



Mid-Atlantic Fishery Management Council

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MEMORANDUM

Date: March 25, 2022
To: Council
From: Brandon Muffley, Council staff
Subject: State of the Ecosystem and EAFM Risk Assessment – Meeting Materials

On Tuesday, April 5, 2022, Dr. Sarah Gaichas (NEFSC) will present the 2022 Mid-Atlantic State of the Ecosystem report. Dr. Gaichas will also summarize the updates and changes in the 2022 EAFM risk assessment that is informed by indicators in the State of the Ecosystem report and updated analyses by Council staff. The Council will review the findings and ecosystem considerations contained in both documents and provide any feedback on the future development and utility of the information provided.

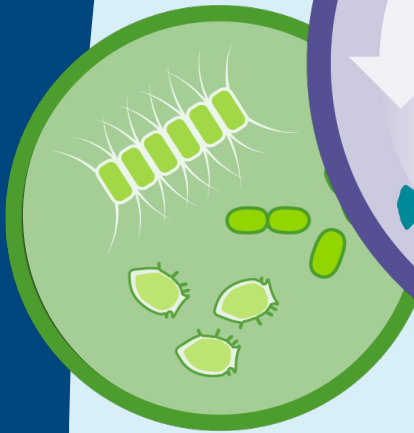
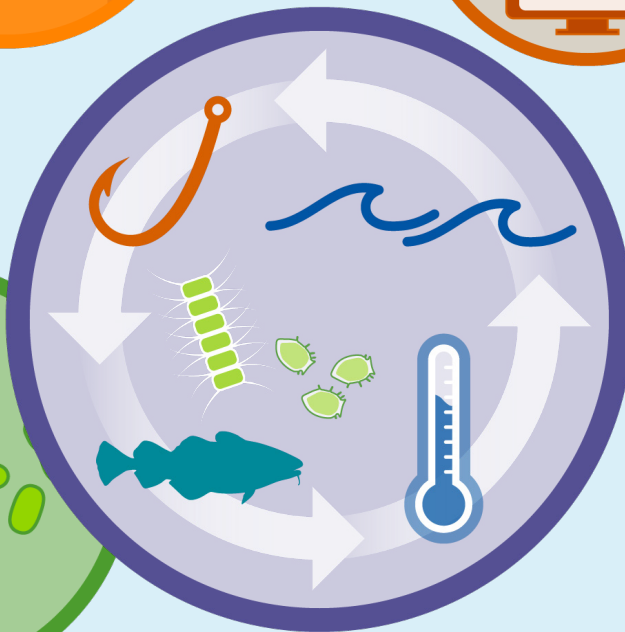
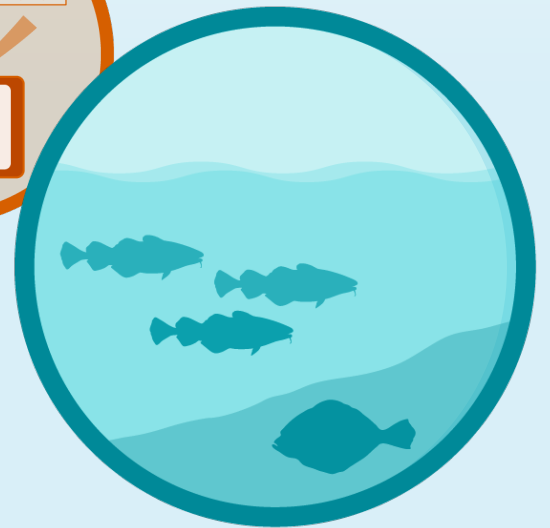
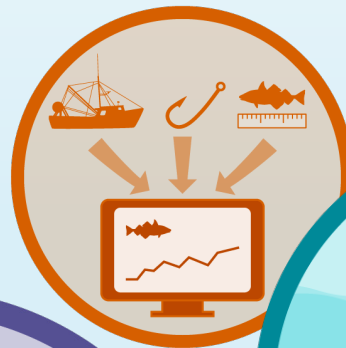
Materials listed below are provided for Council consideration of this agenda item.

Materials behind the tab:

- 2022 Mid-Atlantic State of the Ecosystem report
- Cover letter and State of the Ecosystem response memo
- 2022 Mid-Atlantic EAFM Risk Assessment update

2022 State of the Ecosystem

Mid-Atlantic



NOAA
FISHERIES

Performance Relative to Fishery Management Objectives

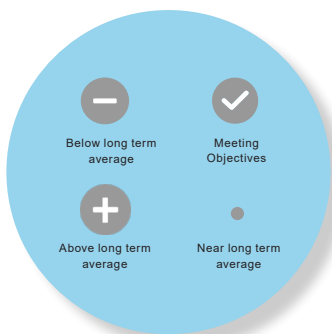
Trends and status of indicators related to broad ecosystem-level fishery management objectives, with implications for the Mid-Atlantic Fishery Management Council (MAFMC)

OBJECTIVE (INDICATOR)	Seafood production (total and MAFMC managed landings)	Commercial profits (indicator not updated, 2020 regional landings not yet available)	Recreational opportunities (effort and fleet diversity)		
TREND			Effort	Fleet diversity	Trend
CURRENT STATUS	Status not updated for 2020	Status not updated for 2020	Effort	Fleet diversity	
IMPLICATIONS	Regional commercial landings data are not yet available for 2020, but coastwide landings trends for federally managed species were mixed when compared to recent years. Recreational harvest is declining due to multiple drivers. COVID-19 seems to have exacerbated existing trends in both commercial and recreational fisheries where data are available, but impacts are not uniform across fisheries.	Regional commercial revenue data are not yet available for 2020. Coastwide, revenue was down across many federally managed species, due to a mix of both lower prices (summer flounder, scup, black sea bass, squids, monkfish) and landings (surfclam, ocean quahogs, monkfish).	Recreational effort shows a long term increasing trend and has returned to pre-2018 levels, but fleet diversity is decreasing because of a shift away from party/charter to shore-based fishing. This shift results in a decreased range of recreational fishing opportunities. Shore-based anglers will have access to different species/sizes of fish than vessel-based anglers.		

Biomass trends within the ecosystem continue to be stable. Climate indicators continue trending toward unprecedented levels, which affects stock distributions and will generate other ecosystem changes.

OBJECTIVE (INDICATOR)	Stability (fishery and ecosystem diversity maintained over time)	Social and cultural (community fishery engagement, reliance, and environmental justice vulnerability)	Protected species (coastwide bycatch, population numbers, mortalities)
TREND	Fishery Ecosystem	Status only indicator	Bycatch Population NARW
CURRENT STATUS	Fishery Ecosystem	Environmental justice status for top commercial and recreational communities	Bycatch Harbor porpoise Population NARW
IMPLICATIONS	<p>Fishery: Commercial fleet diversity metrics suggests stable capacity to respond to the current range of fishing opportunities.</p> <p>Recreational: Species catch diversity has been maintained by a different set of species over time.</p> <p>Ecosystem: Adult fish diversity indices are stable, but several climate and oceanography metrics are changing and should be monitored as warning signs for potential regime shift or ecosystem restructuring.</p>	<p>These indicators are used to identify top fishing communities and those with environmental justice concerns based on 2019 data. Highlighted communities may be vulnerable to changes in fishing patterns due to regulations and/or climate change. When any of these communities also experience environmental justice issues, they may have lower ability to successfully respond/adapt to change.</p> <p>All communities showing environmental justice concerns score high in the poverty index, while some also score high in personal disruption and population composition indices.</p>	<p>Mixed bycatch trends through 2019 are related to fishery management, shifts in population distribution combined with fishery shifts, and population increase for seals. Bycatch indices were not updated because of low 2020 observer coverage caused by COVID-19 restrictions.</p> <p>Population drivers for North Atlantic Right Whales (NARW) include combined fishery interactions/vessel strikes, distribution shifts, and copepod availability.</p> <p>Unusual mortality events continue for 3 large whale species.</p>

Current Status



Risks to Meeting Fishery Management Objectives

Climate and Ecosystem Productivity Risks

Climate change, most notably ocean warming and changes in the Gulf Stream, continues to affect the Mid-Atlantic ecosystem:

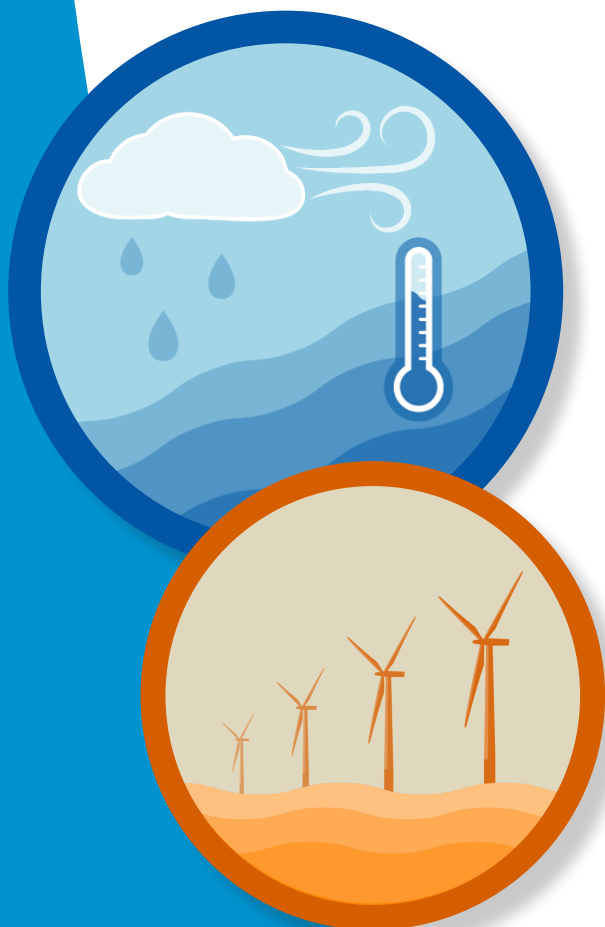
- Frequent and intense marine heatwaves observed for the last decade continued in 2021.
- The Gulf Stream is becoming less stable, which can affect the physics, chemistry, and biology of the Northeast Shelf.
- Warm, salty, less acidic offshore water is transported onto the shelf more frequently, upwelling deepwater nutrients and reducing acidification in the outer shelf portions of the Mid-Atlantic Bight, but reducing the horizontal extent of the cold pool habitat.
- The cold pool is becoming warmer, smaller, and shorter in duration, which affects habitat for multiple federally managed species.

- Phytoplankton chlorophyll concentrations were below average throughout summer 2021 in the Mid-Atlantic Bight.
- Warming Chesapeake Bay water temperatures are having negative impacts on striped bass at all life stages. Temperature and oxygen conditions are being used to inform fishery closure decisions.
- Submerged aquatic vegetation coverage is increasing in portions of Chesapeake Bay, but declining in the lower region due to increased temperatures. These changes are impacting essential fish spawning and nursery habitats.
- Fish condition was poor for many species in 2021, and productivity is declining for multiple species.

Other Ocean Uses: Offshore Wind Risks

More than 20 offshore wind development projects are proposed for construction on the Northeast shelf, covering more than 1.7 million acres by 2030. An additional 6 lease areas (488,000 acres) were recently identified in the New York Bight, and more areas are anticipated off the Delmarva Peninsula. If all existing and proposed leases are developed in the Northeast:

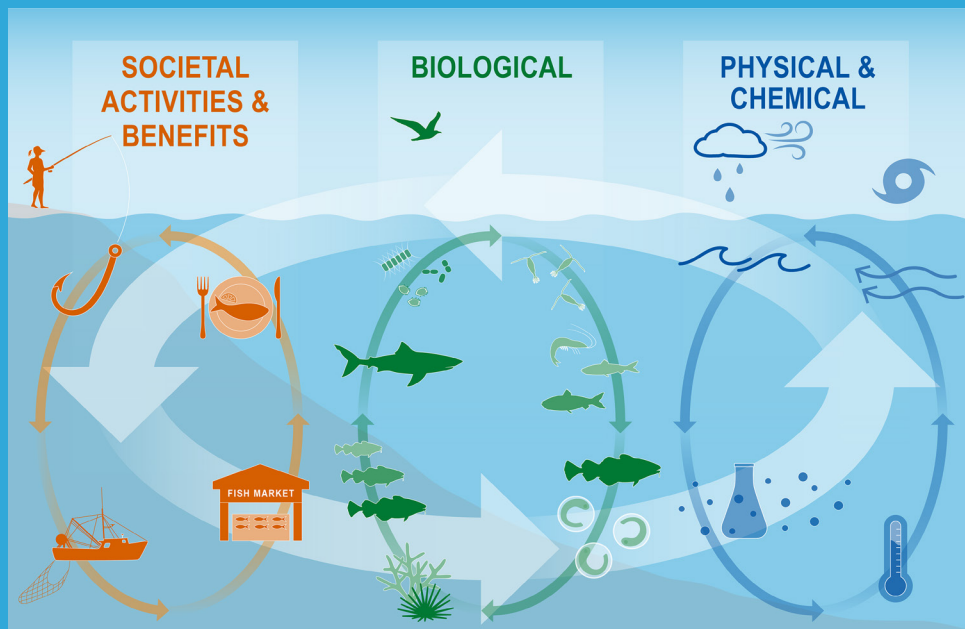
- 1-31% of port revenue from fisheries currently comes from areas proposed for offshore wind development. Some of these port communities score medium-high to high in environmental justice concerns and gentrification vulnerability.
- Up to 20% of annual commercial landings and revenue for Mid-Atlantic species occur in lease areas and may shift to other areas.
- Development will affect species differently, negatively affecting species that prefer soft bottom habitat while potentially benefiting species that prefer hard structured habitat.
- Planned wind areas overlap with one of the only known right whale foraging habitats, and altered local oceanography could affect right whale prey availability. Development also brings increased vessel strike risk and the potential impacts of pile driving noise.
- Current plans for rapid buildout in a patchwork of areas would spread the impacts differentially throughout the region.



Characterizing Ecosystem Change

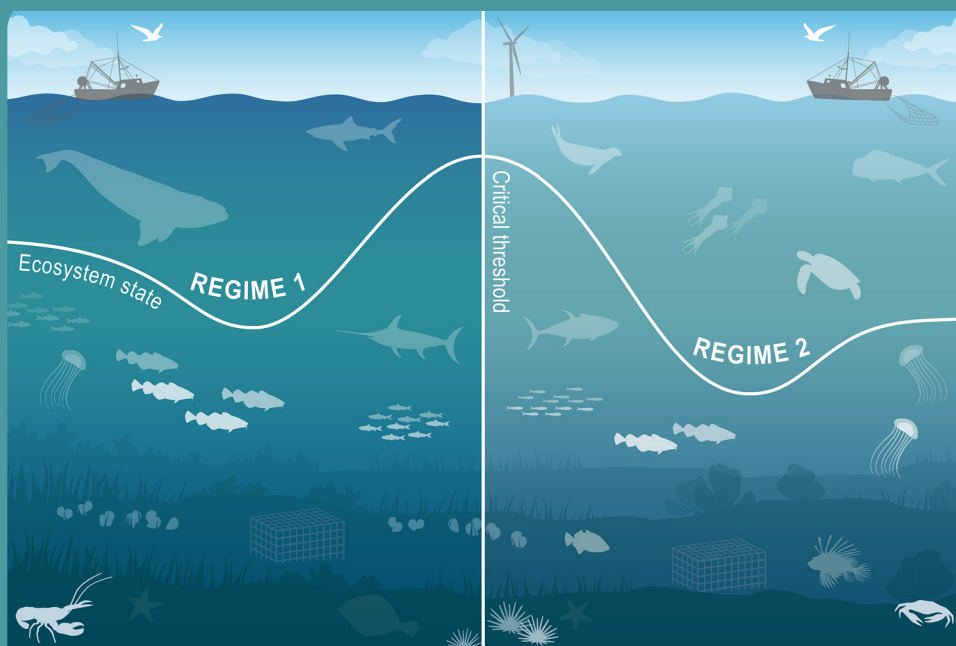
Multiple System Drivers

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 are 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 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 allow the MAFMC 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 data 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(s)? 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 terms¹, detailed technical methods documentation², and indicator data³ are available online. The details of standard figure formatting (Fig. 47a), categorization of fish and invertebrate species into feeding guilds (Table 4), and definitions of ecological production units (EPUs, including the Mid-Atlantic Bight, MAB; Fig. 47b) are provided at the end of the document.

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

Objective Categories	Indicators reported
Provisioning and Cultural Services	
Seafood Production	Landings; commercial total and by feeding guild; recreational harvest
Profits	Revenue decomposed to price and volume
Recreation	Angler trips; recreational fleet diversity
Stability	Diversity indices (fishery and ecosystem)
Social & Cultural	Community engagement/reliance and environmental justice 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>

Special note on data availability for the 2022 report

The Catch Accounting and Monitoring System (CAMS) that will be used to provide commercial landings and discard information at the Ecological Production Unit (EPU) scale is under development. As of February 2022, our standard indicators relying on EPU scale landings data cannot be calculated for 2020 (commercial seafood production, commercial profits, ecosystem overfishing). We provide information based on coastwide commercial landings information available at this time in [1]⁴, and will calculate our standard indicators at EPU scales with disaggregated 2020 commercial landings data when they are available.

Seafood Production

Indicators: Landings; commercial and recreational

Total commercial landings (black) within the Mid-Atlantic are not yet available for 2020; Figure 1 includes data only through 2019. However, we do not anticipate the long-term declining trend in landings to change.

Coastwide landings at the Federal fishery management plan (FMP) level were mixed in 2020 when compared to recent years [1]. Landings of monkfish and of combined surfclam and ocean quahog declined in 2020, while landings of combined summer flounder, scup, and black sea bass increased, and landings of combined squid species increased in 2020.

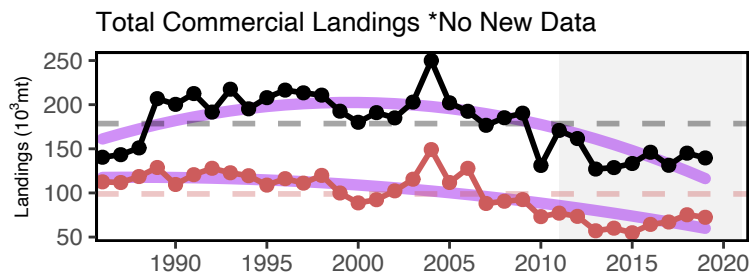


Figure 1: Total commercial seafood landings through 2019 (black) and Mid-Atlantic managed seafood landings (red).

Total recreational harvest (retained fish presumed to be eaten) is down in the MAB (Fig. 2). Although harvest has increased from a historic low in 2018, it is still below the average value for the series.

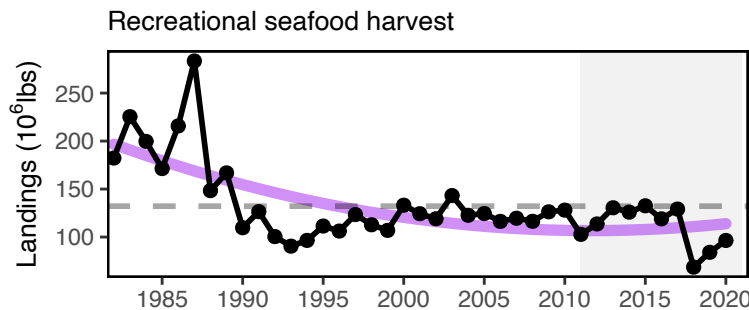


Figure 2: Total recreational seafood harvest (millions of pounds) in the Mid-Atlantic region.

Recreational shark landings show an increase in pelagic sharks over the past decade, with a sharp decrease in 2018 - 2019 persisting through 2021 (Fig 3). This is likely influenced by regulatory changes implemented in 2018 intended to rebuild shortfin mako stocks. In 2021 the International Commission for the Conservation of Atlantic Tunas

⁴<https://spo.nmfs.noaa.gov/sites/default/files/TM221.pdf>

(ICCAT) finalized recommendations for a two-year retention ban (ICCAT Rec.21-09), which will also affect total overall landings of pelagic sharks in coming years.

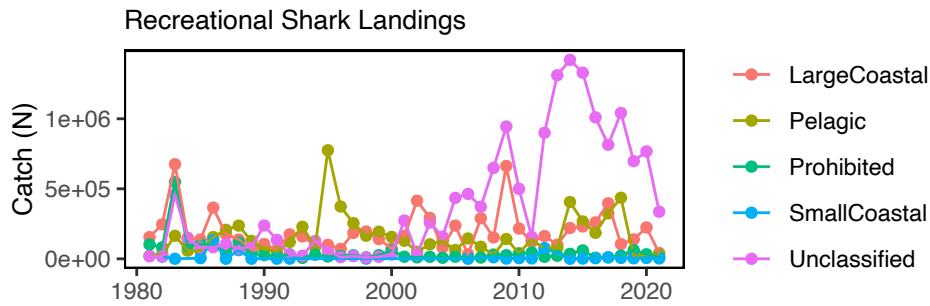


Figure 3: Recreational shark landings from Marine Recreational Information Program.

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.⁵

Implications

Declining commercial and recreational landings can be driven by many interacting factors, including combinations of ecosystem and stock production, management actions, market conditions (including COVID-19 disruptions), and environmental change. While we cannot evaluate all possible drivers at present, here we evaluate the extent to which stock status and system biomass trends may play a role.

Stock Status and Catch Limits Single species management objectives (1. maintaining biomass above minimum thresholds and 2. maintaining fishing mortality below overfishing limits) are being met for all but two MAFMC managed species, though the status of six stocks is unknown (Fig. 4).

⁵https://noaa-edab.github.io/ecodata/human_dimensions_MAB#Commercial; “Oyster Aquaculture” tab

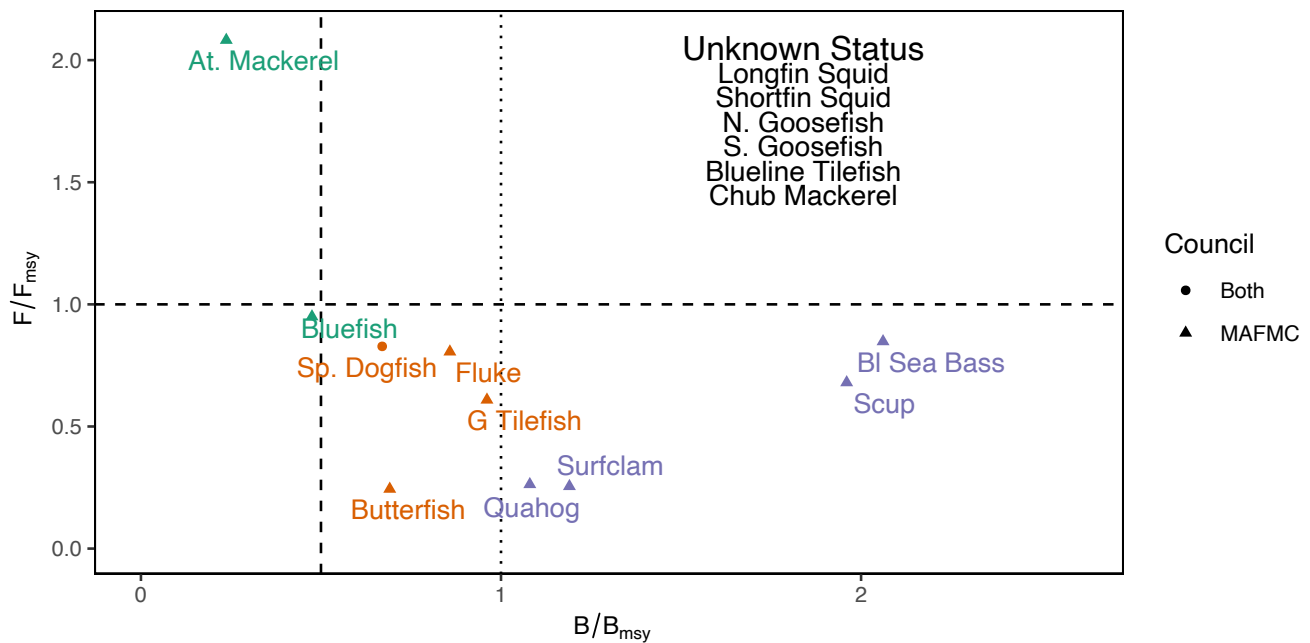


Figure 4: Summary of single species status for MAFMC and jointly federally managed stocks (Spiny dogfish and both Goosefish). The dotted vertical line is the target biomass reference point of B_{msy} . The dashed lines are the management thresholds of one half B_{msy} (vertical) or F_{msy} (horizontal). 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).

Stock status affects catch limits established by the Council, which in turn may affect landings trends. Summed across all MAFMC managed species, total Acceptable Biological Catch or Annual Catch Limits (ABC or ACL) have been relatively stable 2012-2020 (Fig. 5). The recent total ABC or ACL is lower relative to 2012-2013, with much of that decrease due to declining Atlantic mackerel ABC. This is true even with the addition of blueline tilefish management in 2017 contributing an additional ABC and ACL to the total 2017-2020, due to that fishery’s small relative size.

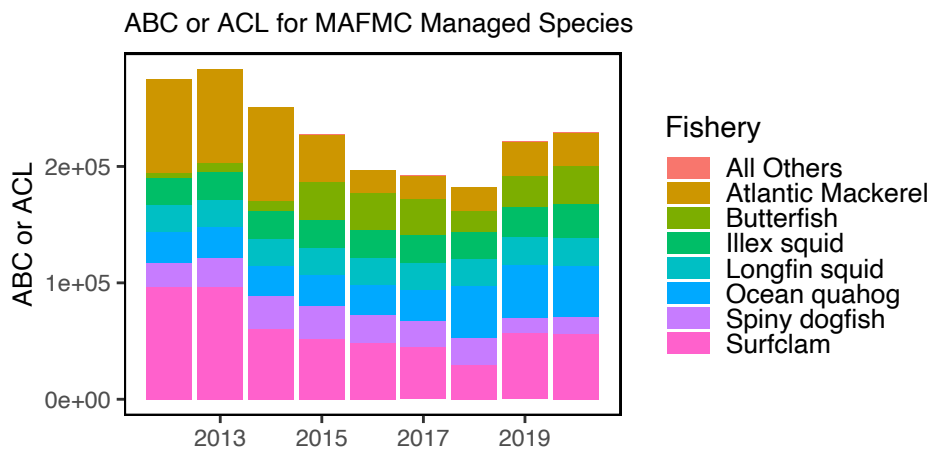


Figure 5: Sum of catch limits across all MAFMC managed fisheries.

Nevertheless, the percentage caught for each stock’s ABC/ACL suggests that these catch limits are not gener-

ally constraining as most species are well below the 1/1 ratio (Fig. 6). Therefore, stock status and associated management constraints are unlikely to be driving decreased landings for the majority of species.

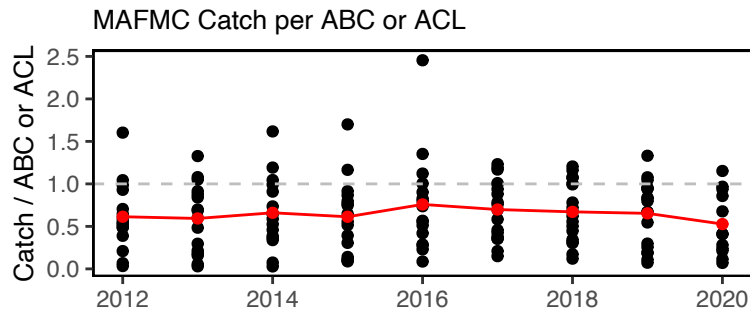


Figure 6: Catch divided by ABC/ACL for MAFMC managed fishes. Chub mackerel removed due extremely low catch. Outliers = Recreational Black Sea Bass.

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. 7). 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.

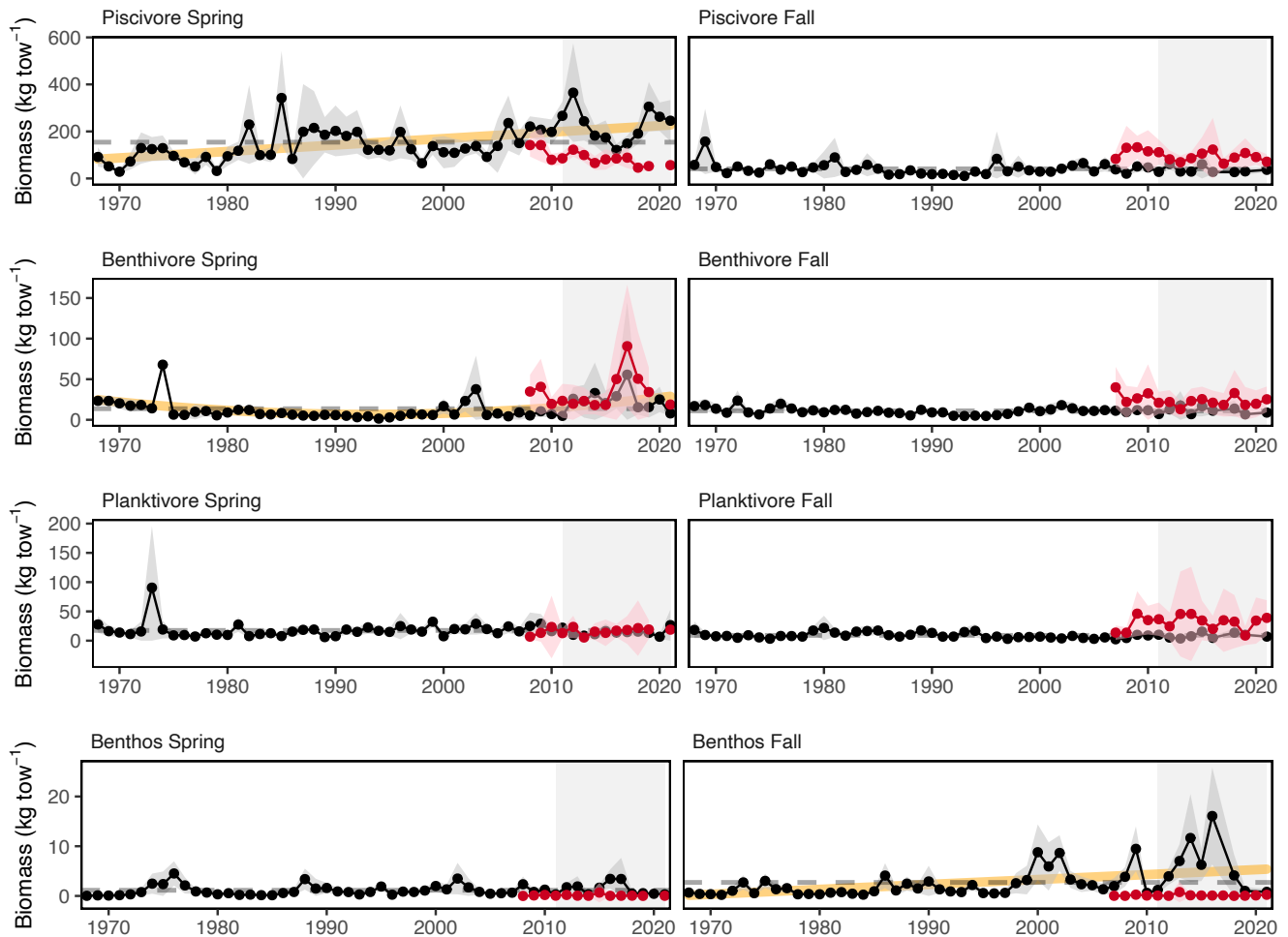


Figure 7: Spring (left) and fall (right) surveyed biomass in the Mid-Atlantic Bight. Data from the NEFSC Bottom Trawl Survey are shown in black, with the nearshore NEAMAP survey shown in red. The shaded area around each annual mean represents 2 standard deviations from the mean.

Effect on Seafood Production Stock status is mostly acceptable, and aggregate biomass trends appear stable, so 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, 2021 was the sixth warmest year on record⁶ with regional marine heatwaves apparent (see [Climate Risks section](#)).

⁶<https://www.climate.gov/news-features/features/2021-global-climate-summary-6th-warmest-year-record>

- Stocks are shifting distribution, moving towards the northeast and into deeper waters throughout the Northeast US Large Marine Ecosystem (Fig. 8).

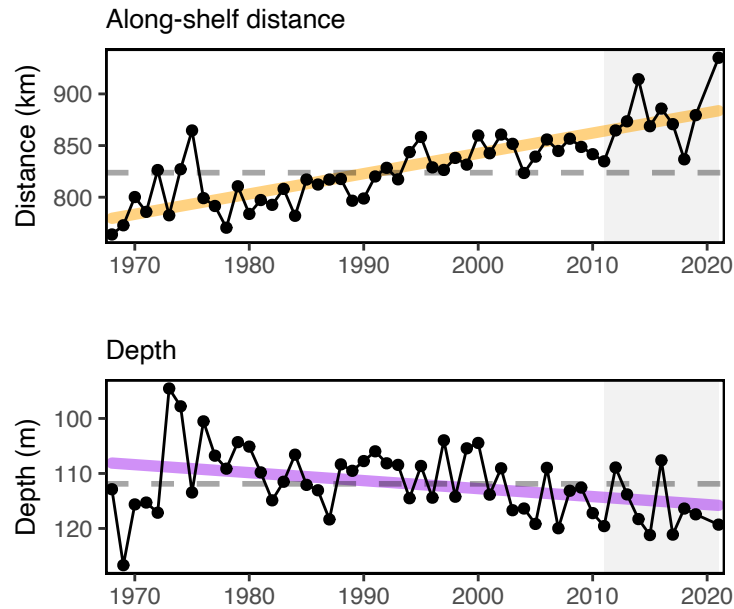


Figure 8: Aggregate species distribution metrics for species in the Northeast Large Marine Ecosystem.

- Some ecosystem composition and production changes have been observed (see [Stability section](#)).
- Some fishing communities are affected by environmental justice vulnerabilities (see [Environmental Justice and Social Vulnerability section](#)).

Commercial Profits

Indicators: revenue (a proxy for profits)

Total commercial revenues (black) within the Mid-Atlantic are not yet available for 2020; Figure 9 includes data only through 2019. However, we do not anticipate the long-term declining trend in revenue from managed species (red) to change. Coast-wide, a number of species managed by the MAFMC have seen decreases in revenue when compared to the average revenue generated between 2015 and 2019 [1]. This decline was driven by a mix of landings declines (monkfish, combined surfclam and ocean quahog) and price declines (monkfish, combined squid species, and combined summer flounder, scup, and black sea bass).

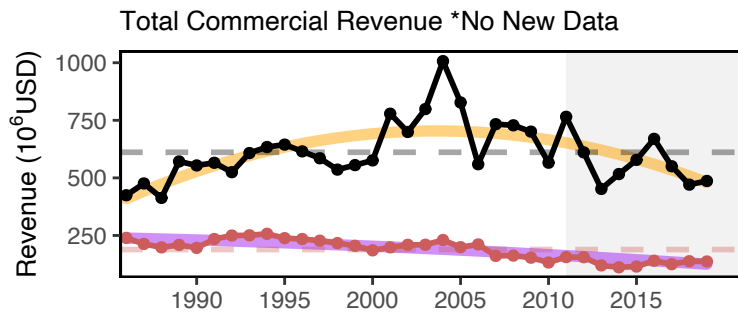


Figure 9: Revenue through 2019 for the for the Mid-Atlantic region: total (black) and from MAFMC managed species (red).

Implications

The Bennet indicator evaluating changes in landings volume and price for the Mid-Atlantic will be updated when 2020 Mid-Atlantic landings become available.

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 increased over the long term, with 2020 effort above the long-term average (Fig. 10). However, recreational fleet diversity (i.e., effort by shoreside, private boat, and for-hire anglers) has declined over the long term (Fig. 11).

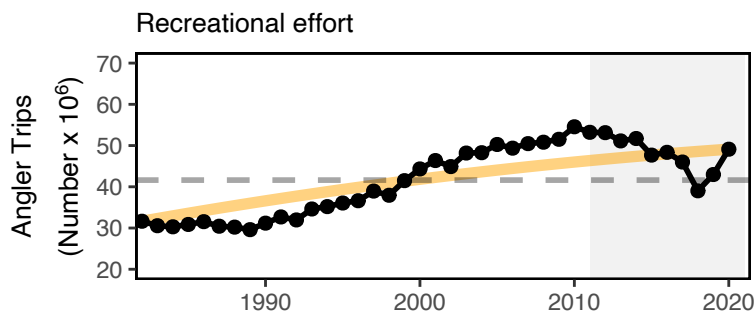


Figure 10: Recreational effort in the Mid-Atlantic.

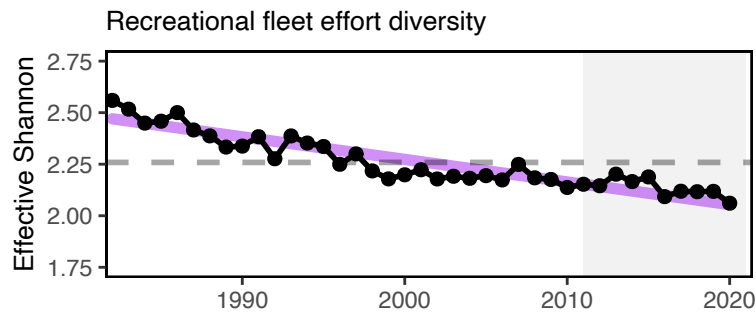


Figure 11: Recreational fleet effort diversity in the Mid-Atlantic.

Implications

Increased angler trips in 2020 relative to previous years strongly influence the long term increase in recreational effort. While the overall number of recreational opportunities in the MAB is above the long term average, the continuing decline in recreational fleet effort diversity suggests a potentially reduced range of recreational fishing options.

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 is accessible both from shore and from a vessel, shore anglers typically have access to smaller individuals. 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 fleet and species catch diversity, and recreational species catch diversity (with fleet effort diversity discussed above), and diversity in zooplankton, and larval and adult fishes.

Fishery Diversity Diversity estimates have been developed for fleets landing managed species, 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 ft, 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. 12). This indicates similar commercial fleet composition and species targeting opportunities over time.

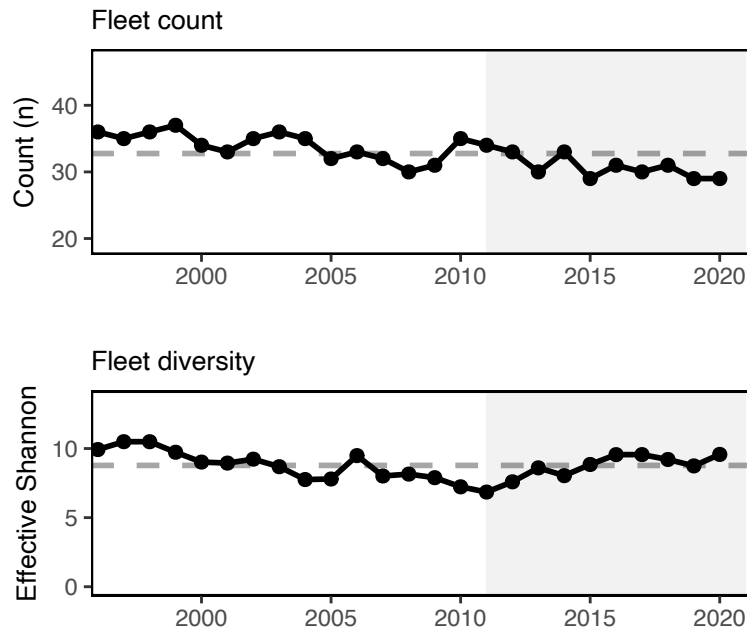


Figure 12: Commercial fleet count and diversity in the Mid-Atlantic.

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, but below, the long term average (Fig. 13).

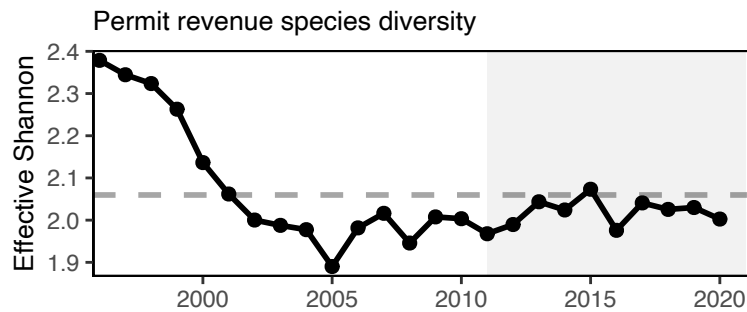


Figure 13: Species revenue diversity in the Mid-Atlantic.

As noted above, recreational fleet effort diversity is declining (Fig. 11), so this metric suggests an unstable range of recreational fishing opportunities. However, recreational species catch diversity has no long term trend so is considered stable, and has been at or above the long term average in 7 of the last 10 years (Fig. 14).

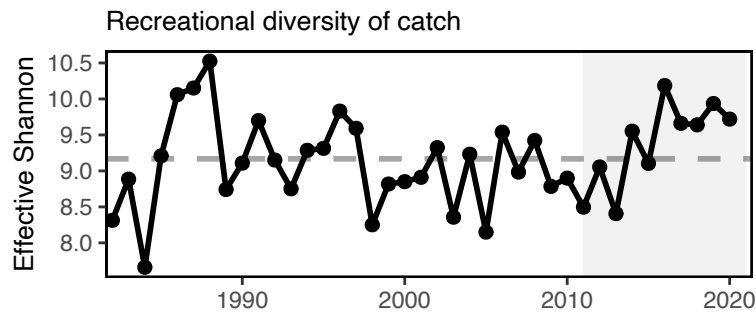


Figure 14: Diversity of recreational catch in the Mid-Atlantic.

Ecological Diversity Ecological diversity indices show mixed trends. Up to 2019, zooplankton diversity was increasing in the MAB (Fig. 15). 2020 surveys were incomplete due to COVID-19. Zooplankton and larval fish diversity indicators will be updated once 2021 survey results have been processed. 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 (2009-2021) are calculated separately. Despite this, adult fish diversity indices appear stable over time, with current values within one standard deviation from most historic estimates (Fig. 16).

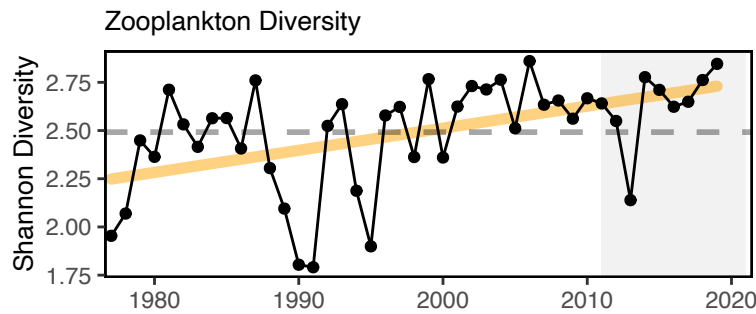


Figure 15: Zooplankton diversity in the Mid-Atlantic Bight up to 2019, based on Shannon diversity index.

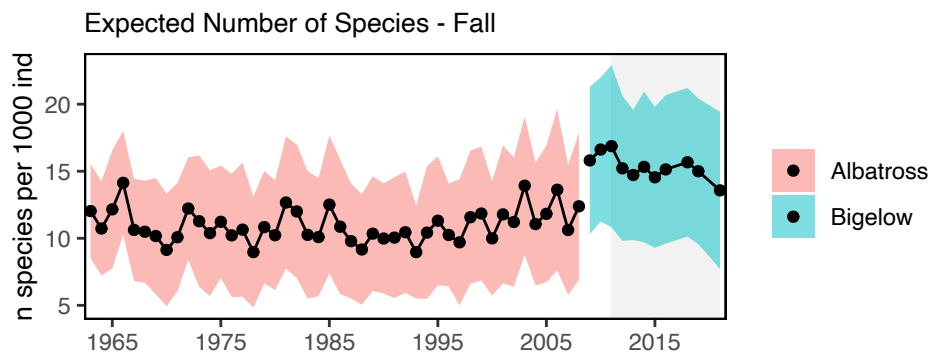


Figure 16: Adult fish diversity in the Mid-Atlantic Bight, based on expected number of species. Results from survey vessels Albatross and Bigelow are reported separately due to catchability differences.

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 angler trips.

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 through 2019 is driven by the declining dominance of the calanoid copepod *Centropages typicus*, with a similar composition of other zooplankton species.

Stable 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). In addition, the change in survey vessels complicates interpretation of long term fish diversity trends.

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.

Environmental Justice and Social Vulnerability

Indicators: Environmental Justice and Social Vulnerability in commercial and recreational fishing communities

Social vulnerability measures social factors that shape a community's ability to adapt to change. A subset of these can be used to assess potential environmental justice issues. Environmental Justice is defined in Executive Order 12898 as federal actions intended to address disproportionately high and adverse human health and environmental effects of federal actions on minority and low-income populations. Three of the existing NOAA Fisheries Community Social Vulnerability Indicators (CSVIs), the Poverty Index, Population Composition Index, and Personal Disruption Index, can be used for mandated Environmental Justice analysis⁷.

Commercial fishery engagement measures the number of permits and dealers, and pounds and value landed in a community, while reliance expresses these numbers based on the level of fishing activity relative to the total population of a community. Recreational fishery engagement measures shore, private vessel, and for-hire fishing effort while reliance expresses these numbers based on fishing effort relative to the population of a community.

In 2021, we reported the top ten most engaged, and top ten most reliant commercial and recreational fishing communities and their associated social vulnerability. Here we apply the same selection standard for top ten fishing communities for both sectors, and focus on examining the environmental justice vulnerability in these communities.

Communities plotted in the upper right section of Fig.17 scored high for both commercial engagement and reliance, including Cape May and Barnegat Light, NJ, and Reedville, VA. Communities that ranked medium-high or above for one or more of the environmental justice indicators are highlighted in bright orange: Newport News, VA; Atlantic City, NJ; Hampton Bays/Shinnecock, NY; and Beaufort, Columbia and Hobucken, NC.

⁷<https://www.fisheries.noaa.gov/national/socioeconomics/social-indicators-coastal-communities>

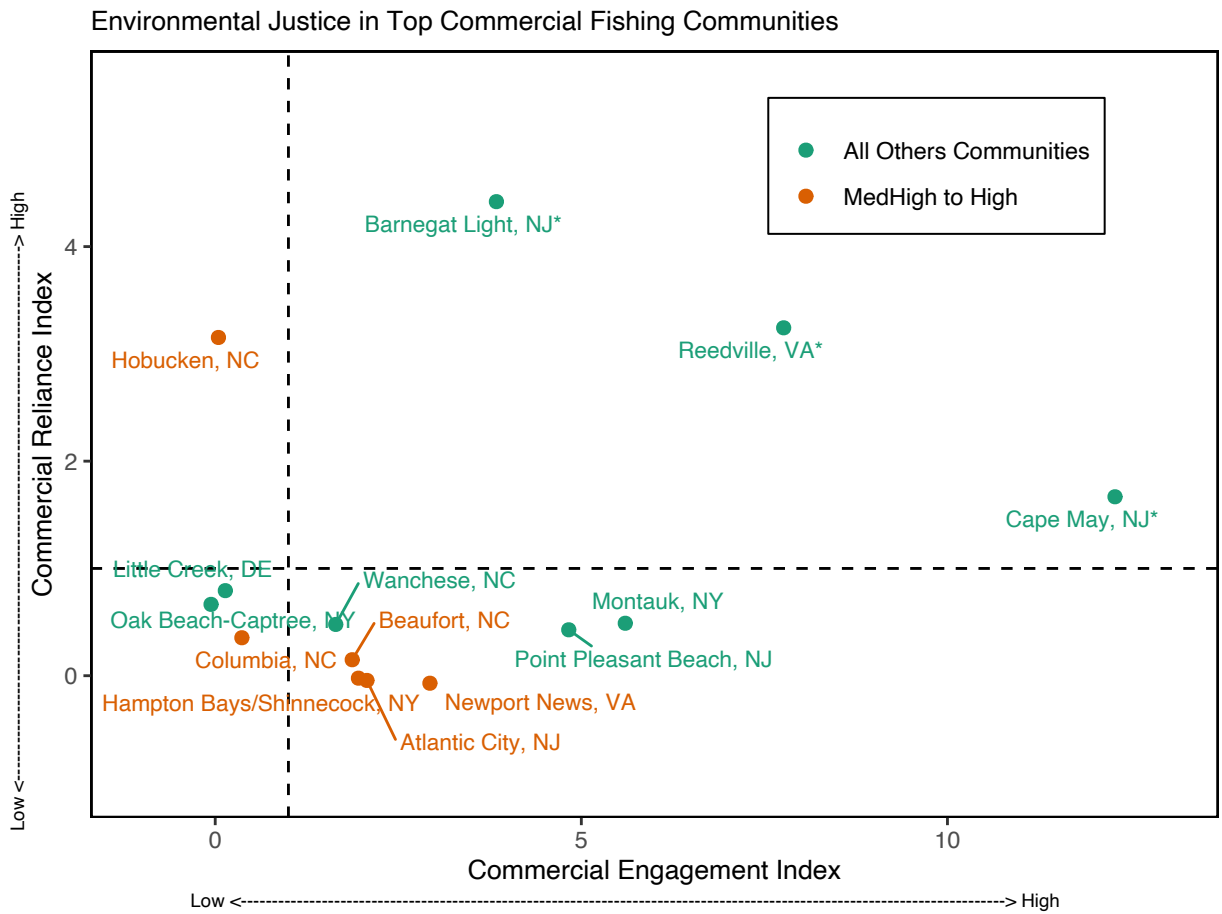


Figure 17: Commercial engagement, reliance, and environmental justice vulnerability for the top commercially engaged and reliant fishing communities in the Mid-Atlantic. Communities ranked medium-high or above for one or more of the environmental justice indicators are highlighted in bright orange. *Community scored high (1.00 and above) for both commercial engagement and reliance indicators.

Fig. 18 shows the detailed scores of the three environmental justice indicators for the same communities plotted in Fig.17. Communities are plotted clockwise in a descending order of commercial engagement scores from high to low, with the most highly engaged community, Cape May, NJ, listed on the top. Among the communities ranked medium-high or above for environmental justice vulnerability, Newport News, VA scored medium-high for the population composition index. Atlantic City, NJ scored high for all of the three environmental justice indicators. Hampton Bays/Shinnecock, NY scored medium-high for the population composition index. Beaufort, NC scored medium-high and very close to high for the poverty index. Columbia, NC scored high for the personal disruption index and the poverty index, and medium-high for the population composition index. Hobucken, NC scored high for the personal disruption index and the poverty index.

Environmental Justice Vulnerability in Top Commercial Fishing Communities (Mid-Atlantic)

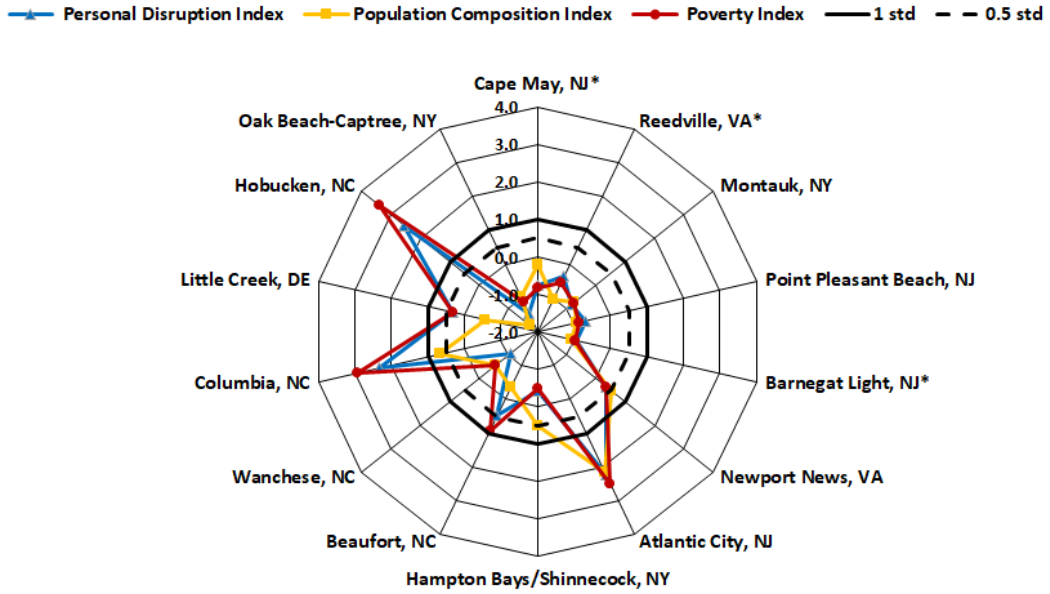


Figure 18: Environmental justice indicators (Poverty Index, population composition index, and personal disruption index) for top commercial fishing communities in Mid-Atlantic. *Community scored high (1.00 and above) for both commercial engagement and reliance indicators.

Communities plotted in the upper right section of Fig.19 scored high for both recreational engagement and reliance, including Barnegat Light, NJ and Deal Island, MD. Communities that ranked medium-high or above for one or more of the environmental justice indicators are highlighted in bright orange: Hatteras and Morehead City, NC.

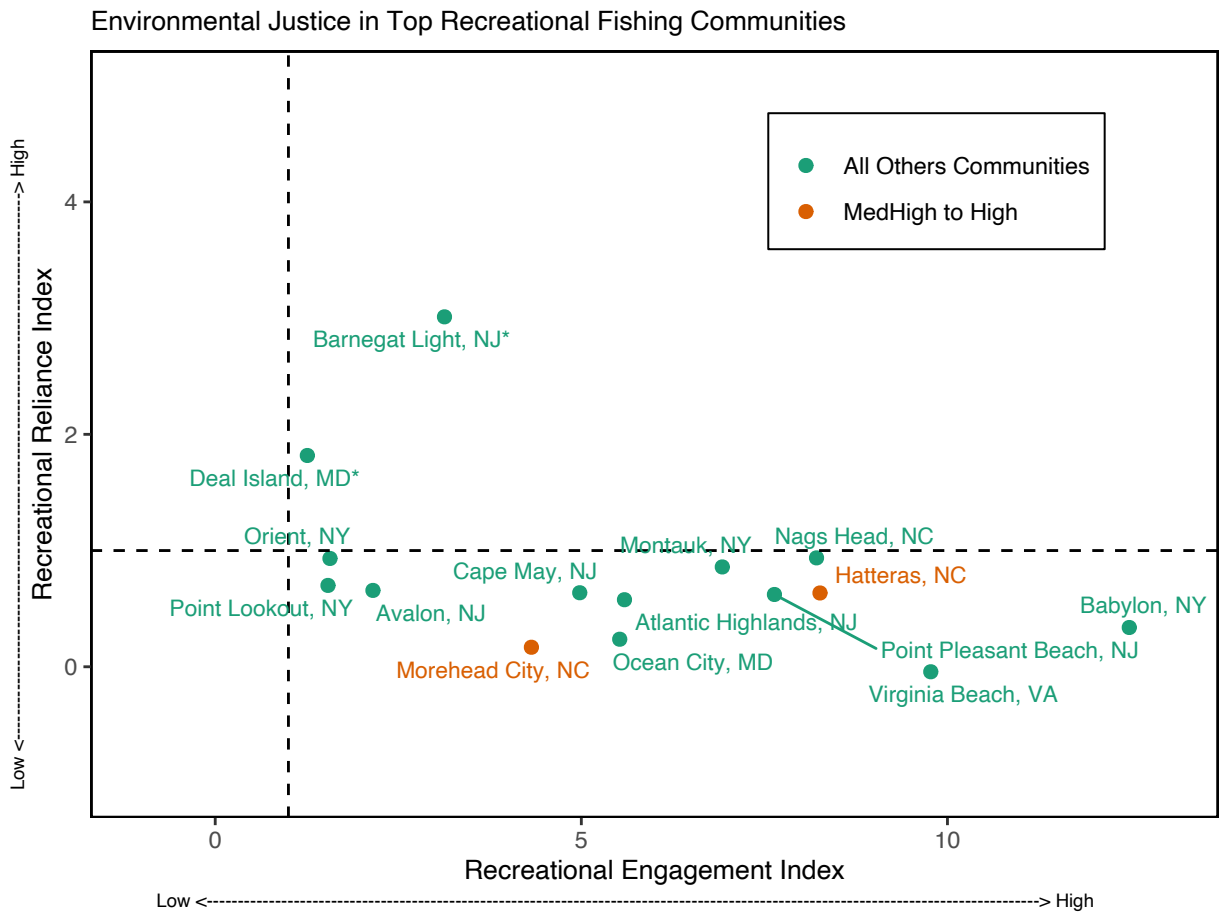


Figure 19: Recreational engagement and reliance, and environmental justice vulnerability, for the top recreationally engaged and reliant fishing communities in the Mid-Atlantic. Communities ranked medium-high or above for one or more of the environmental justice indicators are highlighted in bright orange. *Community scored high (1.00 and above) for both recreational engagement and reliance indicators.

Fig. 20 orders communities clockwise in a descending order of recreational engagement scores from high to low, with the most highly engaged community, Babylon, NY, listed on the top. The two communities with environmental justice concerns, Hatteras and Morehead City, NC, both scored medium-high for the poverty index.

Environmental Justice Vulnerability in Top Recreational Fishing Communities (Mid-Atlantic)

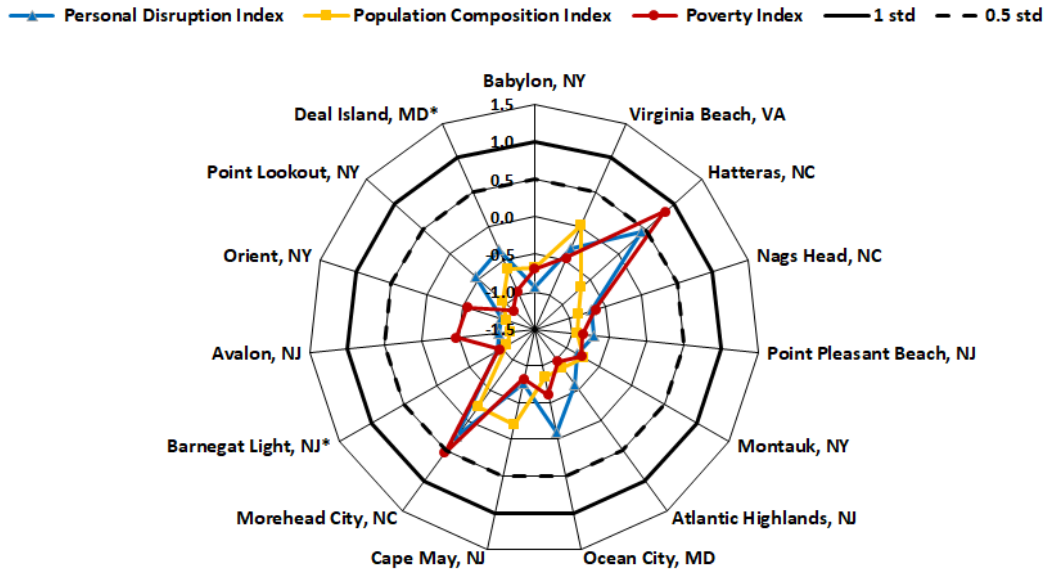


Figure 20: Environmental justice indicators (Poverty Index, population composition index, and personal disruption index) for top recreational fishing communities in Mid-Atlantic. *Community scored high (1.00 and above) for both recreational engagement and reliance indicators.

Both commercial and recreational fishing are important activities in Montauk, NY, Barnegat Light, Cape May and Point Pleasant Beach, NJ, meaning these communities may be impacted simultaneously by commercial and recreational regulatory changes. All of these communities scored lower than medium-high for all of the three environmental justice indicators, indicating that environmental justice may not be a major concern in these communities at the moment based on the indicators analyzed.

Implications

These plots provide a snapshot of the presence of environmental justice issues in the most highly engaged and most highly reliant commercial and recreational fishing communities in the Mid-Atlantic. 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 including environmental justice issues, they may have lower ability to successfully respond to change.

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. 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

As of 2019, rolling 5 year average bycatch indices for both harbor porpoise and gray seal bycatch were below current PBR thresholds, thus meeting management objectives. However, the 2019 bycatch estimate for gray seals was the highest in the time series and above PBR for that year (see 2021 report⁸). Bycatch indices were not updated because of low 2020 observer coverage caused by COVID-19 restrictions.

The North Atlantic right whale population was on a recovery trajectory until 2010, but has since declined (Fig. 21). Reduced survival rates of adult females and diverging abundance trends between sexes have also been observed. It is estimated that there are fewer than 100 adult females remaining in the population.

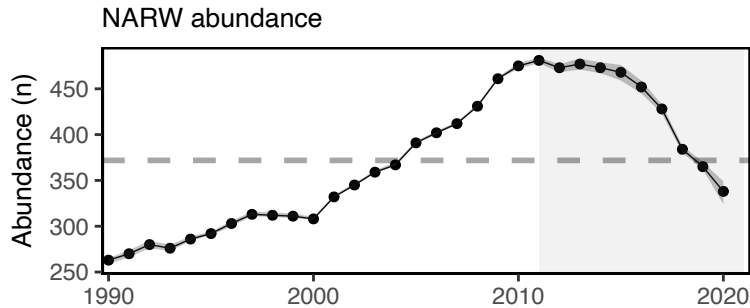


Figure 21: Estimated North Atlantic right whale abundance on the Northeast Shelf.

North Atlantic right whale calf counts have generally declined after 2009 to the point of having zero new calves observed in 2018 (Fig. 22). However, seven new calves were born in 2019, 10 were born in 2020, and preliminary 2021 observations of 18 calves have been recorded as of January 2022.

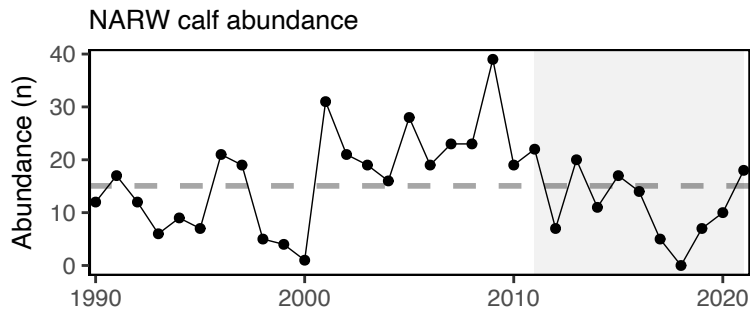


Figure 22: Number of North Atlantic right whale calf births, 1990 - 2021.

This year, the Unusual Mortality Event (UME) for North Atlantic right whales continued. Since 2017, the total UME right whale mortalities includes 34 dead stranded whales, 13 in the US and 21 in Canada. When alive but seriously injured whales (16) are taken into account, 50 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 strikes⁹.

Two additional UMEs continued from previous years for humpback whales and minke whales; suspected causes include human interactions and/or infectious disease. A UME for both gray and harbor seals was declared from

⁸<https://repository.library.noaa.gov/view/noaa/29525>

⁹<https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2022-north-atlantic-right-whale-unusual-mortality-event>

2018-2020 due to a high number of mortalities thought to be caused by phocine distemper virus, but is pending closure as of January 2022¹⁰.

Implications

Bycatch management measures have been implemented to maintain bycatch below PBR thresholds. The downward trend in harbor porpoise bycatch could 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. 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 one in 1988 to nine 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 of increase on the other three islands, with a maximum increase of 26.3% (95%CI: 21.6 - 31.4%; [5], and see the 2021 New England report¹¹). 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 both the fixed gear fisheries in the U.S. and Canada and vessel strikes in the U.S. are contributing substantially to the decline of the species [6]. 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]. Additional potential stressors include offshore wind development, which overlaps with important habitat areas used year-round by right whales, including mother and calf migration corridors and foraging habitat [9,10]. This area is also the only known right whale winter foraging habitat. Additional information can be found in the [offshore wind risks section](#).

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

Risks to meeting fishery management objectives

Climate and Ecosystem Productivity

Large scale climate related changes in the ecosystem can lead to changes in important habitats and ecological interactions, potentially resulting in regime shifts and ecosystem reorganization.

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

Ocean and estuarine temperature and salinity Ocean temperatures continue to warm at both the surface (Fig. 23) and bottom (Fig. 24) throughout the Northeast Shelf including the Mid-Atlantic. Seasonal sea surface temperatures in 2021 were above average throughout the year, with some seasons rivaling or exceeding the record warm temperatures observed in 2012.

¹⁰<https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events>

¹¹<https://repository.library.noaa.gov/view/noaa/29524>

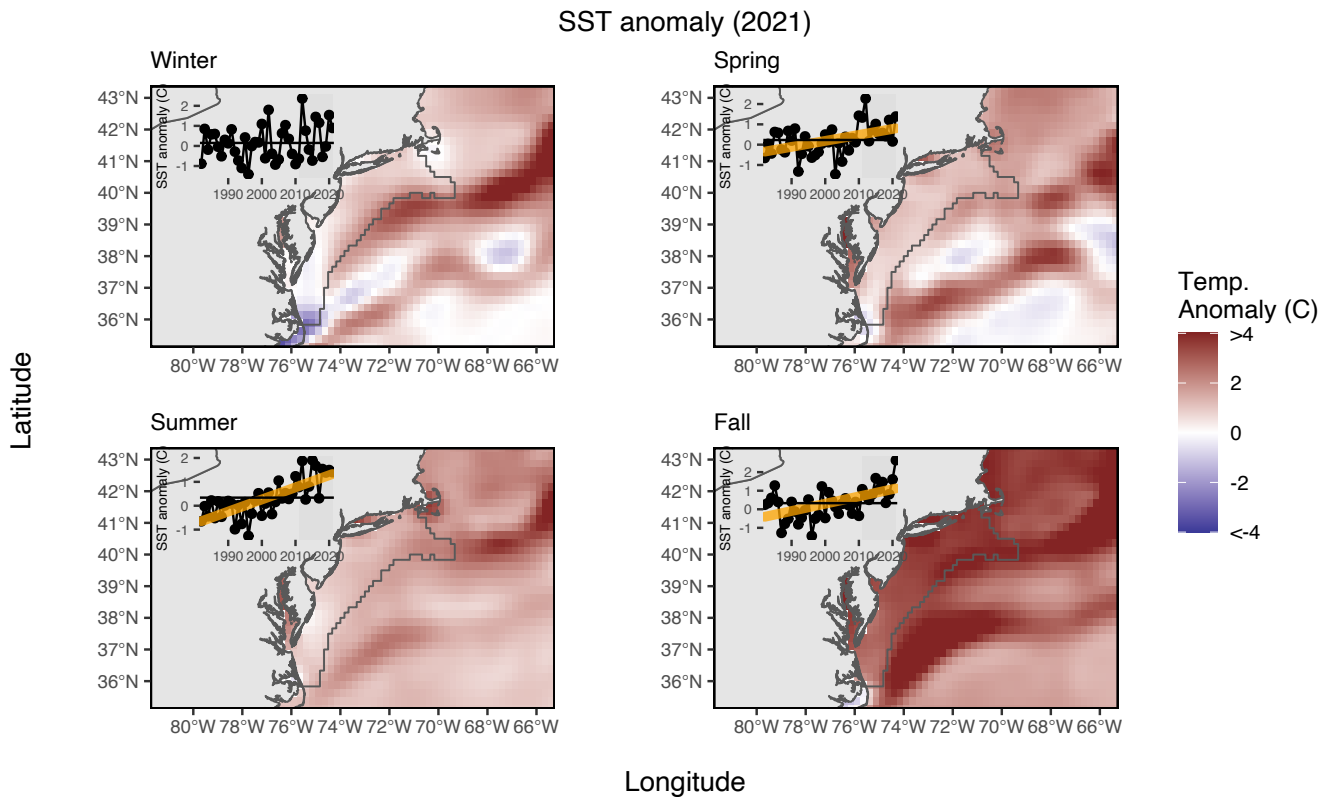


Figure 23: MAB (grey outline) seasonal sea surface temperature (SST) time series overlaid onto 2021 seasonal spatial anomalies. Seasons are defined as: Jan-Mar for winter, Apr-Jun for spring, Jul-Sep for summer, and Oct-Dec for fall.

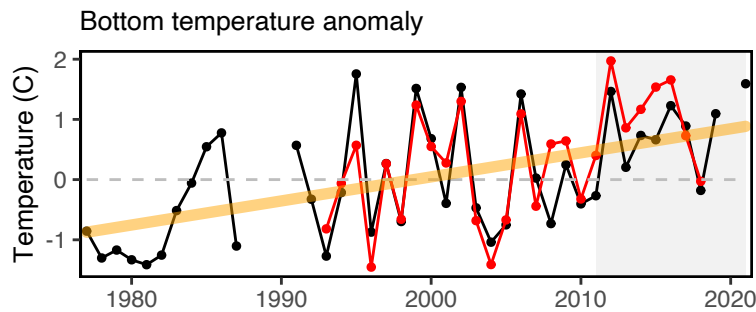


Figure 24: Annual bottom temperature in the MAB (black = in situ observations, red = observations from modeled reanalysis for comparison).

The Chesapeake Bay experienced a warmer-than-average winter and fall in 2021, and average conditions in the spring and summer, relative to the baseline period 2008-2020 (Fig. 25) as measured by satellites¹² (note that Chesapeake Bay seasonal definitions and baseline periods are different from the sea surface temperature anomalies reported in Fig.23 for the full Mid-Atlantic region). Similar 2021 seasonal temperature patterns were observed by bouys¹³ (Fig. 25), which also indicated above-average salinity in the Chesapeake Bay throughout the summer, with a decrease in salinity from late July to early August (Fig. 25). Salinity fell below average in September and remained at lower levels throughout fall 2021.

¹²<https://coastwatch.noaa.gov/cw/index.html>

¹³<https://buoybay.noaa.gov/>

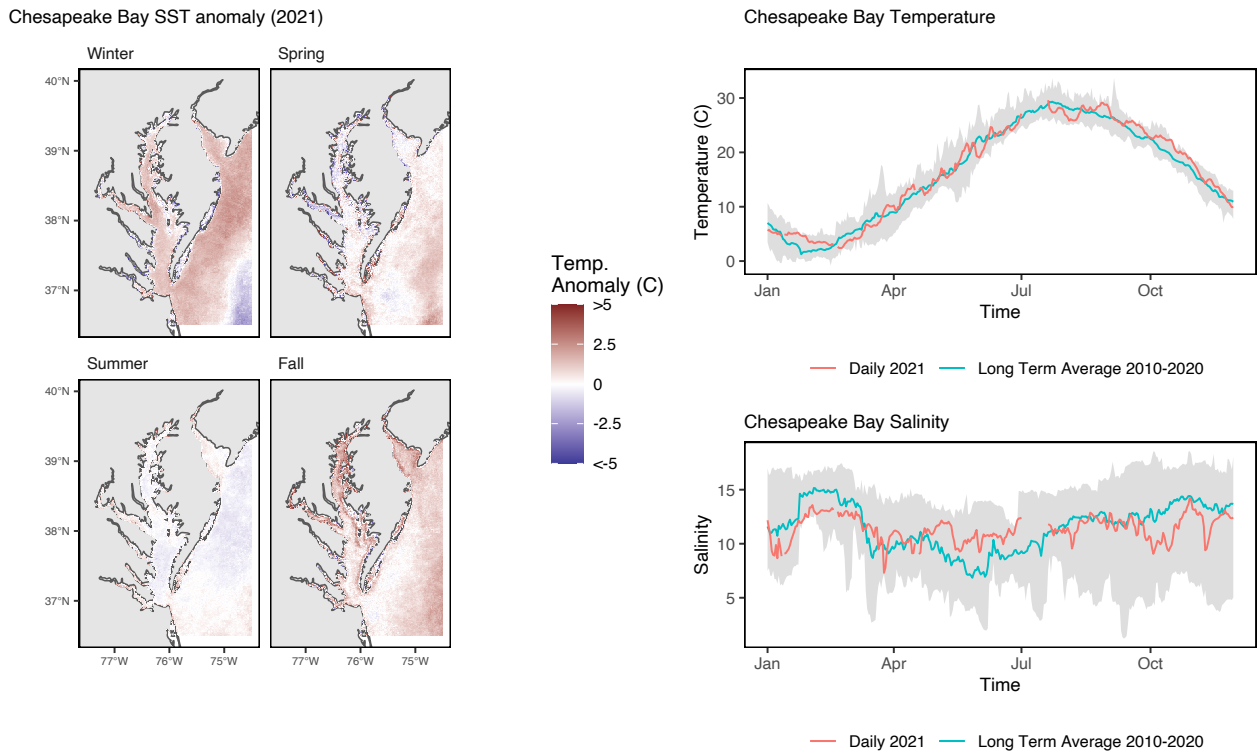


Figure 25: Left panel: 2021 sea surface temperature anomalies for the Chesapeake Bay. Data are from NOAA’s multi-satellite SST products and produced by NOAA’s Coastwatch Program. Seasons are defined to match the annual life cycles of many biological resources in Chesapeake Bay: Dec-Feb for winter, Mar-May for spring, Jun-Aug for summer, and Sep-Nov for fall. Right panel: NOAA Chesapeake Bay Interpretive Buoy System Gooses Reef buoy sea water temperature (top) and salinity (bottom); Red = 2021, Blue = Long term average 2010-2020.

Marine heatwaves A marine heatwave is a warming event that lasts for five or more days with sea surface temperatures warmer than 90% of previously observed (1982-2011) temperatures for that date [11]. Marine heatwaves measure not just high 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. The region is experiencing more frequent marine heatwaves over the last decade, including 2021, compared to the historical period.

In 2021, the Mid-Atlantic Bight experienced seven distinct marine heatwaves with the strongest event beginning on September 13 and lasting 53 days (Fig. 26). Relative to prior years, this marine heatwave ranked 9th on record in terms of maximum intensity and 4th on record in terms of cumulative intensity.

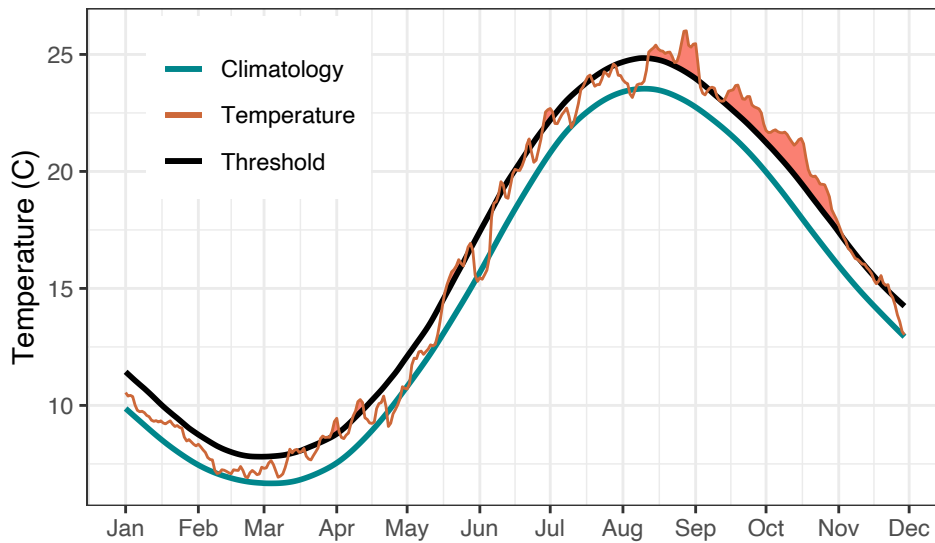


Figure 26: Marine heatwave events (red shading above black line) in the Mid-Atlantic occurring in 2021.

Ocean currents and features Variability of the Gulf Stream is one of the major drivers of changes in the oceanographic conditions of the Slope Sea and subsequently the Northeast U.S. continental shelf [12]. Changes in the Gulf Stream and Slope Sea can affect large-scale climate phenomena as well as local ecosystems and coastal communities. During the last decade, the Gulf Stream has become less stable and shifted northward [13,14] (Fig. 27). A more northern Gulf Stream position is associated with warmer ocean temperature on the northeast shelf [15], a higher proportion of Warm Slope Water in the Northeast Channel, and increased sea surface height along the U.S. east coast [16].

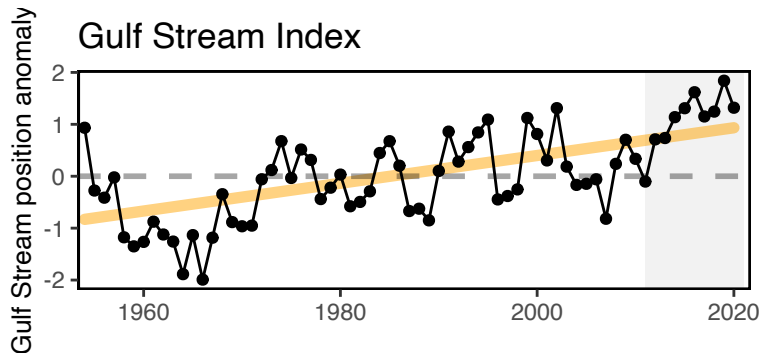


Figure 27: Index representing changes in the location of the Gulf Stream north wall. Positive values represent a more northerly Gulf Stream position.

Since 2008, the Gulf Stream has moved closer to the Grand Banks, reducing the supply of cold, fresh, and oxygen-rich Labrador Current waters to the Northwest Atlantic Shelf [17]. Nearly every year since 2010, warm slope water made up more than 75% of the annual slope water proportions entering the Gulf of Maine. In 2017 and 2019, almost no cooler Labrador Slope water entered the Gulf of Maine through the Northeast Channel (Fig. 28). The changing proportions of source water affect the temperature, salinity, and nutrient inputs to the Gulf of Maine ecosystem. In 2021, warm slope water continued to dominate (86.1%) inputs to the Gulf of Maine. The 2022 position of the north wall of the Gulf Stream is forecasted to be similar to 2021 [18], extending this pattern.

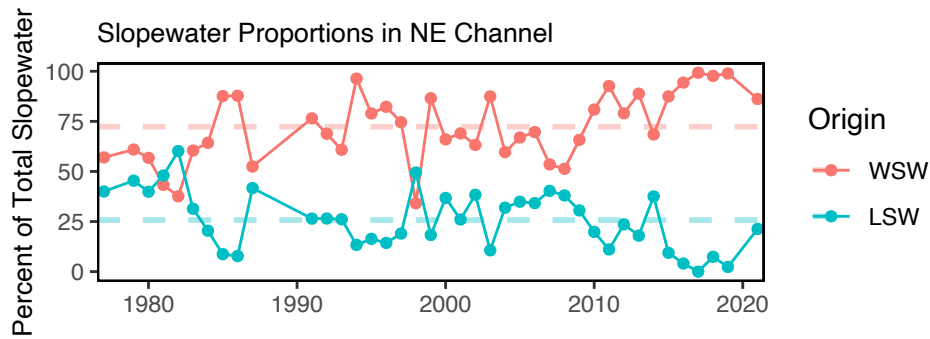


Figure 28: Proportion of Warm Slope Water (WSW) and Labrador Slope Water (LSW) entering the Gulf of Maine through the Northeast Channel.

The increased instability of the Gulf Stream position and warming of the Slope Sea may also be connected to the regime shift increase in the number of warm core rings formed annually in the Northwest Atlantic [12,19] (Fig. 29). Timing of ring formation may also be changing. In 2021, a remarkable number of rings were observed simultaneously near the shelf break in June. When warm core ring water moves onto the continental shelf, it can alter the habitat and disrupt seasonal movements of fish [20].

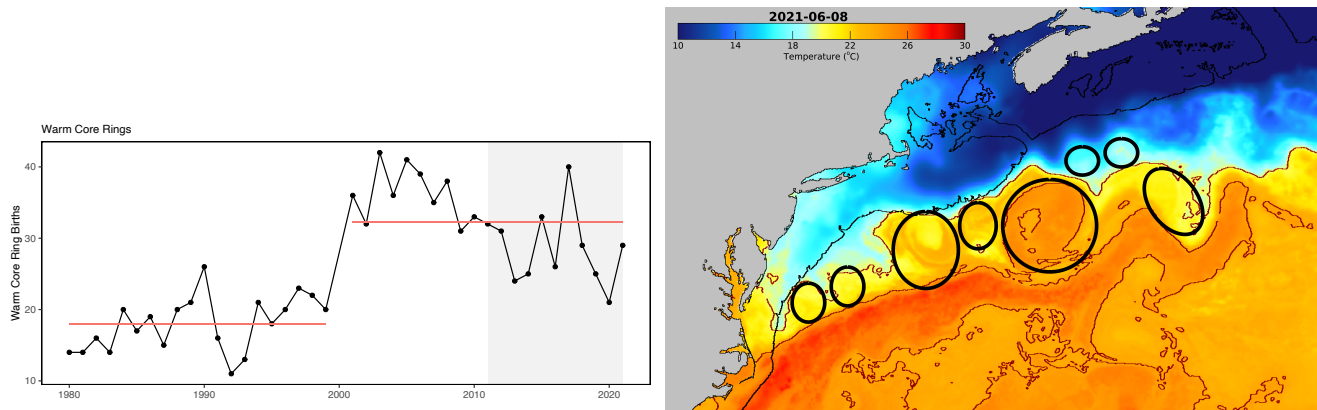


Figure 29: Warm core ring formation on the Northeast U.S. Shelf: Annual number of rings (left) and June 2021 rings (right), where the black line is the 200 m isobath (the shelf break) and the red lines are the 20 and 24 degree isotherms.

When warm core rings and eddies interact with the continental slope they can transport warm, salty water to the continental shelf [21], and this is now happening more frequently [20,22]. These interactions can be significant contributors to marine heatwaves in the Mid-Atlantic Bight [21,23] as well as the movement of shelf-break species inshore [20,24,25].

Changes in ocean temperature and circulation alter habitat features such as the seasonal cold pool, a 20–60 m thick band of cold, relatively uniform near-bottom water that persists from spring to fall over the mid and outer shelf of the MAB and southern flank of Georges Bank [26,27]. 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 [26,28]. The average temperature of the cold pool is getting warmer over time [29,30], the area is getting smaller [31], and the duration is getting shorter (Fig. 30).

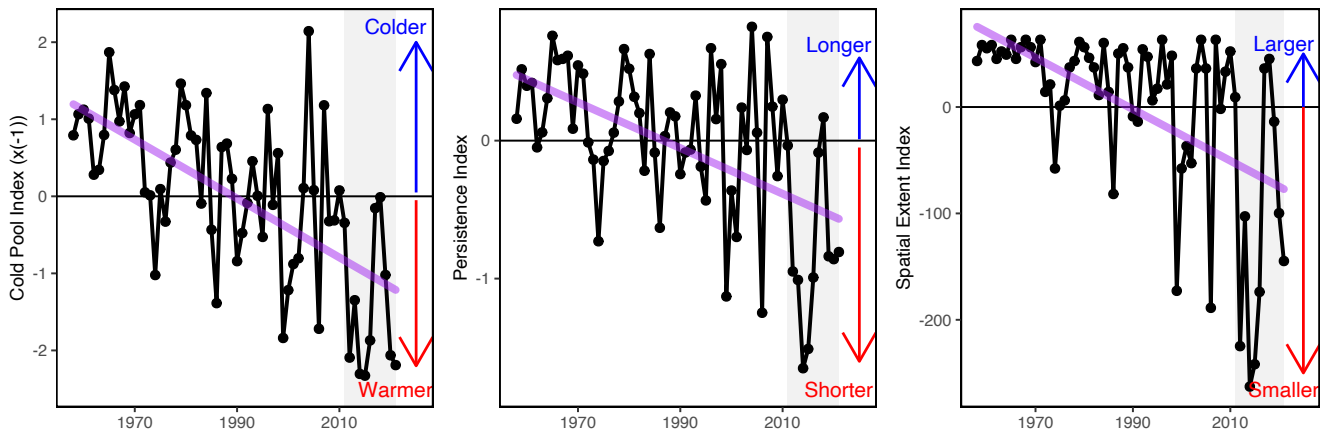


Figure 30: Seasonal cold pool indices: mean temperature within the cold pool, cold pool persistence, and spatial extent.

Ocean Acidification Ocean acidification (OA) has caused measured declines in global ocean pH. On the Northeast Shelf, summer bottom pH (2007-2021) varied spatially and temporally, ranging from 7.69-8.07 (Fig. 31, left panel). The lowest pH values were recorded in western Long Island Sound, and nearshore to mid-shelf waters off the coast of New Jersey. In summer 2021, water column pH from the glider-based profiles ranged from 7.67-8.22 (Fig. 31, right panel). The lowest pH occurred in bottom waters, reaching minimum values in shallow waters typically inhabited by Atlantic surfclams (27-56 m) in the southern flank of the Hudson Canyon (mean pH = 7.80).

This seasonal pH minimum in the Mid-Atlantic is associated with cold pool subsurface and bottom water, which is cut off from mixing with surface water by strong stratification. Fall mixing and slope water intrusions act to increase the pH in outer shelf waters [32].

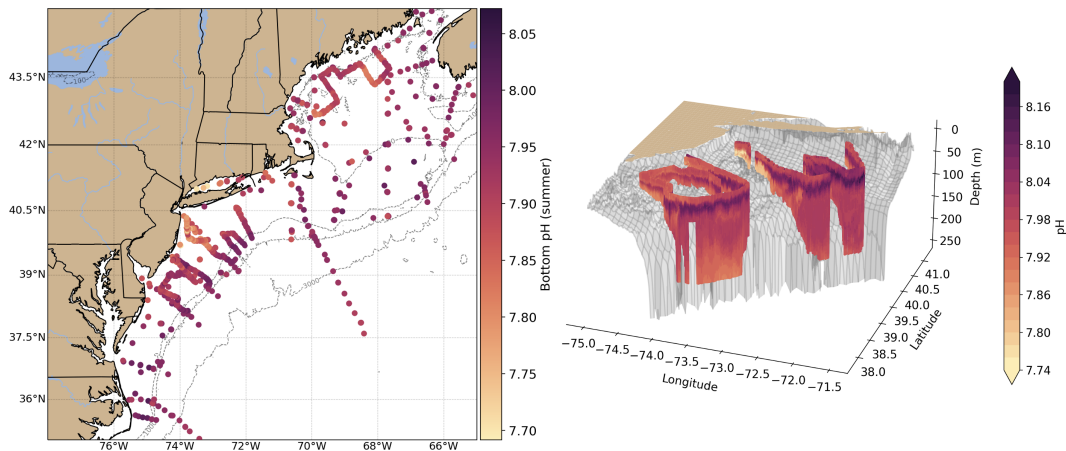


Figure 31: Left: Summer bottom pH collated from all quality-controlled vessel- and glider-based measurements from 2007-2021. Right: Glider-based pH profiles collected during summer 2021 in the Mid-Atlantic.

Ecosystem Productivity Indicators: phytoplankton, zooplankton, forage fish, fish condition

Phytoplankton Phytoplankton support the food web as the primary food source for zooplankton and filter feeders such as shellfish. Numerous environmental and oceanographic factors interact to drive the abundance, composition, spatial distribution, and productivity of phytoplankton. In 2021, MAB phytoplankton biomass (surface chlorophyll) was above average in winter, but below average during the spring and summer months. Below average phytoplankton biomass could be due to reduced nutrient flow to the surface and/or increased grazing pressure. A short fall

bloom was detected in November. Primary productivity (the rate of photosynthesis) was average to below average throughout 2021 (Fig. 32).

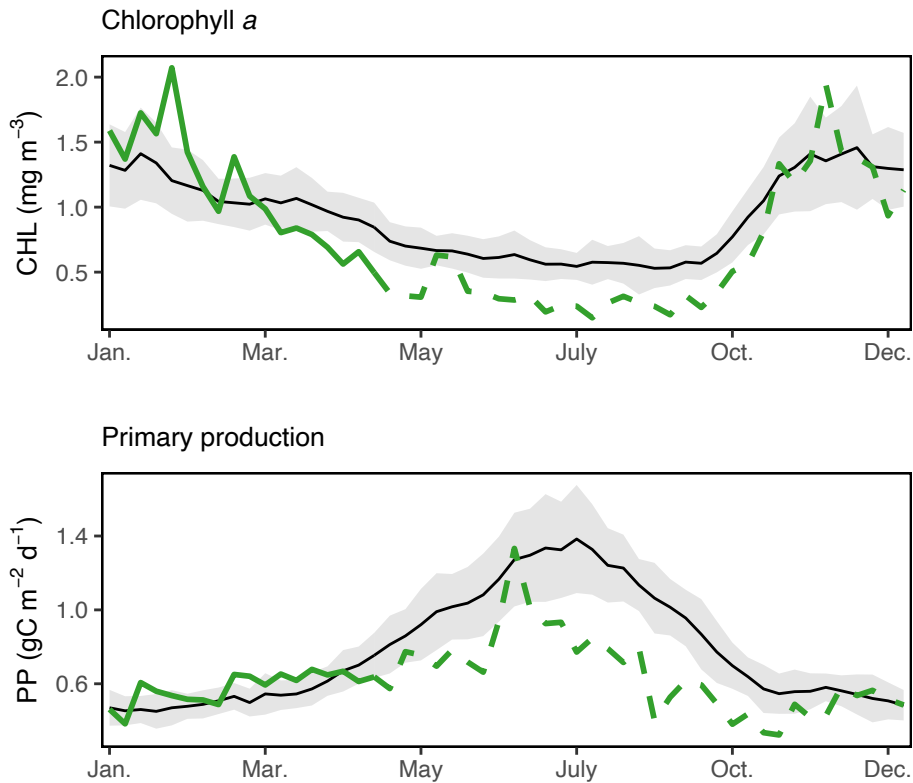


Figure 32: Weekly chlorophyll concentrations and primary productivity in the Mid-Atlantic are shown by the colored line for 2021 (dashed portion indicates preliminary data from a near real-time satellite source). The long-term mean is shown in black and shading indicates +/- 1 standard deviation.

The seasonal cycle of phytoplankton size distribution shows that the spring and fall bloom periods are dominated by larger-celled microplankton, while smaller-celled nanoplankton dominate during the warmer summer months. The proportion of the smallest phytoplankton, picoplankton (0.2-2 microns), is relatively constant throughout the year. In 2021, microplankton proportions were above average during the winter and fall bloom periods, but below average for the summer months (Fig. 33).

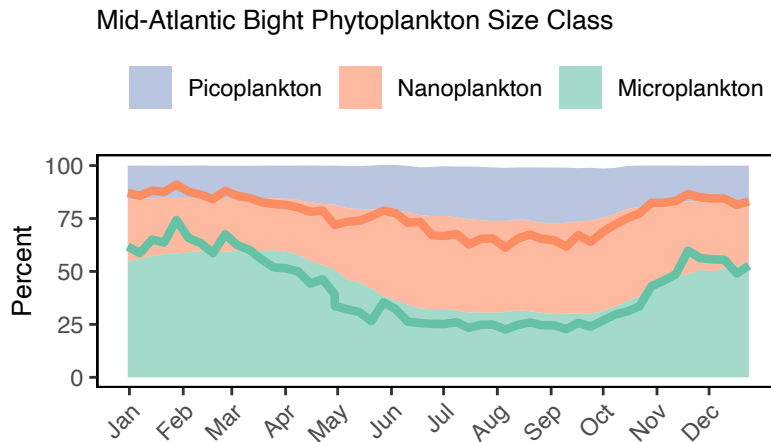


Figure 33: The annual climatology (1998-2020) percent composition of the phytoplankton size classes in the Mid-Atlantic based on satellite observations in the shaded portions. The 2021 proportions for the microplankton (>20 microns, green) and nanoplankton (2-20 microns, orange) are shown in the bold lines.

Zooplankton While zooplankton indicators could not be updated for this report due to 2020 survey disruptions and lags in sample processing, data up to 2019 showed long-term increasing trends of gelatinous zooplankton and krill on the northeast shelf (see 2021 report¹⁴). Preliminary 2021 observations found the total volume of plankton caught in the bongo net was significantly greater than the previous years due to increased gelatinous zooplankton, predominantly salps (*Thalia democratica*). Unusually high concentrations of salps were found throughout the Northeast shelf and in the Slope Sea during other summer 2021 scientific surveys, which may be associated with water mass intrusions at the shelf break [33,34]. Salps are filter feeders feeding on phytoplankton and other small particles and may have contributed to the below average phytoplankton biomass in summer 2021 (Fig. 32).

Forage Fish Energy Content Nutritional value (energy content) of juvenile and adult forage fish as prey is related to environmental conditions, fish growth, and reproductive cycles. Forage energy density measurements from NEFSC trawl surveys 2017-2021 are building toward a time series to evaluate trends (Fig. 34). Limited data from the spring 2020 survey, and complete spring 2021 survey measurements were consistent with previous reports: 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, longfin squid (*Loligo* in figure) and shortfin squid (*Illex* in figure) were also lower than previous estimates [35,36]. Energy density of alewife, butterfish, sand lance, and Atlantic mackerel varies seasonally, with seasonal estimates both higher and lower than estimates from previous decades.

¹⁴<https://repository.library.noaa.gov/view/noaa/29525>

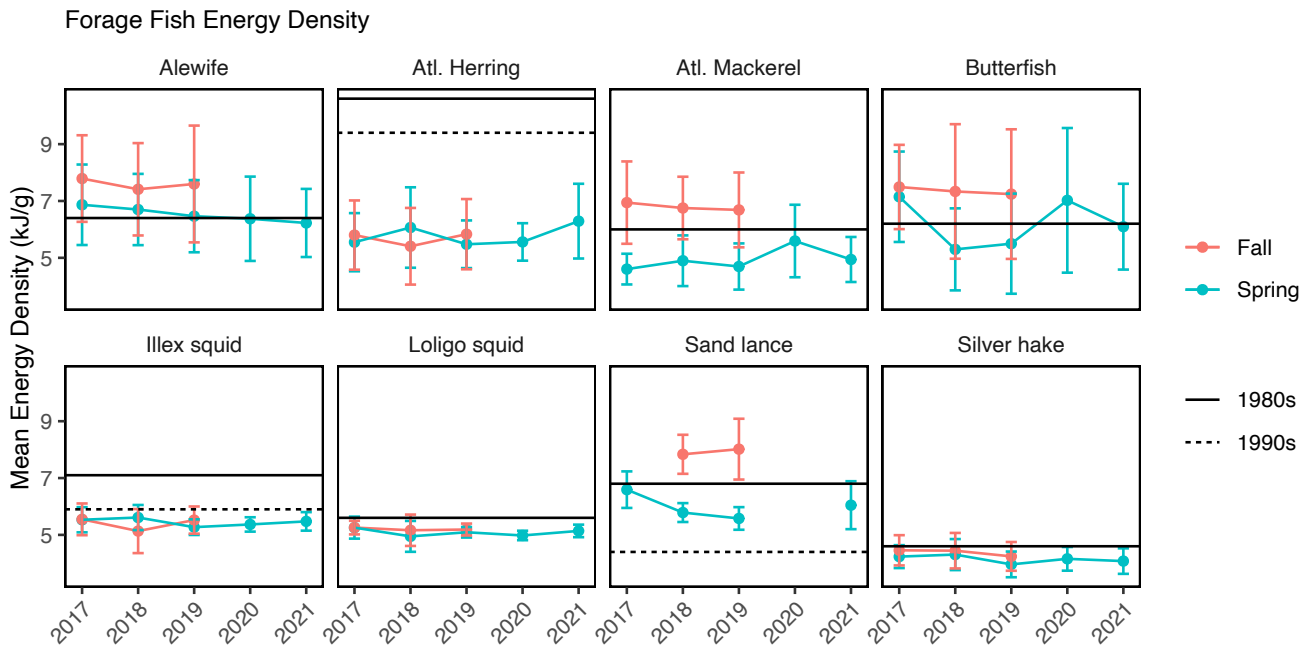


Figure 34: Forage fish energy density mean and standard deviation by season and year, compared with 1980s (solid line; Steimle and Terranova 1985) and 1990s (dashed line; Lawson et al. 1998) values.

Fish Condition 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 [37]. Heavier and fatter fish at a given length have higher relative condition which is expected to improve 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. However, most species in the MAB had below average or poor condition again in 2021 (Fig. 35). Preliminary results of synthetic analyses show that changes in temperature, zooplankton, fishing pressure, and population size influence the condition of different fish species.

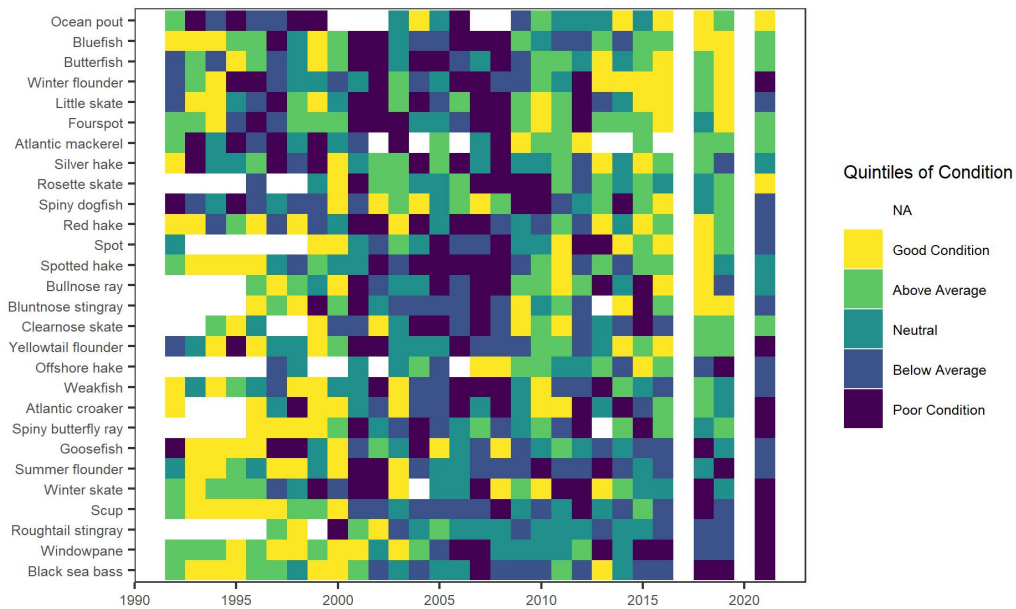


Figure 35: Condition factor for fish species in the MAB based on fall NEFSC bottom trawl survey data. MAB data are missing for 2017 due to survey delays, and no survey was conducted in 2020.

Fish Productivity We describe patterns of aggregate fish productivity in the Mid-Atlantic with the small fish per large fish anomaly indicator, derived from NEFSC bottom trawl survey data (Fig. 36). The indicator shows that productivity has been declining in this region since 2010.

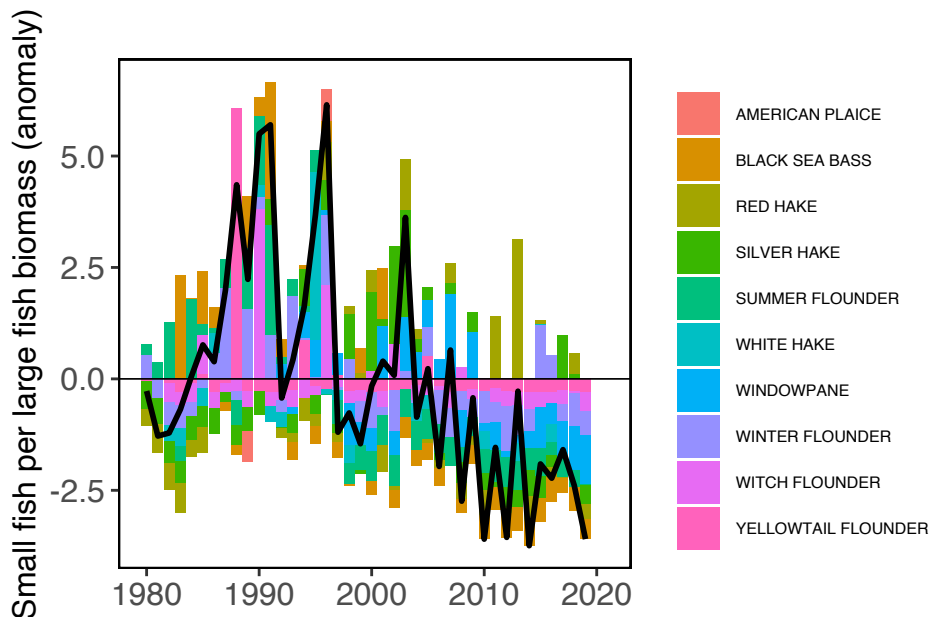


Figure 36: Small fish per large fish biomass anomaly in the Mid-Atlantic Bight. The summed anomaly across species is shown by the black line.

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 was increasing in the MAB as of 2019, while adult fish diversity indices appear stable over time, with current values within one standard deviation from most historic estimates (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, Fig. 37) 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.

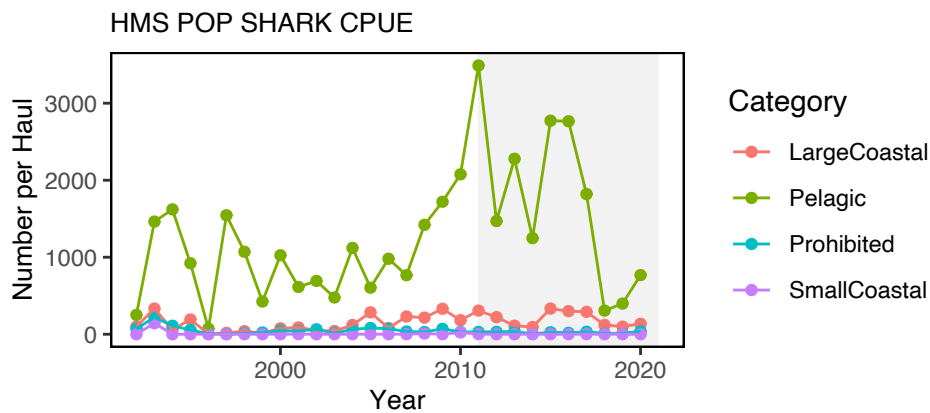


Figure 37: Estimated number of sharks per unit effort from Highly Migratory Species Pelagic Observer Program data.

Stock status is mixed for Atlantic Highly Migratory Species (HMS) stocks (including sharks, swordfish, billfish, and tunas) occurring in the Mid-Atlantic region. While there are several HMS species considered to be overfished or that have unknown stock status, the population status for some managed Atlantic sharks and tunas is at or above the biomass target (Fig. 38), suggesting the potential for robust predator populations among these managed species.

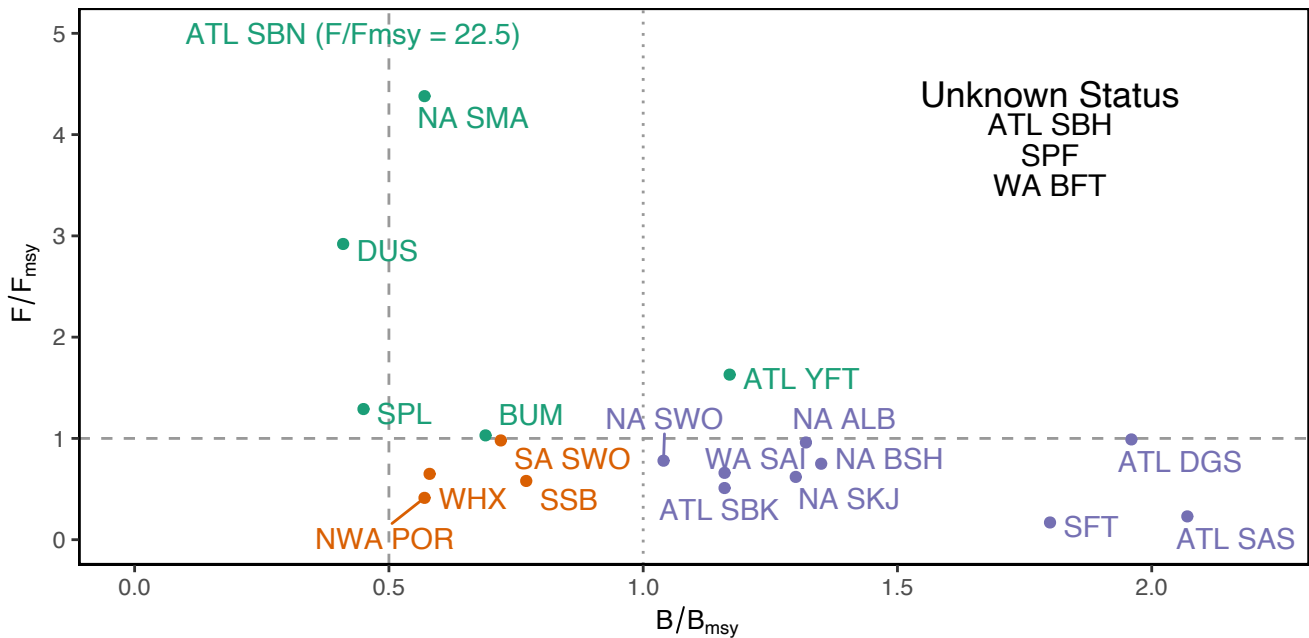


Figure 38: Summary of single species status for HMS stocks; key to species names at <https://noaa-edab.github.io/tech-doc/atlantic-highly-migratory-species-stock-status.html>.

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 Risk Indicators: habitat assessments, submerged aquatic vegetation, estuarine habitat quality, fishing gear impacts

Habitat Assessments The Northeast Regional Marine Fish Habitat Assessment (NRHA) is a collaborative effort to describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast. This includes mapping inshore and offshore habitat types used by focal fish species, summarizing impacts of habitat climate vulnerability on these species, modeling predicted future species distributions, and developing a publicly accessible decision support tool to visualize these results. This is a three-year project led by the New England and Mid-Atlantic Fishery Management Councils in collaboration with many partners including NOAA Fisheries, and will be completed in July 2022¹⁵.

As part of the NRHA work, climate vulnerability information from NOAA’s Habitat Climate Vulnerability Assessment [38] and the Northeast Fish and Shellfish Climate Vulnerability Assessment [39]¹⁶ is synthesized for approximately 70 species in the northeast region. For example, black sea bass, scup, and summer flounder have

¹⁵<https://www.mafmc.org/nrha>

¹⁶<https://www.fisheries.noaa.gov/new-england-mid-atlantic/climate/northeast-vulnerability-assessment>

been linked to several highly vulnerable nearshore habitats from salt marsh, submerged aquatic vegetation, and 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 table¹⁷.

Submerged Aquatic Vegetation Submerged aquatic vegetation (SAV) is designated as a Habitat Area of Particular Concern (HAPC) for summer flounder and is important habitat for many fish species, particularly during vulnerable juvenile stages. Increased SAV coverage (including wild celery, water stargrass, and hydrilla) in the tidal fresh areas of the Chesapeake Bay (Fig. 39) has been attributed to restoration efforts. This ecosystem engineering has improved water quality, promoting further expansions of SAV meadows. However, in the higher salinity region near the mouth of the Chesapeake Bay (Fig. 39), increased water temperatures, especially during the summer, have led to a decline in eelgrass coverage.

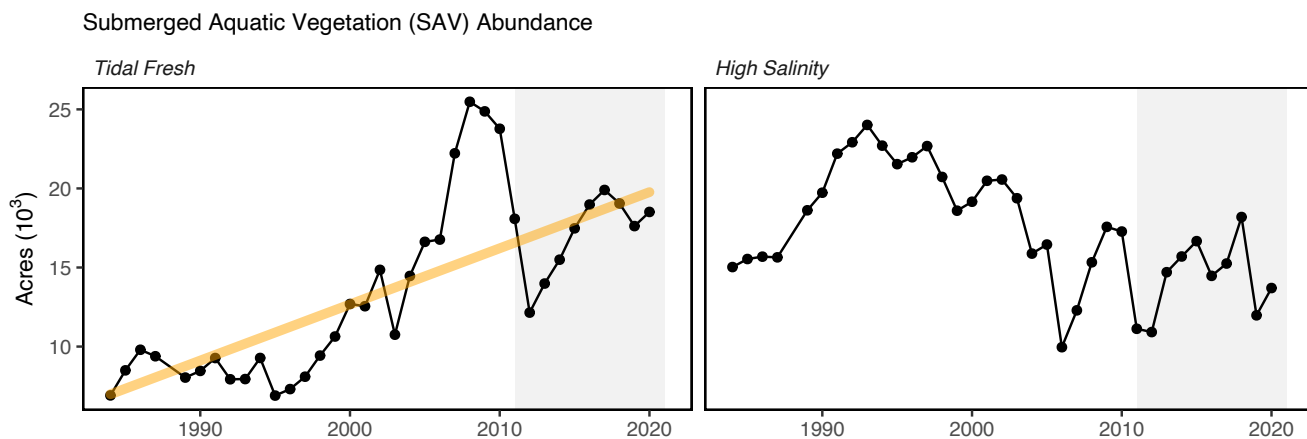


Figure 39: Submerged Aquatic Vegetation (SAV) coverage in tidal fresh and high salinity regions of the Chesapeake Bay.

Estuarine Habitat Quality (Chesapeake Bay) Many important MAFMC managed species (e.g., summer flounder, scup, black sea bass, and bluefish) use estuarine habitats as nurseries or are considered estuarine and nearshore coastal-dependent, and interact with other important estuarine-dependent species (e.g., striped bass and menhaden). An integrated measure of multiple water quality criteria shows a significantly increasing proportion of Chesapeake Bay waters meeting or exceeding EPA water quality standards over time ([40]; Fig. 40). This pattern was statistically linked to total nitrogen reduction, indicating responsiveness of water quality status to management actions implemented to reduce nutrients. Water quality trends and status may be used to inform aquaculture siting decisions in Chesapeake Bay.

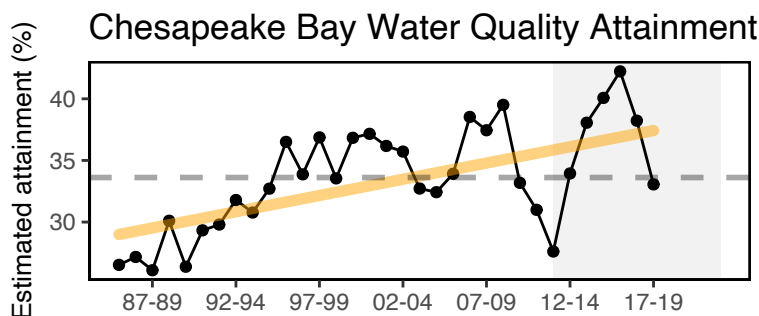


Figure 40: Water quality attainment in Chesapeake Bay following rolling three year assessment periods.

¹⁷https://noaa-edab.github.io/ecodata/Hab_table

Fishing Gear Impacts Estimates of the impacts of fishing gear on habitat are available through the habitat section of the Northeast Ocean Data Portal¹⁸. The data portal hosts selected outputs from the Northeast Fishing Effects Model which combines seafloor data (sediment type, energy regime) with fishing effort data to generate percent habitat disturbance estimates in space and time. More detailed information can be found in the Synthetic Indicator Catalog.¹⁹

Implications

Links between climate change and managed species Estuarine, nearshore, and offshore 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 Increasing water temperatures in Chesapeake Bay have negative impacts on striped bass at all life stages, although improvements in water quality mitigate some impacts. Declining recruitment since 2000 is associated with higher winter and spring water temperatures and lower freshwater flows, which compress the reproductive season, cause production of zooplankton prey earlier in the season before striped bass larvae are feeding, and reduce concentration of zooplankton prey in larval habitat.

In 2021, average summer water temperatures combined with better dissolved oxygen conditions likely improved habitat quality for larger juvenile and adult striped bass in the summer. The expansion of submerged aquatic vegetation meadows in the tidal fresh region of the Chesapeake Bay (Fig. 39) is likely benefiting species like striped bass who use this as spawning and nursery habitat in the spring. However, similar to 2020, the warm winter in 2021 may have reduced larval survival, despite the average spring temperatures and high spring flows, which represent favorable conditions for striped bass recruitment success.

Understanding habitat conditions can enhance recreational fishery management. Maryland Department of Natural Resources is incorporating habitat conditions into striped bass catch-and-release management, including 1) a two-week summer closure directed at reducing catch-and-release mortality²⁰ as a substitute for harvest season reductions, and 2) the Striped Bass Fishing Advisory²¹, which lets anglers know the relative level of risk of released fish dying due to high temperatures.

Blue Crabs Warmer winter temperatures may benefit Chesapeake Bay blue crabs, an important commercial and forage species. Above-average fall and winter temperatures in 2021 may have reduced overwintering mortality [41–43] and contributed to increased productivity of blue crabs going into 2022. Longer growth seasons are associated with increased production of blue crabs and oysters in Chesapeake Bay. Blue crabs are moving northward with warming temperatures and have been documented in the Gulf of Maine [44], with implications for both their management and for the inshore ecosystems.

Eastern Oyster Oyster reefs provide habitat for several managed fish species including juvenile black sea bass and summer flounder. Increased Chesapeake Bay salinity has been linked to high juvenile oyster abundance [45]. In 2021, high oyster spat set was predicted based on high summer salinity²², and was observed in Maryland during fall 2021. Virginia oyster recruitment was at record levels 2019-2020 and was above average in 2021.

Summer Flounder and Black Sea Bass The reduced amount of Chesapeake Bay water volume with low oxygen (hypoxic volume) in June and July 2021 suggests better environmental conditions during a critical period of juvenile production for key species such as black sea bass and summer flounder. The increase in hypoxic volume in the fall, however, may have been particularly harmful as it coincided with above-average water temperatures. Additionally, eelgrass in the higher salinity areas near the mouth of the Chesapeake Bay (Fig. 39) is critical nursery habitat for summer flounder, and recent declines seen in SAV coverage could negatively impact recruitment survival.

¹⁸<https://www.northeastoceandata.org/data-explorer/>

¹⁹<https://noaa-edab.github.io/catalog/northeast-fishing-effects-model.html>

²⁰https://dnr.maryland.gov/fisheries/Documents/StripedBass_regulations2022.pdf

²¹https://dnr.maryland.gov/fisheries/Pages/SB_forecast.aspx

²²<https://content.buoybay.noaa.gov/sites/default/files/NCBOSeasonalSummary2021Summer.pdf>

Surfclam Ocean acidification also has different implications, depending on the species and life stage. Recent lab studies have found that surf clams exhibited metabolic depression in a pH range of 7.46-7.28 [46]. Computer models are in development to help determine the long term implications of growth on surf clam populations. Aggregated data from 2007-2021 show that summer bottom ocean pH (7.69-8.07, Fig. 31) has not yet reached the metabolic depression threshold observed for surfclams in lab studies so far.

Northern Shortfin Squid Since 2017, extraordinarily high availability of northern shortfin squid have been observed in the Mid-Atlantic, resulting in high fishery catch per unit effort (CPUE) and early fishery closures. High instances of squid catch near the shelf break are significantly related to low bottom temperatures (< 10 degrees C), high salinity (>35.6 psu), increased chlorophyll frontal activity as well as the presence and orientation of warm core rings. Warm core rings are an important contributor to squid availability, likely influencing habitat conditions across different life stages. In particular, fishing effort was concentrated on the eastern edge of warm core rings, which are associated with upwelling and enhanced productivity.

Heatwave impacts While marine heatwaves lasting over days may disturb the marine environment, long lasting events such as the warming in 2012 (Fig. 41) can have significant impacts to the ecosystem [23]. The 2012 heatwave affected the lobster fishery most notably, but other species also shifted their geographic distributions and seasonal cycles [47]. The 2012 heatwave was caused by a shift in the atmospheric Jet Stream, whereas the 2017 marine heatwave in the Mid-Atlantic was associated with a strong positive salinity anomaly and is likely related to cross-shelf flow driven by the presence of a warm core ring adjacent to the shelfbreak south of New England [23]. During the 2017 event, warm water fish typically found in the Gulf Stream were caught in shallow waters near Block Island, RI [20]. Ocean temperatures in 2021 rivaled or exceeded the record temperatures in 2012 in some seasons, but the impacts to fisheries have yet to be determined.

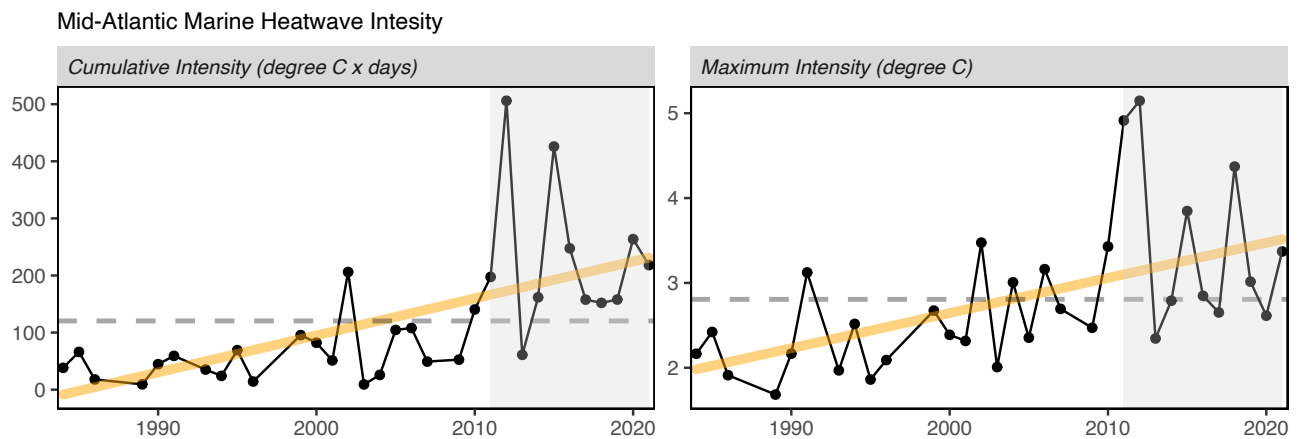


Figure 41: Marine heatwave cumulative intensity (left) and maximum intensity (right) in the Mid-Atlantic Bight.

Cold pool impacts Changes in the cold pool habitat can affect species distribution, recruitment, and migration timing for multiple federally managed species. Southern New England-Mid Atlantic yellowtail flounder recruitment and settlement are related to the strength of the cold pool [29]. The settlement of pre-recruits during the cold pool event represents a bottleneck in yellowtail life history, during which a local and temporary increase in bottom temperature negatively impacts the survival of the settlers. Including the effect of cold pool variations on yellowtail recruitment reduced retrospective patterns and improved the skill of short-term forecasts in a stock assessment model [29,30]. The cold pool also provides habitat for the ocean quahog [31,48]. Growth rates of ocean quahogs in the MAB (southern portion of their range) have increased over the last 200 years whereas little to no change has been documented in the northern portion of their range in southern New England, likely a response to a warming and shrinking cold pool [49].

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. 8). We hope to expand this analysis beyond fish. Marine mammal distribution maps are available online²³; 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. 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.

The apparent decline in productivity across multiple managed species in the MAB, along with low fish condition for many species in 2021, also suggest changing ecosystem productivity at multiple levels. During the 1990s and early 2000s high relative abundance of smaller bodied copepods and a lower relative abundance of *Calanus finmarchicus* was associated with regime shifts to lower fish recruitment [50]. The unprecedented climate signals along with the trends toward lower productivity across multiple managed species indicate a need to continually evaluate whether management reference points remain appropriate, and to evaluate if ecosystem regime shifts have occurred or reorganization is in progress.

Other Ocean Uses: Offshore Wind

Indicators: development timeline, revenue in lease areas, coastal community vulnerability

As of February 2022, 24 offshore wind development projects are proposed for construction over the next decade in the Northeast (timelines and project data are based on Tables E-2, E-4, and E-4-2 of South Fork Wind Farm Final Environmental Impact Statement). Offshore wind areas are anticipated to cover more than 1.7 million acres by 2030 in the Greater Atlantic region (Fig. 42). Beyond 2030 values include acreage for the NY Wind Energy Areas (WEA) and Gulf of Maine Area of Interest for floating research array.

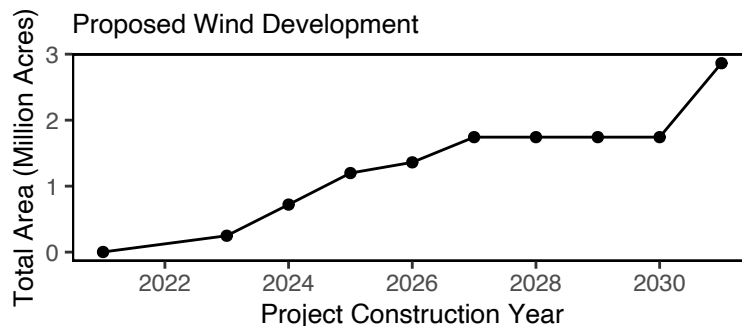
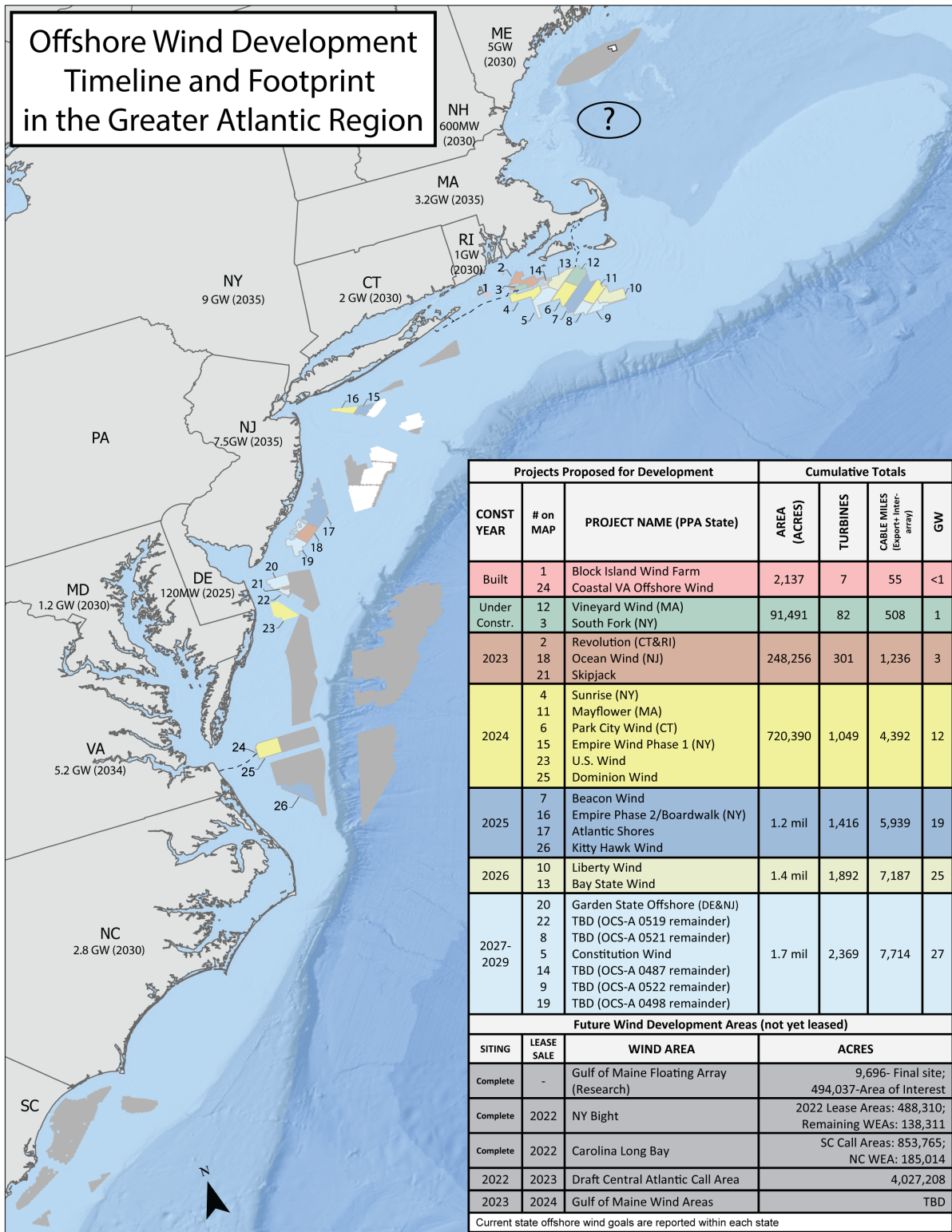


Figure 42: Proposed wind development on the northeast shelf.

²³<https://www.nefsc.noaa.gov/AMAPPSviewer/>



Wind area boundaries, construction data and timelines are frequently updated. This map contains the most recent published information as of 2/2/22. Sources: South Fork Wind Farm FEIS, BOEM GIS data, BOEM Leasing Path Forward 2021-2025

Figure 43: All Northeast Project areas by year construction ends (each project has 2 year construction period).

Just over 2,500 foundations and more than 7,000 miles of inter-array and offshore export cables are proposed to date.

The colored chart in Fig. 43 also presents the offshore wind development timeline in the Greater Atlantic region with the estimated year that foundations would be constructed (matches the color of the wind areas). These timelines and data estimates are expected to shift but represent the most recent information available as of February 2022. 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. Future wind development areas are also presented. Additional lease areas, totalling over 488,000 acres in the NY Bight are available for BOEM’s 2022 lease sale. It’s anticipated that the NY Bight leases will fulfill outstanding offshore wind energy production goals for NY and NJ. VA and NC have outstanding goals that cannot be fulfilled within the existing lease areas, and it is expected that these will be fulfilled with future development off the Delmarva Peninsula.

Based on federal vessel logbook data, average commercial fishery revenue from trips in the current offshore wind lease areas and the New York Bight leasing areas identified in the proposed sale notice represented 2-20% of the total annual revenue for the most affected fisheries in federal waters from 2008-2019 (Fig. 44).

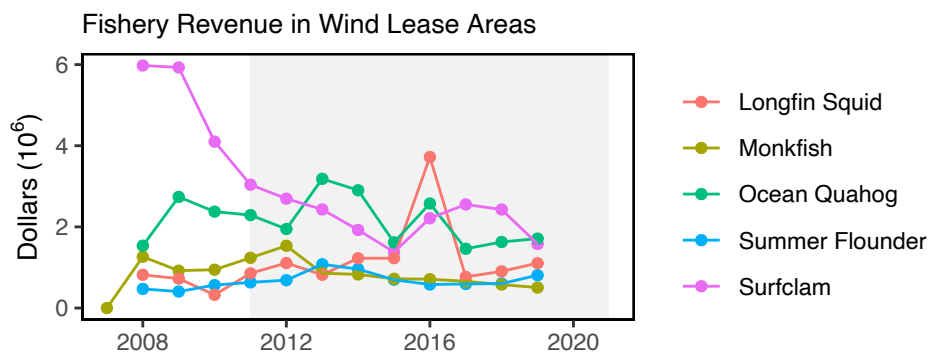


Figure 44: Wind energy revenue in the Mid-Atlantic.

The surfclam fishery could be the most affected fishery, with a maximum of 20% of annual fishery revenue occurring within potential wind lease areas during this period, followed by chub mackerel (15%), ocean quahog (13%), and Atlantic mackerel (10%). The *Illex* squid and bluefish fisheries were the least affected, at 1-2% maximum annual revenue affected, respectively. A maximum of 9% of the annual scup revenues were affected by these areas, with similar effects for the longfin squid (8%), blueline tilefish and black sea bass (7%), and monkfish and golden tilefish (6%) fisheries. The proposed New York Bight lease areas represented up to 5% of total annual fishery revenue from any MAFMC fishery during 2008-2019, with the surfclam fishery most affected. Similar patterns are observed when examining the proportion of annual fishery landings within current and proposed lease areas (see Table 2).

Table 2: Top ten species Landings and Revenue from Wind Energy Areas.

GARFO and ASMFC Managed Species	Maximum Percent Total Annual Regional Species Landings	Minimum Percent Total Annual Regional Species Landings	Maximum Percent Total Annual Regional Species Revenue	Minimum Percent Total Annual Regional Species Revenue
Atlantic surfclam	21 %	6 %	20 %	6 %
American eel	13 %	2 %	18 %	0 %
Atlantic menhaden	17 %	3 %	17 %	3 %
Atlantic chub mackerel	15 %	0 %	16 %	0 %
Yellowtail flounder	14 %	0 %	15 %	0 %
Offshore hake	14 %	0 %	14 %	0 %
Ocean quahog	14 %	5 %	13 %	5 %
Atlantic sea scallops	12 %	1 %	10 %	1 %
Skate wings	10 %	5 %	10 %	5 %
Atlantic mackerel	9 %	0 %	10 %	0 %

Proposed wind development areas interact with the region’s federal scientific surveys. Scientific surveys are impacted by offshore wind in four ways: 1. Exclusion of NOAA Fisheries’ sampling platforms from the wind development

area due to operational and safety limitations; 2.Impacts on the random-stratified statistical design that is the basis for scientific assessments, advice, and analyses; 3.Alteration of benthic and pelagic habitats, and airspace in and around the wind energy development, requiring new designs and methods to sample new habitats; and, 4.Reduced sampling productivity through navigation impacts of wind energy infrastructure on aerial and vessel survey operations. Increase vessel transit between stations may decrease data collections that are already limited by annual days-at-sea day allocations. The total survey area overlap ranges from 1-14% for all Greater Atlantic federal surveys. Individual survey strata have significant interaction with wind, including the sea scallop survey (up to 96% of individual strata) and the bottom trawl survey (BTS, up to 60% strata overlap). Additionally, up to 50% of the southern New England North Atlantic right whale survey’s area overlaps with proposed project areas. A region-wide survey mitigation program is underway (Table 3)

Table 3: Survey mitigation planning.

Survey	1.Evaluate designs & Impacts	2.Design New Methods	3.Calibrate New/Existing Surveys	4.Bridge Solutions	5.Conduct New Surveys	6.Comms & Data
Fall BTS	Started	Initial	No	No	No	Initial
Spring BTS	Started	Initial	No	No	No	Initial
EcoMon	No	No	No	No	No	No
Scallop	Started	Initial	No	No	No	No
Shellfish(Clams)	No	No	No	No	No	No
Right Whale (Air)	Initial	Initial	Initial	No	No	No
Marine Mammal/Turtle (Ship/Air)	No	No	No	No	No	No
Altantic Shark (Bottom Long-Line	No	No	No	No	No	No
GOM Bottom Long-Line	No	No	No	No	No	No
GOM Shrimp Survey	No	No	No	No	No	No
Atlantic Shark COASTPAN	No	No	No	No	No	No

Equity and environmental justice (EJ) are priority concerns with offshore wind development and fisheries impacts in the Northeast. Fig. 45 links historic port revenue (2008-2019) from within all wind lease areas as a proportion of the port’s total revenue based on vessel trip reports as described in the revenue and landings of species in the wind indicator above. The range (minimum and maximum) of total percent revenue from within wind energy areas is presented in the graph and ports are sorted from greatest to least revenue from within wind areas.

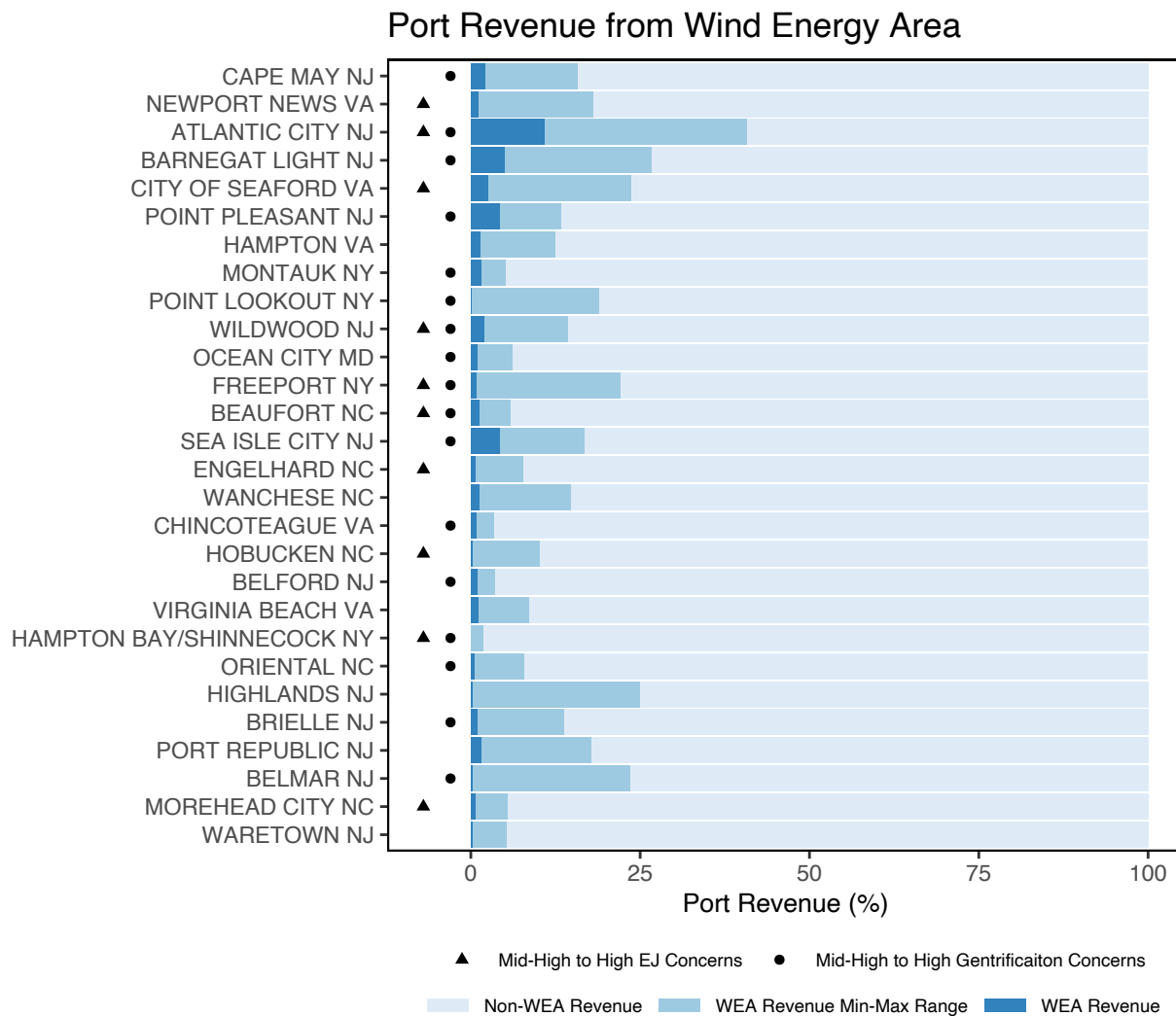


Figure 45: Percent of port revenue from Wind Energy Areas (WEA) in descending order from most to least port revenue from WEA. EJ = Environmental Justice.

For example, Atlantic City, NJ had a minimum of 11% and maximum of 30% overlap of wind energy revenue to the total port revenue between 2008-2019. Those communities that score Med-High or higher in at least one of the vulnerability indicators that address environmental justice concerns (i.e., Poverty, Population Composition, Personal Disruption; see indicator definitions) are noted with a triangle. Gentrification pressure is also highlighted here, with those communities that score Med-High or higher in one or more gentrification pressure indicators (i.e., Housing Disruption, Retiree Migration, Urban Sprawl) represented with a circle (Fig. 45). BOEM reports that cumulative offshore wind development (if all proposed projects are developed) could have moderate impacts on low-income members of environmental justice communities who work in the commercial fishing and for-hire fishing industry due to disruptions to fish populations, restrictions on navigation and increased vessel traffic, as well as existing vulnerabilities of low-income workers to economic impacts [51].

Top fishing communities high in environmental justice concerns (i.e., Atlantic City, NJ, Newport News, VA, Hobucken and Beaufort, NC) should be considered in decision making to reduce the social and economic impacts and aid in the resilience and adaptive capacity of underserved communities. It also highlights communities where we need to provide further resources to reach underserved and underrepresented groups and create opportunities for and directly involve these groups in the decision-making process.

Implications

Current plans for rapid buildout of offshore wind in a patchwork of areas spreads the impacts differentially throughout the region (Fig. 43).

Up to 20% of total average revenue for major Mid-Atlantic commercial species in lease areas could be forgone or reduced and associated effort displaced if all sites are developed. Displaced fishing effort can alter historic fishing area, timing, and method patterns, which can in turn change habitat, species (managed and protected), and fleet interactions. Several factors, including fishery regulations, fishery availability, and user conflicts affect where, when, and how fishing effort may be displaced.

Planned development overlaps right whale mother and calf migration corridors and a significant foraging habitat that is used throughout the year [9] (Fig 46). Turbine presence and extraction of energy from the system could alter local oceanography [52] and may affect right whale prey availability. Proposed wind development areas also bring increased vessel strike risk from construction and operation vessels. In addition, there are a number of potential impacts to whales from pile driving and operational noise such as displacement, increased levels of communication masking, and elevated stress hormones.

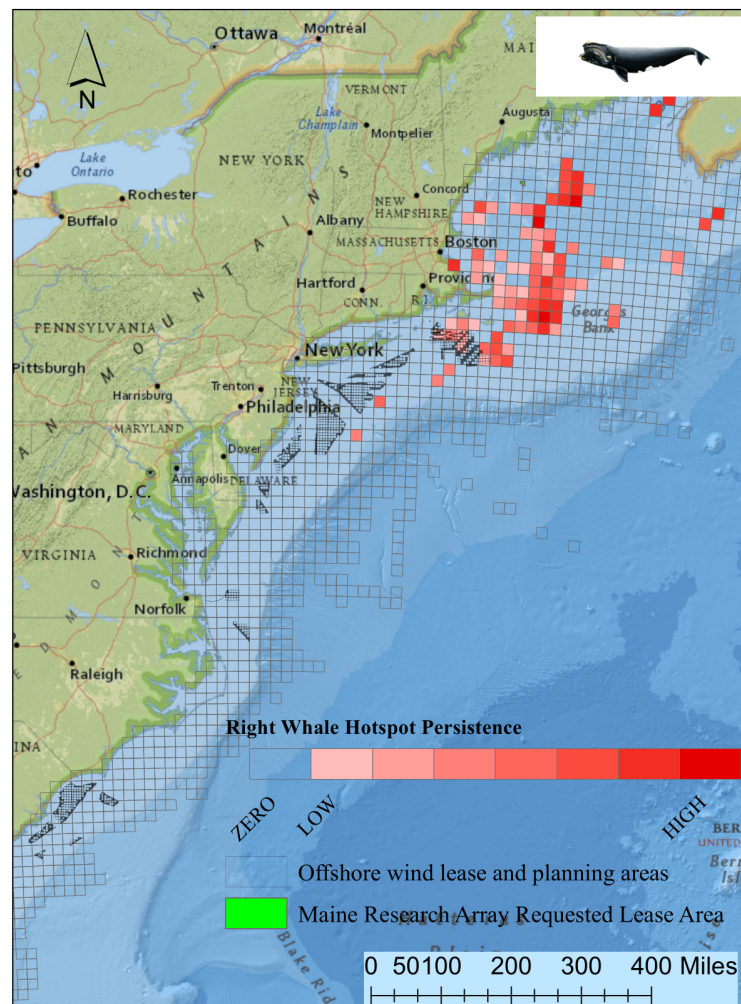


Figure 46: Northern Right Whale persistent hotspots and Wind Energy Areas.

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

The increase of offshore wind development can have both positive (e.g., employment opportunities) and negative (e.g., space-use conflicts) effects. Continued increase in coastal development and gentrification pressure has resulted in loss of fishing infrastructure space within ports. Understanding these existing pressures can allow for avoiding and mitigating negative impacts to our shore support industry and communities dependent on fishing. Some of the communities with the highest revenue overlap with offshore wind that are also vulnerable to gentrification pressure are Point Pleasant and Atlantic City, NJ, Ocean City, MD, and Beaufort, NC.

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Document Orientation

The figure format is illustrated in Fig 47a. 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 2021, 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. 47b) level.

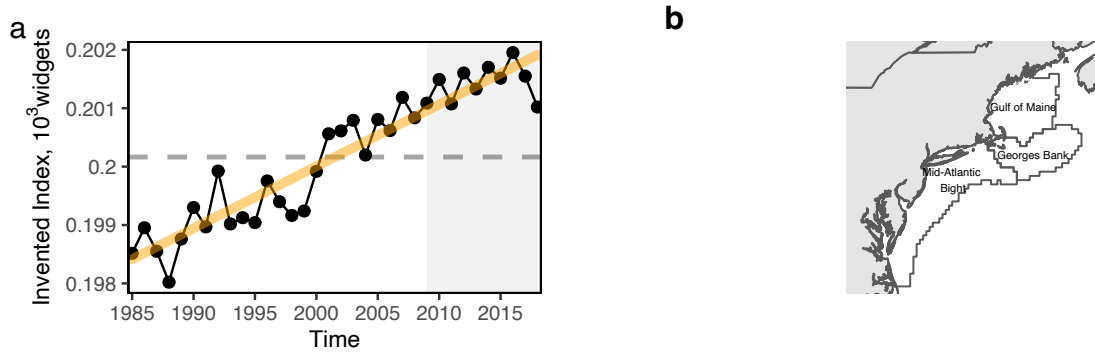


Figure 47: Document orientation. a. Key to figures. b. The Northeast Large Marine Ecosystem.

Fish and invertebrates are aggregated into similar feeding categories (Table 4) to evaluate ecosystem level trends in predators and prey.

Table 4: 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
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23 March, 2022

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 comments and requests received on the 2019, 2020, and 2021 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 feedback 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 Status and Progress columns briefly summarize how we responded, with a more detailed response in the numbered Memo Section. In each detailed response, we refer to SOE sections where changes are found or describe information that was not sufficiently developed to include in the 2022 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.

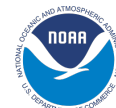
Sincerely,

A handwritten signature in black ink, appearing to read "Sarah Gaichas".

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

encl: State of the Ecosystem 2022: Request Tracking Memo

cc: Jon Hare



State of the Ecosystem 2022: Request Tracking Memo

March 8, 2022

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.

Request	Year	Source	Status	Progress	Memo Section
Add "This report is for [audience]"	2021	MAFMC SSC	In SOE	Introduction section	1
State management objectives first in report	2021	NEFMC	In SOE	Introduction section + Table	2
Ocean acidification (OA) in NEFMC SOE	2021	NEFMC SSC	In SOE	Climate risks section	3
Habitat impact of fishing based on gear.	2021	NEFMC	In SOE	Habitat risks section	4
Revisit right whale language	2021	NEFMC	In SOE	Protected species section	5
Sum of TAC/ Landings relative to TAC	2021	MAFMC SSC	In SOE-MAFMC	Seafood production section	6
Estuarine Water Quality	2020	NEFMC	In SOE-MAFMC, In progress-NEFMC	Climate and Habitat Risks sections MAFMC; Intern collated New England NERRS data	7
More direct opportunities for feedback	2021	MAFMC SSC	In progress	MAFMC SSC ecosystem subgroup	8
Further definition of regime shift	2021	MAFMC SSC	In progress	Regime shift analyses for specific indicators define "abrupt" and "persistent" quantitatively	9
Expand collaboration with Canadian counterparts	2021	MAFMC SSC	In progress	Currently drafting a NMFS-DFO climate/fisheries collaboration framework.	10
Fall turnover date index	2021	MAFMC SSC	In progress	See Current Conditions report	11
Links between species availability inshore/offshore (estuarine conditions) and trends in recreational fishing effort?	2021	MAFMC	In progress	Bluefish prey index inshore/offshore partially addresses	12
Apex predator index (pinnipeds)	2021	NEFMC	In progress	Protected species branch developing time series	13
Forage availability index (Herring/Sandlance)	2021	NEFMC	In progress	Bluefish prey index partially addresses	14
Fishery gear modifications accounted for in shark CPUE?	2021	MAFMC	In progress	Updated methods in tech-doc	15
Trend analysis	2021	NEFMC SSC	In progress	Evaluating empirical thresholds	16
Regime shifts in Social-Economic indicators	2021	NEFMC SSC	In progress	National working group and regional study	17
Linking Condition	2020	MAFMC	In progress	Not ready for 2022	18
Cumulative weather index	2020	MAFMC	In progress	Data gathered for prototype	19
VAST and uncertainty	2020	Both Councils	In progress	Not ready for 2022	20
Seal index	2020	MAFMC	In progress	Not ready for 2022	21

(continued)

Request	Year	Source	Status	Progress	Memo Section
Breakpoints	2020	NEFMC	In progress	Evaluating empirical thresholds	22
Management complexity	2019	MAFMC	In progress	Student work needs further analysis, no further work this year	23
Shellfish growth/distribution linked to climate (system productivity)	2019	MAFMC	In progress	Project with A. Hollander	24
Avg weight of diet components by feeding group	2019	Internal	In progress	Part of fish condition project	25
Mean stomach weight across feeding guilds	2019	MAFMC	In progress	Intern evaluated trends in guild diets	26
Inflection points for indicators	2019	Both Councils	In progress	Evaluating empirical thresholds	27
Recreational bycatch mortality as an indicator of regulatory waste	2021	MAFMC SSC	Not started	Lacking resources this year	28
Sturgeon Bycatch	2021	MAFMC SSC	Not started	Lacking resources this year	29
Decomposition of diversity drivers highlighting social components	2021	MAFMC SSC	Not started	Lacking resources this year	30
Changing per capita seafood consumption as driver of revenue?	2021	MAFMC	Not started	Lacking resources this year	31
Nutrient input, Benthic Flux and POC(particulate organic carbon) to inform benthic productivity by something other than surface indicators	2021	MAFMC SSC	Not started	Lacking resources this year	32
Relate OA to nutrient input; are there "dead zones" (hypoxia)?	2021	MAFMC	Not started	Lacking resources this year	33
Indicators of chemical pollution in offshore waters	2021	MAFMC	Not started	Lacking resources this year	34
How does phyto size comp affect EOF indicator, if at all?	2021	MAFMC	Not started	May pursue with MAFMC SSC eco WG	35
Indicator of scallop pred pops poorly sampled by bottom trawls	2021	NEFMC	Not started	Lacking resources this year	36
Compare EOF (Link) thresholds to empirical thresholds (Large, Tam)	2021	MAFMC SSC	Not started	May pursue with MAFMC SSC eco WG	37
Time series analysis (Zooplankton/Forage fish) to tie into regime shifts	2021	MAFMC SSC	Not started	Lacking resources this year	38
Optimum yield for ecosystem	2021	NEFMC	Not started	May pursue with MAFMC SSC eco WG	39
Re-evaluate EPU's	2020	NEFMC	Not started	Lacking resources this year	40
Incorporate social sciences survey from council	2020	NEFMC	Not started	Lacking resources this year	41
Biomass of spp not included in BTS	2020	MAFMC	Not started	Lacking resources this year	42

(continued)

Request	Year	Source	Status	Progress	Memo Section
Reduce indicator dimensionality with multivariate statistics	2020	NEFMC	Not started	Lacking resources this year	43
Estuarine condition relative to power plants and temp	2019	MAFMC	Not started	Lacking resources this year	44
Young of Year index from multiple surveys	2019	MAFMC	Not started	Lacking resources this year	45

Responses to comments

1 Add “This report is for [audience]”

The first sentence of each report now states the audience.

2 State management objectives first in report

The graphical summary on page 1 (MAFMC) and 1-2 (NEFMC) summarizes management objectives (columns in each table) and indicator performance relative to those objectives. Table 1 in the main body of each report (reproduced below) lists management objectives and indicators linked to those objectives.

Table 2: Ecosystem-scale fishery management objectives in the Mid-Atlantic Bight

Objective Categories	Indicators reported
Provisioning and Cultural Services	
Seafood Production	Landings; commercial total and by feeding guild; recreational harvest
Profits	Revenue decomposed to price and volume
Recreation	Angler trips; recreational fleet diversity
Stability	Diversity indices (fishery and ecosystem)
Social & Cultural	Community engagement/reliance and environmental justice 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

3 Ocean acidification (OA) in NEFMC SOE

Ocean acidification information was included in the MAFMC report in 2021, and was expanded to the Gulf of Maine and added to the NEFMC report in 2022. In both reports, OA information is presented in the Climate Risks section. Additional information is available in the Indicator catalog: <https://noaa-edab.github.io/catalog/ocean-acidification-and-shellfish.html>

4 Habitat impact of fishing based on gear

Both SOEs were revised this year to include a section on Habitat Risks. Both reports include a Fishing Gear Impacts subsection within the Habitat Risks section that links to detailed information on the outputs of the Northeast Fishing Effects Model. Detailed model results are available at the Northeast Ocean Data Portal (<https://www.northeastoceandata.org/data-explorer/>) under the Habitat/Fishing Effects - Seabed Habitat Disturbance and Fishing Effects - Intrinsic Seabed Habitat Vulnerability.

More details are available on the Indicator catalog page <https://noaa-edab.github.io/catalog/northeast-fishing-effects-model.html>

5 Revisit right whale language

The NEFMC requested a review and update of language in the Protected Species section on right whales. Language was edited in 2021, and a revised 2021 report was submitted to both Councils in April 2021. The report of record for each region (MAFMC, NEFMC) contains the revised text and notes the revision history as a footnote. Revised language was carried through to the 2022 reports.

6 Sum of TAC/ Landings relative to TAC

The MAFMC SSC requested information on landings relative to allowable catches. This information was provided by Council staff for 2012-2020 for all MAFMC fisheries and presented in 2022 MAFMC report as one of the multiple potential drivers of Seafood Production.

7 Estuarine Water Quality

The 2022 MAFMC report was updated with additional Chesapeake Bay water quality indicators, as well as a new indicator on submerged aquatic vegetation.

The NEFMC requested more information on estuarine habitats. In 2021, PEP intern Rhegan Thomason (U. Texas) developed a reproducible data workflow using open data science tools and principles that will be used to provide estuarine habitat information into annual SOE reports. She used data from the National Estuarine Research Reserve System (NERRS) to explore water quality and climate indicators at four sites in the New England region. NERRS conducts research and monitors the ecosystems to “track short-term variability and long-term changes due to natural and anthropogenic disturbances.” We acquired and compiled data from the NERRS Centralized Data Management Office to create a partially automated workflow that analyzes and visualizes available data. We developed open access code to generate time series and climatologies for temperature, dissolved oxygen, salinity, and chlorophyll. The project used RStudio with GitHub integration to version control data and code as well as enhance collaboration and transparency (<https://github.com/rheganthomason/NERRSdata>). This workflow was designed to be reproducible and available for future use anywhere the data is applicable.

An Indicator catalog chapter details further results: <https://noaa-edab.github.io/catalog/NERRs.html>. We welcome feedback to develop this information for future SOE reports.

8 More direct opportunities for feedback

The MAFMC SSC requested more opportunities for SOE report development and feedback to improve use in management. An SSC ecosystem working group was established in 2021 to coordinate SSC needs with ecosystem indicator investigations. NEFSC secured funding to support SSC-requested analyses that will evaluate aspects of SOE indicators along with management uses. Results of this work will be reported as they become available, but proposed analyses may address several other points raised by both SSCs and Councils, including evaluations of ecosystem overfishing indicators (points 35, 37), indicator thresholds (points 16, 22, 27), and system level optimum yields (point 39).

9 Further definition of regime shift

Regime shifts are currently described in the SOE graphical summary as “large, abrupt and persistent changes in the structure and function of an ecosystem.” This plain-language general definition is used by many sources on regime shifts (e.g., <https://www.regimeshifts.org/what-is-a-regime-shift>) as well as in the scientific literature (e.g., [1]).

Further technical definitions of “abrupt” “and”persistent” for a particular indicator or set of indicators may vary, and can be based on the outcomes of multiple analyses. In many analyses, “abrupt” represents a single-year shift between different levels of a time series indicator, and “persistent” means the indicator stays in the new state for multiple years after the shift rather than returning to the previous state.

For example, [1] identified regime shifts where “results of the chronological clustering, PCA, and change point analysis were complementary.” In other words, groups of similar years were detected by multiple methods and compared to determine persistence within a regime, and changepoint analysis detects whether abrupt change has occurred between those groups of years with similar conditions.

The regime shift in warm core rings presented in the SOE also used multiple methods incorporated into a “sequential regime shift detection algorithm” ([2]; <https://noaa-edab.github.io/tech-doc/warm-core-rings.html>). The algorithm looks for “abrupt change” and “persistence” by comparing time series means prior to and after the inclusion of each new observation, evaluating the amount of change within the current time period, and determining whether the current year represents a change point.

Technical definitions of “abrupt” and “persistent” for regime shift analyses presented in the SOE can be found either in the SOE Technical Documentation (<https://noaa-edab.github.io/tech-doc/>), in literature cited within the SOE, or both.

10 Expand collaboration with Canadian counterparts

NEFSC are currently drafting a NMFS-DFO climate/fisheries collaboration framework. We can expand some of our environmental indicators to include NW Atlantic indicators, and welcome feedback on priority indicators for this expansion.

11 Fall turnover date index

An index of fall turnover timing is presented in the NEFSC Current Conditions report each year: <https://www.fisheries.noaa.gov/new-england-mid-atlantic/climate/current-conditions-northeast-us-shelf-ecosystem-spring-2021-update#fall-thermal-transition-day>

As noted in the Current Conditions summary, “the fall thermal transition continues to shift to progressively later on the year, raising concern over the timing of production cycles in the food web.”

We can include these indicators or summarize results from Current Conditions and other sources in the SOE, in particular as they are prioritized by the Councils.

12 Links between species availability inshore/offshore (estuarine conditions) and trends in recreational fishing effort?

Work is in progress to evaluate bluefish availability inshore vs offshore along with trends in recreational fishing catch per unit effort for the 2022 Bluefish Research Track Assessment. The index in development relates bluefish availability to prey, rather than estuarine conditions. It remains to be seen if prey availability is related to recreational CPUE, but results can be summarized in an upcoming SOE if this seems relevant.

13 Apex predator index (pinnipeds)

Understanding the dynamics of apex predators, including pinnipeds and sharks, is the aim of the restructured SOE section on Ecosystem Structure Indicators. This section is a work-in progress, which will add information as it becomes available. The NEFSC Protected Species Branch is working towards time series for many apex predators (see also point 21, Seal Index), and the HMS shark CPUE time series is another component. We hope to have a more integrated apex predator index in future SOE reports.

14 Forage availability index (Herring/Sandlance)

As noted under point 12, work is in progress to evaluate bluefish availability inshore vs. offshore along with trends in recreational fishing effort for the 2022 Bluefish Research Track Assessment. While there are not plans to distinguish different forage fish species for this work, the aggregate forage fish index may be presented in the SOE reports in coming years.

Additional research on sandlance co-occurrence on Stellwagen Bank with seabird and marine mammal predators has been added to the Indicator catalog (<https://noaa-edab.github.io/catalog/sandlance.html>) for potential expansion in the future.

15 Fishery gear modifications accounted for in shark CPUE

Methods for the HMS Pelagic Observer Program (POP) shark CPUE indicator have been posted to the SOE Technical Documentation website (<https://noaa-edab.github.io/tech-doc/>). The Pelagic Observer Program does collect information on hooks (<https://www.fisheries.noaa.gov/inport/item/30713>), but at this time it is unclear how or whether information on circle hooks is specifically incorporated into the CPUE index. We are updating the methods with more detail for the next report.

16 Trend analysis

Points 16, 22 and 27 are related, and exploratory analysis evaluating trends, empirical breakpoints, and thresholds for individual indicators are in progress. Initial comparisons of current SOE trends are available online at <https://connect.fisheries.noaa.gov/content/24ac5977-ec9f-4c32-ab8d-045cd526e6/>

17 Regime shifts in Social-Economic indicators

The National Integrated Ecosystem Assessment Human Dimensions Working Group is working on regime shifts in social indicators. The WG, led by Geret DePiper, has a special issue call open for Marine Policy: <https://www.journals.elsevier.com/marine-policy/call-for-papers/special-issue-call-for-papers-assessing-social-change-and-ranking-outcomes-in-support-of-ecosystem-based-management-regime-shifts-nonlinearities-and-ecosystem-status>. There will be one paper for the Northeast (Walden and DePiper, presented at the SOE synthesis meeting) and a cross regional manuscript. This information can be incorporated into a future SOE as it becomes available.

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. 1).

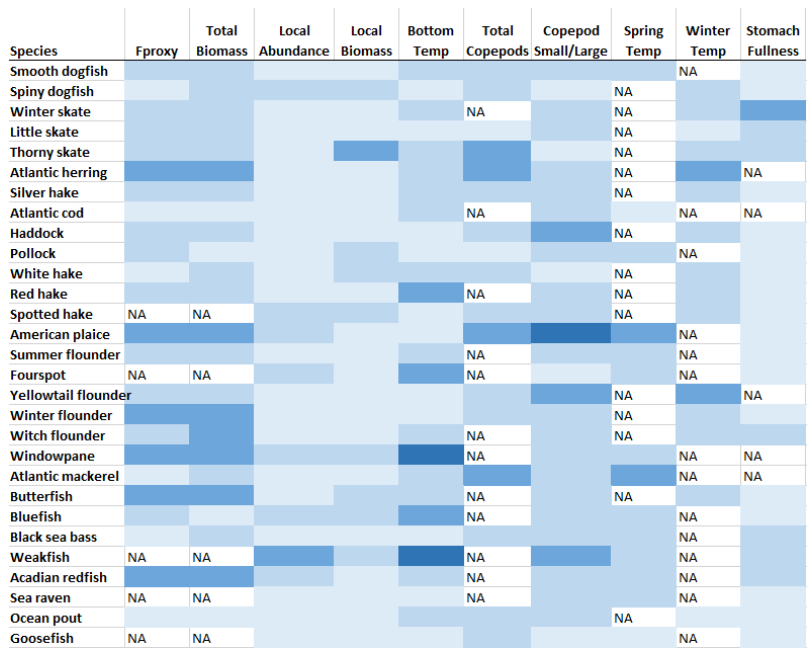


Figure 1: Preliminary results: GAM fish condition deviance explained by environmental variables, with darker cells indicating more important variables for that species.

Correlations between the potential drivers of condition are also being explored. Indices that are correlated ($R > 0.3$, dark cells in Fig. 2) will not be used together in future full GAM analyses.

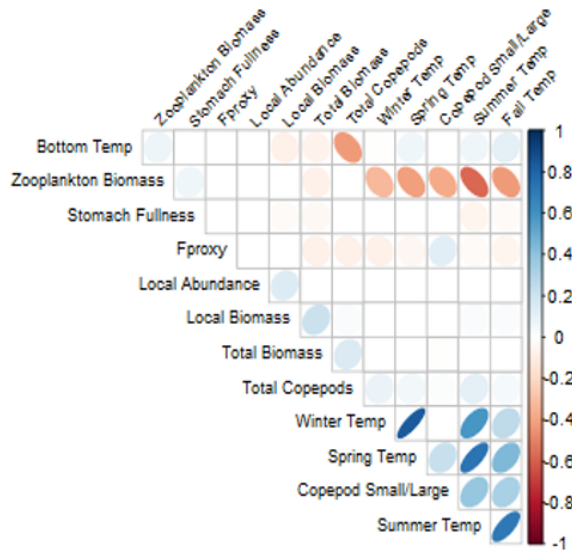


Figure 2: Preliminary results: correlations between potential environmental drivers of fish condition.

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 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 3).

Table 3: 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

Funding has been obtained to have 1 or 2 interns working on creating this index. The plan is for it to be available for the 2023 SOE.

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.

20 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; [3]). Work on model-based estimates is currently in review and may be presented in an upcoming report.

21 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 2022 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 [4].

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 EPU is complex. However, a gray seal survey was in progress in 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.

22 Breakpoints

Points 16, 22 and 27 are related, and exploratory analysis evaluating trends, empirical breakpoints, and thresholds for individual indicators are in progress.

While this could not be addressed for individual indicators in 2022, our 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.

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 development is welcome.

24 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. While in-person work has not been possible to date, bottom temperature and other ecosystem indicators are currently being incorporated into Ms Hollander's work.

25 Avg weight of diet components by feeding group

In 2021, IN FISH intern Ava De Leon (U. Miami) investigated diet data collected aboard the NEFSC bottom trawl survey 1973-2019 across all predators combined. Trend analyses were performed on four prey categories, including benthic invertebrates, fish, pelagic invertebrates, and other in the regions of Georges Bank, Mid-Atlantic Bight and the Gulf of Maine during the Fall and Spring seasons.

Each category can be described in general:

BENINV includes prey that are clearly identifiable as benthic (bottom dwelling) invertebrates by either name or general taxonomic category. Similarly, PELINV includes prey clearly identifiable as pelagic (water column dwelling) invertebrates, including some shrimp species that spend much time in the water column.

FISH includes all fish, whether identified as individual species or as a taxonomic category, or "unidentified fish." The FISH category also includes the commercially fished squid species, *Illex* and *Doryteuthis* (formerly *Loligo*).

OTHER includes everything that could not be placed into one of the above categories; for example, "unidentified invertebrates," taxonomic categories that could be either benthic or pelagic, digested animal remains, plant material, etc.

In the Mid-Atlantic Bight in the Fall there were notable trends of increasing fish, and decreasing benthic invertebrates and pelagic invertebrates in predator diets. Other regions and seasons did not show significant diet trends.

All predators combined, MAB, FALL

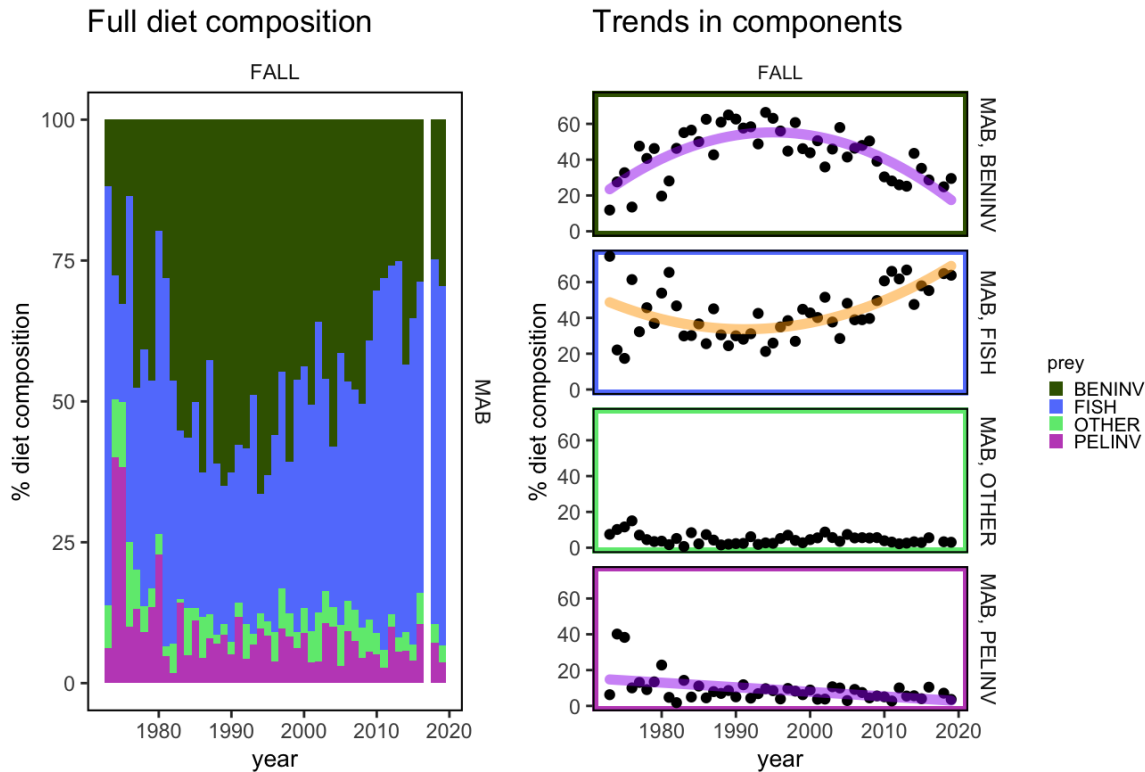


Figure 3: Diet composition for all predators combined collected on Fall NEFSC surveys in the Mid-Atlantic. See text for prey group definitions. Significant trends are shown using the standard State of the Ecosystem format: orange lines indicate a significant increasing trend and purple lines indicate a significant decreasing trend

There was no significant trend in predator size over time for the Mid-Atlantic. The number of stomachs sampled from all predators combined has increased over time for both seasons and all regions. There isn't one dominantly sampled predator over time, so it would be difficult to say that any single predator was driving the aggregate trends. The proportion of piscivores sampled was dominant for much of the 1980s and 1990s, and the proportion benthivores sampled has been higher and more consistent in all areas and seasons since about 2000.

Details of the work are summarized at <https://sgaichas.github.io/learnR-dietdata/ExplainTrends.html>, and an Indicator catalog chapter is in progress here <https://noaa-edab.github.io/catalog/diet-composition-analysis.html>.

This information is also being examined as part of the fish condition links project described above. We welcome feedback on further directions for this work.

26 Mean stomach weight across feeding guilds

This information is being examined as part of the fish condition links project, and is related to the initial work described on trends in diet components by feeding group (25) above. However, we had insufficient resources to develop an independent indicator for the SOE in 2021.

27 Inflection points for indicators

Both Councils have requested more information on ecosystem thresholds and inflection points. In 2021, we calculated two ecosystem overfishing indicators with proposed thresholds [5] for each ecological production unit (EPU) on the northeast US shelf.

Points 16, 22 and 27 are related, and exploratory analysis evaluating trends, empirical breakpoints, and thresholds for individual indicators are in progress. While this could not be addressed for individual indicators in 2022, we did include new Ecosystem Overfishing (EOF) indicators with proposed thresholds. Simulation testing the EOF indicators is one of the potential analyses identified by the MAFMC SSC Ecosystem working group, so work on this may proceed over the coming year.

We welcome suggestions for which additional indicators or groups of indicators should be prioritized for inflection point/threshold analysis in upcoming years.

28 Recreational bycatch mortality as an indicator of regulatory waste

We had insufficient resources to address this in 2021.

29 Sturgeon Bycatch

We had insufficient resources to address this in 2021.

30 Decomposition of diversity drivers highlighting social components

We had insufficient resources to address this in 2021.

31 Changing per capita seafood consumption as driver of revenue

We had insufficient resources to address this in 2021.

32 Nutrient input, Benthic Flux and POC (particulate organic carbon) to inform benthic productivity by something other than surface indicators

While there is investigation into these issues related to ongoing end-to-end ecosystem model development at NEFSC, we had insufficient resources to address this as a standalone ecosystem indicator in 2021.

33 Relate OA to nutrient input; are there “dead zones” (hypoxia)?

Ocean acidification (OA) information was updated and expanded for the Mid-Atlantic report, and included for the first time in the New England report in 2022 (see point 3 above).

Comprehensive data on nutrient input onto the Northeast US shelf is lacking. However, as noted above, nutrient dynamics are under investigation within ongoing end-to-end ecosystem model development at NEFSC. We had insufficient resources to address this as a standalone ecosystem indicator or integrate it with OA indicators in 2021.

34 Indicators of chemical pollution in offshore waters

We had insufficient resources to address this in 2021.

35 How does phyto size comp affect ecosystem overfishing (EOF) indicators, if at all?

Ecosystem overfishing indicators could not be updated this year due to delayed landings data, as noted in the SOE. However, more detailed information on phytoplankton size composition was presented in the Ecosystem Productivity Indicators section. We anticipate addressing this question in future years as we further develop the EOF indicators. Simulation testing the EOF indicators is one of the potential analyses identified by the MAFMC SSC Ecosystem working group, so work on this may proceed over the coming year.

36 Indicator of scallop pred pops poorly sampled by bottom trawls

We had insufficient resources to address this in 2021.

37 Compare EOF (Link) thresholds to empirical thresholds (Large, Tam)

Ecosystem overfishing indicators could not be updated this year due to delayed landings data, as noted in the SOE. As noted above under points 16, 22 and 27, exploratory analysis evaluating trends, empirical breakpoints, and thresholds for individual indicators are in progress. Simulation testing the EOF indicators is one of the potential analyses identified by the MAFMC SSC Ecosystem working group, so work on this may proceed over the coming year.

38 Time series analysis (Zooplankton/Forage fish) to tie into regime shifts

Zooplankton and forage fish time series presented in the 2021 report could not be updated this year due to survey interruptions and sample processing delays. We hope to initiate this work in the coming years.

39 Optimum yield for ecosystem

This is related to the EOF indicators first presented in 2021. Ecosystem overfishing indicators could not be updated this year due to delayed landings data, as noted in the SOE. Simulation testing the EOF indicators and evaluating ecosystem reference points such as optimum yield is among the potential analyses identified by the MAFMC SSC Ecosystem working group, so work on this may proceed over the coming year.

40 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 2021.

41 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 2021. We welcome input from the New England Council and staff on how best to incorporate this information in future reports.

42 Biomass of spp not included in BTS

We continued to include information on sharks this year, 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 2021.

43 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 2021.

44 Estuarine condition relative to power plants and temp

We had insufficient resources to address this in 2021.

45 Young of Year index from multiple surveys

The MA SSC was interested in a young of year index from multiple surveys. The SOE includes a fish productivity index (direct links [MAB](#), [GB](#) and [GOM](#)), 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. 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 further in 2021.

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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 management¹, and revised the document in February 2019². 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 2022 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 2022 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. As part of the Council's 2022 Implementation Plan, the Council will initiate a comprehensive review of the risk assessment where new/different risk elements and analyses that could inform the risk criteria can be considered. This review will likely begin later in 2022 (the fall) and continue in 2023 and will likely include working with the Council's Ecosystem and Ocean Planning Committee and Advisory Panel.

¹http://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	$F < F_{msy}$	Unknown, but weight of evidence indicates low overfishing risk	Unknown status	$F > F_{msy}$
B status	$B > B_{msy}$	$B_{msy} > B > 0.5 B_{msy}$, or unknown, but weight of evidence indicates low risk	Unknown status	$B < 0.5 B_{msy}$
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
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 Landings	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 Landings	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 2021: Ecological risk elements

Species added: 1

Chub mackerel was formally added to the Mackerel, Squid, Butterfish (MSB) Fishery Management Plan (FMP) in December 2020. We ranked as many risk elements as possible for chub mackerel given data availability (Table 5).

Chub mackerel risk rankings and justifications

Chub mackerel **Assessment performance** ranks high risk because there is no stock assessment, nor data to conduct one in this region. **F status** and **B status** are unknown, but the weight of evidence indicates low risk of high fishing mortality or low biomass for this species in the Mid-Atlantic, and therefore rank low-moderate risk. Chub mackerel are not predators of MAFMC managed species, and we could not find evidence that chub mackerel are significant prey of MAFMC managed species³ or protected species on the Northeast US shelf [4], so they ranked low risk for all three **Food web** elements. Chub mackerel were not included in the Northeast US climate vulnerability assessment [5], so we leave the **Climate** and **Distribution shifts** elements unranked until further study is completed. Chub mackerel do not depend on **Estuarine habitat**, so rank low risk for this element.

Decreased Risk: 0

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

Increased Risk: 0

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

Update on Estuarine Habitat Quality (Chesapeake Bay)

Many important MAFMC managed species (e.g., summer flounder, scup, black sea bass, and bluefish) use estuarine habitats as nurseries or are considered estuarine and nearshore coastal-dependent, and interact with other important estuarine-dependent species (e.g., striped bass and menhaden). An integrated measure of multiple water quality criteria shows a significantly increasing proportion of Chesapeake Bay waters meeting or exceeding EPA water quality standards over time ([6]; Fig. 1). This pattern was statistically linked to total nitrogen reduction, indicating responsiveness of water quality status to management actions implemented to reduce nutrients. Water quality trends and status may be used to inform aquaculture siting decisions in Chesapeake Bay.

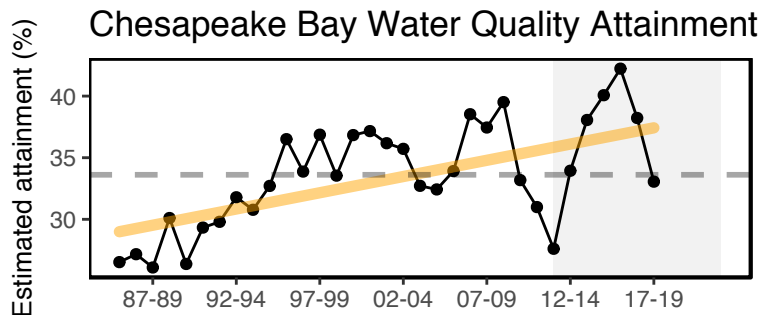


Figure 1: Water quality attainment in Chesapeake Bay following rolling three year assessment periods.

In 2019, we also 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.

³<https://fwdp.shinyapps.io/tm2020/>

However, as reported in the 2020-2022 SOEs, 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. The Chesapeake Bay experienced a warmer-than-average winter and fall in 2021, and average conditions in the spring and summer. Trends in tidal freshwater submerged aquatic vegetation (SAV) have improved over time, while SAV in high salinity habitats declined.

These annual updates in Chesapeake Bay temperature, salinity, dissolved oxygen, and SAV may partially account for the recent drop in the overall water quality indicator. This 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 in the SOE for Chesapeake Bay striped bass and blue crabs, as well as summer flounder and black sea bass) could be incorporated into future risk assessments as the science continues to develop.

Update on Climate risks

Current risks to species productivity (and therefore to achieving OY) due to projected climate change in the Northeast US were derived from a comprehensive assessment [5]. 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 (77%) or very highly (23%) exposed to climate risk in this region, with a range of sensitivity (low-62%, moderate-15%, high-15%, and very high-8%) to expected climate change in the Northeast US. The combination of exposure and sensitivity results in the overall vulnerability ranking for each species (see the **Climate** column of Table 5).

In 2021, the SOE was restructured with an entire section focused on Climate risks to meeting fishery management objectives. New information has been added to the SOE that could be used to update species-specific Climate risk rankings in the future. The 2022 SOE includes multiple climate indicators including surface and bottom water temperature, marine heat waves, Gulf Stream position and warm core rings, cold pool area and persistence, and ocean acidification measurements. Combined with species sensitivity information from lab work, these indicators could be used to further clarify climate risks to managed species, as presented for surfclams and ocean acidification in the 2021-2022 SOEs.

Indicators can also be used to identify beneficial conditions for managed species. For example, since 2017, extraordinarily high availability of northern shortfin squid have been observed in the Mid-Atlantic, resulting in high fishery catch per unit effort (CPUE) and early fishery closures. High instances of squid catch near the shelf break are significantly related to low bottom temperatures (< 10 degrees C), high salinity (>35.6 psu), increased chlorophyll frontal activity as well as the presence and orientation of warm core rings. Warm core rings are an important contributor to squid availability, likely influencing habitat conditions across different life stages. In particular, fishing effort was concentrated on the eastern edge of warm core rings, which are associated with upwelling and enhanced productivity.

Potential new indicators

Habitat Climate Vulnerability combined with Species Climate Vulnerability

A Habitat Climate Vulnerability Assessment (HCVA) for habitat types in the Northeast US Large Marine Ecosystem was published in January 2021 [7]. 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 [5]. The ACFHP matrix identified the importance of coastal 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.⁴

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 HCVA. The HCVA team is currently working with MAFMC and NEFMC on synthesizing habitat assessment information and developing narratives for ~75 species. We include two here so that the Council may provide feedback to improve their utility for management in general and for potential future inclusion in the EAFM risk assessment.

Black Sea Bass *Summary:* Black sea bass were determined to have, overall, a high vulnerability to climate change, due to very high climate exposure related to high surface and air temperature in both inshore and offshore waters, and moderate climate sensitivity of early life history stage requirements. However, climate change is predicted to have a positive effect on black sea bass, due to warmer temperatures increasing spawning and therefore recruitment, and a potential expansion in distribution of the species shifting farther north [5].

The habitats important to black sea bass, such as submerged aquatic vegetation and shellfish reefs, are high and highly vulnerable to projected climate change, respectively. In particular, both habitats are sensitive to higher sea surface temperature and non-climate stressors. Additionally, intertidal habitats such as shellfish reefs are also vulnerable to projected changes in air temperatures, sea level rise, and pH. Although the climate vulnerability of subtidal rocky habitat was assessed as low, intertidal rocky bottom was assessed as high because of higher sea level, air temperature, and pH. Steimle et al. [9] include use of salt marsh edge and channel habitats for young-of-year black sea bass, and estuarine emergent wetlands were determined to have very high climate vulnerability. 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 [10], but additional information on the use and importance of intertidal rocky bottom or intertidal benthic habitat use by adults is lacking. According to [10], black sea bass eggs have been collected in the water column over the continental shelf, as have 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:
 - 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.

⁴https://noaa-edab.github.io/ecodata/Hab_table

- 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 [10], 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 [5].

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 2021: Economic, Social, and Food production risk elements

Elements not updated: 2

Commercial landings data at the spatial scale relevant to the MAFMC risk assessment are not yet available for 2020. As a result, we were unable to update the **Commercial Revenue** and **Commercial Food production** risk elements for this report. These remain at risk levels assessed in 2021 based on data through the end of 2019. Given trends in the broader region in commercial landings and revenue for 2020 [11], we do not expect the risk rankings for these elements to change when Mid-Atlantic scale data becomes available.

Decreased Risk: 1

Recreational value has changed from high risk to low-moderate risk based on 2022 indicator updates. Recreational value was ranked high risk in the 2018 risk assessment due to a significant decrease in angler trips over the most recent 10 years of the time series. In 2019, the risk assessment noted that in the updated MRIP angler trip time series, “declines are less pronounced than measured previously. A reduction from the highest risk ranking to a lower risk category may be warranted.”

Updated information has eliminated the recent trend, and contributed to a long term increase in recreational effort (angler trips), with 2020 effort above the long-term average (Fig. 2).

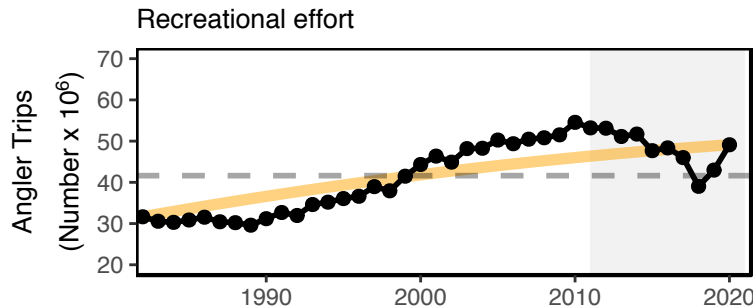


Figure 2: Recreational effort in the Mid-Atlantic.

The long term increase in recreational angler trips results in an updated low-moderate risk ranking according to Council criteria.

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 criteria.

Potential new indicators

Recreational Fleet Diversity

Recreational diversity indices could be considered as additional risk element(s) to complement the existing Commercial fishery resilience (revenue diversity) element. While recreational value measured as angler trips has gone from high risk to low-moderate risk based on updated data, recreational fleet diversity (i.e., effort by shoreside, private boat, and for-hire anglers) has declined over the long term (Fig. 3).

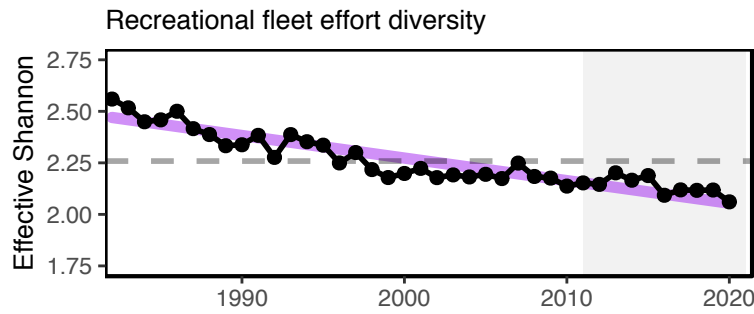


Figure 3: Recreational fleet effort diversity in the Mid-Atlantic.

Increased angler trips in 2020 relative to previous years strongly influence the long term increase in recreational effort. While the overall number of recreational opportunities in the MAB is above the long term average, the continuing decline in recreational fleet effort diversity suggests a potentially reduced range of recreational fishing options.

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 is accessible both from shore and from a vessel, shore anglers typically have access to smaller individuals. 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.

Environmental justice vulnerability in commercial and recreational fishing communities

Social vulnerability measures social factors that shape a community’s ability to adapt to change. A subset of these can be used to assess potential environmental justice issues. Environmental Justice is defined in Executive Order 12898 as federal actions intended to address disproportionately high and adverse human health and environmental effects of federal actions on minority and low-income populations. Three of the existing NOAA Fisheries Community Social Vulnerability Indicators (CSVIs), the Poverty Index, Population Composition Index, and Personal Disruption Index, can be used for mandated Environmental Justice analysis⁵.

Commercial fishery engagement measures the number of permits and dealers, and pounds and value landed in a community, while reliance expresses these numbers based on the level of fishing activity relative to the total population of a community. Recreational fishery engagement measures shore, private vessel, and for-hire fishing effort while reliance expresses these numbers based on fishing effort relative to the population of a community.

In 2021, we reported the top ten most engaged, and top ten most reliant commercial and recreational fishing communities and their associated social vulnerability. Here we apply the same selection standard for top ten fishing communities for both sectors, and focus on examining the environmental justice vulnerability in these communities.

Communities plotted in the upper right section of Fig.4 scored high for both commercial engagement and reliance, including Cape May and Barnegat Light, NJ, and Reedville, VA. Communities that ranked medium-high or above for one or more of the environmental justice indicators are highlighted in bright orange: Newport News, VA; Atlantic City, NJ; Hampton Bays/Shinnecock, NY; and Beaufort, Columbia and Hobucken, NC.

⁵<https://www.fisheries.noaa.gov/national/socioeconomics/social-indicators-coastal-communities>

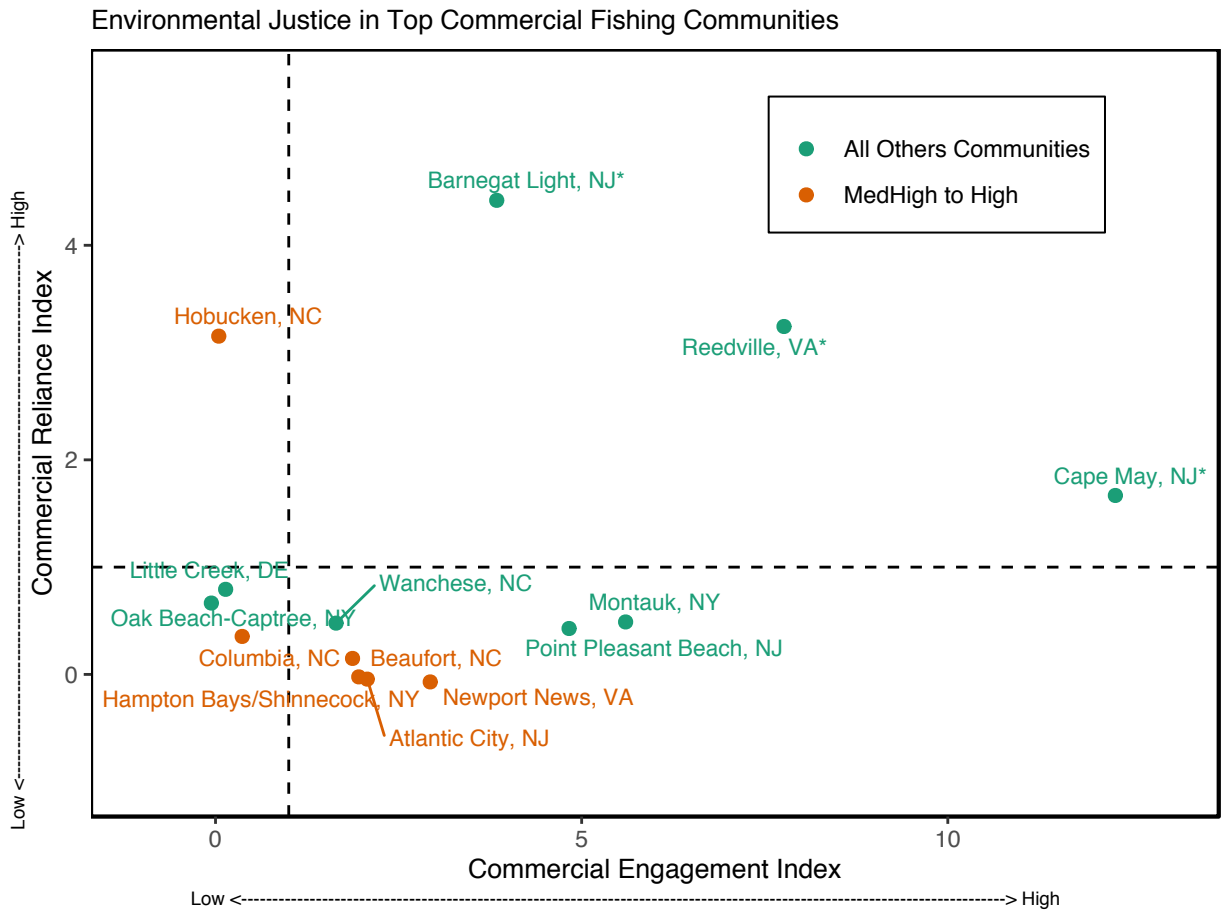


Figure 4: Commercial engagement, reliance, and environmental justice vulnerability for the top commercially engaged and reliant fishing communities in the Mid-Atlantic. Communities ranked medium-high or above for one or more of the environmental justice indicators are highlighted in bright orange. *Community scored high (1.00 and above) for both commercial engagement and reliance indicators.

Fig. 5 shows the detailed scores of the three environmental justice indicators for the same communities plotted in Fig.4. Communities are plotted clockwise in a descending order of commercial engagement scores from high to low, with the most highly engaged community, Cape May, NJ, listed on the top. Among the communities ranked medium-high or above for environmental justice vulnerability, Newport News, VA scored medium-high for the population composition index. Atlantic City, NJ scored high for all of the three environmental justice indicators. Hampton Bays/Shinnecock, NY scored medium-high for the population composition index. Beaufort, NC scored medium-high and very close to high for the poverty index. Columbia, NC scored high for the personal disruption index and the poverty index, and medium-high for the population composition index. Hobucken, NC scored high for the personal disruption index and the poverty index.

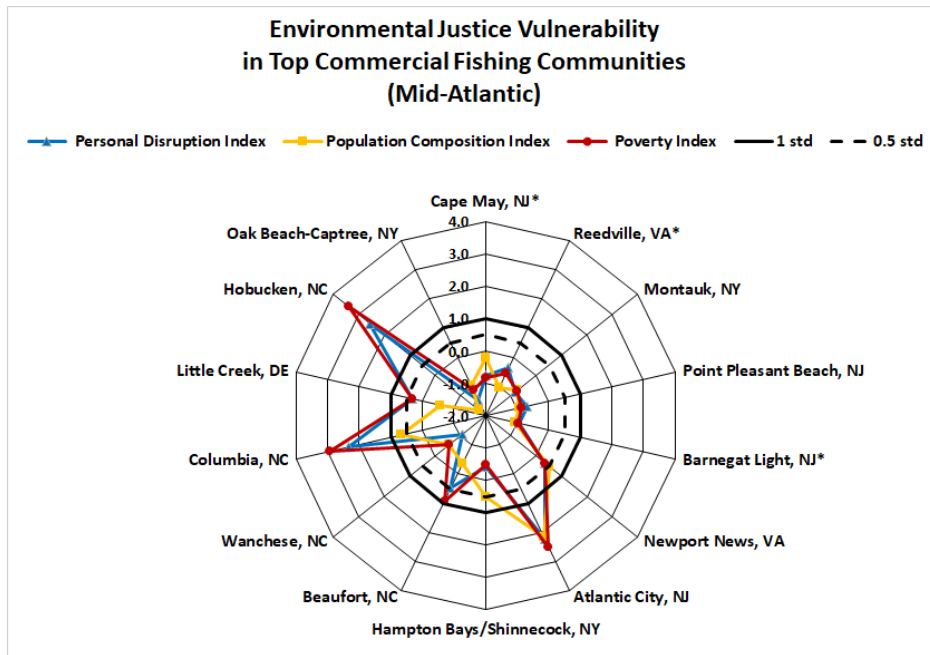


Figure 5: Environmental justice indicators (Poverty Index, population composition index, and personal disruption index) for top commercial fishing communities in Mid-Atlantic. *Community scored high (1.00 and above) for both commercial engagement and reliance indicators.

Communities plotted in the upper right section of Fig.6 scored high for both recreational engagement and reliance, including Barnegat Light, NJ and Deal Island, MD. Communities that ranked medium-high or above for one or more of the environmental justice indicators are highlighted in bright orange: Hatteras and Morehead City, NC.

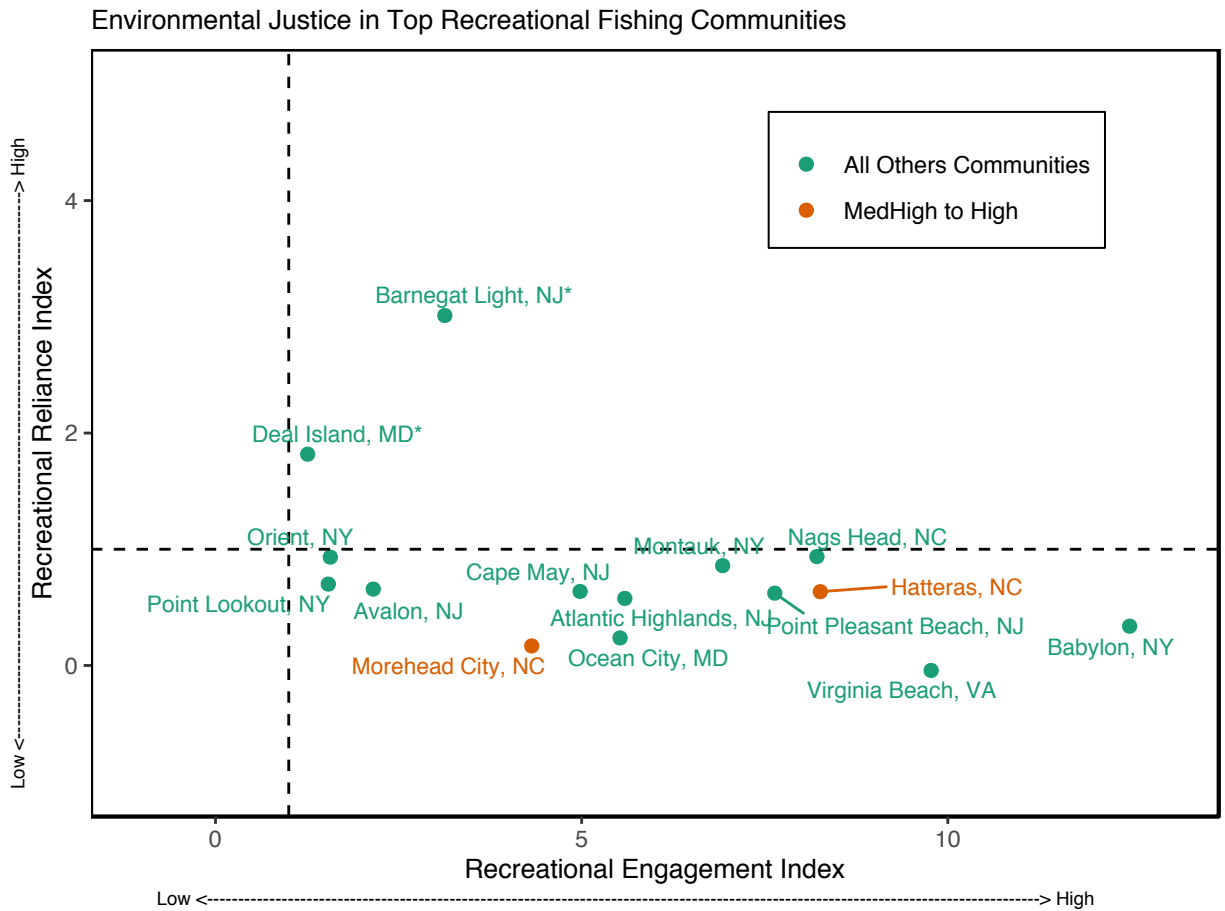


Figure 6: Recreational engagement and reliance, and environmental justice vulnerability, for the top recreationally engaged and reliant fishing communities in the Mid-Atlantic. Communities ranked medium-high or above for one or more of the environmental justice indicators are highlighted in bright orange. *Community scored high (1.00 and above) for both recreational engagement and reliance indicators.

Fig. 7 orders communities clockwise in a descending order of recreational engagement scores from high to low, with the most highly engaged community, Babylon, NY, listed on the top. The two communities with environmental justice concerns, Hatteras and Morehead City, NC, both scored medium-high for the poverty index.

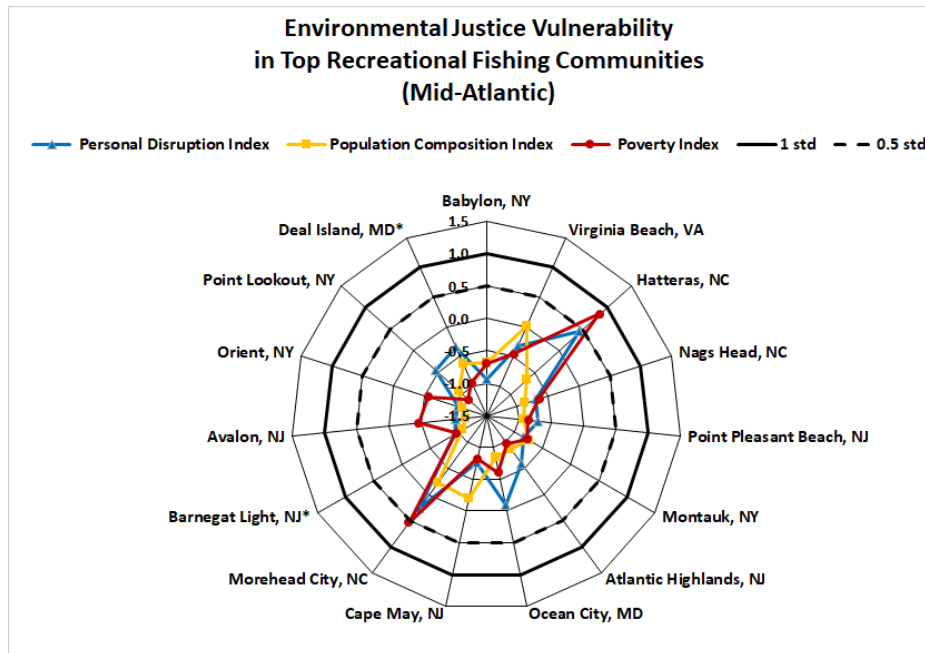


Figure 7: Environmental justice indicators (Poverty Index, population composition index, and personal disruption index) for top recreational fishing communities in Mid-Atlantic. *Community scored high (1.00 and above) for both recreational engagement and reliance indicators.

Both commercial and recreational fishing are important activities in Montauk, NY, Barnegat Light, Cape May and Point Pleasant Beach, NJ, meaning these communities may be impacted simultaneously by commercial and recreational regulatory changes. All of these communities scored lower than medium-high for all of the three environmental justice indicators, indicating that environmental justice may not be a major concern in these communities at the moment based on the indicators analyzed.

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

Changes from 2021: 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 and were updated in 2021. In 2022, a similar update was conducted with Council staff reviewing the 2021 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 7 and the justification for any ranking change can be found below.

Updated Justifications

The **Discards** risk ranking (moderate-high) for Surfclam and Ocean Quahog did not change from 2021 to 2022; however, the justification for the ranking was modified to be more reflective of current considerations. The justification now states: “allocated minimal coverage under SBRM as a result of discard being low percent of total catch; however, co-occurrence of surfclams and quahogs raised as major issue (2022 implementation plan action).”

The **Management Control** risk rankings were evaluated for all managed species with catch information through 2020. The justification language for each species was modified to reflect the updated data used to evaluate management control (total catch compared to ABC or ACL, as appropriate) but only those species with a change in risk ranking are included in this document (see Decreased/Increased Risk sections below). It was noted that this ranking may change in the next review for Scup given anticipated overages in 2021.

Decreased Risk: 8

The **Allocation** risk ranking for commercial Summer Flounder, Scup, Black Sea Bass, and Bluefish decreased from high to low. The Council took final action on the commercial/recreational allocation amendment for these species in 2021 and no additional allocation related actions are under consideration. The recreational allocation risk ranking for all for species remains as high risk given the Council's continued consideration of recreational sector separation as part of the Recreational Reform Initiative.

The **Regulatory Complexity/Stability** risk ranking for Butterfish and Longfin Squid decreased from high to medium-high. The regulations for these species are complex but have remained relatively unchanged for several years. The **Regulatory Complexity/Stability** risk ranking for both recreational and commercial Blueline Tilefish changed from medium-high to low-medium. Regulatory changes to the recreational possession limits for different vessel categories were approved several years ago and measures have not changed since. Similarly, regulatory changes to the commercial trip limits to accommodate larger landings and achieve optimal were approved several year ago and have not changed since.

Increased Risk: 4

The **Regulatory Complexity/Stability** risk ranking for recreational Atlantic Mackerel increased from low to low-medium. There are currently minimal recreational management regulations for Atlantic Mackerel; however, the Council is considering potential new/additional regulations as part of the rebuilding amendment currently being developed.

The **Regulatory Complexity/Stability** risk ranking for *Illex* Squid increased from low-medium to medium-high. *Illex* regulations are somewhat complex and have not changed much recently, but potential new regulations are being considered.

The **Management Control** risk ranking for both commercial and recreational Blueline Tilefish increased from low to low-medium. Recent overages have been observed in both sectors (the 2021 recreational overage could be large). A two-step lowering of the commercial trip limit has been implemented and should minimize future overages.

Potential new indicators

Other ocean uses: offshore wind energy development timeline, revenue in lease areas, coastal community vulnerability

As of February 2022, 24 offshore wind development projects are proposed for construction over the next decade in the Northeast (timelines and project data are based on Tables E-2, E-4, and E-4-2 of South Fork Wind Farm Final Environmental Impact Statement). Offshore wind areas are anticipated to cover more than 1.7 million acres by 2030 in the Greater Atlantic region (Fig. 8). Beyond 2030 values include acreage for the NY Wind Energy Areas (WEA) and Gulf of Maine Area of Interest for floating research array.

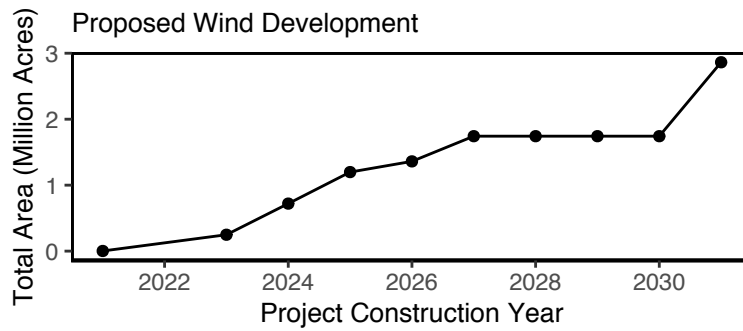
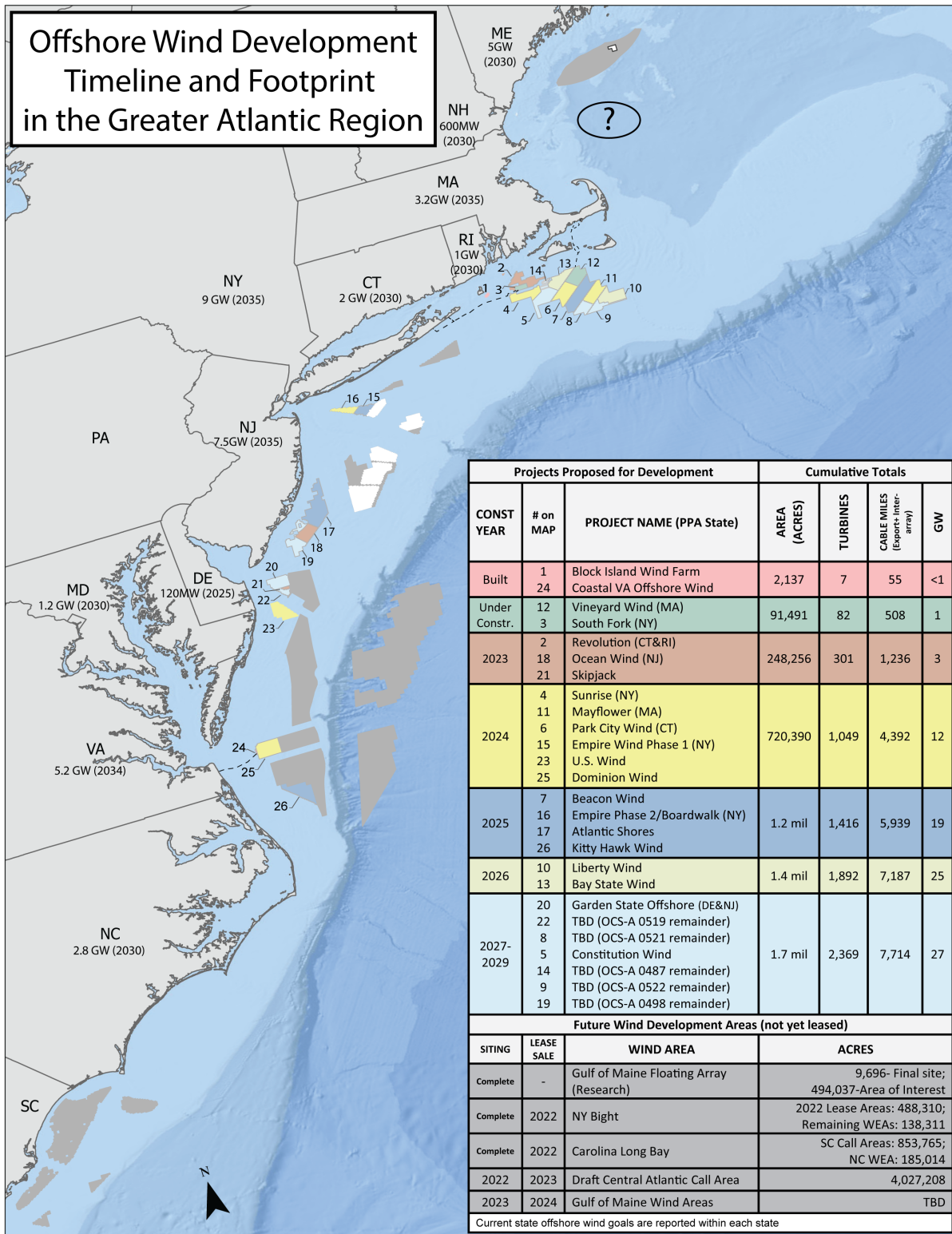


Figure 8: Proposed wind development on the northeast shelf.

Just over 2,500 foundations and more than 7,000 miles of inter-array and offshore export cables are proposed to date. The colored chart in Fig. 9 also presents the offshore wind development timeline in the Greater Atlantic region with the estimated year that foundations would be constructed (matches the color of the wind areas). These timelines and data estimates are expected to shift but represent the most recent information available as of February 2022. 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. Future wind development areas are also presented. Additional lease areas, totalling over 488,000 acres in the NY Bight are available for BOEM’s 2022 lease sale. It’s anticipated that the NY Bight leases will fulfill outstanding offshore wind energy production goals for NY and NJ. VA and NC have outstanding goals that cannot be fulfilled within the existing lease areas, and it is expected that these will be fulfilled with future development off the Delmarva Peninsula.



Wind area boundaries, construction data and timelines are frequently updated. This map contains the most recent published information as of 2/2/22
Sources: South Fork Wind Farm FEIS, BOEM GIS data, BOEM Leasing Path Forward 2021-2025

Figure 9: All Northeast Project areas by year construction ends (each project has 2 year construction period).

Based on federal vessel logbook data, average commercial fishery revenue from trips in the current offshore wind

lease areas and the New York Bight leasing areas identified in the proposed sale notice represented 2-20% of the total annual revenue for the most affected fisheries in federal waters from 2008-2019 (Fig. 10).

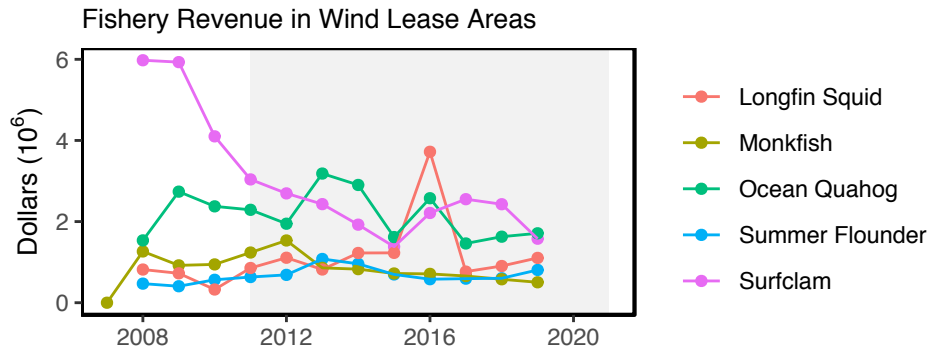


Figure 10: Wind energy revenue in the Mid-Atlantic.

The surfclam fishery could be the most affected fishery, with a maximum of 20% of annual fishery revenue occurring within potential wind lease areas during this period, followed by chub mackerel (15%), ocean quahog (13%), and Atlantic mackerel (10%). The *Illex* squid and bluefish fisheries were the least affected, at 1-2% maximum annual revenue affected, respectively. A maximum of 9% of the annual scup revenues were affected by these areas, with similar effects for the longfin squid (8%), blueline tilefish and black sea bass (7%), and monkfish and golden tilefish (6%) fisheries. The proposed New York Bight lease areas represented up to 5% of total annual fishery revenue from any MAFMC fishery during 2008-2019, with the surfclam fishery most affected. Similar patterns are observed when examining the proportion of annual fishery landings within current and proposed lease areas (see Table 3).

Table 3: Top ten species Landings and Revenue from Wind Energy Areas.

GARFO and ASMFC Managed Species	Maximum Percent Total Annual Regional Species Landings	Minimum Percent Total Annual Regional Species Landings	Maximum Percent Total Annual Regional Species Revenue	Minimum Percent Total Annual Regional Species Revenue
Atlantic surfclam	21 %	6 %	20 %	6 %
American eel	13 %	2 %	18 %	0 %
Atlantic menhaden	17 %	3 %	17 %	3 %
Atlantic chub mackerel	15 %	0 %	16 %	0 %
Yellowtail flounder	14 %	0 %	15 %	0 %
Offshore hake	14 %	0 %	14 %	0 %
Ocean quahog	14 %	5 %	13 %	5 %
Atlantic sea scallops	12 %	1 %	10 %	1 %
Skate wings	10 %	5 %	10 %	5 %
Atlantic mackerel	9 %	0 %	10 %	0 %

Proposed wind development areas interact with the region’s federal scientific surveys. Scientific surveys are impacted by offshore wind in four ways: 1. Exclusion of NOAA Fisheries’ sampling platforms from the wind development area due to operational and safety limitations; 2.Impacts on the random-stratified statistical design that is the basis for scientific assessments, advice, and analyses; 3.Alteration of benthic and pelagic habitats, and airspace in and around the wind energy development, requiring new designs and methods to sample new habitats; and, 4.Reduced sampling productivity through navigation impacts of wind energy infrastructure on aerial and vessel survey operations. Increase vessel transit between stations may decrease data collections that are already limited by annual days-at-sea day allocations. The total survey area overlap ranges from 1-14% for all Greater Atlantic federal surveys. Individual survey strata have significant interaction with wind, including the sea scallop survey (up to 96% of individual strata) and the bottom trawl survey (BTS, up to 60% strata overlap). Additionally, up to 50% of the southern New England North Atlantic right whale survey’s area overlaps with proposed project areas. A region-wide survey mitigation program is underway (Table 4)

Table 4: Survey mitigation planning.

Survey	1.Evaluate designs & Impacts	2.Design New Methods	3.Calibrate New/Existing Surveys	4.Bridge Solutions	5.Conduct New Surveys	6.Comms & Data
Fall BTS	Started	Initial	No	No	No	Initial
Spring BTS	Started	Initial	No	No	No	Initial
EcoMon	No	No	No	No	No	No
Scallop	Started	Initial	No	No	No	No
Shellfish(Clams)	No	No	No	No	No	No
Right Whale (Air)	Initial	Initial	Initial	No	No	No
Marine Mammal/Turtle (Ship/Air)	No	No	No	No	No	No
Altantic Shark (Bottom Long-Line)	No	No	No	No	No	No
GOM Bottom Long-Line	No	No	No	No	No	No
GOM Shrimp Survey	No	No	No	No	No	No
Atlantic Shark COASTPAN	No	No	No	No	No	No

Equity and environmental justice (EJ) are priority concerns with offshore wind development and fisheries impacts in the Northeast. Fig. 11 links historic port revenue (2008-2019) from within all wind lease areas as a proportion of the port’s total revenue based on vessel trip reports as described in the revenue and landings of species in the wind indicator above. The range (minimum and maximum) of total percent revenue from within wind energy areas is presented in the graph and ports are sorted from greatest to least revenue from within wind areas.

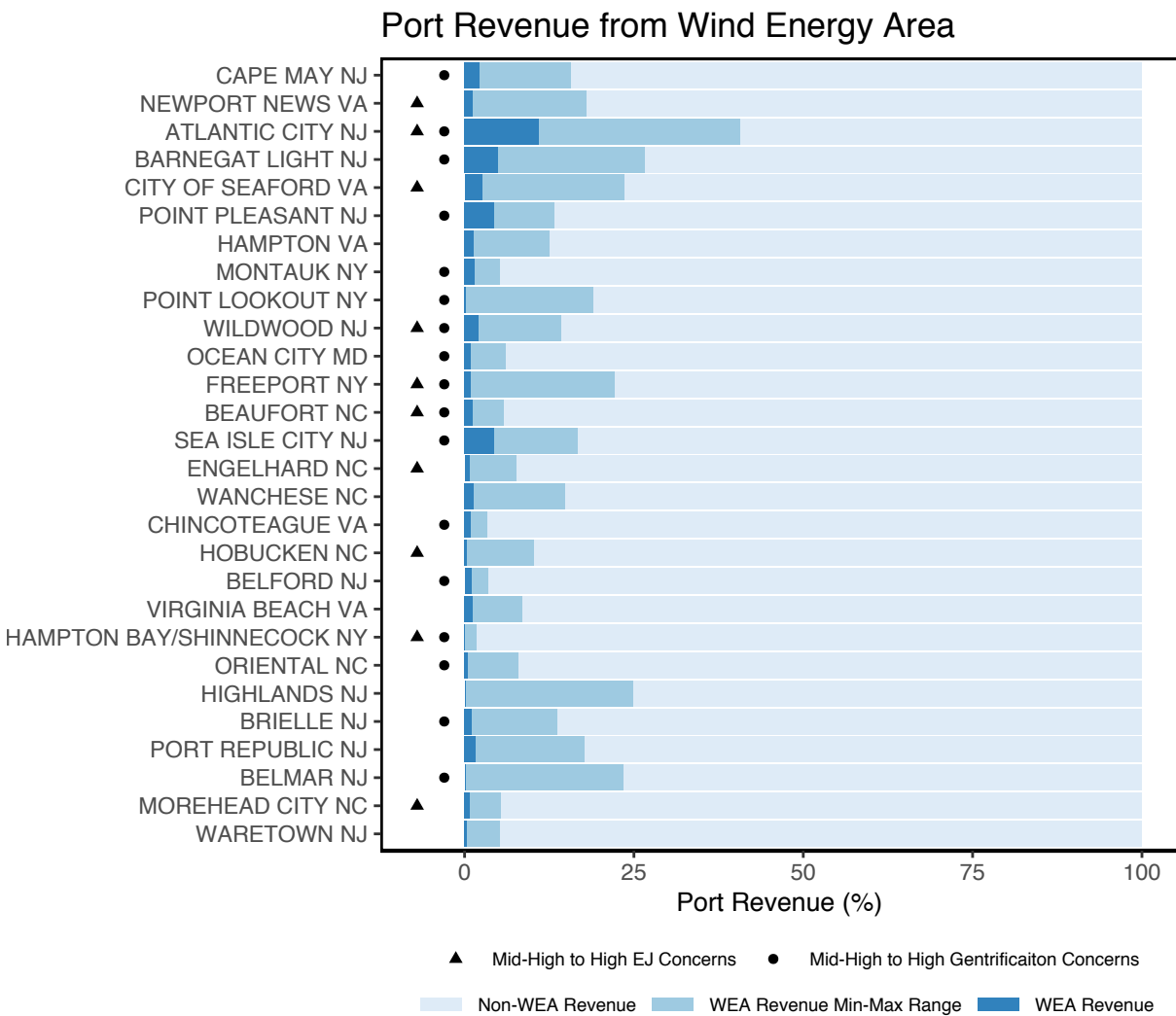


Figure 11: Percent of port revenue from Wind Energy Areas (WEA) in descending order from most to least port revenue from WEA. EJ = Environmental Justice.

For example, Atlantic City, NJ had a minimum of 11% and maximum of 30% overlap of wind energy revenue to the total port revenue between 2008-2019. Those communities that score Med-High or higher in at least one of the vulnerability indicators that address environmental justice concerns (i.e., Poverty, Population Composition, Personal Disruption; see indicator definitions) are noted with a triangle. Gentrification pressure is also highlighted here, with those communities that score Med-High or higher in one or more gentrification pressure indicators (i.e., Housing Disruption, Retiree Migration, Urban Sprawl) represented with a circle (Fig. 11). BOEM reports that cumulative offshore wind development (if all proposed projects are developed) could have moderate impacts on low-income members of environmental justice communities who work in the commercial fishing and for-hire fishing industry due to disruptions to fish populations, restrictions on navigation and increased vessel traffic, as well as existing vulnerabilities of low-income workers to economic impacts [12].

Top fishing communities high in environmental justice concerns (i.e., Atlantic City, NJ, Newport News, VA, Hobucken and Beaufort, NC) should be considered in decision making to reduce the social and economic impacts and aid in the resilience and adaptive capacity of underserved communities. It also highlights communities where we need to provide further resources to reach underserved and underrepresented groups and create opportunities for and directly involve these groups in the decision-making process.

Implications

Current plans for rapid buildout of offshore wind in a patchwork of areas spreads the impacts differentially throughout the region (Fig. 9).

Up to 20% of total average revenue for major Mid-Atlantic commercial species in lease areas could be forgone or reduced and associated effort displaced if all sites are developed. Displaced fishing effort can alter historic fishing area, timing, and method patterns, which can in turn change habitat, species (managed and protected), and fleet interactions. Several factors, including fishery regulations, fishery availability, and user conflicts affect where, when, and how fishing effort may be displaced.

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

The increase of offshore wind development can have both positive (e.g., employment opportunities) and negative (e.g., space-use conflicts) effects. Continued increase in coastal development and gentrification pressure has resulted in loss of fishing infrastructure space within ports. Understanding these existing pressures can allow for avoiding and mitigating negative impacts to our shore support industry and communities dependent on fishing. Some of the communities with the highest revenue overlap with offshore wind that are also vulnerable to gentrification pressure are Point Pleasant and Atlantic City, NJ, Ocean City, MD, and Beaufort, NC.

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.

2022 EAFM Risk Tables

Table 5: 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
Chub mackerel	h	lm	lm	l	l	l	na	na	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 6: 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	lm	l	mh	l	lm	h	mh

Table 7: 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	l
Scup-R	lm	l	lm	mh	mh	h
Scup-C	l	lm	mh	mh	mh	l
Black sea bass-R	h	l	mh	mh	h	h
Black sea bass-C	h	lm	h	mh	h	l
Atl. mackerel-R	lm	l	l	lm	l	l
Atl. mackerel-C	l	lm	mh	h	lm	h
Butterfish-C	l	lm	mh	mh	mh	l
Longfin squid-C	l	mh	h	mh	h	l
Shortfin squid-C	lm	lm	lm	mh	l	h
Golden tilefish-R	na	l	l	l	l	l
Golden tilefish-C	l	l	l	l	l	l
Blueline tilefish-R	lm	l	l	lm	l	l
Blueline tilefish-C	lm	l	l	lm	l	l
Bluefish-R	lm	l	l	lm	mh	h
Bluefish-C	l	l	lm	lm	lm	l
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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