4], therefore they rank moderate-high risk for the Climate element of the MAFMC EAFM risk assessment. Surfclam climate vulnerability was based on both sensitivity and exposure to ocean acidificaiton, exposure to ocean warming, and low adult mobility. Recent lab studies have found that surfclams exhibited metabolic depression in a pH range of 7.46-7.28 [6]. At pH of 7.51, short term experiments indicated that surfclams were selecting particles differently, which may have long term implications for growth [6]. Computer models would help in determining the long term implications of growth on surfclam populations. Data from about one year of observations (2018-2019) show that seasonal ocean pH has not yet reached the metabolic depression threshold observed for surfclams in lab studies so far; however, thresholds at different life stages, specifically larval stages that are typically more vulnerable to ocean acidification, have not yet been determined. Monitoring pH in surfclam habitats could be used to assess Climate risk in the future.

Potential new indicators

Habitat Climate Vulnerability

A Habitat Climate Vulnerability Assessment (HCVA; [7]) for habitat types in the Northeast US Large Marine Ecosystem was completed in 2020. To better understand which species depend on vulnerable habitats, the Atlantic Coastal Fish Habitat Partnership (ACFHP) habitat-species matrix [8] was used in conjunction with the results of the HCVA and the Northeast Fish and Shellfish Climate Vulnerability Assessment (FCVA) completed in 2016 [4]. The ACFHP matrix identified the importance of nearshore benthic habitats to each life stage of select fish species, which helps elucidate species that may be highly dependent on highly vulnerable habitats that were identified in the HCVA.

Several MAFMC managed species, including black sea bass, scup, and summer flounder, are dependent on several highly vulnerable nearshore habitats from salt marsh through shallow estuarine and marine reefs. Details on highly vulnerable habitats with linkages to a variety of species, including which life stages have different levels of dependence on a particular habitat, are available in a detailed table.[3]

Species highlighted here are those that are highly dependent on highly vulnerable habitats. A ranking matrix was created using the habitat vulnerability rankings compared to the habitat importance rankings to determine the criteria, and for the purposes of this submission, "high dependence on a highly vulnerable habitat" encompasses moderate use of very highly vulnerable habitats, high use of highly or very highly vulnerable habitats, or very high use of moderately, highly, or very highly vulnerable habitats.

Preliminary species narratives have been developed by Grace Roskar and Emily Farr (NMFS Office of Habitat Conservation), using information from the entire team that worked on the HCVA. We include two here so that the Council may provide feedback to improve their utility for management in general and for potentail future inclusion in the EAFM risk assessment.

Black Sea Bass *Summary:* Black sea bass have a high vulnerability to climate change, due to very high exposure related to surface and air temperature in both inshore and offshore waters, and moderate sensitivity of early life history requirements. Climate change is predicted to have a positive effect on black sea bass, due to warmer temperatures increasing spawning and therefore recruitment, and distribution of the species shifting farther north [4].

The habitats important to black sea bass, such as shellfish reefs, submerged aquatic vegetation, and subtidal rocky bottom habitats, are vulnerable to projected changes in sea surface temperature. Additionally, intertidal habitats such as shellfish reefs are also vulnerable to projected changes in air temperatures and sea level rise. Habitat condition and habitat fragmentation were also of concern for shellfish reefs and submerged aquatic vegetation. The species itself is also vulnerable to temperature changes, as mentioned above. The overlapping high importance of intertidal and subtidal shellfish reefs to black sea bass and the very high to high climate vulnerability of these habitats, respectively, show a potential critical nexus of climate vulnerability.

Mid-Atlantic *Summary:* Shellfish reef habitats are highly important for both juveniles/young-of-the-year and adults. These life stages utilize both marine and estuarine shellfish reefs, in both intertidal and subtidal zones, which are very highly vulnerable and highly vulnerable, respectively. Other important habitats for black sea bass include submerged aquatic vegetation, which is highly vulnerable, and subtidal sand and rocky bottom habitats, which have low vulnerability. More information is needed on use of intertidal benthic habitats by black sea bass. Juvenile occurrence on sandy intertidal flats or beaches is rare, according to [9], but additional information on the use and importance of intertidal rocky bottom or intertidal benthic habitat use by adults is lacking. According to [9], black sea bass eggs have been collected in the water column over the continental shelf, as has larvae. As water column habitats were not included in ACFHP's assessment of habitat importance, finer-scale information on the importance of specific pelagic habitats is needed for the species.

Habitat importance by life stage:

- Juveniles/Young-of-the-year:

[3] https://noaa-edab.github.io/ecodata/Hab_table

- Marine and estuarine intertidal shellfish reefs, which are very highly vulnerable to climate change, are of high importance.

- Marine and estuarine submerged aquatic vegetation and subtidal shellfish reefs, which are highly vulnerable to climate change, are of high importance.

- Marine intertidal rocky bottom habitats, which are highly vulnerable to climate change, are of high importance.

- Marine (<200 m) and estuarine subtidal rocky bottom habitats, which have a low vulnerability to climate change, are also of high importance.

• Adults:

- Marine and estuarine intertidal shellfish reefs, which are very highly vulnerable to climate change, are of high importance.

- Marine and estuarine subtidal shellfish reefs, which are highly vulnerable to climate change, are of high importance.

- Marine intertidal rocky bottom habitats, which are highly vulnerable to climate change, are of high importance.

- Marine and estuarine submerged aquatic vegetation, which are highly vulnerable to climate change, are of moderate importance.

- Marine (<200 m) and estuarine subtidal rocky bottom habitats, which have a low vulnerability to climate change, are also of high importance.

- Marine (<200 m) and estuarine subtidal sand habitats, including sandy-shelly areas, which have a low vulnerability to climate change, are also of moderate importance.

New England *Summary:* All habitats in New England for black sea bass were ranked as moderately important, likely indicating that the species uses a diverse range of habitats rather than high dependence on a specific habitat type. Shellfish reef habitats are moderately important for both juveniles/young-of-the-year and adults. These life stages utilize both marine and estuarine shellfish reefs, in both intertidal and subtidal zones, which are very highly vulnerable and highly vulnerable, respectively. Juveniles/young-of-the-year are also moderately dependent on native salt marsh habitats, which are highly vulnerable to climate change. Other moderately important habitats for black sea bass include submerged aquatic vegetation, which is highly vulnerable, and subtidal sand and rocky bottom habitats, which have low vulnerability. More information is needed on use of intertidal benthic habitats by black sea bass. Juvenile occurrence on sandy intertidal flats or beaches is rare, according to [9], but additional information on the use and importance of intertidal rocky bottom or intertidal benthic habitat use by adults is lacking.

Habitat importance by life stage:

• Juveniles/Young-of-the-year:

- Marine and estuarine submerged aquatic vegetation and subtidal shellfish reefs, which are all highly vulnerable to climate change, are of moderate importance.

- Marine and estuarine intertidal shellfish reefs, which are very highly vulnerable to climate change, are of moderate importance.

- Native salt marshes, which are very highly vulnerable to climate change, are of moderate importance. Marine (<200 m) and estuarine subtidal rocky bottom habitats, which have a low vulnerability to climate change, are of moderate importance.

• Adults:

- Marine and estuarine submerged aquatic vegetation and subtidal shellfish reefs, which are all highly vulnerable to climate change, are of moderate importance.

  - Marine and estuarine intertidal shellfish reefs, which are very highly vulnerable to climate change, are of moderate importance.

  - Marine (<200 m) and estuarine subtidal rocky bottom habitats, which have a low vulnerability to climate change, are of moderate importance.

  - Structured sand habitats in marine (<200 m) and estuarine subtidal areas, which have a low vulnerability to climate change, and marine intertidal areas, which are highly vulnerable, are of moderate importance.

Summer Flounder *Summary:* Summer flounder were ranked moderately vulnerable to climate change due to very high exposure to both ocean surface and air temperature, but low sensitivity to all examined attributes. Broad dispersal of eggs and larvae and seasonal north-south migrations by adults lend the species a high potential for distribution shifts. However, climate change is expected to have a neutral effect on the species, although there is high uncertainty surrounding this. The dispersal of eggs and larvae and the broad use of both estuarine and marine habitats could result in climate change having a positive effect, but uncertainty remains [4].

The habitats important to summer flounder, such as intertidal benthic habitats, submerged aquatic vegetation, and native salt marsh habitats, are vulnerable to projected changes in temperature as well as sea level rise. Subtidal benthic habitats are vulnerable to changes in sea surface temperature. The species itself is also vulnerable to such factors, as they are exposed to changes in conditions in both inshore and offshore habitats. The overlapping high importance of native salt marsh and submerged aquatic vegetation habitats to the species and the very high and high climate vulnerability of these habitats, respectively, show a potential critical nexus of climate vulnerability.

Mid-Atlantic *Summary:* Marine and estuarine sand and mud habitats are highly important to juvenile and adult summer flounder, and these habitats range in their vulnerability to climate change. For example, marine intertidal sand is highly vulnerable, whereas subtidal mud and sand habitats have low vulnerability. In addition to these fine bottom benthic habitats, native salt marshes are highly important to juveniles and moderately important to adults, yet these habitats are very highly vulnerable to climate change. Eggs and larvae utilize pelagic continental shelf habitats; however, water column habitats were not included in ACFHP's assessment of habitat importance. Finer-scale information on the importance of specific pelagic habitats is needed for the species.

Habitat importance by life stage:

- Juveniles/Young-of-the-year:
  - Marine and estuarine intertidal shellfish reefs, which are very highly vulnerable to climate change, are of moderate importance.
  - Marine and estuarine subtidal shellfish reefs, which are highly vulnerable to climate change, are of moderate importance.
  - Marine and estuarine submerged aquatic vegetation, which are highly vulnerable habitats, are of high importance.
  - Native salt marsh habitats, which are very highly vulnerable to climate change, are of high importance.
  - Marine and estuarine subtidal and intertidal sand and mud bottom habitats are of high importance. These habitats range in climate vulnerability, from high vulnerability of marine intertidal sand to low vulnerability of marine subtidal sand and mud (<200 m) and estuarine subtidal sand.
- Adults:
  - Marine and estuarine submerged aquatic vegetation, which are highly vulnerable habitats, are of moderate importance.

  - Native salt marsh habitats, which are very highly vulnerable to climate change, are of moderate importance.
  - Marine and estuarine subtidal and intertidal sand and mud bottom habitats are of high importance. These habitats range in climate vulnerability, from high vulnerability of marine intertidal sand to low vulnerability of marine subtidal sand and mud (<200 m) and estuarine subtidal sand.
- Spawning Adults:
  - Marine subtidal (<200 m) sand habitats, which have a low vulnerability to climate change, are of high importance.

We seek Council feedback on how best to include information on habitat climate vulnerability for managed species in future EAFM risk assessments.

Changes from 2020: Economic, Social, and Food production risk elements

Decreased Risk: 0

No indicators for existing economic, social, and food production elements have changed enough to warrant decreased risk rankings according to the Council risk critiera.

Increased Risk: 0

No indicators for existing economic, social, and food production elements have changed enough to warrant increased risk rankings according to the Council risk critiera.

Potential new indicators

Social vulnerability in commercial and recreational fishing communities

Social vulnerability measures social factors that shape a community's ability to adapt to change and does not consider gentrification pressure (see detailed definitions). Communities that ranked medium-high or above for one or more of the following indicators: poverty, population composition, personal disruption, or labor force structure, are highlighted in red.

Commercial fishery engagement measures the number of permits, dealers, and landings in a community, while reliance expresses these numbers based on the level of fishing activity relative to the total population of a community. In 2020, we reported that the number of highly engaged Mid-Atlantic commercial fishing communities had declined over time, and engagement scores had also declined in medium-highly engaged communities. Here we focus on the top ten most engaged, and top ten most reliant commercial fishing communities and their associated social vulnerability (Fig. 2). Barnegat Light and Cape May, NJ, and Reedville, VA are highly engaged and reliant with medium-high to high social vulnerability.

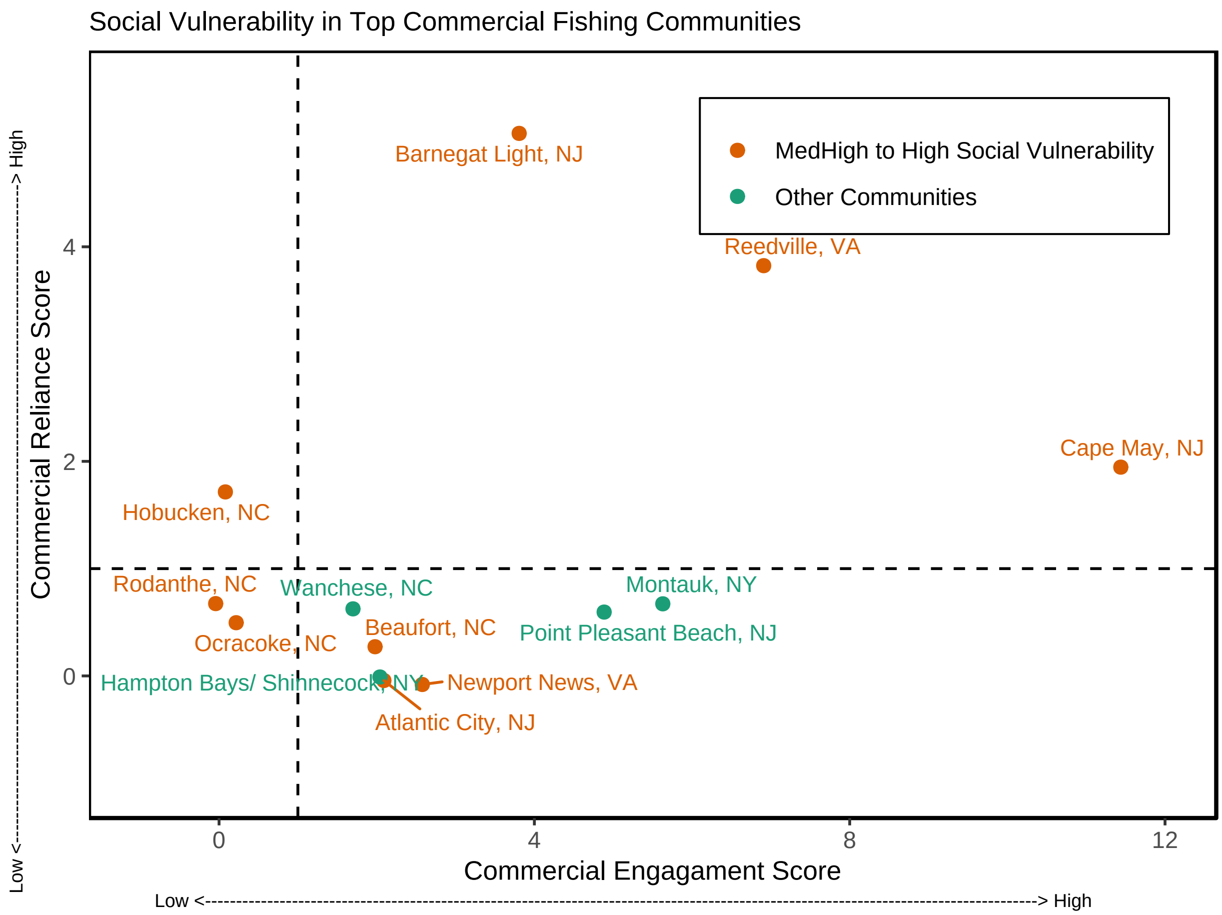

Figure 2: Commercial engagement, reliance, and social vulnerability for the top commercial fishing communities in the Mid-Atlantic.

Recreational fishery engagement measures shore, private vessel, and for-hire fishing activity while reliance expresses these numbers based on fishing effort relative to the population of a community. Of the nine recreational communities that are most engaged and reliant, Avon, Ocracoke and Hatteras, NC and Barnegat Light and Cape May, NJ scored medium-high or above for social vulnerability (Fig. 3).

Both commercial and recreational fishing are important activities in Montauk, NY; Barnegat Light, Cape May, and Point Pleasant Beach, NJ; and Ocracoke and Rodanthe, NC, meaning some of these communities may be impacted simultaneously by commercial and recreational regulatory changes. Of these communities, three scored medium-high or above for social vulnerability.

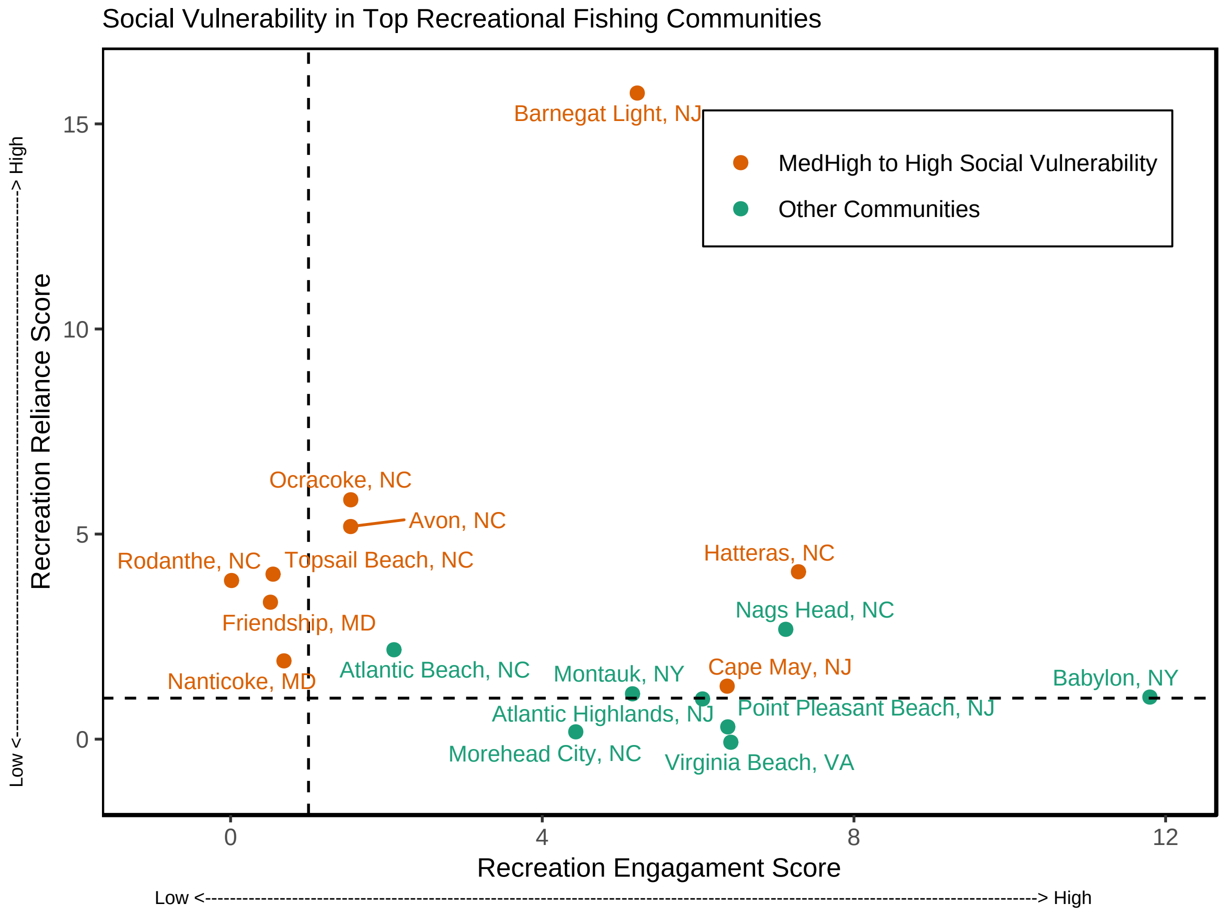

Figure 3: Recreational engagement, reliance, and social vulnerability for the top recreational fishing communities in the Mid-Atlantic.

These plots provide a snapshot of the relationship between social vulnerability and the most highly engaged and most highly reliant commercial and recreational fishing communities in the Mid-Atlantic. Similar plots are used to inform the annual California Current Ecosystem Status Report. These communities may be vulnerable to changes in fishing patterns due to regulations and/or climate change. When any of these communities are also experiencing social vulnerability, they may have lower ability to successfully respond to change. These indicators may also point to communities that are vulnerable to environmental justice issues. Additional analysis related to ecosystem shifts and National Standard 8 of the Magnuson-Stevens Act is ongoing.

Recreational Fleet Diversity

Indicators for the diversity of recreational effort (i.e. access to recreational opportunities) by mode (party/charter boats, private boats, shore-based), and diversity of catch (NEFMC, MAFMC, SAFMC, and ASMFC managed species) have been included in the SOE and may be useful to parallel commercial diversity metrics in the EAFM risk assessment. Recreational fleet diversity has declined over the long term (Fig. 4).

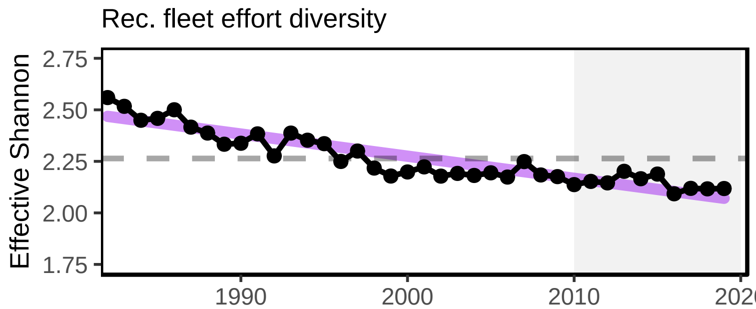

Figure 4: Recreational fleet effort diversity in the Mid-Atlantic.

The absence of a long-term trend in recreational effort suggests relative stability in the overall number of recreational opportunities in the MAB. However, the decline in recreational fleet diversity suggests a potentially reduced range of opportunities.

The downward effort diversity trend is driven by party/charter contraction (from a high of 24% of angler trips to 7% currently), and a shift toward shorebased angling. Effort in private boats remained stable between 36-37% of angler trips across the entire series.

Changes in recreational fleet diversity can be considered when managers seek options to maintain recreational opportunities. Shore anglers will have access to different species than vessel-based anglers, and when the same species, typically smaller fish. Many states have developed shore-based regulations where the minimum size is lower than in other areas and sectors to maintain opportunities in the shore angling sector.

We seek Council feedback on whether to include fishing community vulnerability and recreational diversity indicators within the EAFM risk assessment, and if so, what risk criteria should be applied to these indicators.

Changes from 2020: Management risk elements

Management risk elements contain a mixture of quantitatively (Fishing Mortality Control, Technical Interactions, Discards, and Allocation) and qualitatively (Other Ocean Uses and Regulatory Complexity) calculated rankings. In general, the management indicators evaluate a particular risk over several years; therefore, the rankings should remain fairly consistent on an annual basis unless something changed in the fishery or if a management action occurred. A comprehensive evaluation and update of all management risk elements was conducted by Council staff in 2020. In 2021, Council staff reviewed the 2020 rankings and associated justifications to determine if any significant fishery or management changes would result in a change in a risk element ranking. The updated management risk element rankings can be found in Table 5 and the justification for any ranking change can be found below.

Updated Justifications

The **Other Ocean Use** risk ranking (moderate-high) for recreational black sea bass did not change from 2020 to 2021; however, the justification for the ranking was modified to be more reflective of current considerations. The justification now states: "potential habitat impacts primarily from offshore energy (wind, gas, oil) development. Offshore wind turbine foundations may create new structured habitat (reef effect) and create new recreational fishing opportunities."

The 2020 risk assessment report included chub mackerel for the first time but was not yet a managed species within the Mackerel, Squid, and Butterfish Fishery Management Plan (FMP). Chub mackerel was formally added to the FMP in 2020 and, therefore, some of the language for the ranking justifications were updated. None of the rankings changed from 2020 (Table 5) and the revised justifications are provided below:

- **Management Control:** first annual landings limit implemented September 2017 and has not been exceeded. First ABC implemented in Sept 2020, represents a liberalization compared to previous measures.
- **Technical Interactions:** some marine mammal interactions.

- **Other Ocean Use:** potential loss of access, particularly for mobile gear, due to offshore energy development (wind, gas, oil) in some fishing areas but most fishing far offshore.
- **Regulatory Stability:** simpler regulations than some other species (e.g., commercial possession limit only after ACL is close to being exceeded, no minimum fish size limit, no gear restrictions, no recreational management measures except for permit requirement). Management measures first implemented in 2017, revised in 2020.
- **Discards:** the first ABC and ACL were implemented in 2020 and were not exceeded. Discards generally make up 6% or less of total catch.
- **Allocation:** the stock is not allocated and there are currently no allocation concerns.

Decreased Risk: 5

The **Allocation** risk ranking for *Illex* squid decreased from high to low. The Council took final action on the *Illex* permitting amendment in 2020 and no additional allocation related actions are under consideration.

The **Regulatory Complexity** risk ranking for recreational black sea bass decreased from high to moderate-high. Changes to recreational management measures have become less frequent and more stable since 2018.

The **Allocation** risk rankings for longfin squid, commercial spiny dogfish, and recreational Atlantic mackerel decreased from high to low. This change corrects an error for these rankings in the 2020 risk assessment table. As per the Council risk criteria, allocation is either scored as low (no recent or ongoing Council discussion) or high (recent or ongoing Council discussion); however, the 2020 risk assessment ranked the allocation indicator for these species as either low-medium or medium-high. After reviewing the justification and rationale for allocation ranking, it was determined the low ranking was most appropriate.

Increased Risk: 0

No indicators for the management risk elements changed enough to warrant increased risk rankings according to the Council risk criteria.

Potential new indicators

Other ocean uses: Offshore wind development metrics

More than 20 offshore wind development projects are proposed for construction over the next decade in the Northeast (projects & construction timelines based on Table E-4 of South Fork Wind Farm Draft Environmental Impact Statement). Offshore wind areas may cover more than 1.7 million acres by 2030 (Fig. 5). Just over 1,900 foundations and more than 3,000 miles of inter-array and offshore export cables are proposed to date. Each proposed project has a two-year construction timeline [10]. Based on current timelines, the areas affected would be spread out such that it is unlikely that any one particular area would experience full development at one time.

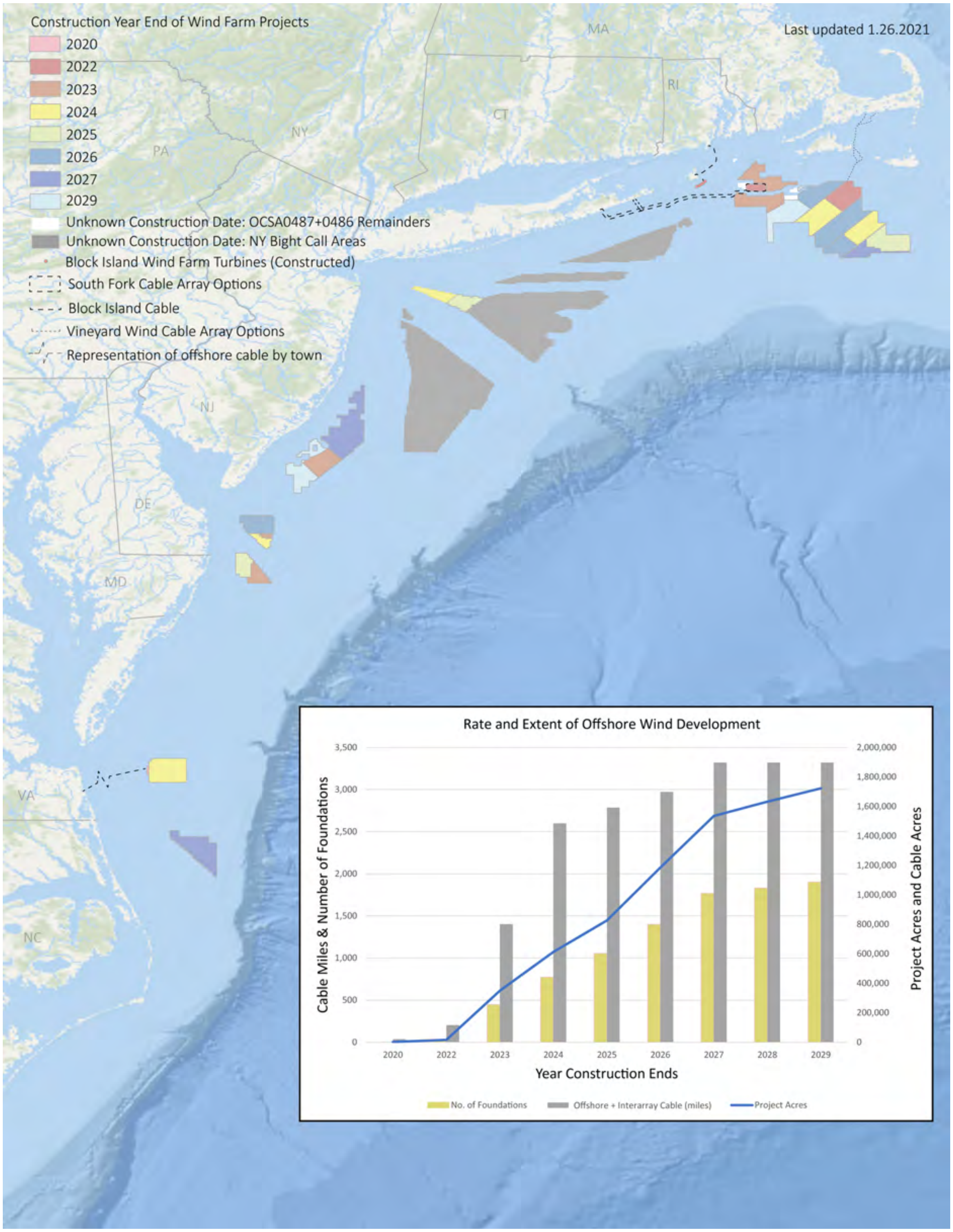

Figure 5: All Northeast Project areas by year construction ends (each project has 2 year construction period). Data for cumulative project areas, number of foundations, offshore cable area (acres) and offshore cable and interarray cable (mile) are displayed in the graph.

Other ocean uses: Commercial fishey revenue in lease areas

Based on vessel logbook data, average commercial fishery revenue from trips in the proposed offshore wind lease areas and the New York Bight Call Areas represented 2-24% of the total average revenue for each MAFMC managed fishery from 2008-2018 (Fig. 6).

The surfclam/ocean quahog fishery was the most affected fishery, with a maximum of 31% of annual fishery revenue occurring within potential wind lease areas during this period. The golden and blueline tilefish fisheries and spiny dogfish fishery were the least affected, at 3-4% maximum annual revenue affected, respectively. A maximum of 11% of the annual monkfish revenues were affected by these areas, with similar effects for the bluefish (10%), summer flounder/scup/black sea bass (9%), and mackerel/squid/butterfish (8%) fisheries. The New York Bight Call Areas represented only 1-5% of total average fishery revenue from any fishery during 2008-2018, with the surfclam/ocean quahog fishery most affected.

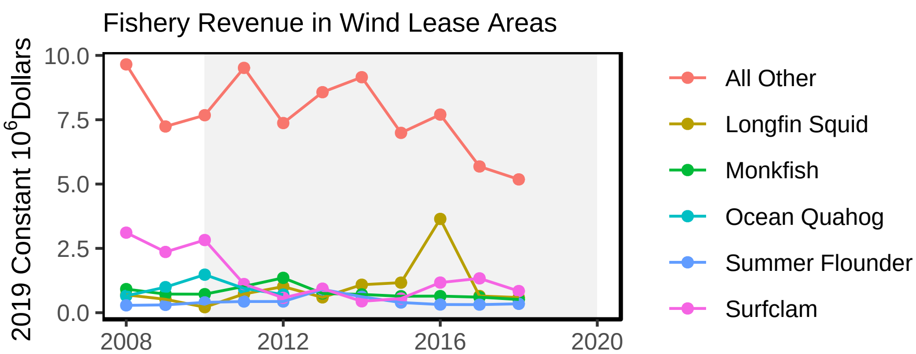

Figure 6: Wind energy revenue in the Mid-Atlantic

Other ocean uses: Wind lease area overlap with scientific surveys

Proposed wind energy project areas and NY Bight Call Areas interact with the region's federal scientific surveys (Fig. 7). The total survey area overlap ranges from 1-14% across ecosystem, shellfish, fish, shark, and protected species surveys. For example, the sea scallop survey will have significant overlap (up to 96% of individual strata) while the bottom trawl survey will have up to 60% overlap. Additionally, up to 50% of the southern New England North Atlantic right whale survey's area overlaps with proposed project areas.

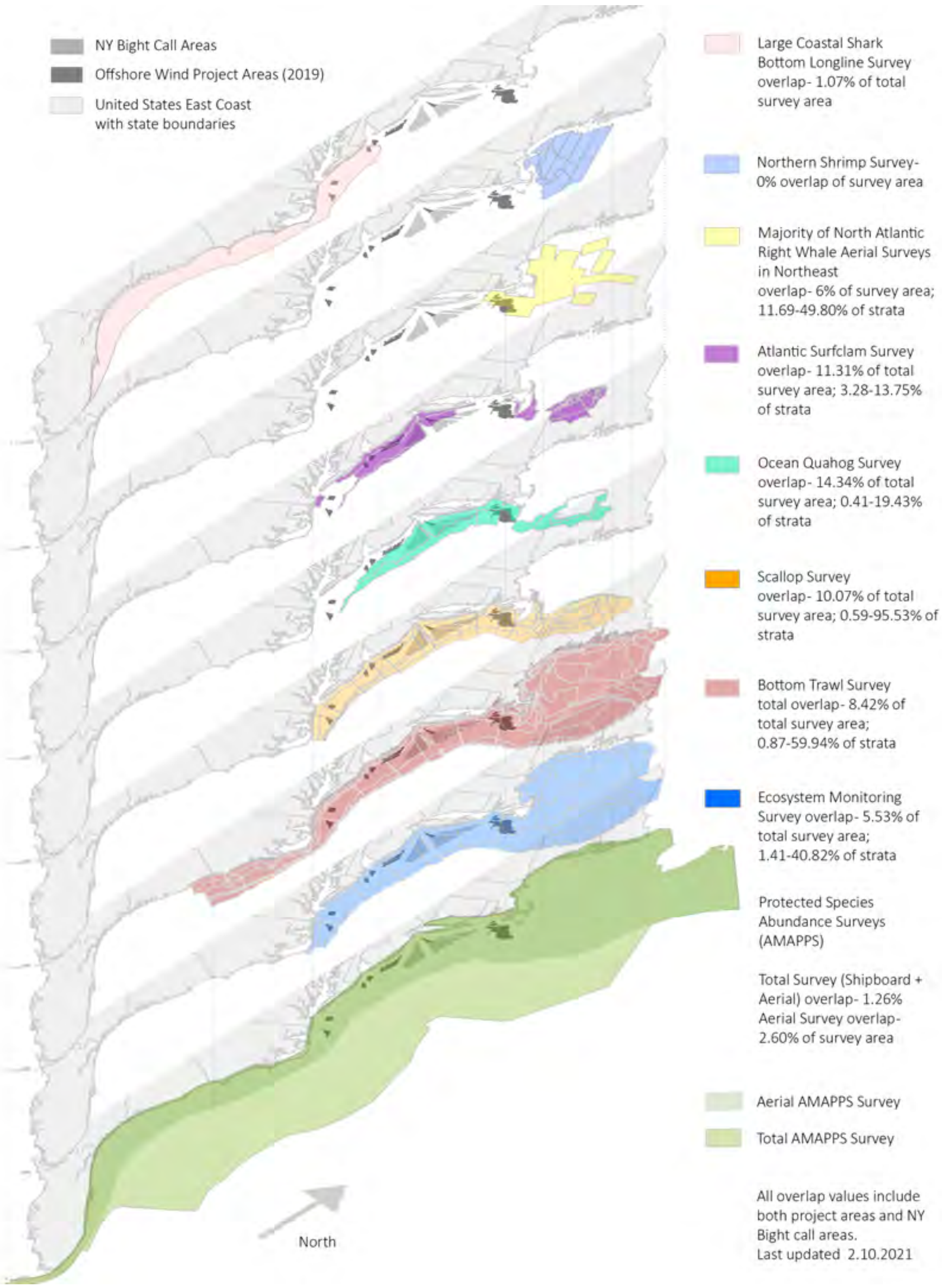

Figure 7: Interaction of Greater Atlantic Fisheries Scientific Surveys and Offshore Wind Development

Implications of offshore wind indicators

Current plans for rapid buildout of offshore wind in a patchwork of areas spreads the impacts differentially throughout the region (Fig. 8).

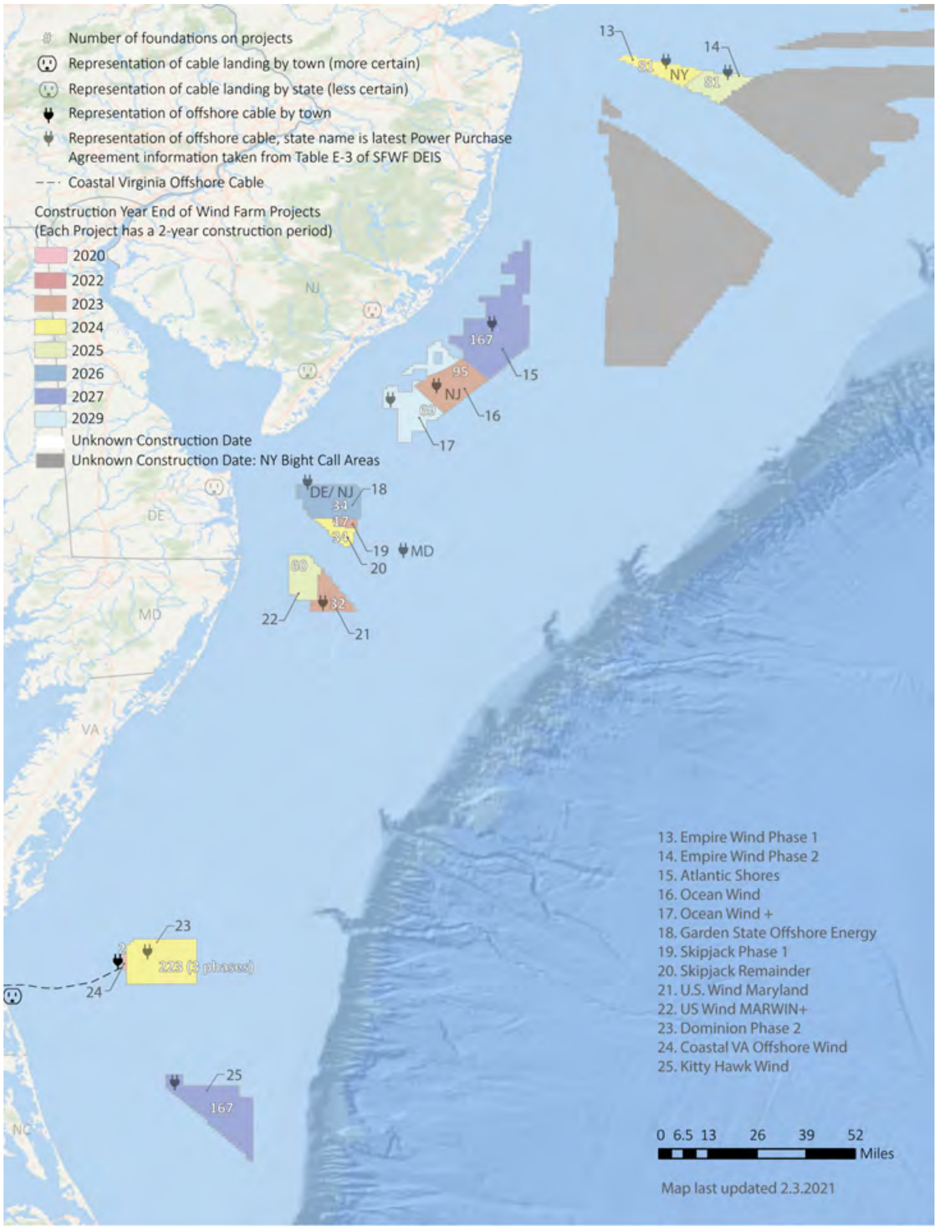

Figure 8: Zoomed in areas with name of Project, number of foundations within each project area and the states that have declared power purchase agreements.

2-24% of total average revenue for major Mid-Atlantic commerical species in lease areas could be displaced if all sites are developed. Displaced fishing effort can alter fishing methods, which can in turn change habitat, species (managed and protected), and fleet interactions.

Right whales may be displaced, and altered local oceanography could affect distribution of their zooplankton prey.

Scientific data collection surveys for ocean and ecosystem conditions, fish, and protected species will be altered, potentially increasing uncertainty for management decision making.

We seek Council feedback on whether to include offshore wind development and related indicators within the EAFM risk assessment, and if so, what risk criteria should be applied to these indicators.

2021 EAFM Risk Tables

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	l	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	lm	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	h	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

Table 4: 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	l	lm	h	mh

Table 5: 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	mh	l
Surfclam-C	l	l	lm	l	mh	l
Summer flounder-R	mh	l	lm	mh	h	h
Summer flounder-C	lm	mh	lm	mh	mh	h
Scup-R	lm	l	lm	mh	mh	h
Scup-C	l	lm	mh	mh	mh	h
Black sea bass-R	h	l	mh	mh	h	h
Black sea bass-C	h	lm	h	mh	h	h
Atl. mackerel-R	lm	l	l	l	l	l
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	l
Shortfin squid-C	lm	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	lm	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	l
Chub mackerel-C	l	lm	lm	lm	l	l
Unmanaged forage	l	l	mh	l	l	l
Deepsea corals	na	na	mh	na	na	na

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