MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

Mid-Atlantic Fishery Management Council
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MEMORANDUM

Date: March 25, 2020

To: Council

From: Brandon Muffley, Staff

Subject: State of the Ecosystem and EAFM Update – Meeting Materials

On Tuesday, April 7, 2020, Dr. Sarah Gaichas (NEFSC) will present the 2020 Mid-Atlantic State of the Ecosystem report. Dr. Gaichas will also summarize the updates and changes in the 2020 EAFM risk assessment. 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. Due to changes in the April meeting agenda, an update on other EAFM related projects will not be presented but a briefing memo on those topics is provided.

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

Materials behind the tab:

1. 2020 Mid-Atlantic State of the Ecosystem report
2. State of the Ecosystem response memo
3. 2020 EAFM Risk Assessment update report
4. Staff memo – EAFM activities update
5. Fact sheet - Short-term distribution forecast research

NOAA
FISHERIES

2020 State of the Ecosystem
Mid-Atlantic

Total commercial fishery landings were scaled to ecosystem productivity. Primary production required to support Mid-Atlantic commercial landings has been declining since 2000.

Engagement in commercial fishing has declined since 2004 for medium to highly engaged Mid-Atlantic fishing communities. This may be related to the overall downward trend in commercial landings since 1986 and the decline in total revenue since 2004.

2018 retained recreational catch in the Mid-Atlantic was the lowest observed since 1982. There is also a similar, although less steep decline in recreational fishing effort. The party/charter sector is expected to continue to shrink. Recreational species catch diversity has been maintained by increased catch of South Atlantic and state managed species.

Habitat modeling indicates that summer flounder, butterfish, longfin squid, and spiny dogfish are among fish species highly likely to occupy wind energy lease areas. Habitat conditions for many of these species have become more favorable over time within wind lease areas.

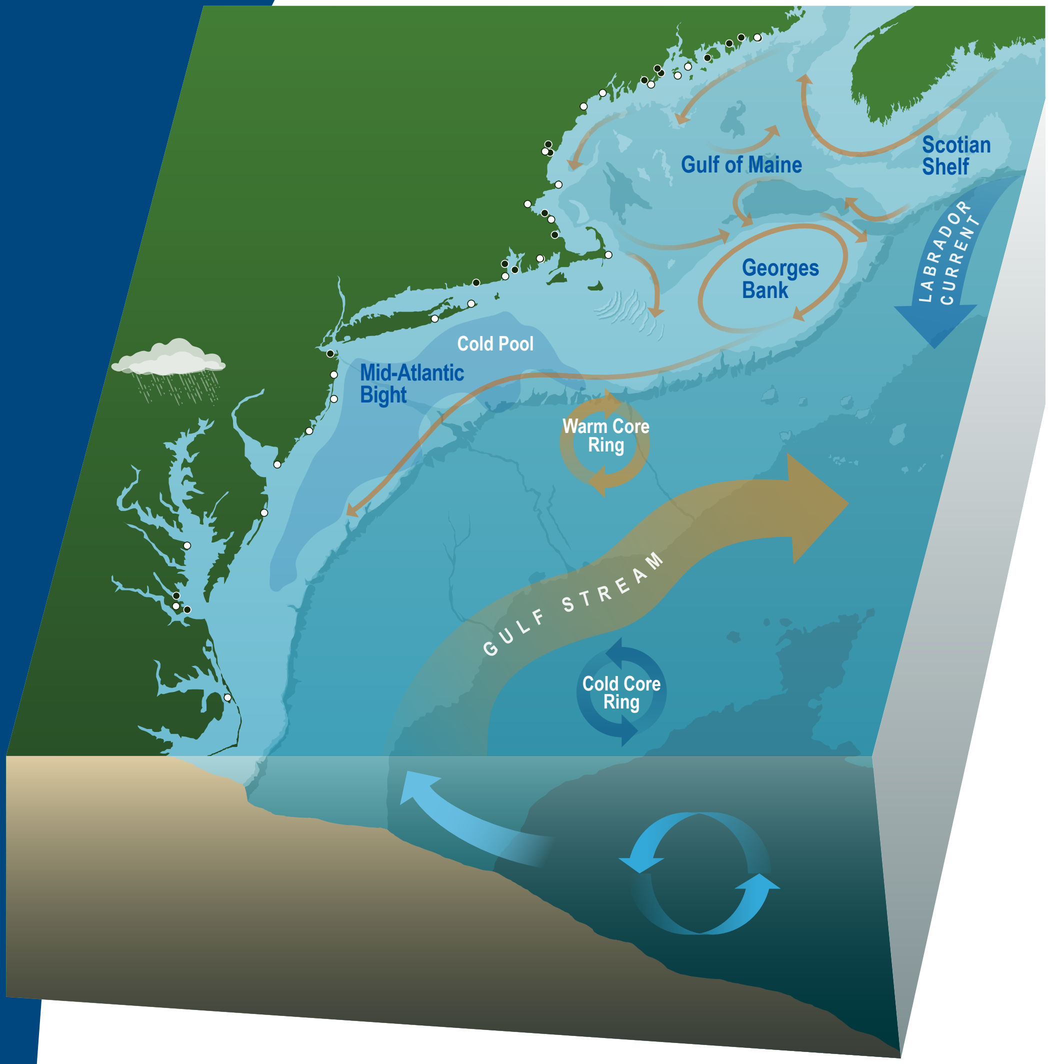
There are no apparent trends in aggregate biomass of predators, forage fish, bottom feeders, and shellfish sampled by trawl surveys, implying a stable food web. However, we continue to see a northward shift in aggregate fish distribution along the Northeast US shelf and a tendency towards distribution in deeper waters.

Forage fish energy content is now being measured regularly, revealing both seasonal and annual variation in energy of these important prey species due to changing ecosystem conditions. Notably, Atlantic herring energy content is half what it was in the 1980-90s.

Nearshore habitats are under stress. Heavy rains in 2018-2019 resulted in unprecedented fresh water and high nutrient flow into the Chesapeake Bay, driving low oxygen, increased oyster mortality, and spread of invasive catfish in this critical Mid-Atlantic nursery habitat. Sea level rise is altering coastal habitats in the Mid-Atlantic, driving declines in nesting seabirds on Virginia islands.

The Northeast US shelf ecosystem continued to experience warm conditions in 2019, with changes in ocean circulation affecting the shelf. The Gulf Stream is increasingly unstable, with more warm core rings resulting in higher likelihood of warm salty water and associated oceanic species such as shortfin squid coming onto the shelf.

The intensity and duration of marine surface heatwaves are increasing, and bottom temperatures both in the seasonal Mid-Atlantic cold pool and shelfwide are increasing. Warmer temperatures increase nutrient recycling and summer phytoplankton productivity.



The Northeast US Shelf is one of the most productive marine ecosystems in the world. Changes in climate, nearshore, and oceanographic processes as well as human uses affect productivity at all trophic levels and impact fishing communities and regional economies.

Research Spotlight

Fish condition, "fatness", is an important driver of population productivity. Condition is affected by changing habitat (e.g. temperature) and ecosystem productivity, and in turn can affect market prices. We are investigating potential factors influencing fish condition to better inform operational fishery management decisions.

https://www.fisheries.noaa.gov/about/northeast-ecosystem-dynamics-and-assessment

Report Structure

The major messages of the report are synthesized in the 2-page summary, above. The information in this report is organized around general ecosystem-level management objectives (Table 1), and indicators related to these objectives are grouped into four general categories in the four sections below: economic and social, protected species, fish and invertebrates, and habitat quality and ecosystem productivity. Each section begins with a summary of main messages with links to other sections, including any new information added at the request of the Fishery Management Councils, and includes figures with brief descriptions of all current indicators. Detailed technical methods documentation[1] and indicator data[2] are available online. The details of standard figure formatting (Fig. 37a), categorization of fish and invertebrate species into feeding groups (Table 4), and definitions of ecological production units (EPUs, including the Mid-Atlantic Bight, MAB; Fig. 37b) are provided at the end of the document.

Table 1: Established ecosystem-scale objectives in the Mid-Atlantic Bight

Objective Categories	**Indicators reported here**
Seafood Production	Landings by feeding guild
Profits	Revenue decomposed to price and volume
Recreation	Days fished; recreational catch
Stability	Diversity indices (fishery and species)
Social & Cultural	Commercial engagement trends
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

Economic and Social

The objectives of U.S. federal fishery management include providing benefits to the Nation in terms of seafood production and recreational opportunities, while considering economic efficiency and effects on coastal communities. The indicators in this section consider these objectives for commercial and recreational fishing sectors separately where possible.

Despite mostly meeting fishery management objectives at the single species level (Fig. 14), long term declines in total seafood production and commercial revenue remain apparent. Indicators highlight a declining diversity of recreational opportunities (fishing modes and species). Further, coastal communities with high fishery engagement and reliance are dependent on a smaller number of species than historically, these species are predominantly high valued shellfish vulnerable to increased ocean temperature and acidification. New analysis of wind energy lease areas and modeled habitat occupancy highlights which species are most likely to be found in wind development areas seasonally (Fig. 10).

Commercial sector (MAB)

The amount of potential yield we can expect from a marine ecosystem depends on the amount of production entering at the base of the food web, primarily in the form of phytoplankton; the pathways this energy follows to reach harvested species; the efficiency of transfer of energy at each step in the food web; and the fraction of this production that is removed by the fisheries. Species such as scallops and clams primarily feed directly on larger phytoplankton species and therefore require only one step in the transfer of energy. The loss of energy at each step can exceed 80-90%. For many fish species, as many as 2-4 steps may be necessary. Given the trophic level and the efficiency of

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[1] https://NOAA-EDAB.github.io/tech-doc

[2] https://github.com/NOAA-EDAB/ecodata

energy transfer of the species in the ecosystem the amount phytoplankton production required (PPR) to account for the observed catch can be estimated.

Primary production required has declined over the past 20 years (Fig. 1). There is also an apparent cyclical pattern. The overall trend is largely driven by the decrease in landings with an increase in primary production over the same period. The landings in many of the years are dominated by species at lower trophic levels (scallops and clams). The periodicity in the PPR index reflects both the periodicity in primary production (see Fig. 36) and the periodicity in the closed areas for scallop harvest.

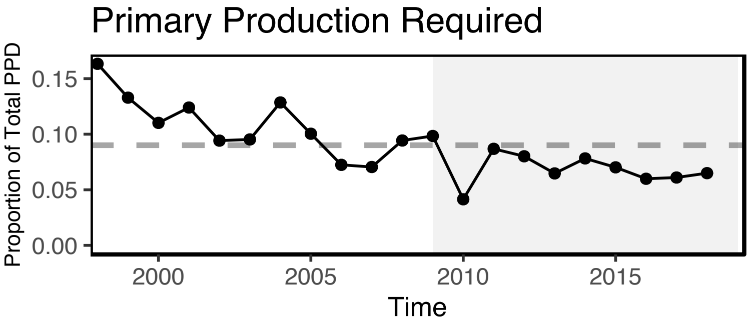

Figure 1: Primary production required to support MAB commercial landings. Included are the top species accounting for 80% of the landings in each year, with 15% transfer efficiency assumed between trophic levels.

Total seafood landings and MAFMC managed species seafood landings have declined over the long term (Fig. 2) with a slight increase 2016-2018. Seafood landings for feeding guilds are also stable or declining overall (Fig. 3), although landings of piscivores and planktivores increased in the MAB. Recent increased landings of *Illex* squid are apparent in the piscivores guild (attributed to the planktivores guild in previous reports). Landings of apex predators are available for 2016-2018 but trends are not detectable in this short time series.

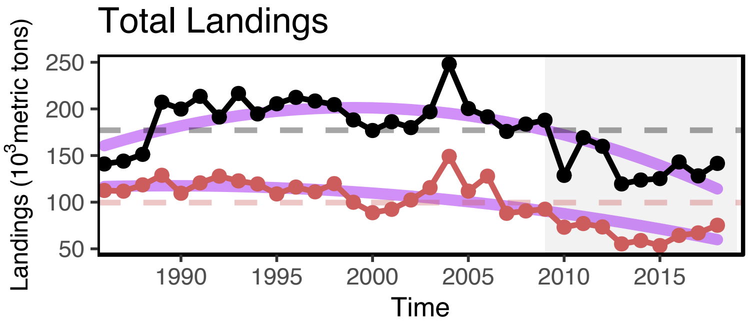

Figure 2: Total commercial seafood landings (black) and Mid-Atlantic managed seafood landings (red).

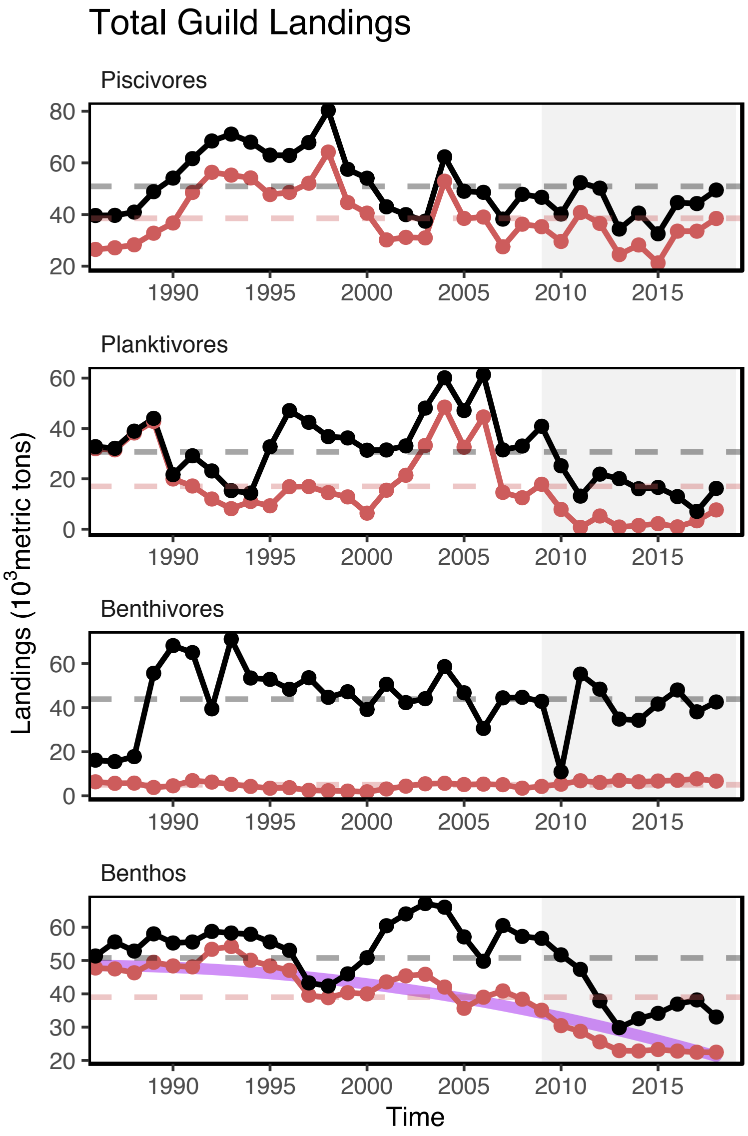

Figure 3: MAFMC managed species landings (red) and total commercial landings (black) by feeding guild.

Revenue for MAFMC managed species has also declined over the long term (Fig. 4), with recent decreases in total revenue driven by decreased prices compared to the 2015 baseline (Fig. 5).

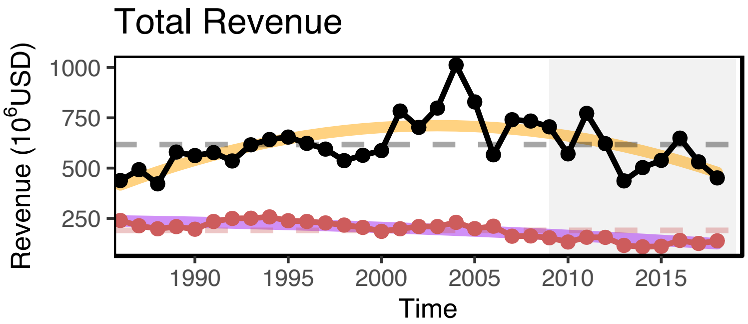

Figure 4: Total revenue for the region (black) and revenue from MAFMC managed species (red).

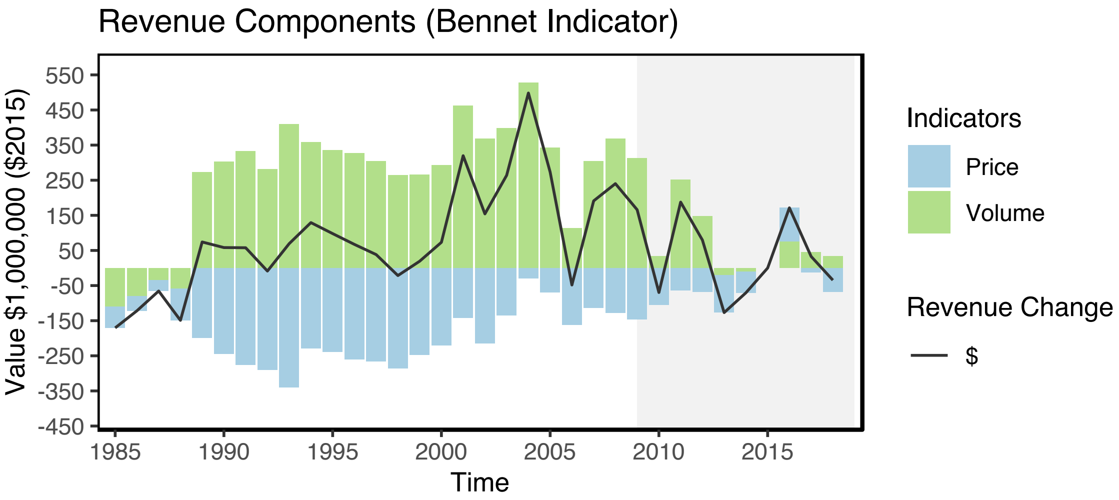

Figure 5: Revenue change from the 2015 base year in 2015 dollars (black), Price (PI), and Volume Indicators (VI) for commercial landings in the Mid-Atlantic.

Commercial fleet diversity indices were updated with 2018 data and remain near the long term average[3].

Commerical fishery engagement measures the number of permits, dealers, and landings in a community[4]. The trend in the number of Mid-Atlantic fishing communities that were highly engaged (red bar) in commercial fishing has shown a decrease since 2004 (Fig. 6). Some of the communities that were highly engaged have moved into the moderate (blue bar) or medium-high (green bar) category, and thus the number of moderately to medium-highly engaged communities have increased. Significant changes in engagement scores have also been observed in medium-highly engaged communities. The average engagement score has decreased since 2004. These changes may be driven by the decline in value landed by primary species such as sea scallops in this group of communities.

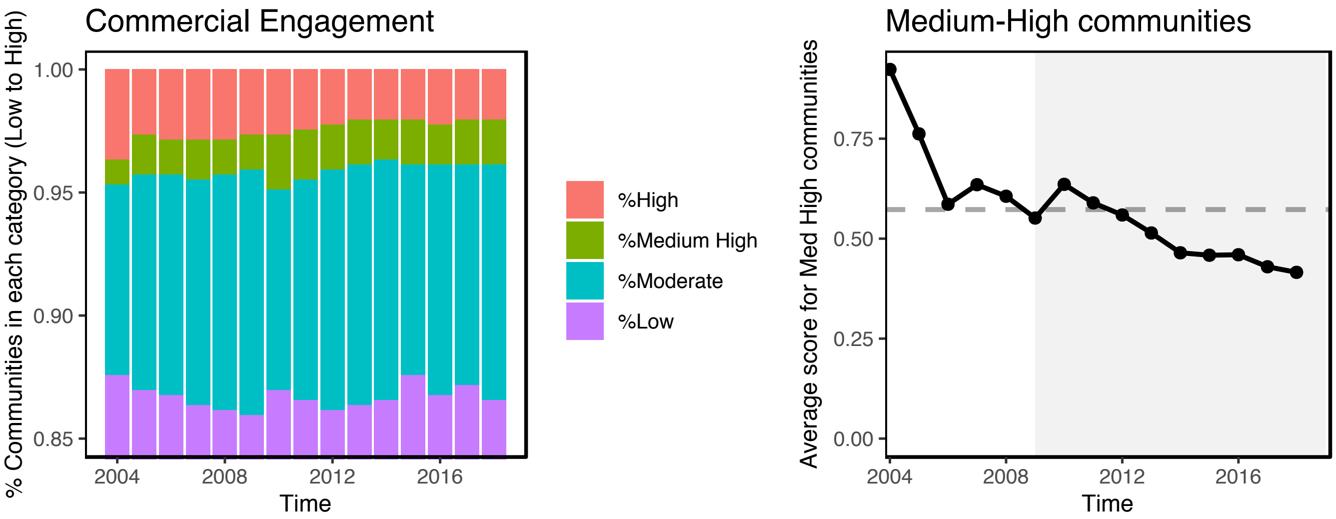

Figure 6: Commercial engagement scores (total pounds landed, value landed, commercial permits, and commercial dealers in a community) for Mid-Atlantic fishing communities, 2004-2018.

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[3] https://noaa-edab.github.io/ecodata/human_dimensions#mid-atlantic

[4] https://www.fisheries.noaa.gov/national/socioeconomics/social-indicator-definitions#fishing-engagement-and-reliance-indices

Recreational sector (Mid-Atlantic states)

Indicators for recreational diversity are presented in this report at the request of the MAFMC. In contrast to the commercial seafood production trends, recreational seafood production has been stable since the mid-1990s with the updated MRIP data (Fig. 7). However, 2018 recreational seafood landings were the lowest observed since 1982, with a 47% drop year over year. This drop involved multiple species, including black sea bass, scup, spot, and bluefish, among others and though accompanied by lower recreational effort in 2018, is not fully explained by changes in effort alone. The survey methodology behind these numbers was updated in 2018, and additional years worth of data is needed to understand whether these declines are driven by changes in the precision or other statistical properties of the data.

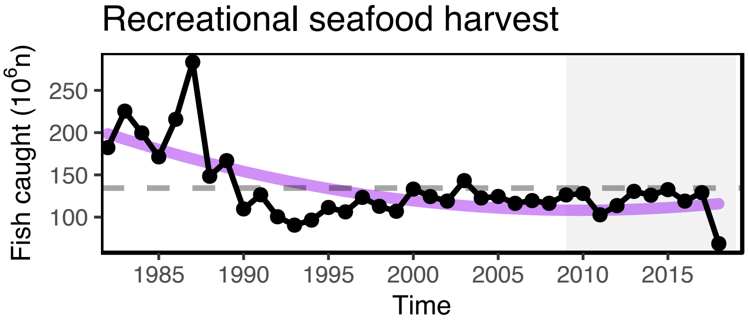

Figure 7: Total recreational seafood harvest in the Mid-Atlantic region.

Updated indicators for recreational opportunities (effort days) show general increases since the 1990s, peaking in the late 2000s and declining since then. This is similar to previously reported trends (Fig. 8).

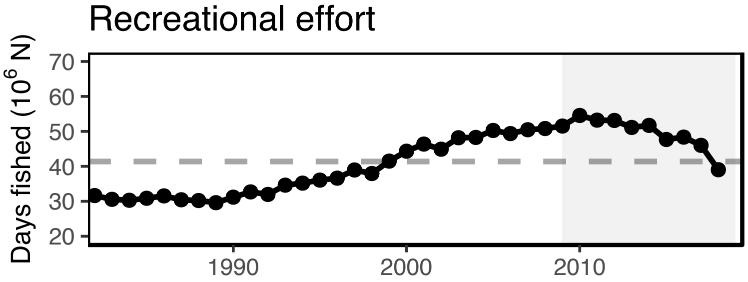

Figure 8: Recreational effort in the Mid-Atlantic.

Indicators for the diversity of recreational effort (i.e. access to recreational opportunities) by mode (party/charter boats, private boats, shore-based), and diversity of catch (NEFMC, MAFMC, SAFMC, and ASMFC managed species) show different trends. The downward effort diversity trend is driven by party/charter contraction (from a high of 24% of angler trips to 7% currently), with a shift towards shorebased angling. Effort in private boats remained stable between 36-37% of angler trips across the entire series. The long-term decrease in species catch diversity in the Mid-Atlantic states reported last year resulted from aggregation of SAFMC and ASMFC managed species into a single group. With SAFMC and ASMFC species considered individually, there is no long term trend in recreational catch diversity. This implies that recent increases in catch of SAFMC and/or ASMFC managed species is helping to maintain diversity in the same range that MAFMC and NEFMC species supported in the 1990s (Fig. 9).

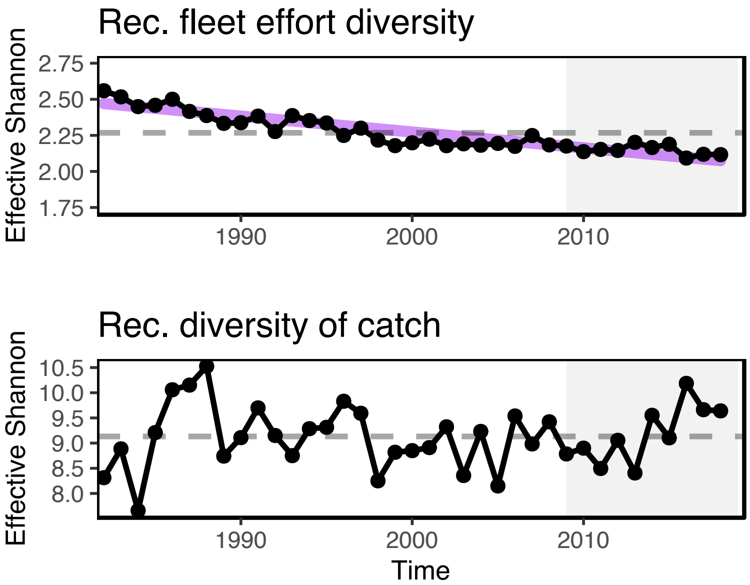

Figure 9: Recreational effort diversity and diversity of recreational catch in the Mid-Atlantic.

Additional social indicators for Mid-Atlantic communities are available online[5].

Fish habitat overlap with offshore wind lease areas (coastwide)

Fish habitat modeling based on NEFSC bottom trawl surveys [1] indicates that summer flounder, butterfish, longfin squid, and spiny dogfish are among fish species highly likely to occupy wind energy lease areas (Fig. 10). Habitat conditions for many of these species have become more favorable over time within wind lease areas (increasing trend in probability of occupancy). Table 2 lists the top 5 species in each season most likely to occupy the wind lease areas in the northern, central, and southern portions of the MAB, along with observed trends in probability of occupancy.

Table 2: Species with highest probability of occupancy species each season and area, with observed trends

	Existing - North		Proposed - North		Existing - Mid		Proposed - Mid		Existing - South	
Season	Species	Trend	Species	Trend	Species	Trend	Species	Trend	Species	Trend
Spring	Little Skate	↗	Atlantic Herring		Little Skate	↗	Spiny Dogfish	↗	Spiny Dogfish	↗
Spring	Atlantic Herring	↘	Little Skate	↗	Atlantic Herring	↘	Atlantic Herring	↘	Longfin Squid	↗
Spring	Windowpane	↗	Longhorn Sculpin	↗	Spiny Dogfish	↗	Little Skate	↗	Summer Flounder	↗
Spring	Winter Skate	↗	Windowpane	↗	Windowpane	↗	Alewife	↘	Clearnose Skate	↗
Spring	Longhorn Sculpin	↗	Alewife	↘	Winter Skate	↗	Silver Hake	↗	Spotted Hake	↗
Fall	Butterfish	↗	Butterfish	↗	Summer Flounder	↗	Longhorn Sculpin	↗	Longfin Squid	↘
Fall	Longfin Squid	↗	Fourspot Flounder		Longfin Squid	↗	Little Skate	↗	Northern Searobin	↗
Fall	Summer Flounder	↗	Longhorn Sculpin	↘	Butterfish	↗	Butterfish	↗	Clearnose Skate	↗
Fall	Winter Flounder	↘	Summer Flounder	↗	Smooth Dogfish	↗	Sea Scallop	↗	Butterfish	↗
Fall	Spiny Dogfish	↘	Spiny Dogfish	↘	Windowpane	↗	Fourspot Flounder	↗	Spiny Dogfish/Spotted Hake	↗

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[5] https://www.st.nmfs.noaa.gov/humandimensions/social-indicators/

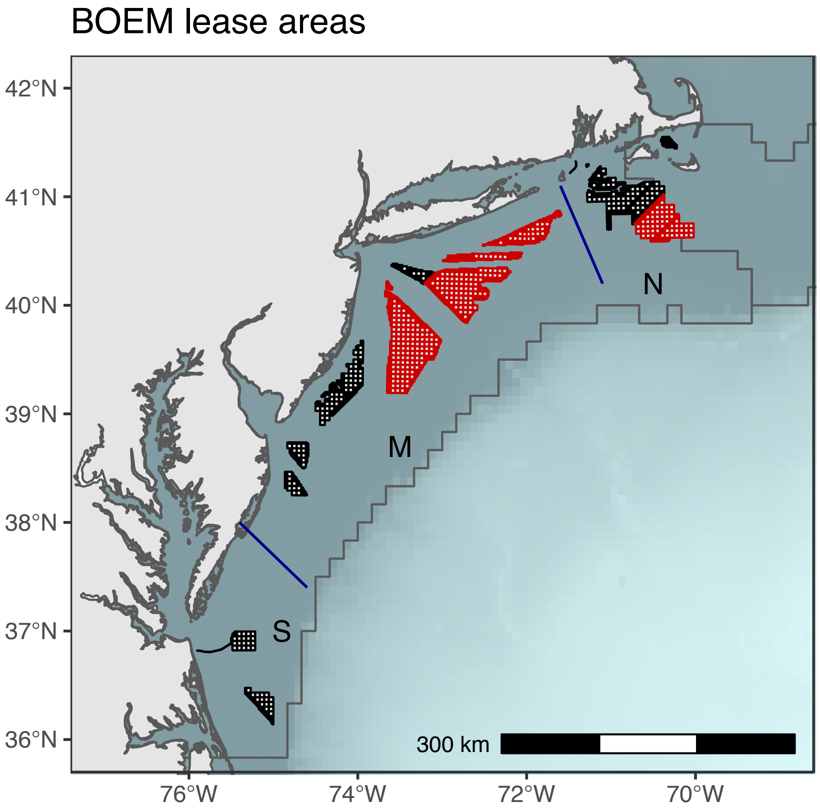

Figure 10: Map of BOEM existing (black) and proposed (red) lease areas in North (N), Mid (M) and South (S) portions of the coast as of February 2019.

Protected Species

Protected species include marine mammals (under the Marine Mammal Protection Act), endangered and threatened species (under the Endangered Species Act), and migratory birds (under the Migratory Bird Treaty Act). In the Northeast US, endangered/threatened species include Atlantic salmon, Atlantic and shortnose sturgeon, all sea turtle species, and 5 baleen whales. 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 US region. Also, a marine mammal climate vulnerability assessment is currently underway and for Atlantic and Gulf of Mexico populations and will be reported on in future versions of this report.

While harbor porpoise bycatch continues to be quite low as reported previously, this year saw the continuation of four Unusual Mortality Events (UMEs) for three large whale species and four seal species, with several mortalities attributed to human interactions. Strong evidence exists to suggest that the level of interaction between right whales and the combination of offshore lobster fishery in the US and snow crab fishery in Canada is contributing substantially to the decline of the species.

Whales (coastwide)

North Atlantic right whales are among the most endangered large whale populations in the world. Changes in right whale trends can have implications for fisheries management where fisheries interact with these whales. Additional management restrictions could have a large impact on fishing times, gears, etc. Although the population increased steadily from 1990 to 2011, it has decreased recently (Fig. 11). Reduced survival rates of adult females and diverging abundance trends between sexes have also been observed. It is estimated that there are only about 100 reproductive adult females remaining in the population. In 2018 there were no new calves observed, and a drop in annual calf production roughly mirrors the abundance decline (Fig. 12), however seven new calves were born in 2019. Right whale distribution has changed since 2010. New research suggests that recent climate driven changes in ocean circulation has 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.

Three large whale Unusual Mortality Events (UMEs) are ongoing for North Atlantic right whales, humpback whales (117 dead to date since January 2016[6]), and minke whales (80 dead to date since January 2017[7]). In all three cases human interaction appears to have contributed to increased mortalities, although investigations are not complete. Since 2017, 30 right whale mortalities have been documented, 9 in the US and 21 in Canada[8]. During 2019, 9 dead right whales have been documented in Canada and one in the US. Three of these mortalities were determined to have been due to vessel strike while the remainder are undetermined at this time.

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[6] https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2020-humpback-whale-unusual-mortality-event-along-atlantic-coast

[7] https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2020-minke-whale-unusual-mortality-event-along-atlantic-coast

[8] https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2020-north-atlantic-right-whale-unusual-mortality-event

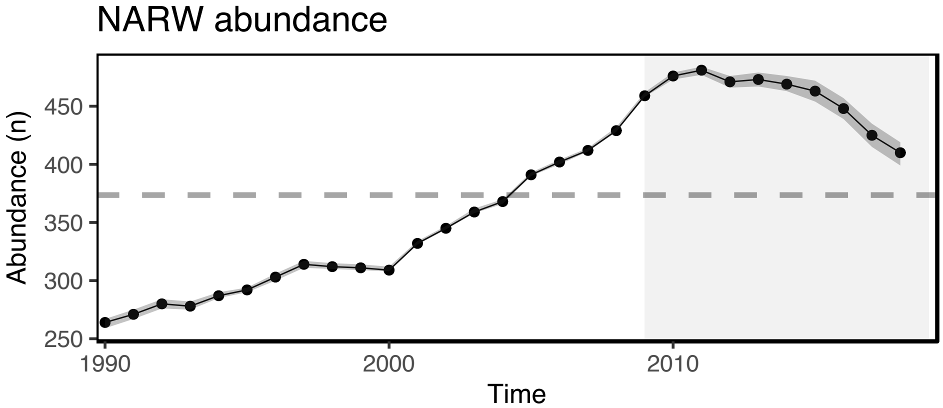

Figure 11: 1990-2018 right whale abundance estimates with 95% credible intervals. These values represent the estimated number of animals alive sometime during the year referenced and NOT at the end of the year referenced. Three known deaths were recorded in 2018, but these deaths were not reflected in the 2018 estimate because those animals were alive sometime during the year. An additional 10 known deaths occurred in 2019.

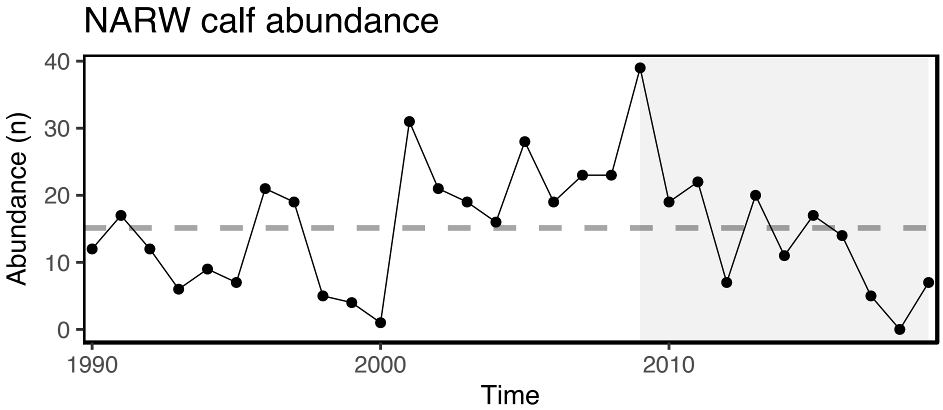

Figure 12: Number of North Atlantic right whale calf births, 1990 - 2019.

Seals (coastwide)

The best current abundance estimate of harbor seals (*Phoca vitulina*) is 75,834 (CV = 0.15), based on a survey conducted during the pupping season in 2012. A population survey was conducted in 2018 to provide updated abundance estimates and these data are in the process of being analyzed, as part of a larger trend analysis. Tagging studies of both gray and harbor seals demonstrate long-range movements throughout the Gulf of Maine and mid-Atlantic.

The number of grey seals (*Halichoerus grypus*) in U.S. waters has risen dramatically in the last 2 decades, with few observed in the early 1990s to roughly 24,000 observed in southeastern Massachusetts in 2015. Roughly 30,000 - 40,000 gray seals were estimated in southeastern Massachusetts in 2015, using correction factors applied to seal counts visible in Google Earth imagery. As of 2016, the size of the grey seal population in Canada, which is part of the same stock as the grey seals in the U.S., was estimated to be roughly 425,000, and increasing by 4% a year. In U.S. waters, the number of pupping sites has increased from 1 in 1988 to 9 in 2019. Mean rates of increase in the number of pups born at various times since 1988 at 4 of the more data-rich pupping sites (Muskeget, Monomoy, Seal, and Green Islands) ranged from -0.2% (95%CI: -2.3 - 1.9%) to 26.3% (95%CI: 21.6 - 31.4%). These high rates of increase provide further support that seals from Canada are continually supplementing the breeding population in U.S. waters. Fisheries interactions have also increased over the past 2 decades, with fewer than 10 total estimated grey seal interactions in 1993, to more than 1000 annually in four out of the last 5 years; this is the highest bycatch of any US marine mammal species.

A UME for both gray and harbor seals was declared in 2018, triggering an investigation into the cause of this event. Tests so far suggest phocine distemper virus as a potential cause, although the investigation is not yet complete. Several cases of phocine distemper in harp (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*) have been identified recently, and these two species have been added to the UME[9].

Current information suggests that gray seals eat primarily sand lance, hakes and flatfish, and squids, while harbor seals consume a variety of groundfish (hakes, cod, haddock, flatfish), redfish, herring and squids, however much of this information comes from juvenile animals and more research is needed on animals at other life stages. Additional analysis of gray and harbor seal diet is currently underway at the NEFSC using a variety of techniques (analysis of stomach contents, fatty acids, and DNA). This information can eventually be coupled with estimates of population abundance and consumption rates to estimate total biomass removals of fish due to pinniped predation.

Nesting waterbird abundance (Virginia)

Many nesting waterbird species on Virginia barrier islands have declined over the last 20-25 years[10]. Between 1993 and 2018, Common Terns declined by 80.6% in coastal Virginia. Considerable declines have been documented in all 3 geographic regions that supported colonies in 1993. These declines have been attributed to habitat loss linked to sea level rise. All functional groups have declined since 1993 (Fig. 13).

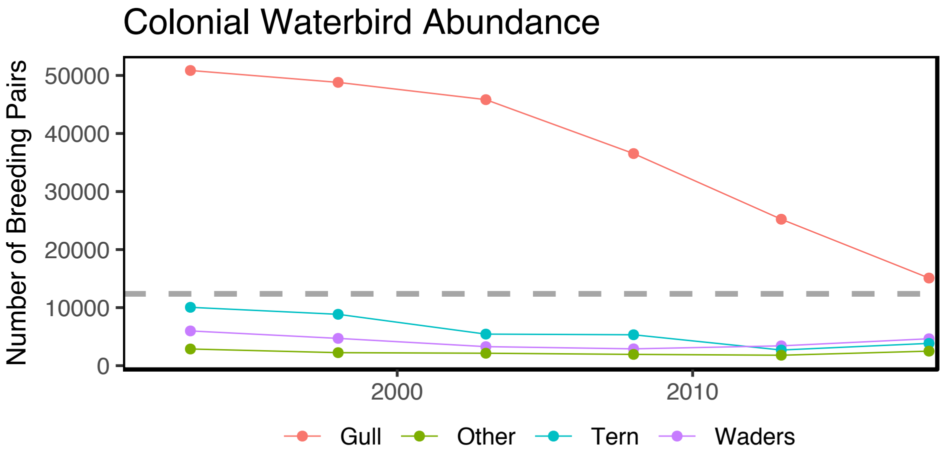

Figure 13: Functional group population estimates derived from Table 4 of Watts, B. D., B. J. Paxton, R. Boettcher, and A. L. Wilke. 2019. Status and distribution of colonial waterbirds in coastal Virginia: 2018 breeding season. Center for Conservation Biology Technical Report Series, CCBTR-19-06. College of William and Mary and Virginia Commonwealth University, Williamsburg, VA. 28 pp.

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[9] https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/2018-2019-pinniped-unusual-mortality-event-along

[10] https://ccbbirds.org/wp-content/uploads/CCBTR-19-06_Colonial-waterbirds-in-coastal-Virginia-2018.pdf

Fish and Invertebrates

Fishery management aims to keep individual harvested species within population ranges where productivity is maximized over the long-term. However, these managed species represent a subset of the full ecosystem, interacting with a wider range of predators and prey and relying on diverse habitats. Indicators in this section summarize single species status as well as tracking trends for broad categories of fish within the ecosystem, including changes in biomass, distribution, condition, and productivity. Changes in overall predator and prey levels as well as distribution have implications for managed fish productivity, fishing operations, and regional fishery management.

Stock status and aggregate distribution (coastwide)

Single species management objectives of maintaining biomass above minimum thresholds and fishing mortality below limits are being met for all but one MAFMC managed species, though the status of four stocks is unknown (Fig. 14). Bluefish biomass is below the threshold, but fishing mortality was below the limit, while mackerel biomass was below the threshold and fishing mortality was above the limit.

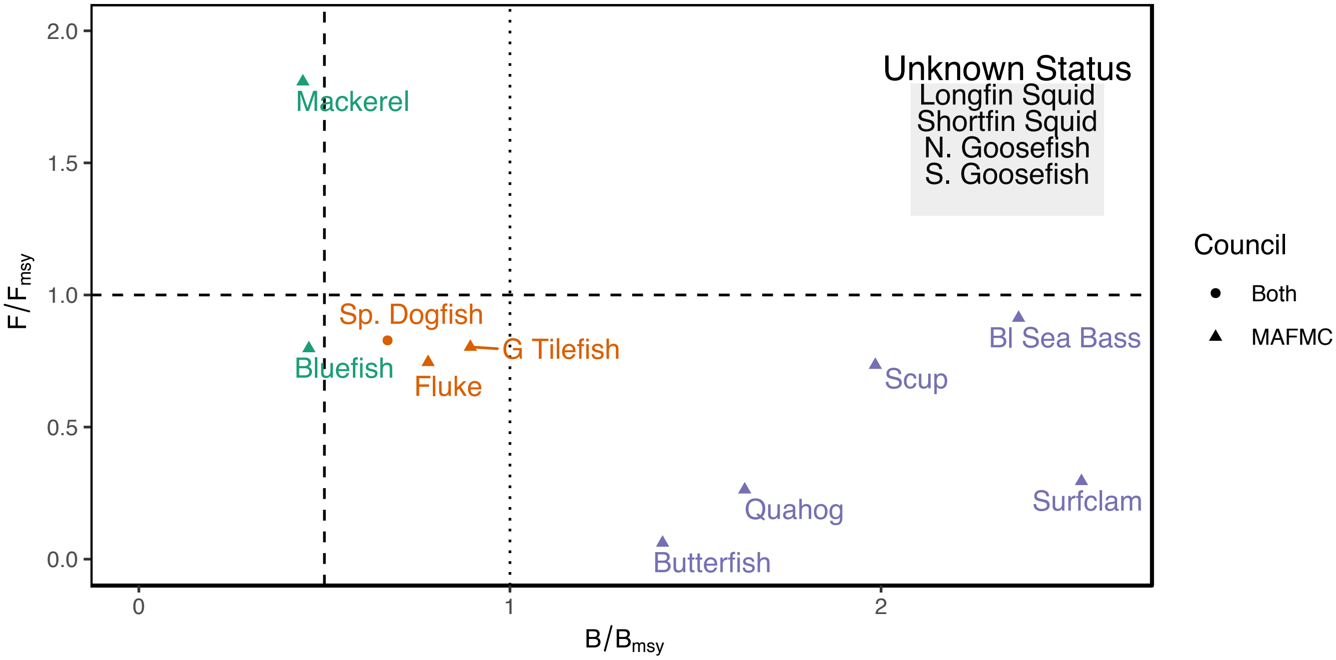

Figure 14: Summary of single species status for MAFMC and jointly managed stocks (Goosefish and Spiny dogfish).

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. 15). We hope to expand analysis beyond fish. Marine mammal distribution maps are available online[11]; updated maps and trends are currently being developed.

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

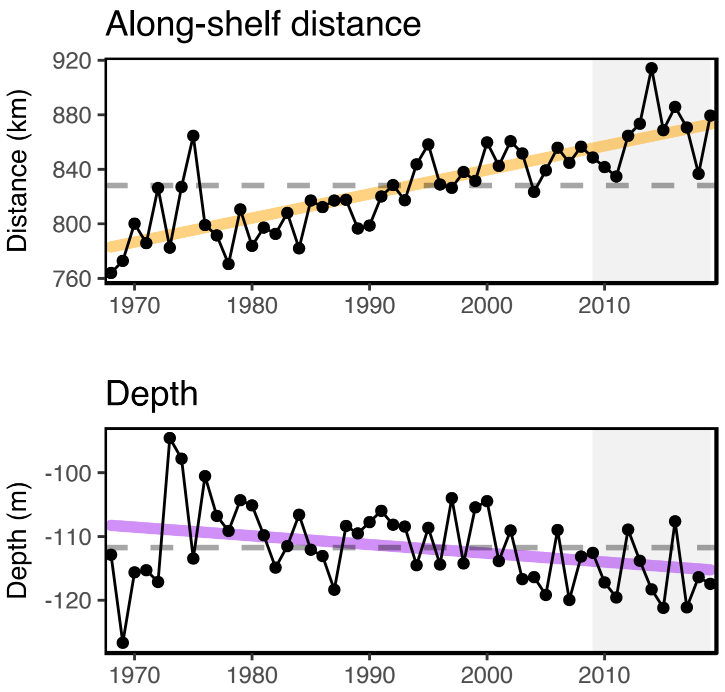

Figure 15: Aggregate species distribution metrics for fish in the Northeast Large Marine Ecosystem. Along-shelf distance measures the center of biomass along an axis oriented from the southwest to the northwest generally following the slope of coastline.

Southeast US fish occurrence (coastwide)

Preliminary analysis of NEFSC trawl survey data shows limited occurrence of South Atlantic Fishery Management Council (SAFMC) managed species groups during the fall, but almost never in spring. Lack of these species on spring surveys suggests that they are not overwintering in our region. There is no detectable trend in fall frequency of occurrence of SAFMC managed species as a group over time, nor are there detectable trends for the most common southeast US shelf species in the trawl surveys: blue runner, Spanish mackerel, chub mackerel, cobia.

Blue runner (*Caranx crysos*) was the southeast US shelf species with the highest frequency of occurrence over time. While there were no detectable trends, recent warm years have led to some observations of blue runner further north within the timing of the fall survey (Fig. 16). Four of the five the most northerly catches have happened since 2010, with the furthest north in 2012 in GOM and 3 on GB in 2018. Other indicators corroborate these observations. For example, butterfish have been observed in Gulf of Maine common tern fledgling diets between 2009-2011 and again in 2018 (New England Report Fig. 13b). As temperature and ocean circulation indicators trend toward extremes (next section), fishery management will likely face continued changes in species distribution.

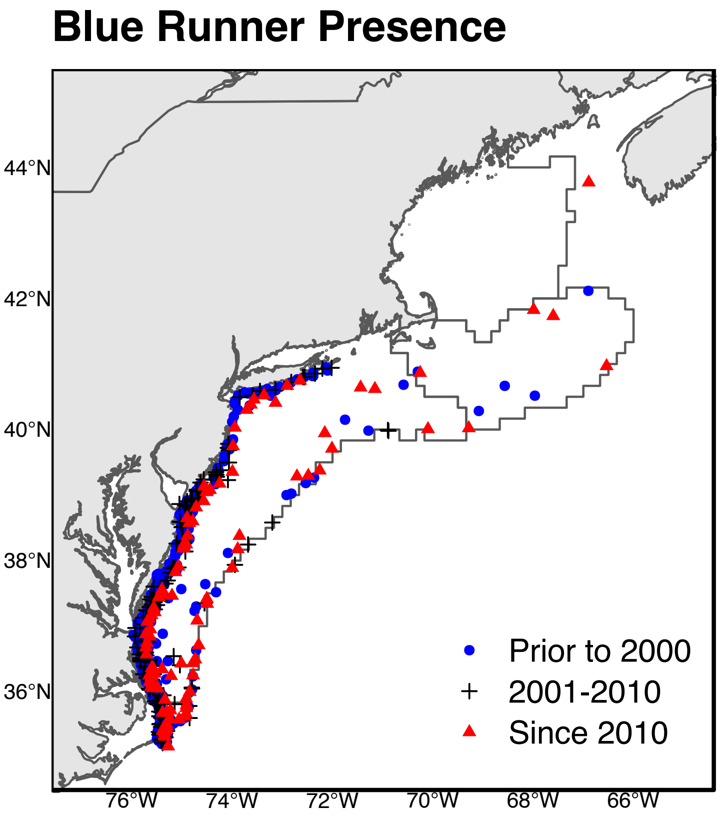

Figure 16: Blue runner presence on Northeast Shelf

Survey biomass (MAB)

Examining trends in biomass by aggregate groups rather than individual species reveals the overall stability of the trophic structure within the system. In past reports we noted several trends in aggregate biomass which might suggest an instability in this structure. This year we include information on survey biomass uncertainty as well as the mean trend. When considering variable catch between survey stations within strata for each year (Fig. 17), several previously identified trends are no longer significant, and others are unlikely to be ecologically significant. For example, our statistical analysis based on annual means suggests that benthivores had a positive trend in spring surveys. However, including sampling variability suggests that this trend is driven by uncertain estimates late in the time series.

Stability in biomass for these aggregate groups would suggest no major disturbances to overall trophic structure in the MAB. Both shelfwide and inshore surveys show stability over time for benthivores and planktivores. Similarly, piscivores and benthos are stable over time in the fall and spring, respectively. Including biomass uncertainty also demonstrates the similarity of trend and often magnitude of estimates between the NEFSC and NEAMAP surveys. These patterns will be explored in more detail using spatio-temporal analyses that include both surveys at once.

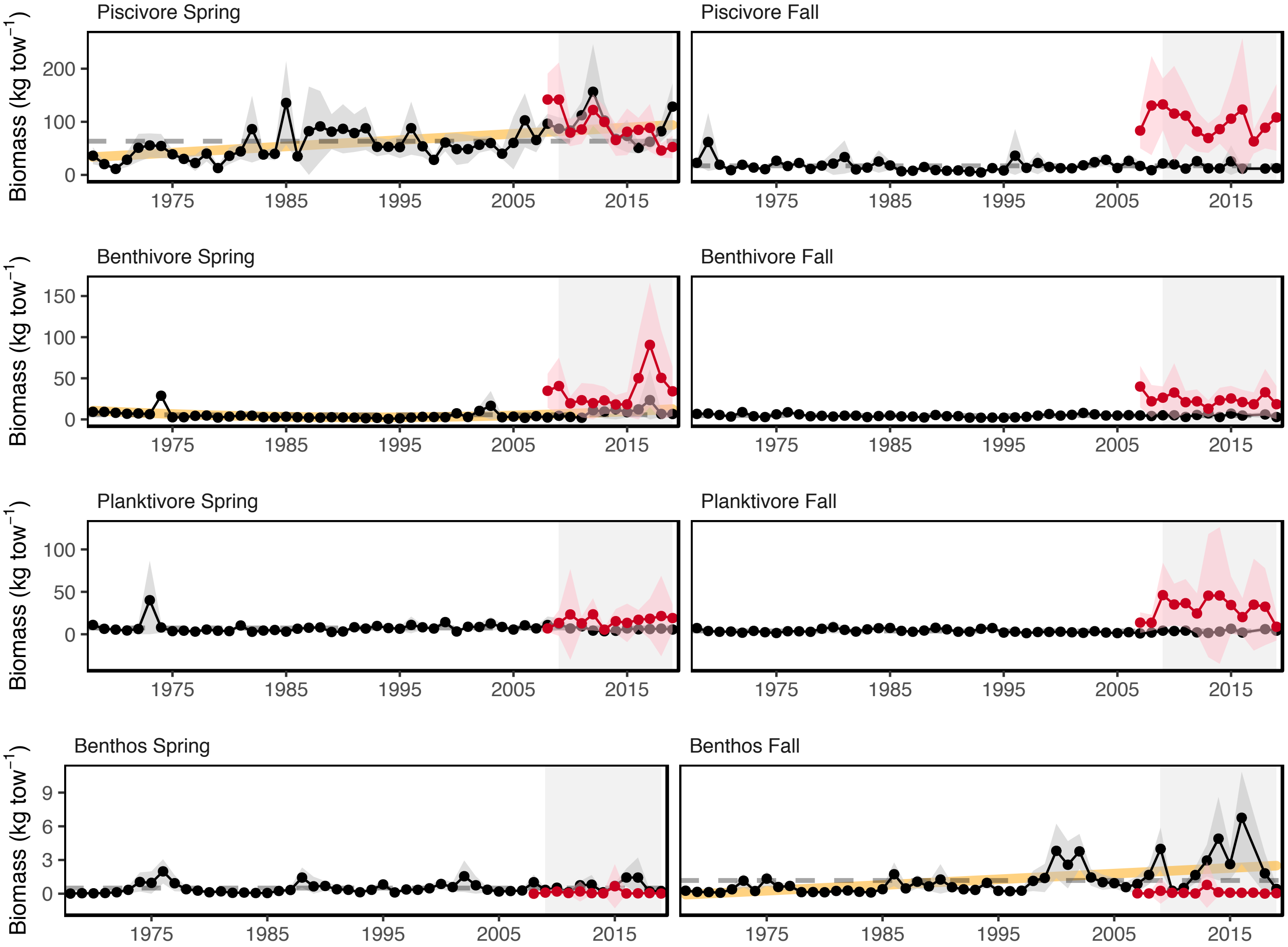

Figure 17: Spring (left) and fall (right) surveyed biomass in the Mid-Atlantic Bight. Data from the NEFSC Bottom Trawl Survey are shown in black, with NEAMAP shown in red. The shaded area around each annual mean represents 2 standard deviations from the mean.

Fish condition (MAB)

Fish condition, a measure of ‘fatness’ as an indicator of health and a factor that influences fecundity, is measured as the weight at a given length in relation to the average. For this report, females of all species adequately sampled in the Mid-Atlantic Bight portion of the fall NEFSC bottom trawl survey were analyzed (rather than both sexes of MAFMC managed species across the full Northeast US Shelf as in past years). Overall, condition factor has been mixed for the past decade, in contrast to overall high condition up to 2000 and overall lower condition for 2001-2010 (Fig. 18). The timing of these shifts is similar to shifts in the small-large zooplankton indicator (Fig. 36). Condition factor for some MAFMC managed species (bluefish, butterfish) were high in the MAB in 2018-2019. Black sea bass and goosefish have had generally poor condition in the MAB since 2015. Summer flounder condition has varied considerably 2016-2019 in the MAB.

Statistical analyses indicate that these trends in condition may be related to temperature changes and copepod size structure, but are not likely related to density dependence for most species. Fish condition is an important driver of population productivity as well as market prices, so we will investigate these potential links to changing habitat (temperature) and ecosystem productivity to evaluate whether they can inform decisions on annual catch limits. Work will continue over the coming year to explore relationships between fish condition and other indicators in this report (Research Spotlight, p. 2).

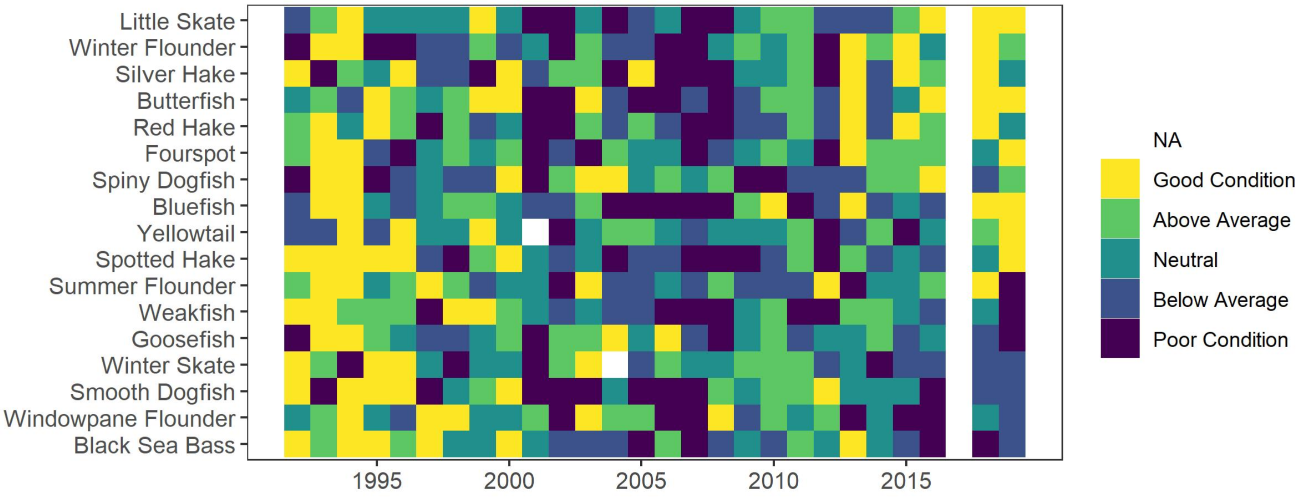

Figure 18: Condition factor for fish species in the MAB. MAB data are missing for 2017 due to survey delays.

Fish productivity (MAB)

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. 19). The indicator shows that fish productivity has been relatively low in this region since 2010, although productivity across all species is trending back up towards average. Species with above average 2018 productivity in the Mid-Atlantic include witch flounder, silver hake and red hake. As for MAFMC managed species in other regions, in 2017 Summer flounder had above average production in the Gulf of Maine while butterfish had above average production on Georges Bank based on this indicator[12]. However, for 2018, it was mainly New England managed species with above average productivity in the New England systems.

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[12] https://noaa-edab.github.io/ecodata/InteractiveSOE

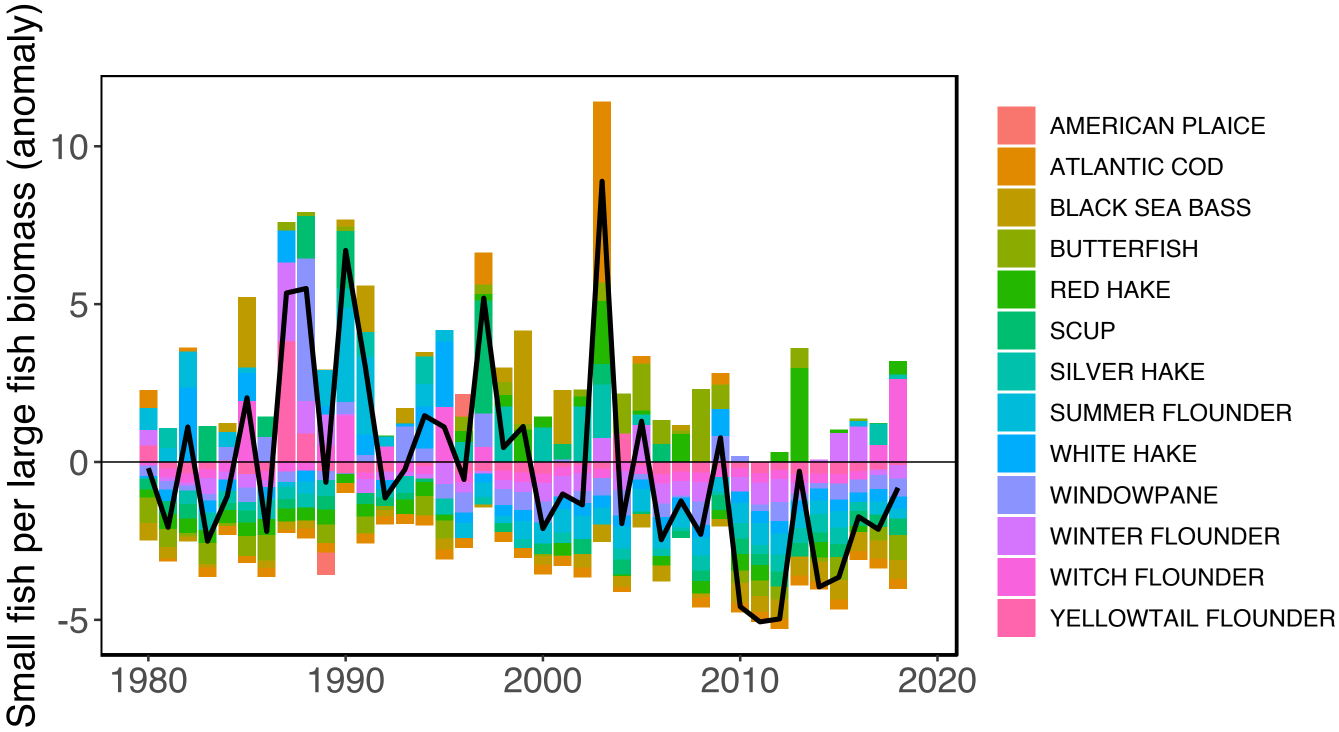

Figure 19: Small fish per large fish biomass anomaly in the Mid-Atlantic Bight. The summed anomaly across species is shown by the black line.

Forage fish energy content (coastwide)

Nutritional value of forage fishes as prey (energy content) is related to both environmental conditions and fish growth and reproductive cycles. Energy content is now being measured systematically on NEFSC trawl surveys, revealing both seasonal and interannual variation as well as differences from older measurements (Table 3). Notably, the energy density of Atlantic herring was almost half the value (5.69 +/- 0.07 kJ/g wet weight) reported in earlier studies (10.6-9.4 kJ/ g wet weight). Silver hake, sandlance, longfin squid (*Loligo* below) and shortfin squid (*Illex* below) were also lower than previous estimates [2,3]. Energy density of Alewife, butterfish and Atlantic mackerel were higher than earlier estimates. Sampling and laboratory analysis is ongoing, with the goal of continuing routine monitoring of energy density of these species.

Table 3: Forage fish mean energy density (ED) mean and standard deviation (SD) by season and year, compared with 1980s (Steimle and Terranove 1985) and 1990s (Lawson et al. 1998) values. N = number sampled.

	2017				2018				Total		1980s	1990s
	Spring		Fall		Spring		Fall					
Species	ED (SD)	N	ED (SD)	N	ED (SD)	N	ED (SD)	N	ED (SD)	N	ED	ED (SD)
Alewife	6.84 (1.62)	128	8.12 (1.46)	50	6.45 (1.21)	47	7.41 (1.6)	42	7.1 (1.62)	267	6.4	
Atl. Herring	5.34 (0.94)	122	5.77 (1.31)	52	6.69 (0.85)	51	5.41 (1.34)	50	5.69 (1.19)	275	10.6	9.4 (1.4)
Atl. Mackerel		NA	7.24 (1.13)	50	5.33 (0.86)	51	6.89 (1.07)	50	6.48 (1.32)	151	6.0	
Butterfish	7.13 (1.59)	65	7.31 (1.45)	89	4.91 (1.12)	53	8.1 (2.7)	50	6.92 (2.04)	257	6.2	
Illex	5.54 (0.4)	77	5.43 (0.51)	52	5.5 (0.52)	50	4.76 (0.79)	50	5.33 (0.63)	229	7.1	5.9 (0.56)
Loligo	5.22 (0.36)	83	5.24 (0.26)	60	4.84 (0.63)	52	4.6 (0.72)	50	5.02 (0.56)	245	5.6	
Sand lance	6.66 (0.54)	18		NA	5.78 (0.34)	60	7.99 (0.74)	8	6.17 (0.81)	86	6.8	4.4 (0.82)
Silver hake	4.25 (0.39)	189	4.42 (0.45)	50	4.19 (0.39)	50	4.55 (0.63)	50	4.31 (0.46)	339	4.6	

Habitat Quality and Ecosystem Productivity

Productivity of harvested fish and protected species, and therefore sustainability of fisheries, depends on adequate habitat, which encompasses physical and chemical conditions and biological productivity at the base of the food web. Many harvested and protected species on the Northeast US shelf occupy several distinct habitats throughout their life cycle, including estuaries, nearshore coastal, and offshore environments. The indicators in this section provide information on the changing conditions encountered by managed species in different seasons and across habitats, which may explain observed changes in species distribution and productivity. New for this year, habitat models were used to determine which species are most likely to occupy offshore wind energy development lease areas. Ultimately, a better understanding of these ecological drivers may permit proactive management in a changing system.

While management limiting nutrient inputs has significantly improved water quality in Chesapeake Bay [4], extremely high precipitation in late 2018-early 2019 led to reduced water quality. Temperature in coastal and offshore habitats continues to trend towards unprecedented levels, accompanied by alterations in ocean circulation patterns. Observed changes at the base of the food web, including timing of production and plankton community composition, affect productivity of protected and managed species in ways we do not yet fully understand.

Estuarine habitat quality (Chesapeake Bay)

Many important MAFMC managed species use estuarine habitats as nurseries or are considered estuarine and nearshore coastal-dependent (summer flounder, scup, black sea bass, and bluefish), and interact with other important estuarine-dependent species (e.g., striped bass and menhaden).

The Chesapeake Bay experienced below average salinity, caused by the highest precipitation levels ever recorded for the watershed throughout 2018 and 2019. Shifts in physical conditions changed the salinity dynamics throughout the Chesapeake Bay environment, impacting habitat conditions and biological responses for multiple species of interest, including eastern oysters, blue crab, striped bass, shad and herring, invasive blue catfish, and underwater seagrasses. Low salinity levels recorded by NOAA Chesapeake Bay Office's Chesapeake Bay Interpretive Buoy System (CBIBS) at Stingray Point showed below-average levels starting in summer 2018 and continuing through spring of 2019 (Fig. 20).

High flows during the winter and spring of Water Year (WY) 2019 came during a critical time of year when the nutrients delivered to the Bay fuel algal blooms, which can cause low dissolved oxygen in the summer. Low dissolved oxygen levels less than 2.0 mg/l (or hypoxia) are harmful to oysters, crabs and fish. The high flows, and associated nutrient loads, during WY 2019 contributed to summer dissolved-oxygen levels in the Bay that were the 3rd lowest recorded in Maryland waters, according to the Maryland Department of Natural Resources[13].

In Maryland, the Spatfall Intensity Index, a measure of oyster recruitment success and potential increase in the population, was 15.0 spat/bu, well below the 34-year median value of 39.8. Blue catfish, an invasive species in the Chesapeake, spread over the last two summers due to the lower salinity levels.

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[13] https://www.usgs.gov/center-news/september-hypoxia-report

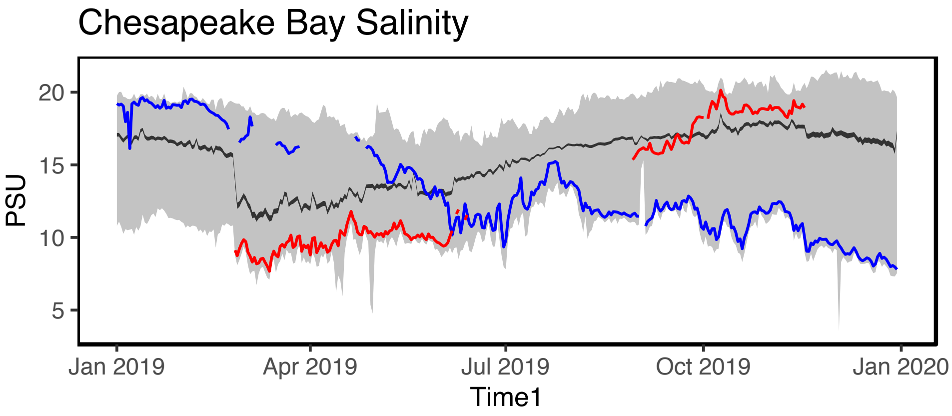

Figure 20: Salinity in Chesapeake Bay throughout 2018 (blue) and 2019 (red) as well as the daily average 2008-2019 (black) and the full observed range 2008-2019 (gray shading).

Estuarine water quality is measured in many other locations coastwide. Work is in progress to evaluate dissolved oxygen, chlorophyll, and nitrogen in NOAA-monitored estuaries throughout the Northeast US to get a better picture of important fishery nursery habitat in the region.

Oceanographic conditions (coastwide)

Globally, 2019 was the 2nd warmest year on record and the last five years have been the warmest in the last 140 years[14].

Since the 1860's, the Northeast US shelf sea surface temperature (SST) has exhibited an overall warming trend, with the past decade measuring well above the long term average (and the trendline; Fig. 21). Changes in the Gulf Stream, increases in the number of warm core ring formations and anomalous onshore intrusions of warm salty water are affecting the coastal ocean dynamics with important implications for commercial fisheries [5].

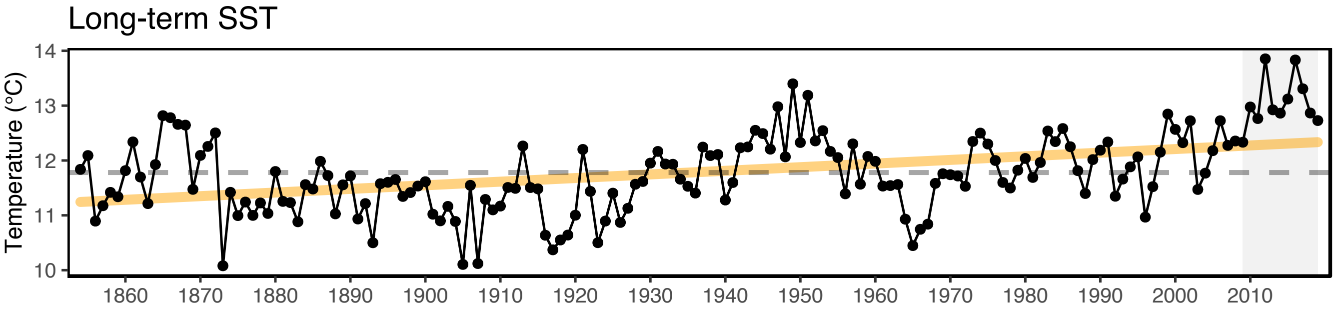

Figure 21: Average annual sea surface temperature (SST) over the Northeast US Shelf

Gulf Stream and Warm Core Rings (coastwide)

The Gulf Stream is shifting further northward and becoming more unstable. Over the last decade, the Gulf Stream Index (GSI) has an increasing trend indicating a northward shift in the Gulf Stream. In 2018, the GSI was at its most northerly position recorded since the year 1995 (Fig. 22). A more northerly Gulf Stream position is associated with warmer ocean temperature on the Northeast US shelf [6], a higher proportion of Warm Slope Water in the Northeast Channel, and increased sea surface height along the U.S. east coast [7].

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[14] https://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-2019-second-warmest-year-on-record

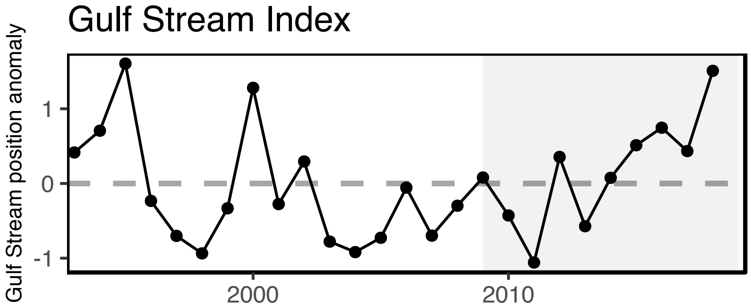

Figure 22: Index representing changes in the location of the Gulf Stream north wall. Positive values represent a more northerly Gulf Stream position.

Concurrently, large amplitude Gulf Stream meanders are forming more frequently further west [8]. There has also been a regime shift since 2000 after which there has been a significant increase in the number of warm core rings formed each year (Fig 23; [9]. The greater number of warm core rings increases the probability of intrusions of warm/salty Gulf Stream water onto the continental shelf. Any resulting accumulation of warmer water will add to the long term warming already occurring on the shelf. This in turn may lead to a response in species distributions [9].

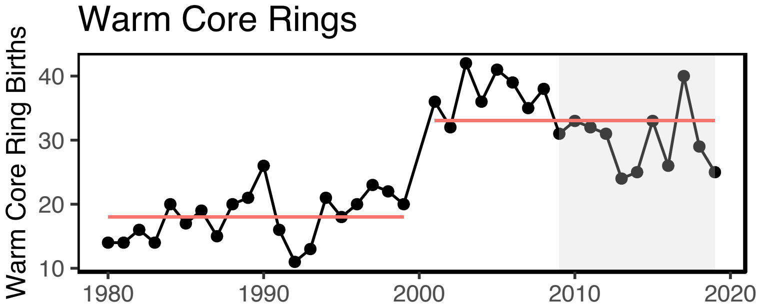

Figure 23: Interannual Variability of the WCR formation between 1980 and 2019. The regime shift (denoted by the split in the red solid line) is significant at the turn of the century. Figure reproduced with permission from Gangopadhyay, et al. (2019). 2018 and 2019 data points based on personal communication with A. Gangopadhyay (2020).

Gulf Stream Index and Labrador Slope Water (Northeast Channel)

The changing position of the Gulf Stream north wall described above directly influences oceanic conditions in the Gulf of Maine (GOM). Since the mid-2000's, warmer, saltier slope water associated with the Gulf Stream has dominated the input into the GOM at the Northeast Channel, with 2017 and 2019 consisting of 99% warm slope water (Fig. 24), the highest estimated in the time series. The changing proportions of source water affect the temperature, salinity, and nutrient inputs to the Gulf of Maine ecosystem.

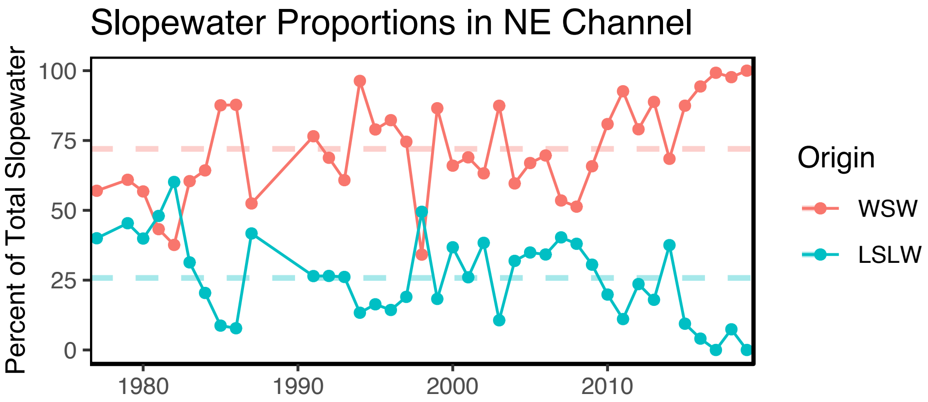

Figure 24: Proportion of Warm Slope Water (WSW) and Labrador slope water (LSLW) entering the GOM through the Northeast Channel.

Ocean temperature, surface and bottom (MAB)

The regional ocean is warming. Annual surface and bottom temperature in the MAB has trended warmer since the early 1980s; while seasonal temperatures have trended warmer in spring, summer, and fall. The 2019 winter MAB temperatures were below average, while the temperatures in spring and summer were among the top six during the satellite data record (1982-2019) and fall was above average (Fig. 25). 2019 MAB bottom temperature was just above the time series average (Fig. 26).

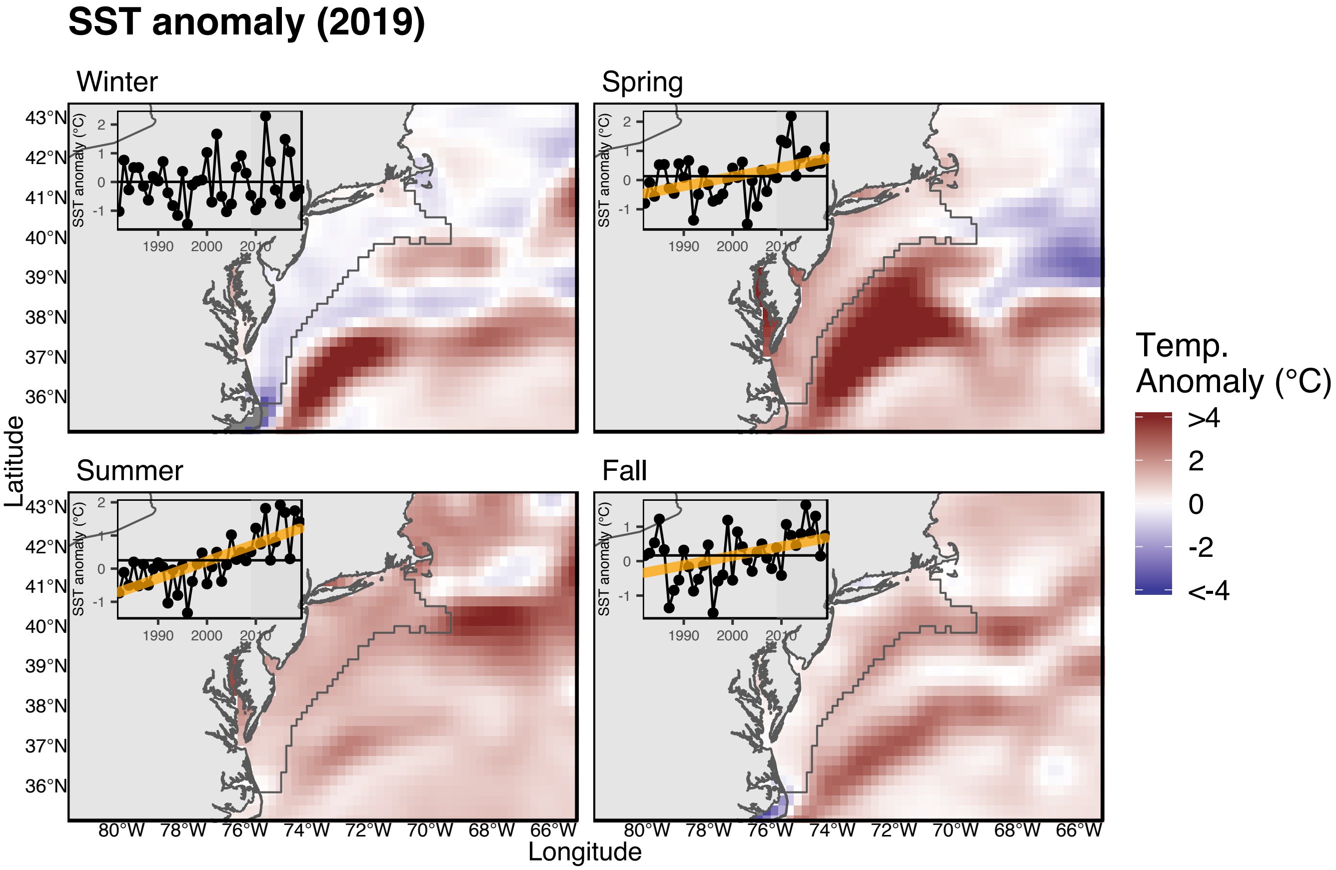

Figure 25: MAB seasonal sea surface time series overlaid onto 2018 seasonal spatial anomalies.

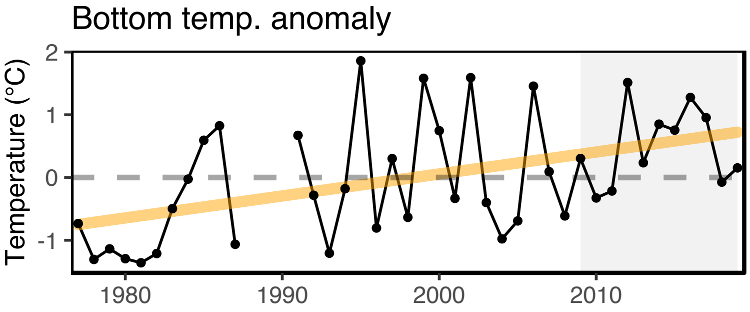

Figure 26: Annual bottom temperature in the Mid-Atlantic Bight.

Cold pool index (MAB)

Changes in ocean temperature and circulation alter habitat features such as the cold pool, a 20–60 m thick band of cold, relatively uniform near-bottom water that persists from spring to fall over the mid-shelf and outer shelf of the Middle Atlantic Bight (MAB) and Southern Flank of Georges Bank [10]. 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 [10]. The average temperature of the cold pool has been getting warmer over time (Fig. 27, calculated based on [11]) and the area of the cold pool is shrinking. These changes can affect distribution and migration timing for species that depend on the cold pool habitat.

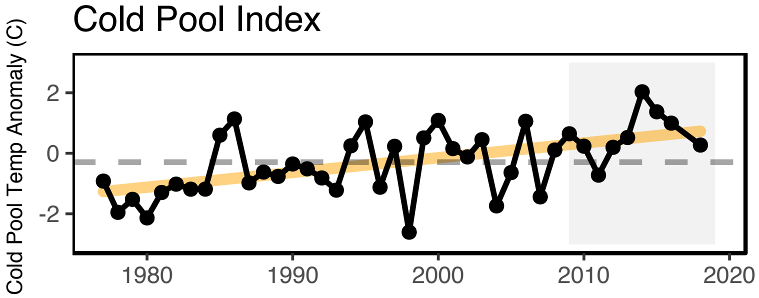

Figure 27: Temperature anomaly in cold pool region, defined as the area with a mean September-October bottom temperature <12°C from 1963 to 2013.

Marine heat waves (MAB)

Marine heatwaves measure not just temperature, but how long the ecosystem is subjected to the high temperature. They are driven by both atmospheric and oceanographic factors and can have dramatic impacts on marine ecosystems. Marine heatwaves are measured in terms of intensity (water temperature) and duration (the cumulative number of degree days) using satellite measurements of daily sea surface temperature. Plotted below are maximum intensity and cumulative intensity, which is intensity times duration. Here we define a marine heatwave as a warming event that lasts for five or more days with sea surface temperatures above the 90th percentile of the historical daily climatology (1982-2010) [12].

The strongest heatwaves on record in the Middle Atlantic Bight occurred in the winter of 2012 in terms of maximum intensity (+5.13 °C above average) and in the winter/summer of 2012 in terms of cumulative intensity (515 °C-days; Fig. 28). In 2019, the Middle Atlantic Bight experienced six distinct marine heatwaves in the spring, summer, and fall with one of the strongest events beginning on July 3 and lasting 21 days (Figs. 29, 30). Relative to prior years, this marine heatwave ranked 17th on record in terms of maximum intensity (+2.88 °C above average on Jul 22). Another strong marine heatwave began on Aug 1 and lasted 24 days, which was 20th on record in terms of cumulative intensity (46 °C-days).

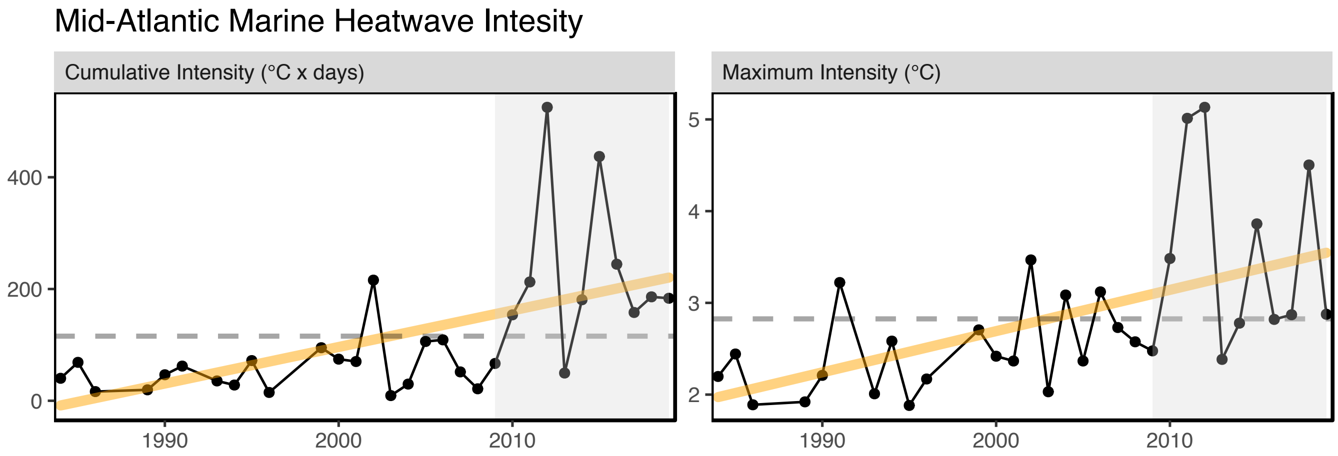

Figure 28: Marine heatwave cumulative intensity (left) and maximum intensity (right) in the Mid-Atlantic Bight.

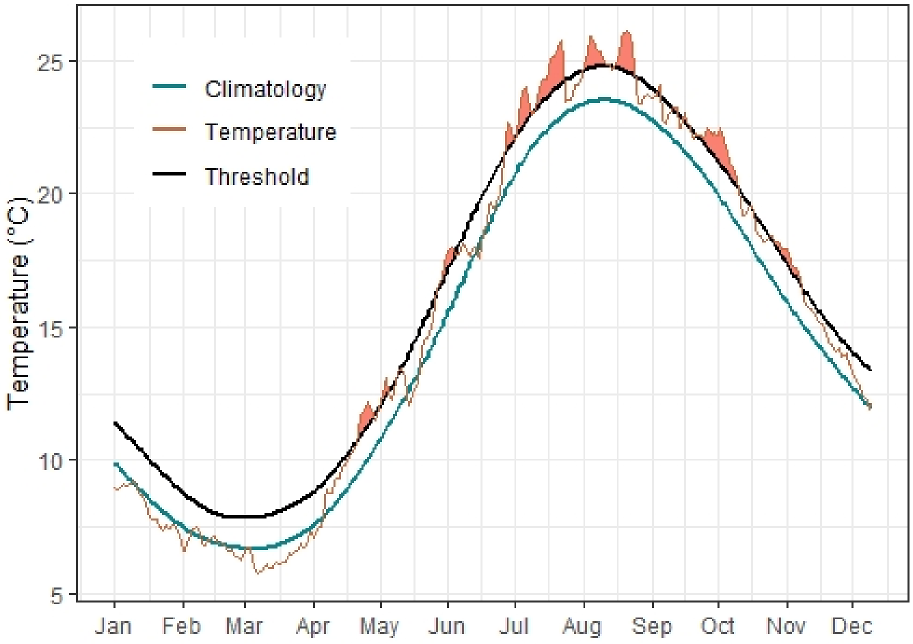

Figure 29: Marine heatwave events (red shading above black threshold line) in the Mid-Atlantic occurring in 2019.

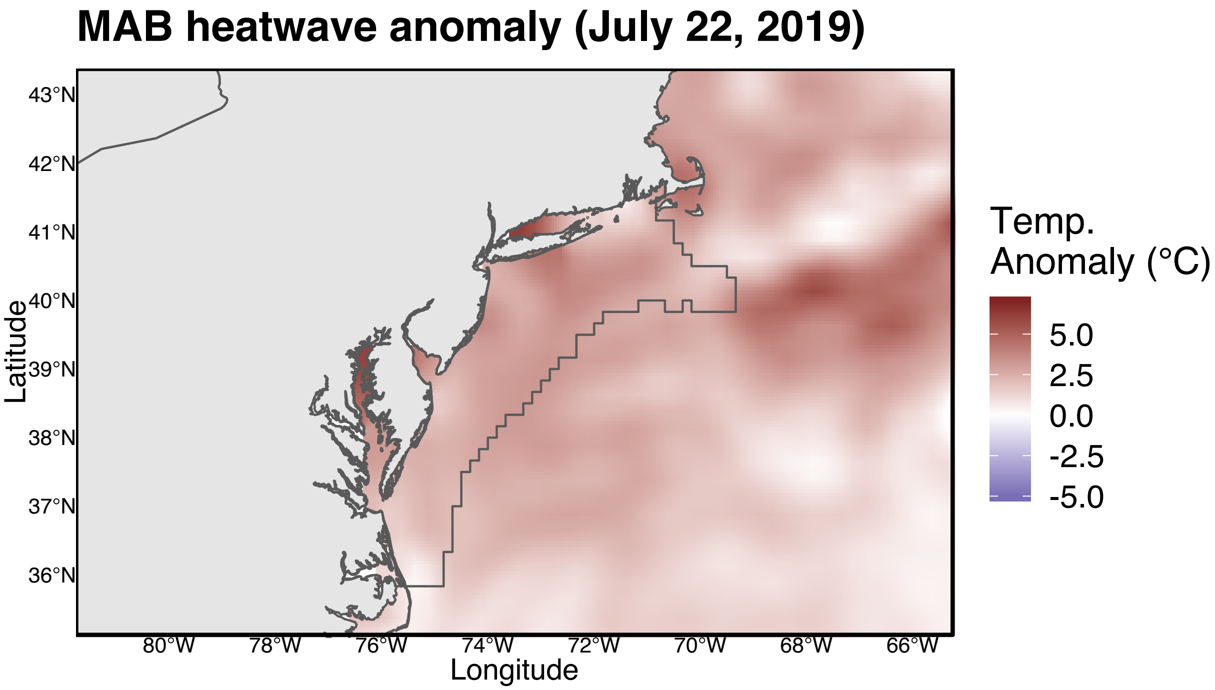

Figure 30: Maximum intensity heatwave anomaly in the Mid-Atlantic Bight occurring on July 22, 2019.

Primary production (MAB)

Phytoplankton primary production is a function of biomass, light, and temperature, and sets the overall level of potential fish and fishery productivity in an ecosystem. All primary production and chlorophyll estimates presented here are satellite-derived. There is a trend of increasing primary production in the Mid-Atlantic, primarily driven by increased summer production, which is due to warmer temperatures and increased bacterial remineralization and nutrient recycling (Fig. 31). This increased productivity is most likely from smaller-celled species that contribute less to fish production compared to larger phytoplankton. The fall of 2019 had an early above average phytoplankton bloom (Fig. 32), most likely comprised of larger diatom species, with above average blooms in the central portion of the shelf (Fig. 33).

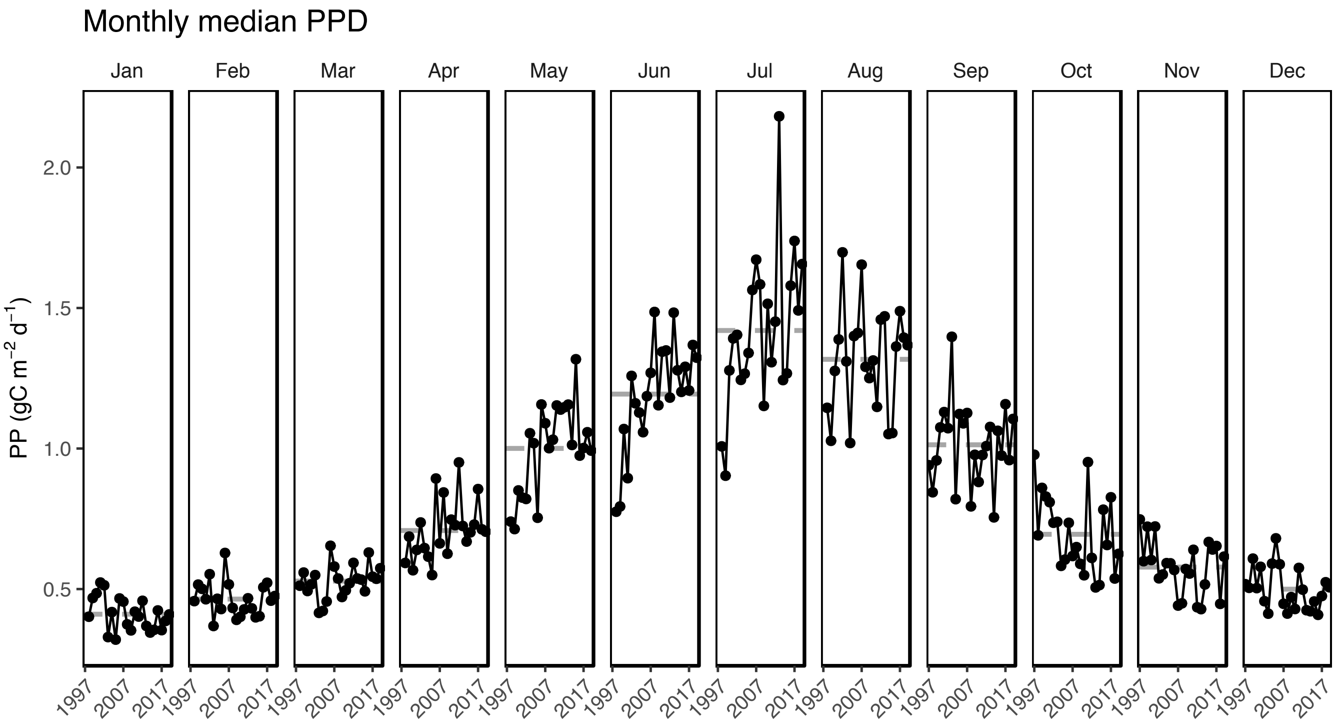

Figure 31: Monthly primary production trends show the annual cycle (i.e. the peak during the summer months) and the changes over time for each month.

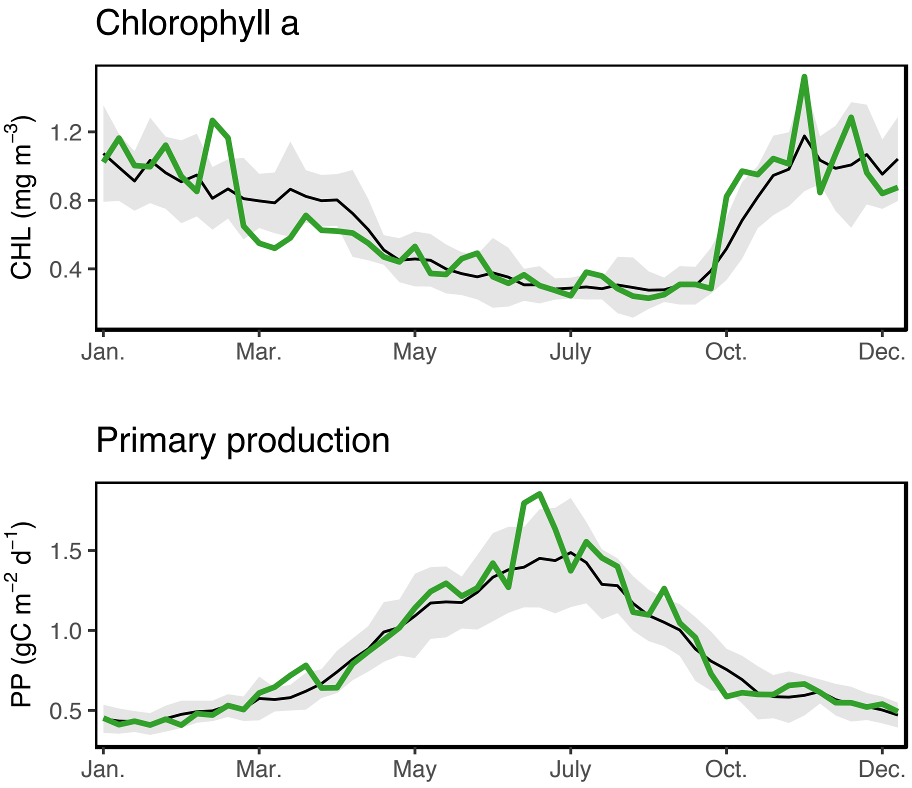

Figure 32: Weekly chlorophyll concentrations in the Mid-Atlantic are shown by the colored line for 2019. The long-term mean is shown in black, and shading indicates +/- 1 sample SD.

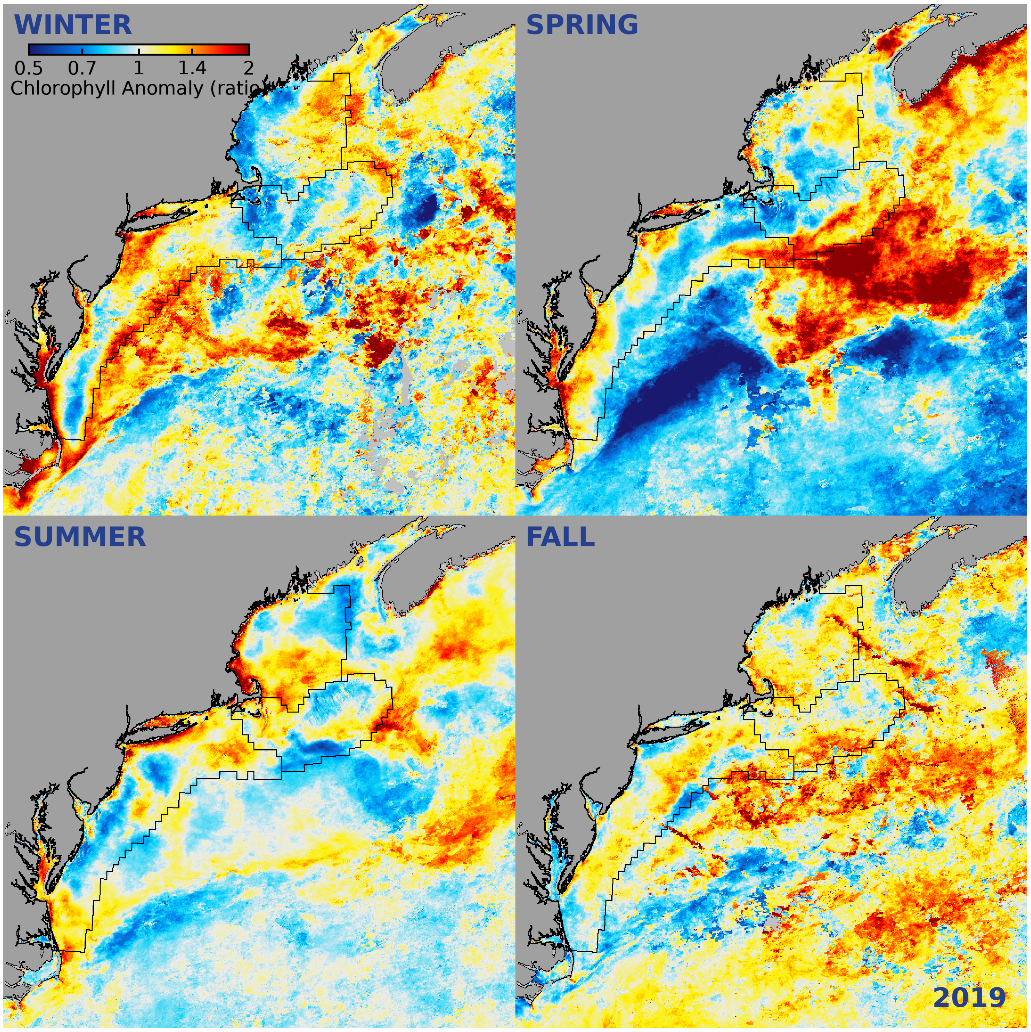

Figure 33: Seasonal chlorophyll a anomalies in 2019.

Zooplankton (MAB)

The most abundant zooplankton species in the MAB are the small-bodied species *Centropages typicus*, *Psuedocalanus* spp., and *Temora longicornis* [13]. The large-bodied species *Calanus finmarchicus* is also abundant in the MAB and is an important prey for larval fish and the North Atlantic right whale. The mean abundance of small-bodied copepods was slightly above average in 2018 (Fig. 34). This increase in abundance from the previous year was driven by all members of the small-bodied taxa above in addition to *Centropages hamatus.* While the long term trend in *Psuedocalanus* abundcance remains significantly negative in the MAB, 2018 abundance values were slightly above the long term mean and were the highest abundance values in the MAB since 1998 for this species. *Calanus finmarchicus* abundance was also higher in 2018 than in the previous 10 years, following a period of lower abundance between 2014-2017 (Fig. 34).

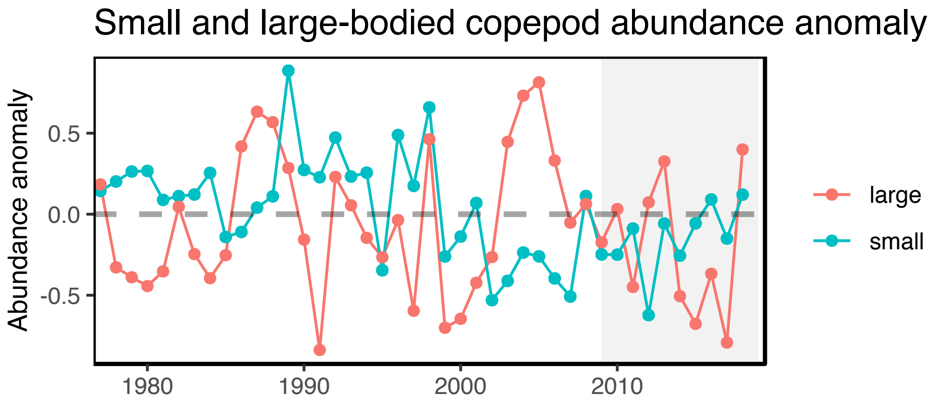

Figure 34: Abundance anomaly time series for copepod size groups found in the MAB.

Cnidarians (jellyfish) exhibit an increasing trend in abundance over the long term record, and higher than normal abundance during the 1990's when the abundance of small-bodied copepods was highest (Fig. 35). Euphausiids (krill), important prey items for many fish species, also exhibit a long term increasing trend in abundance in the MAB (Fig. 35).

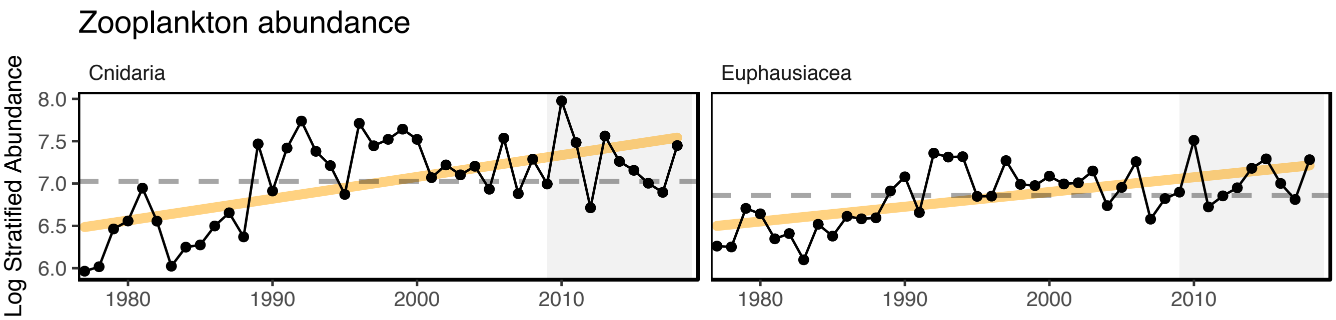

Figure 35: Stratified abundance of cnidarians and euphausiids in Mid-Atlantic Bight.

Fluctuations in primary production over time (Fig. 36) may relate to observed patterns in copeopod size structure (Fig. 34). This period also corresponds with regime shifts in fish recruitment [14].

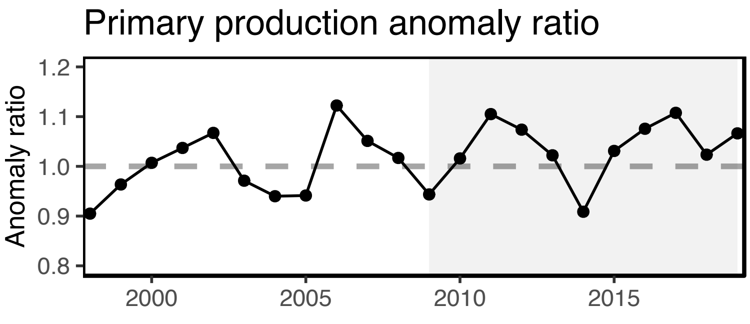

Figure 36: MAB annual primary production anomaly.

Changes in primary productivity, phytoplankton and zooplankton composition and abundance affect the food web and may be related to observed changes in fish condition, recruitment patterns, and forage fish energy content. However, more research and analyses are needed to directly link these connections. Any attempt to predict how the ecosystem will respond to changes in climate and fishing patterns ultimately will depend on understanding these connections. Our objective is to shed light on these fundamental issues and to document changes affecting human communities and the fishery ecosystem on which we depend.

Contributors

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Document Orientation

The figure format is illustrated in Fig 37a. Trend lines are shown when slope is significantly different from 0 at the $p < 0.05$ level. An orange line signifies an overall positive trend, and purple signifies a negative trend. To minimize bias introduced by small sample size, no trend is fit for < 30 year time series. Dashed lines represent mean values of time series unless the indicator is an anomaly, in which case the dashed line is equal to 0. Shaded regions indicate the past ten years. If there are no new data for 2018, the shaded region will still cover this time period. The spatial scale of indicators is either coastwide, Mid-Atlantic states (New York, New Jersey, Delaware, Maryland, Virginia, North Carolina), or at the Mid-Atlantic Bight (MAB) Ecosystem Production Unit (EPU, Fig. 37b) level.

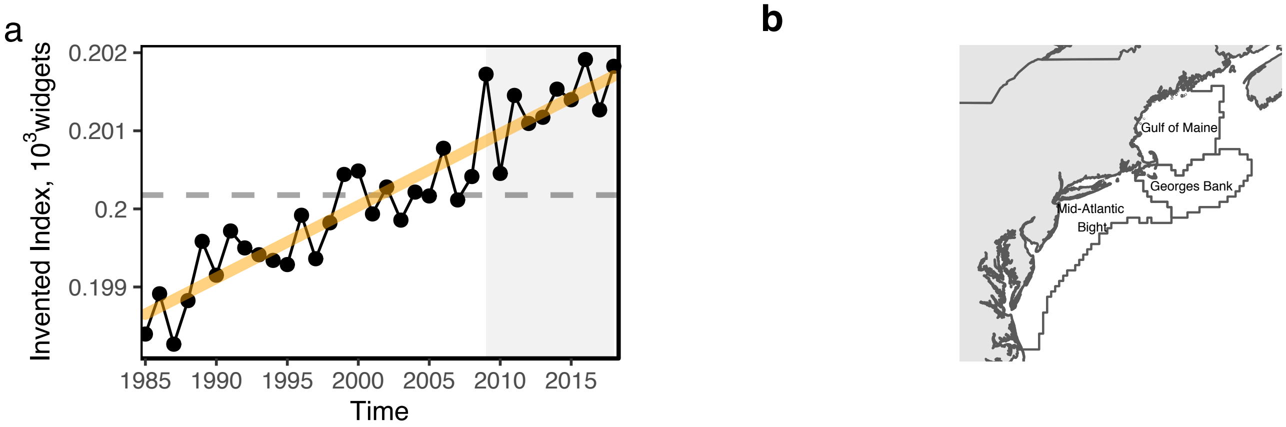

Figure 37: Document orientation. a. Key to figures. b.The Northeast Large Marine Ecosystem.

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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State of the Ecosystem 2020: Response Memo

11 March 2020

Introduction

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

Request	Source	Progress	Memo Section
Formal response to requests	Both Councils	This response memo.	Introduction
Consider report card like Alaska's	Both Councils	SOE summary bullets (page 1).	1
Include summary visualization	Both Councils	SOE infographics (page 1-2).	2
Include uncertainty estimates for all indicators	Both Councils	SOE survey biomass uncertainty included; feedback requested for other indicators.	3
Include Downeast ME (Scotian Shelf EPU)	NEFMC	SOE survey biomass now includes most of downeast ME; human dimensions include downeast ME.	4
Link zooplankton abundance and or community composition to fish condition	NEFMC	SOE page 2 research spotlight.	5
Ocean acidification information	Both Councils	Work in progress to develop baseline and monitoring.	6
Gulf Stream Index/Labrador current interaction	Both Councils	SOE Labrador current and Gulf Stream indices now included in both reports.	7
Include source for PP estimates (satellite vs in situ)	NEFMC	SOE clarified that all PP estimates are from satellite.	8
Shellfish growth/distribution linked to climate (system productivity)	MAFMC	Project with R. Mann student to start late 2020.	9
Estuarine condition relative to power plants and temp	MAFMC	Inadequate resourses to address this year.	10
Frequency and occurrence of warm core rings	MAFMC	SOE added new indicator.	11
Cold pool index	MAFMC	SOE added new indicator.	12
Nutrient inputs and water quality near shore	MAFMC	SOE Chesapeake update; summary of data from National Estuarine Research Reserve network started, example info included here.	13
Link environmental and social, economic indicators	NEFMC	SOE added new PP required, habitat and wind overlap, page 2 conceptual model.	14
Quantitative overlap of wind area and habitat and fishing areas	MAFMC	SOE added new indicator for habitat and wind overlap, wind overlap with fisheries for next round.	15
Include links to Social Science websites	NEFMC	SOE link included in both reports.	16
Management complexity	MAFMC	Project started by summer student in 2018, needs further analysis.	17
South Atlantic Council managed species represented in recreational indices	MAFMC	SOE revised indicator and noted change in report.	18
Add social elements from overview conceptual model to NE conceptual model	NEFMC	Older general conceptual model replaced by specific links between indicators in report.	19

(continued)

Request	Source	Progress	Memo Section
Avg. weight of diet components by feeding group, mean stomach weight across feeding guilds	Both Councils	Stomach fullness analysis started–species level; feedback requested.	20
North Atlantic Right Whale calf production indicator	NEFMC	SOE added new indicator.	21
Distinguish managed species in report	NEFMC	SOE Council managed species separated in landings figures.	22
Marine Mammal consumption	MAFMC	SOE added discussion of seal diets.	23
Small pelagic abundance	MAFMC	SOE have survey planktivore time series but would like to improve; see also SOE forage energy density.	24
Young of Year index from multiple surveys	MAFMC	SOE fish production from NEFSC trawl; feedback reqested on how to expand.	25
Biomass of sharks	MAFMC	HMS provided landings for 3 years and working on full time series, still looking for source of biomass data.	26
Diversity metric for NEFSC trawl survey	NEFMC	Need to reconcile different survey vessel catchabilites or split by vessel.	27
Ecosystem risk score	MAFMC	SOE PP required, marine heat waves are steps towards this; feedback requested for other desired analyses.	28
Inflection points for indicators	Both Councils	SOE warm core rings; general analysis of combined indicators initiated but not yet finished.	29

Responses to comments

1 Report Card

Both Councils asked for a summary "report card" similar to that used in Alaska [1]. The first page of each of this year's SOE reports summarizes the key messages with icons showing the message theme (e.g., commercial fisheries, fishing communities, forage species, system productivity, etc). At present, we synthesized key findings on both existing and new indicators. We welcome suggestions for indicators that should always be tracked in this section, and for further refinements to make this summary more useful.

2 Summary Visualization

Both Councils asked for a summary visualization. The first page of each SOE report uses icons developed to help visualize different report components. The second page of each SOE report has both a map visualizing the key oceanographic features mentioned in the report along with fishing communities, and a conceptual model visualizing potential linkages between report indicators. The conceptual model is discussed further under point 5 below.

3 Uncertainty Estimates

Both Councils asked for uncertainty estimates to be included with indicators. As a first step, we included survey design-based uncertainty estimates[1] for all surveys where we had haul specific information (all but the inshore ME-NH survey). Including this uncertainty led to a different approach to the data, looking for true departures from expected stable dynamics at the functional group level, and provided insight into which trends were potentially noteworthy. Survey biomass uncertainty is included in each SOE (p. 15-16 MAFMC and p. 16-19 NEFMC).

We experimented with a model-based estimate of uncertainty for survey biomass which accounts for both spatial and temporal sources (VAST; [2]). The results are promising (Fig. 1), and may serve not just as a biomass indicator but also an indicator of distribution shifts for species and functional groups. This method can also potentailly combine the inshore and offshore surveys into a single analysis. If the SSCs and Councils consider this approach promising, we will persue it further for next year.

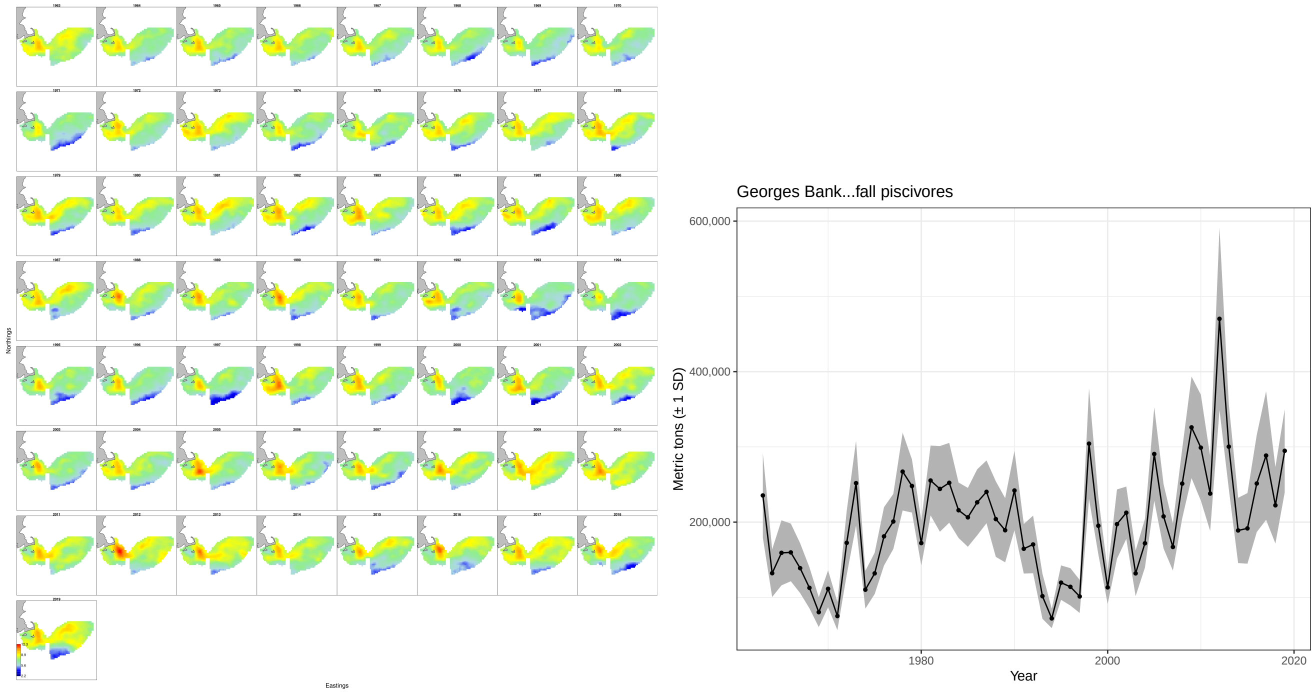

Figure 1: Georges Bank piscivoves biomass and uncertainty as estimated by the VAST model.

Some indicators (e.g. total landings) may have uncertainty which is difficult to calculate (e.g. based on unknown reporting errors). Many other current indicators do not have straightforward uncertainty calculaltions (e.g. diversity indices, anomalies) so we welcome suggestions from the SSC and Council to guide estimation for future reports.

4 Downeast Maine

The NE SSC asked to include downeast ME in future reports, because the Scotian Shelf EPU which includes downeast ME has not been included in previous reports. We felt it was inappropriate to report on the Scotian Shelf EPU, which includes Canadian waters and is an incomplete portion of the full Soctian Shelf. However, this year we recalculated survey biomass using an updated strata set that includes much of downeast ME for the NEFSC (Fig. 2; p. 16-17 NEFMC SOE). Strata were included within an EPU where at least 50% of their area was located. The inshore strata not included in the NEFSC trawl survey biomass are represented in the ME-NH survey (p. 20 NEFMC SOE) Further, fishery catch and revenue data, fishing community data, and recreational indicators have

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[1] https://noaa-edab.github.io/tech-doc/survdat.html

always included downeast ME because both fishing statistical areas and human community data include all of ME. Therefore, fishery and fish biomass information reflects much of the area.

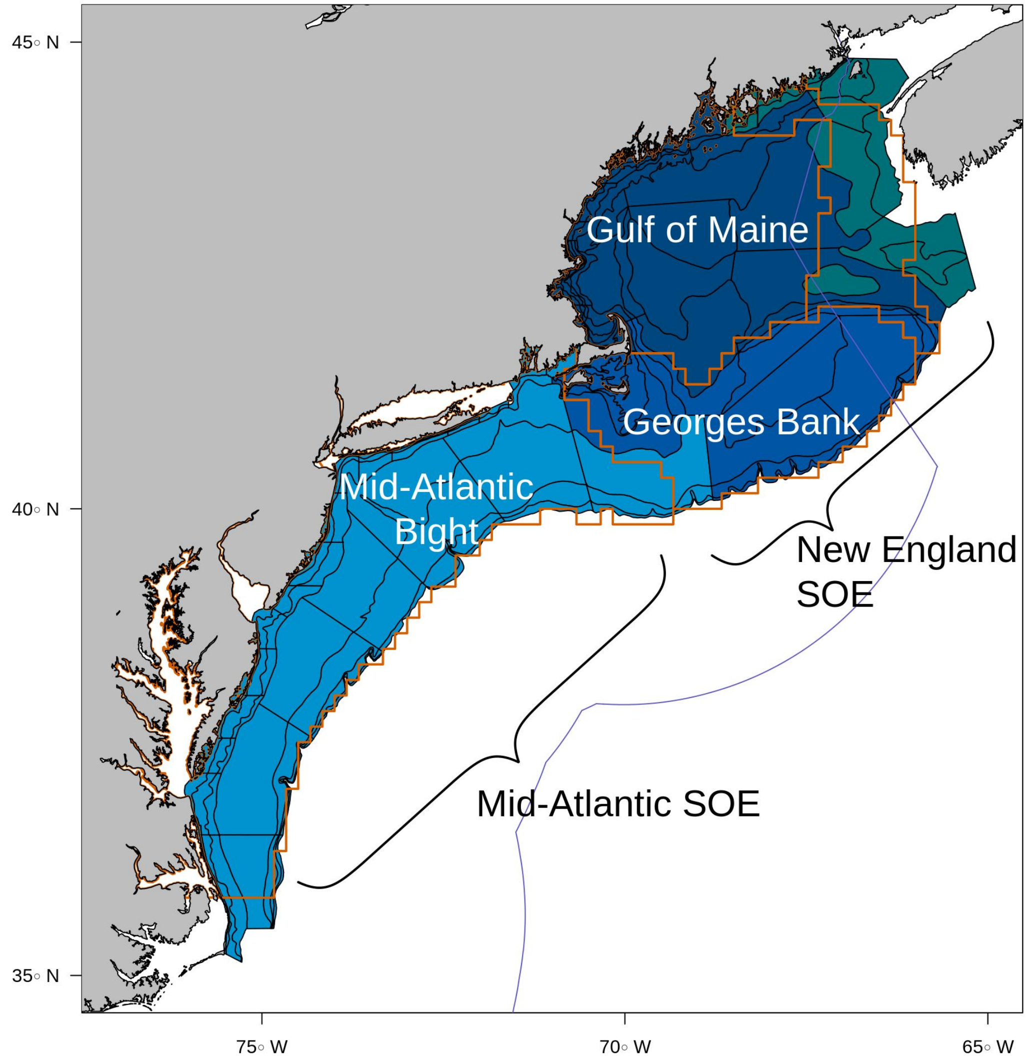

Figure 2: Survey strata mapping to EPUs for biomass estimates

Oceanographic indicators (surface and bottom temperature, phytoplankton, zooplankton) remain at the EPU level. The EPUs were defined based on these characteristics[2] so we are hesitant to alter them for these indicators without a more thorough examination of the EPU definitions in general.

5 Link Zooplankton, Fish Condition

Both Councils have been interested in ecosystem energy flow and how changes in ecosystem productivty link to fishery production. In particular, the NE SSC asked about further links between zooplankton abundance and or community composition to fish condition. Research was initiated during 2019 evaluating statistical relationships between environmental indicators including temperature, depth, and zooplankton community composition and

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[2] https://noaa-edab.github.io/tech-doc/epu.html

fish condition. Initial results are noted in each SOE (p. 16-17 MAFMC and p. 20-21 NEFMC). Further work is ongoing to link more of the indicators in the report using both statistical analysis and potentially structural equation modeling as noted on p. 2 of each SOE under "Research Spotlight." This conceptual model shows the full range of potential linkages, but we plan to start with a subset of linkages (Fig. 3). In particular, potential linkages between zooplankton and forage fish energy content (p. 18 MAFMC and p. 23 NEFMC) may also be explored in the upcoming years.

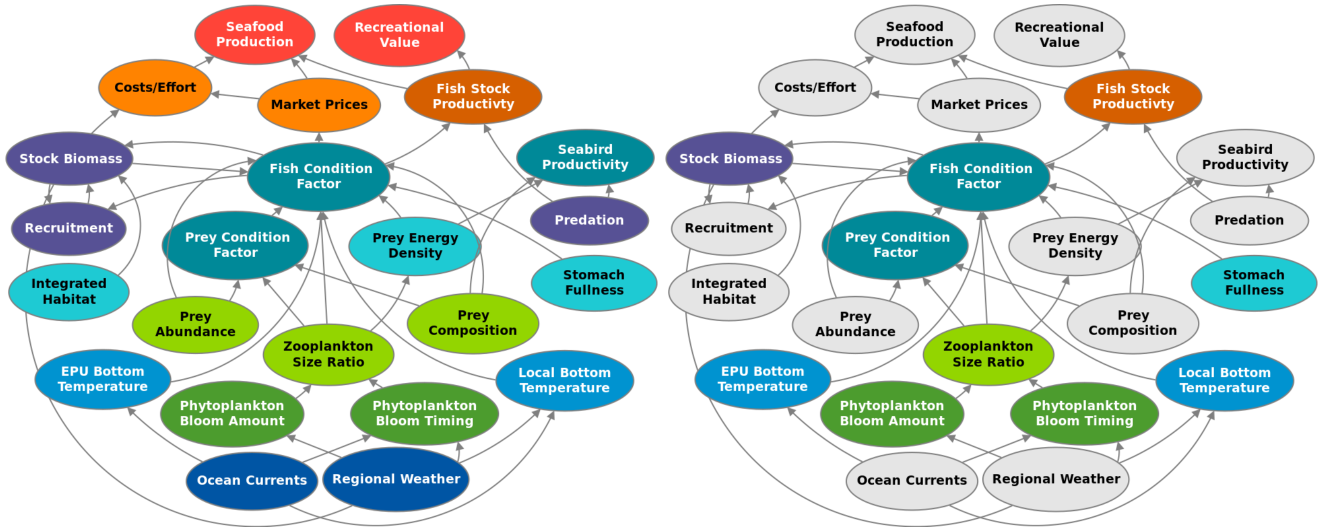

Figure 3: Full set of hypothesized relationships between SOE indicators related to fish condition (left) and subset to be investigated first (right).

6 Ocean Acidification

Both Councils asked for information on ocean acidification (OA). In 2019, NOAA reviewed available OA information and is now finalizing a research plan[3] to address OA comprehensively. Unfortunately, this synthesis was not available in time to include in the 2020 SOE.

The main message of this forthcoming report is that we don't have much of a time series of OA monitoring data for our region yet, but we have been (and will continue) collecting data in the Northeast and that NOAA sees OA monitoring as a priority. There are three main research objectives for 2020-2029 outlined in the report:

1. Document and predict change via monitoring, analysis, and modeling.

2. Characterize and predict biological sensitivity of species and ecosystems.

3. Understand human dimensions and socioeconomic impacts of OA.

Specific work is in progress now and should be available for future SOE reports, including:

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

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[3] https://sab.noaa.gov/sites/SAB/Meetings/2019_Documents/Dec_Meeting/2020%20OA%20Research%20Plan%20DRAFT%20External%20Review.pdf

Until a climatology and time series of OA measurements is available for comparison, we can include other information on OA in the SOE as it becomes available. We welcome feedback and suggestions from the SSC and Council on what information would be most useful.

7 Gulf Stream and Labrador Current

Both Councils were interested in large scale ocean current interactions and requested additional information on the Gulf Stream Index and Labrador current. We have expanded this section and included information on both Gulf Stream warm core rings (see point 11) and on the decreasing proportion of Labrador Current water entering the Gulf of Maine in both SOE reports this year (p. 20-22 MAFMC and p. 24-26 NEFMC).

8 Primary Production Source

The NE SSC asked that we include sources for primary production estimates (satellite vs in situ). We have noted in the SOE that primary production and chlorophyll estimates are satellite-derived (p. 25 MAFMC and p. 31 NEFMC), and continue to include full methods in our technical documentation[4].

9 Shellfish Growth

The MAFMC requested that we investigate how shellfish growth and distribution information could be linked to climate indicators and possibly ecosystem productivity. While this request was beyond our capacity to address this year, we are working with Dr. Roger Mann to host his student working on shellfish growth at NEFSC and to facilitate integration of SOE climate indicators with this work later this year or early next.

10 Power Plants

The MAFMC requested that we investigate estuarine condition relative to power plants and plant-driven changes in water temperature. This request was beyond our capacity to address this year. However, we have initiated work on estuarine water quality in general (see point 13).

11 Warm Core Rings

The MA SSC requested information on the frequency and occurrence of Gulf Stream warm core rings. We have added an indicator based on [3], [4],and [5] to both SOE reports (p. 20-21 MAFMC and p. 24-25 NEFMC). We welcome further comments on the utility of this new indicator.

12 Cold Pool Index

The MA SSC requested a cold pool index. We have added an indicator of cold pool temperature to the MAFMC SOE report, because the cold pool was considered most relevant to the MAB EPU (p. 23 MAFMC). However, if the NEFMC is interested in this index (because some managed species such as winter flounder occupy this habitat) we can include it in future NEFMC SOE reports. We welcome further comments on the utility of this new indicator.

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[4] https://noaa-edab.github.io/tech-doc/chl-pp.html

13 Estuarine Water Quality

The MAFMC requested information on nutrient inputs and water quality near shore and in estuaries. While the Chesapeake water quality index from the 2019 report was not yet updated by the contributor, we included information on the Chesapeake Bay low salinity event in 2018-2019 with notes on how it affected Chesapeake Bay living resources in the SOE (p. 19-20 MAFMC).

This year we started a collaboration with the National Esturarine Research Reserve (NERR) network to assemble information. Here we provide examples of the types of information available and ask for feedback on what type of information would be most useful.

There are NERRs all around the US (Fig. 4), so the first decision is which ones to include. A reasonable starting point might be all of the NERRs from ME to NC, but other locations may be of interest. Then, status for a certain indicator could be mapped across all of the selected NERRs as in Fig. 4.

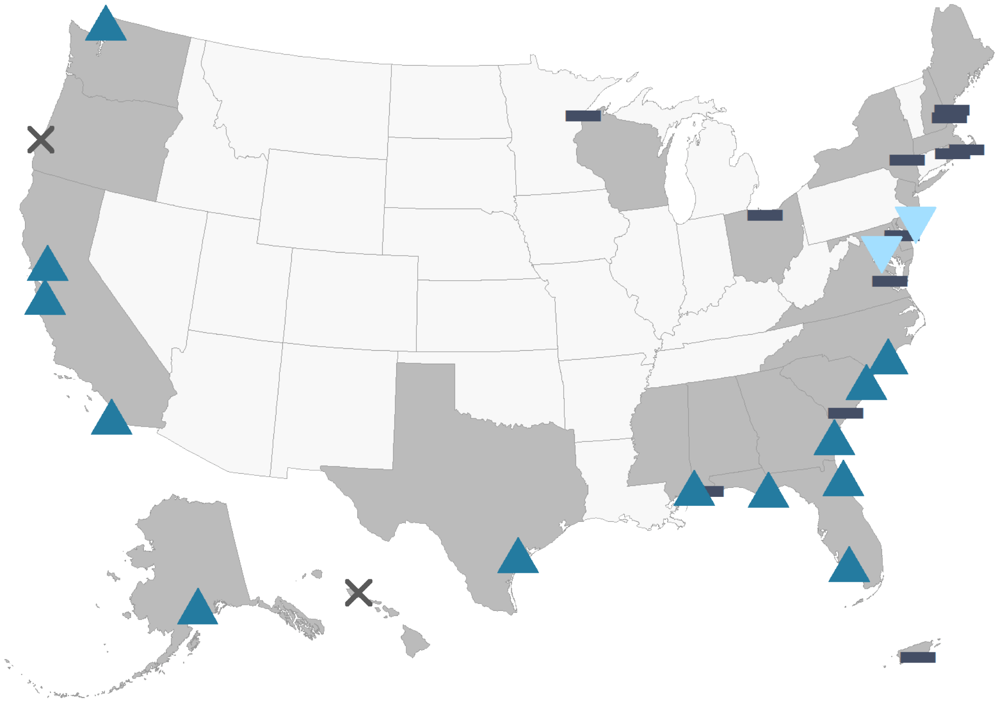
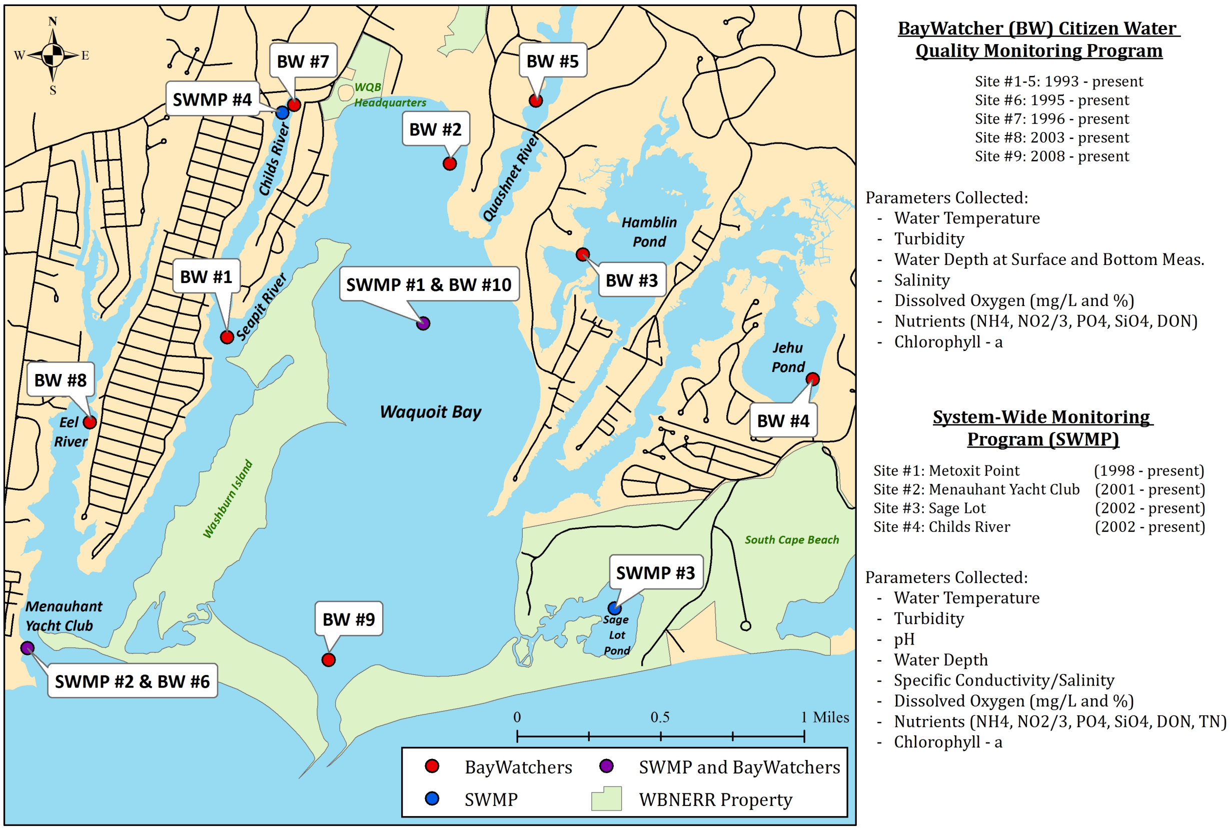


Figure 4: National Estuarine Research Reserve locations in the US, with trend indicators for an example metric: Triangle pointing up = increasing trend; Triangle pointing down = decreasing trend, Flat line = no trend.

Within a particular NERR there may be several sampling locations (Fig. 5), so the next decision would be whether to include many stations or a subset of stations representing certain conditions (or having the longest time series).



BayWatcher (BW) Citizen Water Quality Monitoring Program

Site #1-5: 1993 - present
Site #6: 1995 - present
Site #7: 1996 - present
Site #8: 2003 - present
Site #9: 2008 - present

Parameters Collected:

- Water Temperature
- Turbidity
- Water Depth at Surface and Bottom Meas.
- Salinity
- Dissolved Oxygen (mg/L and %)
- Nutrients (NH4, NO2/3, PO4, SiO4, DON)
- Chlorophyll - a

System-Wide Monitoring Program (SWMP)

Site #1: Metoxit Point	(1998 - present)
Site #2: Menauhant Yacht Club	(2001 - present)
Site #3: Sage Lot	(2002 - present)
Site #4: Childs River	(2002 - present)

Parameters Collected:

- Water Temperature
- Turbidity
- pH
- Water Depth
- Specific Conductivity/Salinity
- Dissolved Oxygen (mg/L and %)
- Nutrients (NH4, NO2/3, PO4, SiO4, DON, TN)
- Chlorophyll - a

Figure 5: Waquit Bay National Estuarine Research Reserve map with sampling locations.

At each station several types of data are collected, so the next decision is which type of information is most useful for the Councils? For example, multiple indicators could contribute to water quality overall in an area, and could be annual or seasonal (Fig. 6), or a single indicator of nutrient input could be of interest across multiple areas (Fig. 7).

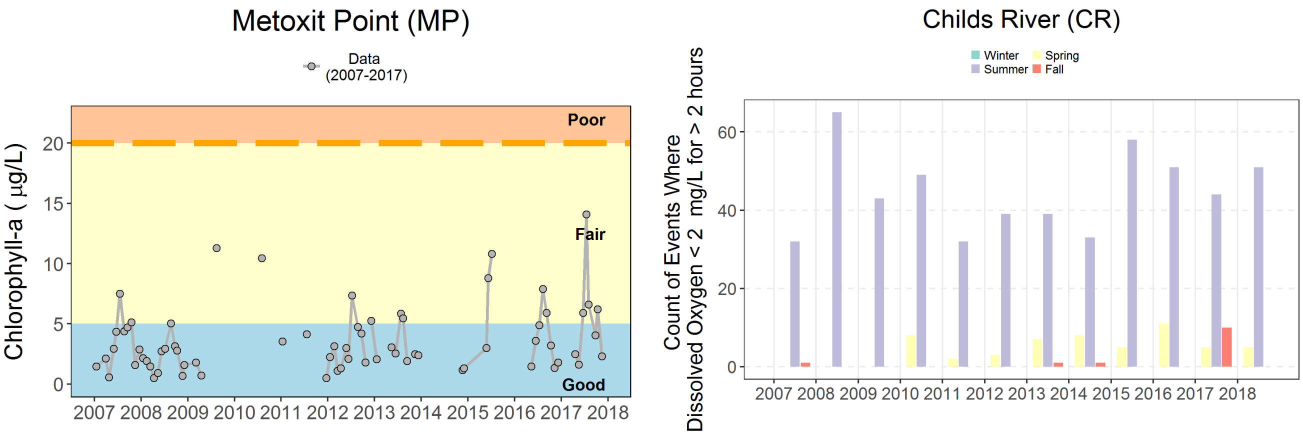


Figure 6: Multiple water quality attributes.

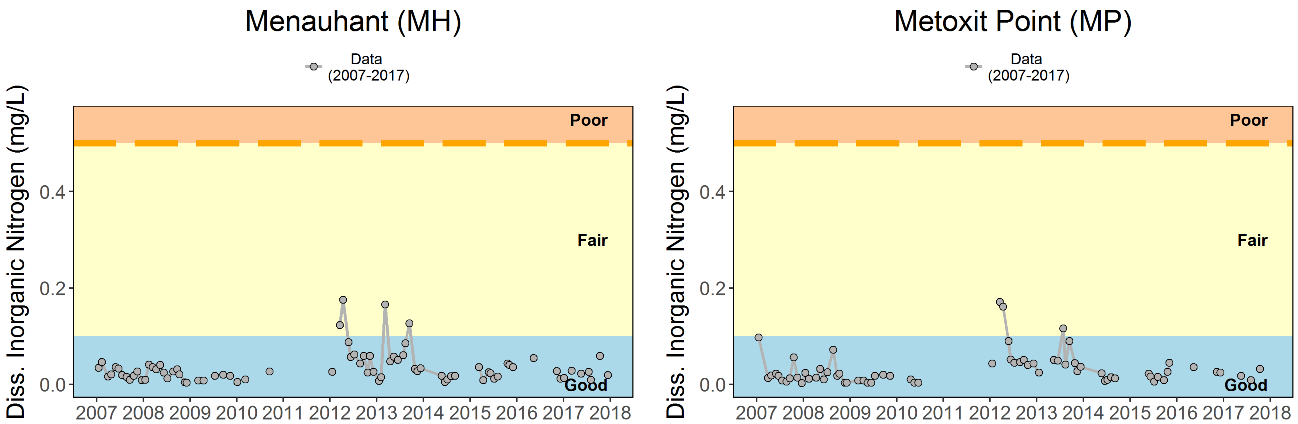


Figure 7: Dissolved Inorganic Nitrogen (DIN) in two locations.

Finally, thresholds for water quality would need to be reviewed (Fig. 7). Several exist and could be used by the Council depending on the ultimate goal for having the indicator.

14 Link Environment and Society

The NEFMC asked for more linkages between environmental and social and economic indicators in the SOE. Two new indicators and the research spotlight linking environmental indicators, fish condition, and fishery economic indicators highlighted under point 5 address this request. The first new indicator places commercial fishery landings in the context of ecosystem produtivity by calculating the primary production required to support landings; it is described in detail below. The second new indicator calculates the probability of occupancy of wind lease areas based on habitat modeling; it is described in detail in point 15.

Primary production required (PPR)

This indicator is included in both SOEs (p. 3-4 MAFMC and NEFMC). It is defined as

$$PPR_t = \sum_{i=1}^{n_t} \left(\frac{landings_{t,i}}{9}\right) \left(\frac{1}{TE}\right)^{TL_i - 1}$$

where n_t = number of species in time t, $landings_{t,i}$ = landings of species i in time t, TL_i is the trophic level of species i, TE = Trophic efficiency. The PPR estimate assumes a 9:1 ratio for the conversion of wet weight to carbon and a constant transfer efficiency per trophic level.

We have explored the index in the following ways. Using:

- *A global transfer efficiency of 15% for all species.*

  This gives comparable estimates to methods used in Figure 7.3 of the 2009 Ecosystem Status Report[5] that applied a combination of transfer efficiencies calculated from EMAX food web models[6]. While many studies use a 10% rule of thumb, that is an approximation as well. One adaptation would be to use a different transfer efficienct for the first level. eg. $\left(\frac{1}{TE_1}\right)\left(\frac{1}{TE_2}\right)^{TL_i-2}$. Whatever choices are made, the sensitivity of the index to such changes should be examined.

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[5] https://www.nefsc.noaa.gov/publications/crd/crd0911/crd0911.pdf

[6] https://www.nefsc.noaa.gov/publications/crd/crd0615/crd0615.pdf

- *Primary production not lagged with landings.*

  This is probably not realistic. You wouldn't expect to see changes in the landing the same year as changes in primary production. This needs to be explored, either using specific lags in time (which may prove problematic since species lower on the food chain will be effected by shorter lags in time versus species higher up the chain) or by adopting some weighted scheme.

- *A threshold of 80% for landings.*

  It would be a good idea to explore the sensitivity of the index for other threshold levels. Of course the higher the threshold used would imply that less common species will then contribute to the index.

- *Combined vertebrates and invertebrates.*

  The landings in some of the EPUs are dominated by invertebrates (Lobster, Clams) which may play a significant part in driving this index. Creating two additional indices, one for vertebrates and one for invertebrates may be an interesting avenue. This will of course imply the inclusion of many other lesser caught species into the index. It will also involve partitioning the landings into vertebrates and invertebrates.

Other comments

- Some classifications in the commercial fisheries database are not at the species level. Some are Genus, Family or even higher orders, some are just general unclassified. eg. (DOGFISH, UNC, FLATFISH, Argentinidae). Most of these cases are associated with lower landings. However if we increase the threshold and/or split landings into vertebrates and invertebrates we will encounter more of these classifications. They will need to be assigned a trophic level which may cause complications and/ or subjective decision making.
- It is possible for species to drop out of the top x% of the landings and be replaced by other species with a similar trophic level and the index will be somewhat insensitive to this (Fig. 8). The mean trophic level would also be insensitive to such changes. This may or may not be of concern, but it may be worth looking into how often this occurs.

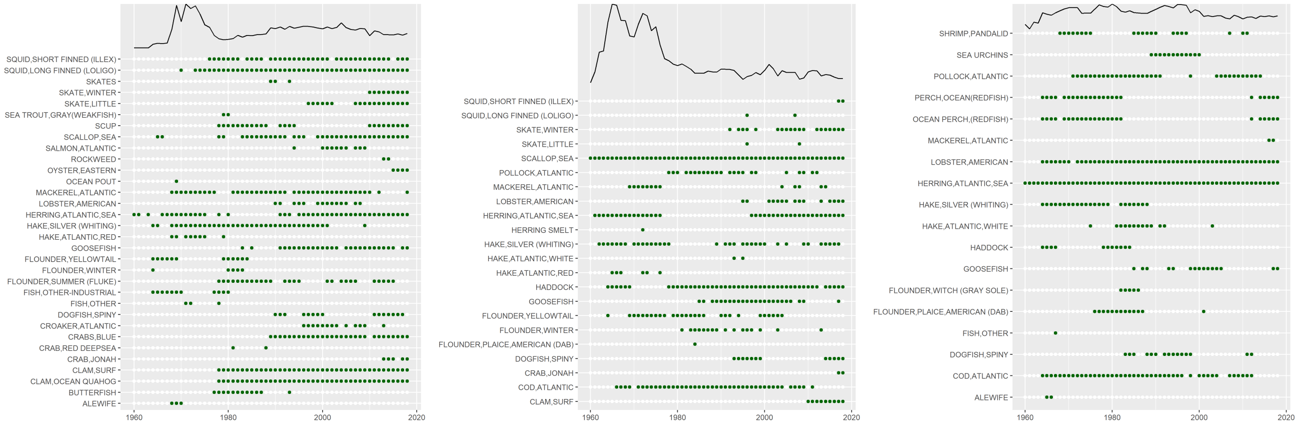

Figure 8: Species included in 80% of landings for each year in the Mid-Atlantic Bight (left), Georges Bank (center), and Gulf of Maine (right).

We welcome feedback for approaches to refine this indicator.

15 Wind Energy Habitat Overlap

The MAFMC requested an index of quantitative overlap of wind energy lease areas and fisheries, in particular to update the EAFM risk assessment (Other ocean uses risk element). A list of species with the highest probability of occupancy in the current and proposed wind lease areas based on habitat modeling is included in both SOEs (p. 8-9

MAFMC and p. 9 NEFMC). This indicator can be refined to meet the needs of both Councils. In future reports we plan to include the overlap of current fisheries with wind lease areas as well.

16 Other Social Science Indicators

The NE SSC asked that we include links to NMFS Social Science indicator websites. These links have been included in both reports (p. 8 MAFMC and p. 9 NEFMC).

17 Management Complexity

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

18 SAFMC and ASMFC Species

The MAFMC asked that South Atlantic Council and Atlantic States Marine Fisheries Commission-managed species be represented in recreational catch diversity indices. This has been done and the updated indicator is included in both SOE reports (p. 7-8 MAFMC and NEFMC).

In addition, NEFSC survey data was analyzed to determine if South Atlantic Council-managed species have become more common in the survey over time. This indicator has also been included in both SOE reports (p. 14-15 MAFMC and p. 15-16 NEFMC).

19 Conceptual Model Social Elements

The NEFMC requested that social elements from the overview conceptual model shown in presentations be added to the New England conceptual model included in the printed SOE report. While this would be a useful update, all of the previous conceptual models have been replaced by different summary visualizations requested by the Councils (see points 1 and 2).

20 Fish Diet Indicators

Both Councils were interested in indicators related to fish diet data. For example, average weight of diet components by feeding group, and mean stomach weight across feeding guilds were mentioned. We initiated exploratory analysis of diet information this year, and present examples of the types of information available to seek feedback on how the Counicls would like indicators developed further.

On NEFSC surveys, most stomach estimates are taken as a volume measure, but there is a standard conversion included in the diet database that gives an approximate stomach weight. This estimated stomach weight was used to calculate stomach fullness (a ratio of stomach weight to fish weight for non-empty stomach samples). Stomach fullness may be a better measure than absolute stomach weight if combining across species into a feeding guild, otherwise big animals with heavier stomachs will dominate the index. Here, stomach fullness was expressed as an annual anomaly for each species in each region. This shows which species have adequate data for inclusion in a time series, and suggests there are not obvious common stomach fullness anomalies across species. We welcome suggestions to clarify methods and objectives for fish stomach data indicators.

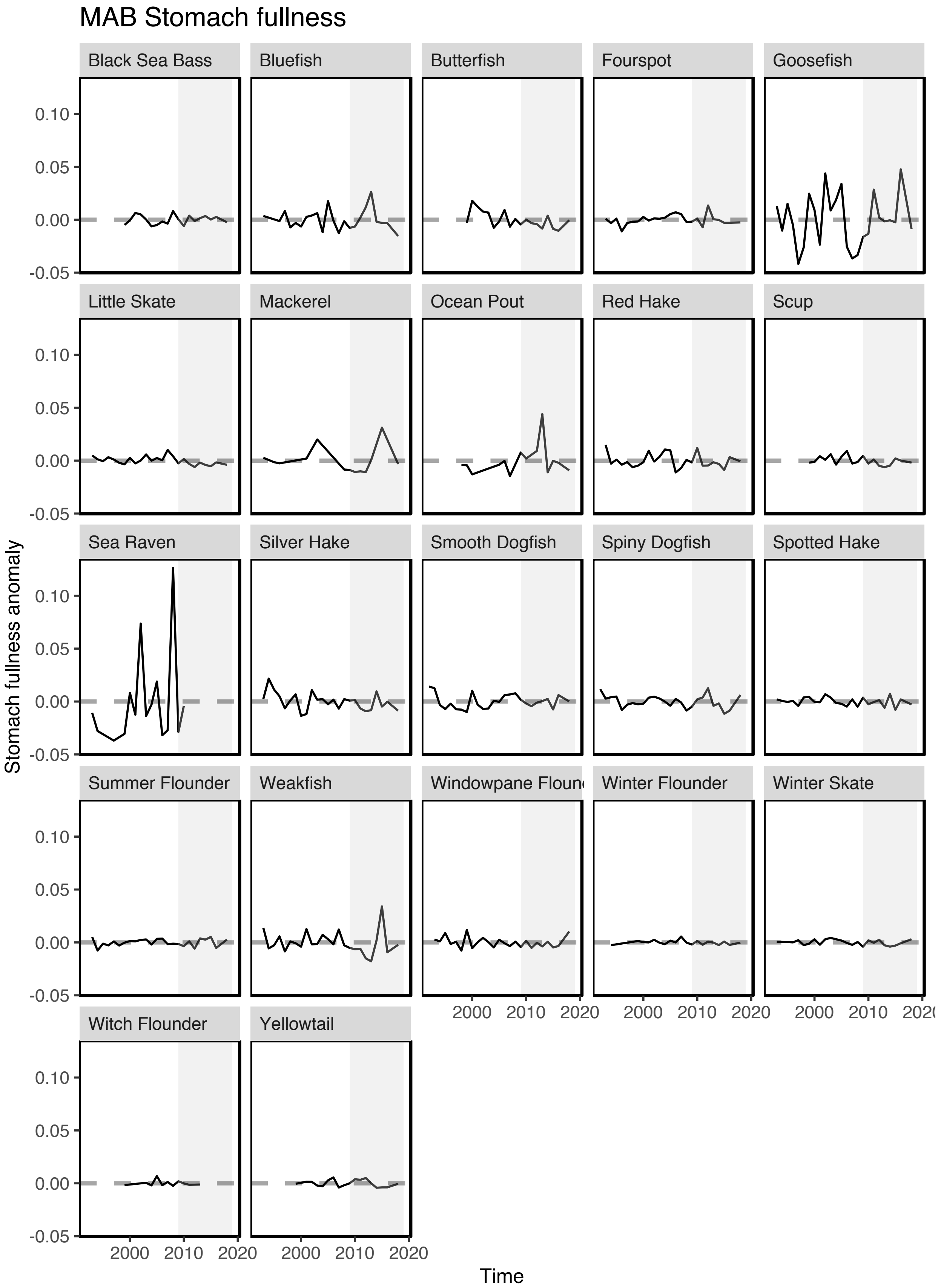

Figure 9: Stomach fullness anomaly in the Mid-Atlantic Bight.

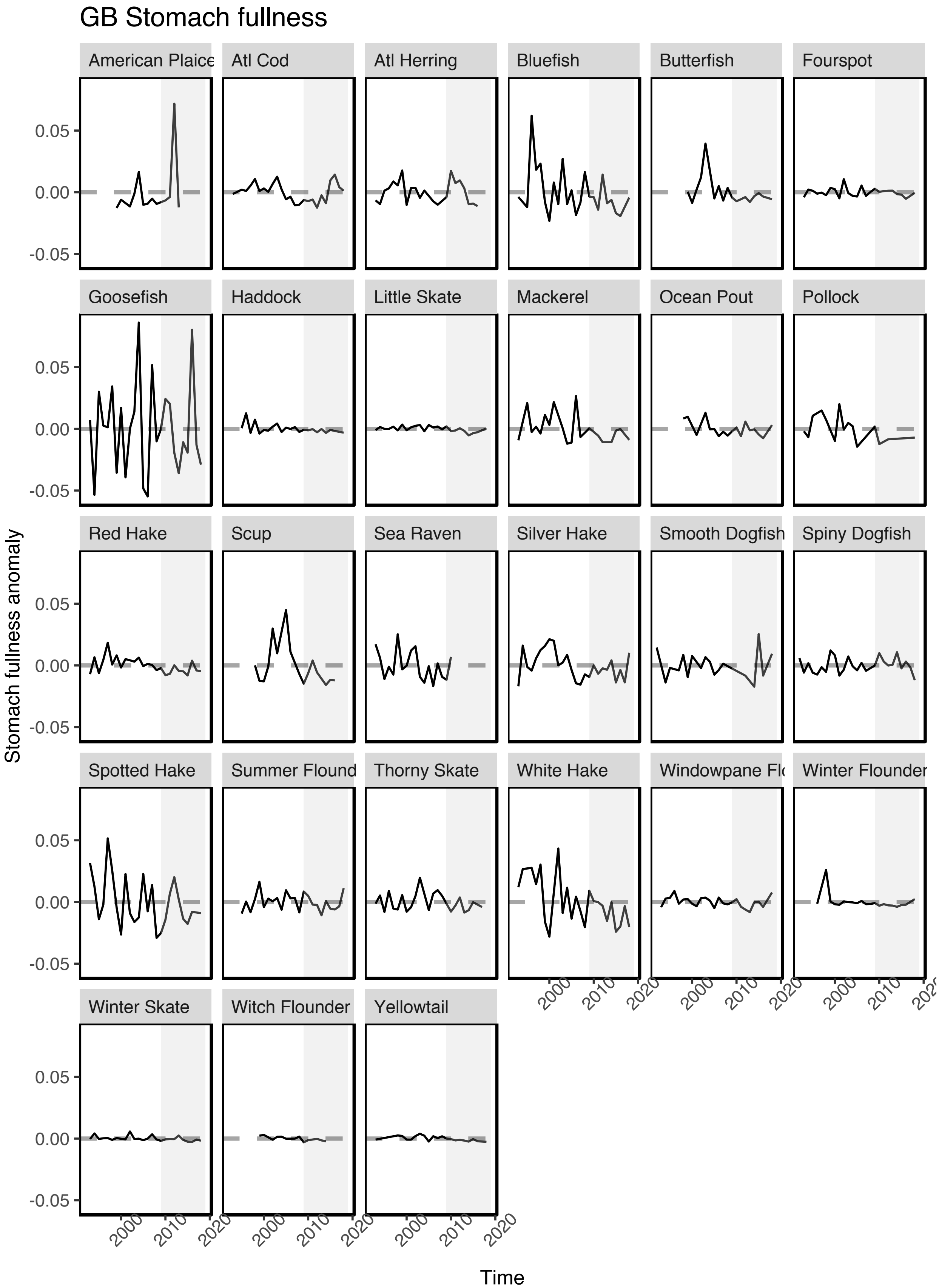

Figure 10: Stomach Fullness Anomaly in New England.

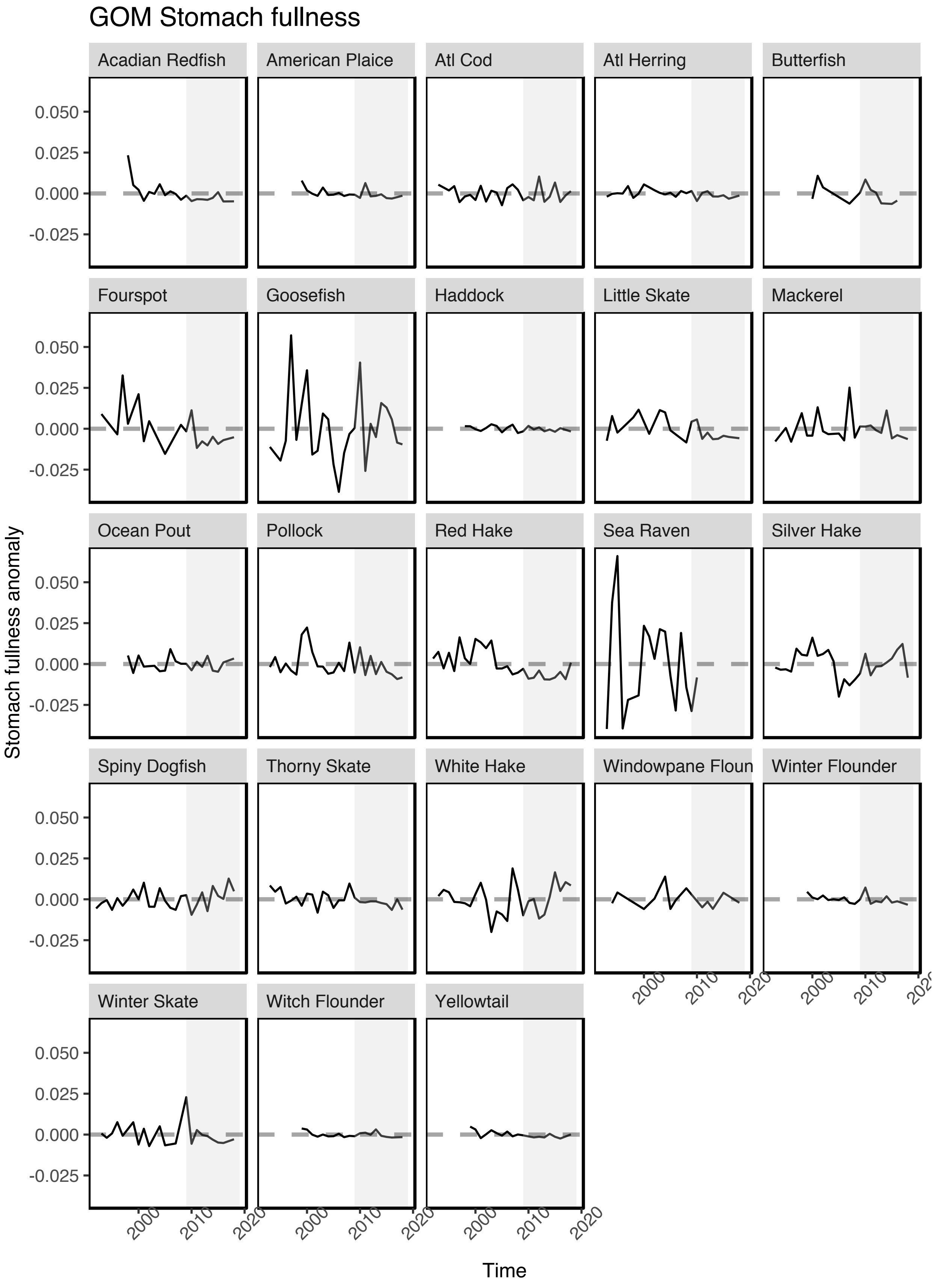

Figure 11: Stomach Fullness Anomaly in New England.

21 Right Whale Calves

The NEFMC requested a North Atlantic Right Whale calf production indicator. This indicator has been added to both SOE reports (p. 10-11 MAFMC and NEFMC).

22 Distinguish Managed Species

The NEFMC requested that managed species be distinguished in the report. Both SOE reports summarize landings as a whole and by Council-managed species in aggregate (p. 4-5 MAFMC and p. 4-6 NEFMC). A table listing which species are managed by which entity is included in each SOE report (Table 4 in both reports). Status of Council-managed species is reported in each SOE (p. 30 MAFMC and p. 38 NEFMC) with jointly managed species indicated.

23 Marine Mammal Consumption

The MAFMC was interested in estimates of marine mammal consumption. While there have been no updated reports of total marine mammal consumption for the US Northeast Shelf ecosystem since 2015 [6], new diet studies are in progress. We included updated information on seal diets in both SOE reports (p. 11-12 MAFMC and NEFMC). Once completed, these diet studies combined with mammal population estimates could be used to update marine mammal consumption estimates.

24 Small Pelagic Abundance

The MAFMC requested indices of small pelagic abundance. While the SOE includes survey biomass estimates of planktivores (p. 15-16 MAFMC and p. 16-20 NEFMC), we would like to improve on these indices. Combining survey information using VAST models as described under point 3 may improve indices for small pelagics, but species not sampled by bottom trawl surveys remain problematic. We welcome feedback on other sources of information to address small pelagic abundance.

Forage energy content is another important consideration which may affect predators as much as fluctuations in abundance. This year we have included initial information on forage energy content in the SOE reports (p. 18 MAFMC and p. 23 NEFMC) which highlights the potential for seasonal and interannual variability in energy content. We plan to develop forage energy content indicators as this time series develops, and welcome feedback on how best to do so.

25 Young of Year Index

The MA SSC was interested in a young of year index from multiple surveys. We have included the fish productivity index in both SOE reports (p. 17-18 MAFMC and p. 21-23 NEFMC), which calculates the number of small fish per biomass of large fish of the same species from NEFSC surveys. This index has been reported previously to MAFMC, and intermittently to NEFMC. We recognize that this is not strictly a young of year index, and it is from a single survey. We seek guidance from the SSC on how to refine this index; would a similar index of small fish numbers to large fish biomass from the NEAMAP survey data be useful? Or would an index of young of year without biomass of larger fish be more useful? If so, how would we best combine species or select species for the index? And should we try to combine surveys or report them separately?

26 Shark Biomass

The MAFMC requested information on biomass of sharks, as fishermen had reported encountering more blacktip, spinner, and sandbar sharks each summer. We were able to obtain catch data from the Highly Migratory Species group at NMFS Headquarters for the past 3 years, and the group is working on assembling a longer time series for future reports. We did not print the 3 year time series in the SOE reports, but visualizations are available along with other commercial landings[7]. To date, we have been unable to get biomass information on sharks at the coastwide level. We welcome suggestions for sources of this information.

27 Trawl Survey Species Diversity

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

We could calculate diversity indices for Albatross and Bigelow years separately to avoid this issue, and will do so if the Councils would find these separate indices useful.

28 Ecosystem Risk Score

The MAFMC requested work towards an ecosystem-level risk score. This system level score could augment information on individual risk elements already included in the MAFMC EAFM risk assessment, which is updated annually. Multiple indicators could be combined to form an integrated risk score (as discussed by the MAFMC Ecosystem and Ocean Planning Committee when evaluting this EAFM risk assessment), and many integrated scores have been suggested in the scientific literature. We seek further guidance on how best to develop an integrated ecosystem risk score for the MAFMC and NEFMC.

In the meantime, the primary production required to support landings introduced in this year's SOEs (p. 3-4 MAFMC and NEFMC, and see point 14 above) may contribute to an overall ecosystem risk score. While there is no established threshold for primary production required, fisheries would likely pose higher ecosystem risk if they require very high proportions of primary production. We welcome comments and suggestions from the Councils to continue this work.

Similarly, the new SOE marine heat wave indicator (p. 23-25 MAFMC and p. 28-31 NEFMC) may contribute to an overall ecosystem risk score from a climate/environmental perspective, as it measures the frequency of extreme temperature conditions in each EPU which pose risks to ecological and fishing communities. This could be integrated with existing climate vulnerability information and/or other report indicators to assess risk. Ultimately, the Council's objectives for this risk score will determine the components used.

29 Thresholds and Inflection Points

Both Councils have been interested in ecosystem-level thresholds and determining where indicators reach inflection points, suggesting changes in trends of concern. The SOEs include statistical analysis to determine where indicators have significant increasing or decreasing trends. However, based on a recent simulation analysis, we are confident in trend assessment only for time series of 30 years or more [7].

Where evidence is strong for shifts, we have looked at state changes rather than trends. The new Gulf Stream warm core ring indicator (p. 20-21 MAFMC and p. 24-25 NEFMC, and see point 11 above) shows a state change in warm core ring production based on a recent publication [5].

Some SOE indicators, such as the new marine heat wave cumulative intensity indicator in the Gulf of Maine (SOE Figure 35 on p. 29 NEFMC) have both significant trends and visually obvious shifts that could reflect a change in state for that indicator, which could be confirmed with further statistical analysis. Work is ongoing to determine statistically where shifts or changepoints across multiple indicators have ocurred, but was not ready for inclusion in this year's reports. We welcome comments and guidance from the Councils on the types of analysis that would be most useful: changepoints for individual indicators, or across many indicators, or both?

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[7] https://noaa-edab.github.io/ecodata/human_dimensions

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Introduction

The Council approved an EAFM Guidance Document in 2016 which outlined a path forward to more fully incorporate ecosystem considerations into marine fisheries management[1], and revised the document in February 2019[2]. The Council's stated goal for EAFM is "to manage for ecologically sustainable utilization of living marine resources while maintaining ecosystem productivity, structure, and function." Ecologically sustainable utilization is further defined as "utilization that accommodates the needs of present and future generations, while maintaining the integrity, health, and diversity of the marine ecosystem." Of particular interest to the Council was the development of tools to incorporate the effects of species, fleet, habitat and climate interactions into its management and science programs. To accomplish this, the Council agreed to adopt a structured framework to first prioritize ecosystem interactions, second to specify key questions regarding high priority interactions and third tailor appropriate analyses to address them [1]. Because there are so many possible ecosystem interactions to consider, a risk assessment was adopted as the first step to identify a subset of high priority interactions [2]. The risk elements included in the Council's initial assessment spanned biological, ecological, social and economic issues (Table 1) and risk criteria for the assessment were based on a range of indicators and expert knowledge (Table 2).

This document updates the Mid-Atlantic Council's initial EAFM risk assessment with indicators from the 2020 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 2020 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.

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

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

Table 1: Risk Elements, Definitions, and Indicators Used

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

Table 2: Risk Ranking Criteria used for each Risk Element

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

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

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

Changes from 2019

Ecological risk elements

Decreased Risk: 0

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

Increased Risk: 1

Bluefish biomass (B) status has changed from low-moderate risk (Bmsy $>$ B $>$ 0.5Bmsy) to high risk (B $<$ 0.5Bmsy) based on the new benchmark assessment (Table 4).

Update on Chesapeake Bay water quality

Many important MAFMC managed species use estuarine habitats as nurseries or are considered estuarine and nearshore coastal-dependent (summer flounder, scup, black sea bass, and bluefish), and interact with other important estuarine-dependent species (e.g., striped bass and menhaden). In 2019, we reported on improving water quality in Chesapeake Bay, and suggested that the Council could reconsider high risk ratings for estuarine-dependent species if this trend continues. However, the Chesapeake Bay experienced below average salinity in 2019, caused by the highest precipitation levels ever recorded for the watershed throughout 2018 and 2019. It is unclear how this will affect the overall water quality indicator (which was not updated for the 2020 report because it requires multiple years to update). The new information below suggests that high risk for estuarine-dependent species is still warranted.

Low salinity levels recorded by NOAA Chesapeake Bay Office's Chesapeake Bay Interpretive Buoy System (CBIBS) at Stingray Point showed below-average levels starting in summer 2018 and continuing through spring of 2019 (Fig. 1).

High flows during the winter and spring of Water Year (WY) 2019 came during a critical time of year when the nutrients delivered to the Bay fuel algal blooms, which can cause low dissolved oxygen in the summer. Low dissolved oxygen levels less than 2.0 mg/l (or hypoxia) are harmful to oysters, crabs and fish. The high flows, and associated nutrient loads, during WY 2019 contributed to summer dissolved-oxygen levels in the Bay that were the 3rd lowest recorded in Maryland waters, according to the Maryland Department of Natural Resources[3].

In Maryland, the Spatfall Intensity Index, a measure of oyster recruitment success and potential increase in the population, was 15.0 spat/bu, well below the 34-year median value of 39.8. Blue catfish, an invasive species in the Chesapeake, spread over the last two summers due to the lower salinity levels.

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[3] https://www.usgs.gov/center-news/september-hypoxia-report

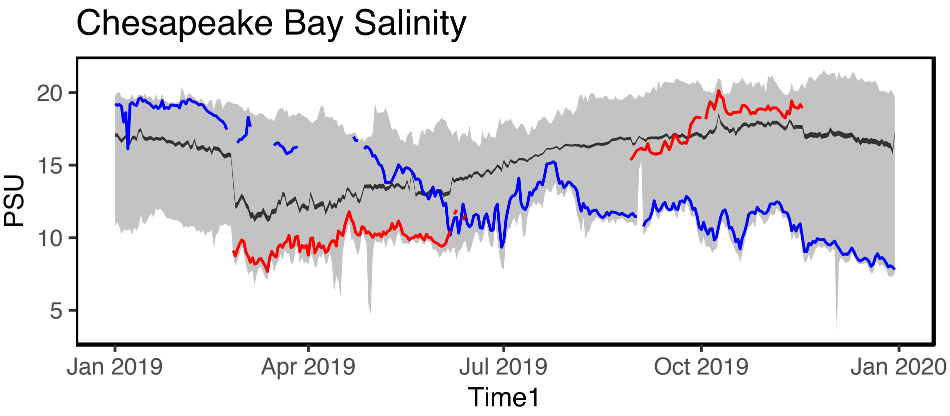

Figure 1: Salinity in Chesapeake Bay throughout 2018 (blue) and 2019 (red) as well as the daily average 2008-2019 (black) and the full observed range 2008-2019 (gray shading).

Economic, Social, and Food production risk elements

Decreased Risk: 0

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

Increased Risk: 0

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

Update on recreational seafood production

Although the risk ranking for recreational seafood production remains at moderate-high based on the continued long term downward trend in this indicator, the most recent data is notable. 2018 recreational seafood landings were the lowest observed since 1982, with a 47% drop year over year (Fig. 2). This drop involved multiple species, including black sea bass, scup, spot, and bluefish, among others and though accompanied by lower recreational effort in 2018, is not fully explained by changes in effort alone. The survey methodology behind these numbers was updated in 2018, and additional years worth of data is needed to understand whether these declines are driven by changes in the precision or other statistical properties of the data.

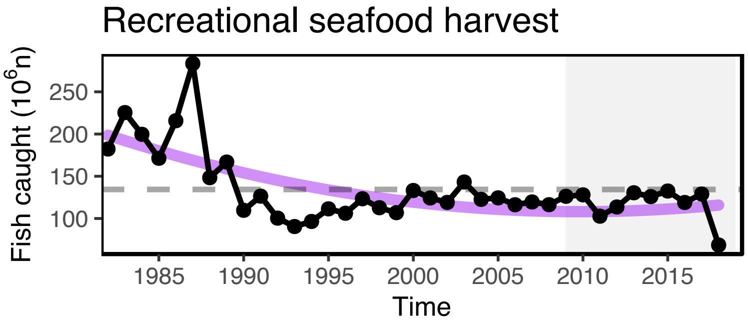

Figure 2: Total recreational seafood harvest in the Mid-Atlantic region.

Potential new indicators

Social-Cultural: Commerical Fishery Engagement

Commerical fishery engagement measures the number of permits, dealers, and landings in a community[4]. The trend in the number of Mid-Atlantic fishing communities that were highly engaged (red bar) in commercial fishing has shown a decrease since 2004 (Fig. 3). Some of the communities that were highly engaged have moved into the moderate (blue bar) or medium-high (green bar) category, and thus the number of moderately to medium-highly engaged communities have increased. Significant changes in engagement scores have also been observed in medium-highly engaged communities. The average engagement score has decreased since 2004. These changes may be driven by the decline in value landed by primary species such as sea scallops in this group of communities.

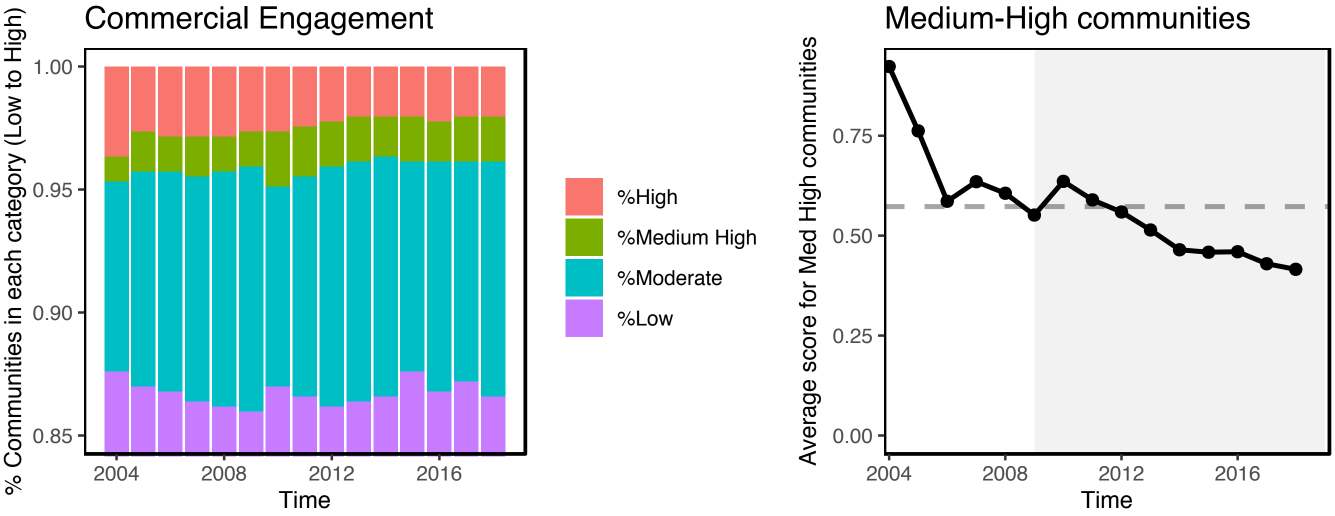

Figure 3: Commercial engagement scores (total pounds landed, value landed, commercial permits, and commercial dealers in a community) for Mid-Atlantic fishing communities, 2004-2018.

Recreational Diversity

Indicators for the diversity of recreational effort (i.e. access to recreational opportunities) by mode (party/charter boats, private boats, shore-based), and diversity of catch (NEFMC, MAFMC, SAFMC, and ASMFC managed species) show different trends. The downward effort diversity trend is driven by party/charter contraction (from a high of 24% of angler trips to 7% currently), with a shift towards shorebased angling. Effort in private boats remained stable between 36-37% of angler trips across the entire series. The long-term decrease in species catch diversity in the Mid-Atlantic states reported last year resulted from aggregation of SAFMC and ASMFC managed species into a single group. With SAFMC and ASMFC species considered individually, there is no long term trend in recreational catch diversity. This implies that recent increases in catch of SAFMC and/or ASMFC managed species is helping to maintain diversity in the same range that MAFMC and NEFMC species supported in the 1990s (Fig. 4).

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[4] https://www.fisheries.noaa.gov/national/socioeconomics/social-indicator-definitions#fishing-engagement-and-reliance-indices

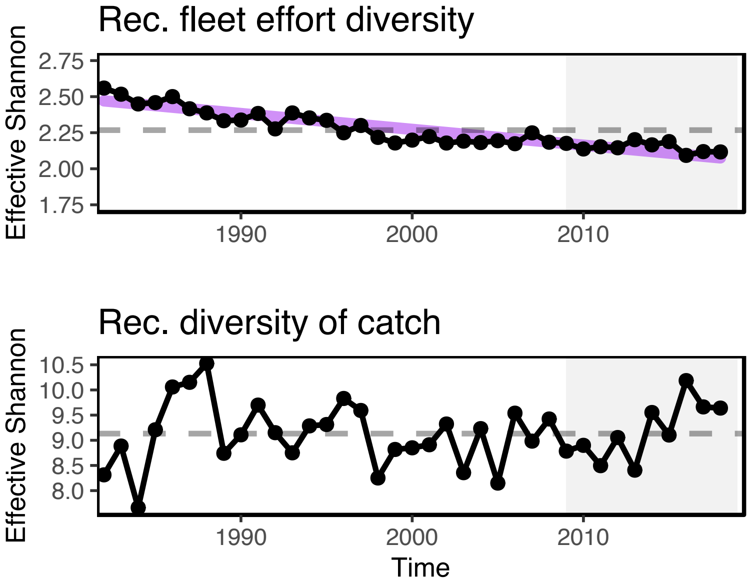

Figure 4: Recreational effort diversity and diversity of recreational catch in the Mid-Atlantic.

We seek Council feedback on whether to include commericial engagement and recreational diversity as an indicators for the EAFM risk assessment, and if so, what risk criteria should be applied to these indicators.

Management risk elements

Management risk elements have not been updated since the original risk assessment was conducted in 2017. 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. The updated management risk element rankings were conducted by the Council staff lead for a particular species (Table 6).

New rankings for chub mackerel and unmanaged forage

In 2019, the Council approved adding chub mackerel to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan; therefore, an evaluation of chub mackerel management risk has been included for the first time. The rankings for chub mackerel can be found in Table 6 and the justification for each ranking is provided below:

- **Management Control:** first annual landings limit implemented September 2017 and has not been exceeded. Proposed ABC expected to be implemented in 2020 and would represent a liberalization compared to measures implemented in 2017.
- **Technical Interactions:** some marine mammal interactions.
- **Other Ocean Use:** potential loss of access, particularly for mobile gear, due to offshore energy development (wind, gas, oil) in some fishing areas but most fishing far offshore.
- **Regulatory Stability:** simpler regulations than some other species (e.g., commercial possession limit only after ACL is close to being exceeded, no minimum fish size limit, no gear restrictions, no recreational management measures except for permit requirement). Management measures first implemented in 2017, will be revised in 2020.
- **Discards:** the first ABC and ACL are expected to be implemented in 2020 and are not expected to be exceeded based on recent trends in the fisheries. Discards generally make up 6% or less of total catch.
- **Allocation:** the stock is not allocated and there are currently no allocation concerns.

When the first risk assessment was completed in 2017, regulations pertaining to unmanaged forage were just implemented and therefore no rankings were provided for the various management risk elements. Rankings for unmanaged forage species are included for the first time (Table 6) and the justification for each ranking is provided below:

- **Management Control:** no stock assessments or ABCs. Only restriction on catch is a possession limit which was first implemented in Sept 2017. Dealer data for 2018-2019 show no trips exceeding that possession limit.
- **Technical Interactions:** forage ecosystem component (EC) species are not managed with OY and they largely do not have notable directed fisheries; therefore, although interactions with other fishery regulations are possible, these interactions likely have minimal impacts.
- **Other Ocean Use:** potential loss or degradation of habitat due to a variety of other uses, especially in nearshore areas used by many forage species.
- **Regulatory Stability:** only regulations are permit and reporting requirement, possession limit, and transit provisions. First implemented in September 2017 and have remained unchanged.
- **Discards:** forage EC species are not managed with ACLs; therefore, discards do not cause closures or trigger AMs. Targeting of these forage species is small-scale.
- **Allocation**: stocks are not allocated and there are currently no allocation concerns.

Decreased Risk: 5

Summer flounder recreational regulatory complexity risk dropped slightly moving from high to medium-high risk. Frequent changes in size, season and possession limits, significant differences between some states remain, but regulatory stability and year to year consistency has improved somewhat since 2014.

Technical interaction risk within the commercial scup fishery decreased from medium-high to low-medium. No accountability measures (AMs) have been triggered due to other fisheries and the commercial scup fishery is considered a category II fishery.

The recreational Atlantic mackerel allocation risk decreased from high to low. There have been no recent Council discussions regarding potential changes to the recreational Atlantic mackerel allocation and the Council recently changed to a simple deduction of expected recreational catch instead of a set recreational allocation.

The longfin squid allocation risk deceased from high to low. There were some allocation discussions during the development and completion of Amendment 20 in 2018, but the Council is currently not considering any allocation changes.

The commercial spiny dogfish allocation risk dropped from high to low. There are no current discussions to modify the commercial allocation and the ASMFC recently completed an action that has added flexibility to transfer regional quotas and match annual variability and reduced the need for allocation changes.

Increased Risk: 14

Discards in the ocean quahog and surfclam fisheries moved from low risk to medium-high risk. While the ocean quahog and surfclam fisheries are allocated minimal coverage under SBRM as a result of discards comprising a low percent of total catch, the comingling of surfclams and quahogs (trips can not be mixed) has resulted in increased discarding of one species is occurring frequently enough to be raised as a concern.

Commercial summer flounder discard risk increased from medium-high to high. Dead discards as a percentage of commercial catch have increased slightly in recent years due to lower quotas and caused ACLs to be exceeded in some years. Discards can be difficult to control given various reasons for discarding, and some uncertainty and variability in discard estimates remain.

The risk to recreational scup management control increased slightly from low to low-moderate. Recreational scup ACL and RHL underages each year since 2011; however, in 2017 the ACL was exceeded by 1% due to recreational discards.

Recreational and commercial scup allocation risk element changed from low to high. In 2019, the Council and ASMFC initiated an amendment to consider changes to the current 78% commercial/22% recreational split of the total allowable catch.

Risks from other ocean uses to the commercial scup fishery increased from low-medium to medium-high due to the potential for habitat impacts and the loss of access from offshore energy development.

Recreational black sea bass discard risk increased from medium-high to high. There is a high recreational discard rate and ACL overages have occurred for at least the past 4 years due to higher discards than assumed during specifications setting process (considering pre-calibration MRIP estimates).

The risk to commercial black sea bass management control rose appreciably from low-medium to high. Commercial landings are generally very close to quota, but the ACL has been exceeded every year from 2015 to 2018 (likely during earlier years as well) due to higher discards than assumed during specifications setting.

These ACL overages due to higher than projected discards resulted in greater risk from commercial black sea bass discards, with the ranking changing from low-medium to high.

The risk to recreational Atlantic mackerel management control increased slightly from low to low-medium. There have been no ACL overages last 5 years using the appropriate MRIP data and the current recreational measures in place should avoid overages generally. However, the recreational sector has been exceeding its assumed harvest, but the commercial management uncertainty buffer has accommodated these overages.

The risk to shortfin squid (*Illex*) management control increased slightly from low to low-medium. There are no ACL's for this fishery; however, there was a 5% ABC overage in 2018. The current management measures that are in place should generally avoid overages.

Illex allocation risk changed from low to high. The Council is currently considering modifications to the *Illex* permitting system which may have allocation implications amongst participants in the fishery.

The recreational bluefish regulatory complexity risk increased slightly from low to low-medium. Regulations recently changed to ensure the reduced RHL is not exceeded as result of the newly determined overfished status. As the rebuilding plan is implemented, future regulatory changes may also be needed.

Potential new indicators

Other ocean uses: Fish habitat overlap with offshore wind lease areas

Fish habitat modeling based on NEFSC bottom trawl surveys [3] indicates that summer flounder, butterfish, longfin squid, and spiny dogfish are among fish species highly likely to occupy wind energy lease areas (Fig. 5). Habitat conditions for many of these species have become more favorable over time within wind lease areas (increasing trend in probability of occupancy). Table 3 lists the top 5 species in each season most likely to occupy the wind lease areas in the northern, central, and southern portions of the MAB, along with observed trends in probability of occupancy.

Table 3: Species with highest probability of occupancy species each season and area, with observed trends

	Existing - North		Proposed - North		Existing - Mid		Proposed - Mid		Existing - South	
Season	Species	Trend	Species	Trend	Species	Trend	Species	Trend	Species	Trend
Spring	Little Skate	↗	Atlantic Herring		Little Skate	↗	Spiny Dogfish	↗	Spiny Dogfish	↗
Spring	Atlantic Herring	↘	Little Skate	↗	Atlantic Herring	↘	Atlantic Herring	↘	Longfin Squid	↗
Spring	Windowpane	↗	Longhorn Sculpin	↗	Spiny Dogfish	↗	Little Skate	↗	Summer Flounder	↗
Spring	Winter Skate	↗	Windowpane	↗	Windowpane	↗	Alewife	↘	Clearnose Skate	↗
Spring	Longhorn Sculpin	↗	Alewife	↘	Winter Skate	↗	Silver Hake	↗	Spotted Hake	↗
Fall	Butterfish	↗	Butterfish	↗	Summer Flounder	↗	Longhorn Sculpin	↗	Longfin Squid	↘
Fall	Longfin Squid	↗	Fourspot Flounder		Longfin Squid	↗	Little Skate	↗	Northern Searobin	↗
Fall	Summer Flounder	↗	Longhorn Sculpin	↘	Butterfish	↗	Butterfish	↗	Clearnose Skate	↗
Fall	Winter Flounder	↘	Summer Flounder	↗	Smooth Dogfish	↗	Sea Scallop	↗	Butterfish	↗
Fall	Spiny Dogfish	↘	Spiny Dogfish	↘	Windowpane	↗	Fourspot Flounder	↗	Spiny Dogfish/Spotted Hake	↗

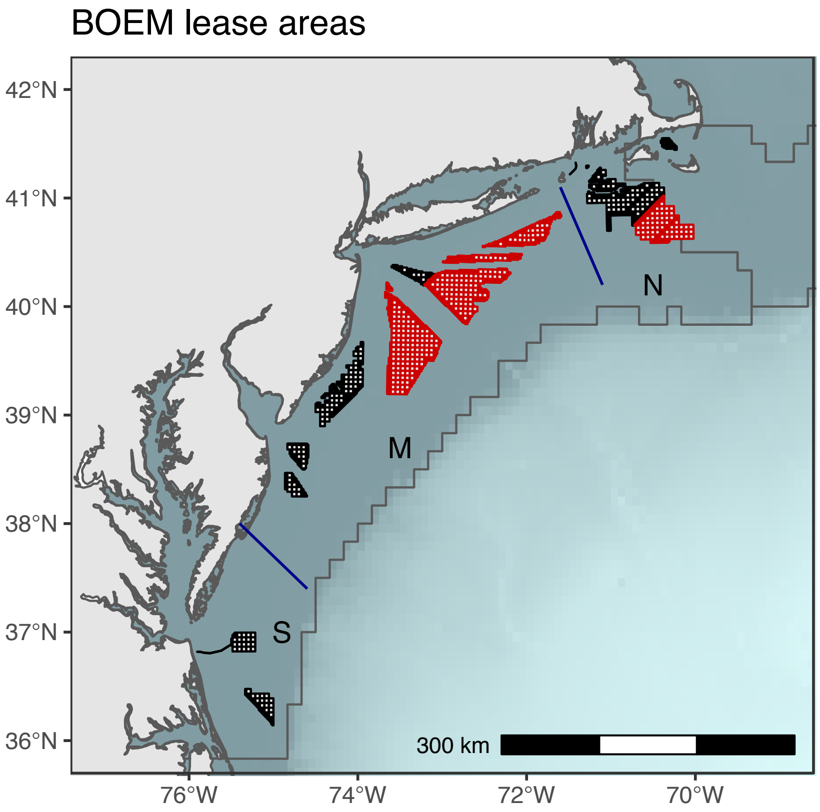

Figure 5: Map of BOEM existing (black) and proposed (red) lease areas as of February 2019.

We seek Council feedback on whether to include information on probability of occupancy in wind lease areas as an indicators for the EAFM risk assessment, and if so, what specific indicators would be most useful and what risk criteria should be applied to these indicators.

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

Species	Assess	Fstatus	Bstatus	FW1Pred	FW1Prey	FW2Prey	Climate	DistShift	EstHabitat
Ocean Quahog	l	l	l	l	l	l	h	mh	l
Surfclam	l	l	l	l	l	l	mh	mh	l
Summer flounder	l	l	lm	l	l	l	lm	mh	h
Scup	l	l	l	l	l	l	lm	mh	h
Black sea bass	l	l	l	l	l	l	mh	mh	h
Atl. mackerel	l	h	h	l	l	l	lm	mh	l
Butterfish	l	l	l	l	l	l	l	h	l
Longfin squid	lm	lm	lm	l	l	lm	l	mh	l
Shortfin squid	lm	lm	lm	l	l	lm	l	h	l
Golden tilefish	l	l	lm	l	l	l	mh	l	l
Blueline tilefish	h	h	mh	l	l	l	mh	l	l
Bluefish	l	l	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 5: Ecosystem level risk analysis results; l=low risk (green), lm= low-moderate risk (yellow), mh=moderate to high risk (orange), h=high risk (red)

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

Table 6: Species and sector level risk analysis results; l=low risk (green), lm= low-moderate risk (yellow), mh=moderate to high risk (orange), h=high risk (red)

Species	MgtControl	TecInteract	OceanUse	RegComplex	Discards	Allocation
Ocean Quahog-C	l	l	lm	l	mh	l
Surfclam-C	l	l	lm	l	mh	l
Summer flounder-R	mh	l	lm	mh	h	h
Summer flounder-C	lm	mh	lm	mh	mh	h
Scup-R	lm	l	lm	mh	mh	h
Scup-C	l	lm	mh	mh	mh	h
Black sea bass-R	h	l	mh	h	h	h
Black sea bass-C	h	lm	h	mh	h	h
Atl. mackerel-R	lm	l	l	l	l	lm
Atl. mackerel-C	l	lm	mh	h	lm	h
Butterfish-C	l	lm	mh	h	mh	l
Longfin squid-C	l	mh	h	h	h	lm
Shortfin squid-C	lm	lm	lm	lm	l	h
Golden tilefish-R	na	l	l	l	l	l
Golden tilefish-C	l	l	l	l	l	l
Blueline tilefish-R	l	l	l	mh	l	h
Blueline tilefish-C	l	l	l	mh	l	h
Bluefish-R	lm	l	l	lm	mh	h
Bluefish-C	l	l	lm	lm	lm	h
Spiny dogfish-R	l	l	l	l	l	l
Spiny dogfish-C	l	mh	mh	mh	lm	mh
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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Michael P. Luisi, Chairman | G. Warren Elliott, Vice Chairman
Christopher M. Moore, Ph.D., Executive Director

MEMORANDUM

Date: March 25, 2020

To: Council

From: Brandon Muffley, Staff

Subject: Update on EAFM activities

Risk Assessment:

The Council's Ecosystem Approach to Fisheries Management (EAFM) guidance document, approved in 2016, provides a structured framework process to incorporate ecosystem considerations in order to evaluate policy choices and trade-offs as they affect FMP species and the broader ecosystem. The first step in the structured framework process includes identifying and prioritizing ecosystem interactions and risks through a comprehensive risk assessment. The Council completed a risk assessment in 2017 to help the Council decide where to focus limited resources to address priority ecosystem considerations in its science and management programs. The risk assessment provides a snapshot of the current risks to meeting the Council's biological, socioeconomic, and management objectives across a variety of factors. The risk assessment was developed and intended to be an adaptive document that is reflective of changing or new science, analysis, and information. For example, many of the indicators and analyses found in the NEFSC Mid-Atlantic State of the Ecosystem report, which is updated annually, were used to form the basis of the Councils risk assessment. Updated assessments, including the comprehensive summary tables, allow the Council to re-evaluate risk on an annual basis, track changes across managed species and sectors, and identify possible management and science priorities.

Relevant sections of the risk assessment were first updated in 2019 utilizing new stock assessment information for Atlantic mackerel and summer flounder and new or updated information contained in the 2019 Mid-Atlantic State of the Ecosystem report[1]. The risk assessment has been updated again in 2020[2] incorporating the recent management track assessment results and the 2020 Mid-Atlantic State of the Ecosystem report. In addition, the management risk elements were updated for all species and sectors, including risk rankings for chub mackerel and unmanaged forage, to reflect recent management actions and outcomes.

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[1] The 2019 EAFM Risk Assessment report can be found at: http://www.mafmc.org/briefing/april-2019.

[2] The 2020 EAFM Risk Assessment report is located behind Tab 1 of the April 2020 briefing book.

Summer Flounder Management Strategy Evaluation:

In 2019, the Council completed the development of a conceptual model that considered 16 different high-risk factors affecting summer flounder and its fisheries. Developing conceptual models is the second step in the Council's EAFM structured framework process. The conceptual model and interactive visualization tool identified the key ecosystem elements and their associated linkages, documented available and missing data sources, and scoped out priority summer flounder management questions and objectives in which to focus limited resources.

The extensive and strategic conceptual model scoping process allowed the Council to consider a variety of management questions and identify one priority area for continued evaluation through the development of a management strategy evaluation (MSE). The Council selected the following management question for further development and analysis:

> *Evaluate the biological and economic benefits of minimizing discards and converting discards into landings in the recreational sector. Identify management strategies to effectively realize these benefits.*

When selecting this question, the Council discussed the various management challenges in addressing and reducing regulatory discards, particularly within the recreational sector summer flounder fishery. The Council noted this question has the potential to align efforts and outcomes within the EAFM process and the Councils typical recreational review and management process. In addition, the Council felt this question provided the most tangible benefits to addressing a Council priority and was best fit for an MSE by evaluating the performance of different management options within an ecosystem context.

Building off the information developed during the conceptual model process, the Council will begin conducting an MSE to address the recreational summer flounder discards question and management objectives. Management strategy evaluation is the next, and third, step in the EAFM structured framework process. An MSE will use a simulation model(s) to evaluate different management approaches within an ecosystem context to determine if the outcomes associated with the different approaches achieve management goals and objectives. Clearly identified and defined objectives, performance metrics, and management strategies will be specified by the Council with input and guidance from an extensive stakeholder process. The stakeholder process and engagement will include the Ecosystem and Ocean Planning Committee, the Summer Flounder, Scup and Back Sea Bass Committee, members of the ASMFC Summer Flounder, Scup and Black Sea Bass Management Board, and a variety of Council and ASMFC technical and advisory bodies.

In the fall of 2019, NEFSC staff submitted a proposal for funding in FY2020 to the NOAA Fisheries Office of Sustainable Fisheries Magnuson-Stevens Act Implementation budget line to support a possible Mid-Atlantic Council EAFM management strategy process. These funds are available to support projects at Regional Offices and Science Centers that improve fisheries conservation and management, including improvements to ecosystem-based fisheries management as one of the priority areas for funding. In late January, NEFSC and Council staff were informed the Mid-Atlantic proposal was selected for funding. These funds will be used to support a full-time contract analyst dedicated to this project that will work with Council, GARFO, and NEFSC staff to interact with stakeholders, synthesize available data, develop and run models, and summarize results. This will allow for more rapid model development and implementation to meet management goals and timelines. A contract analyst currently working at the NEFSC has already been identified that has extensive experience with Mid-Atlantic fisheries, recreational data, and economic, ecosystem, and simulation models that will likely be used in the MSE. It is anticipated the contract analyst will begin working on the project by early May. Proposal funds are also available to support, at least in part, an independent facilitator to help with stakeholder engagement, organize workshops, and develop reports summarizing stakeholder and workshop feedback and outcomes.

Council and NEFSC staff are currently working on finalizing membership for an MSE technical/steering workgroup. This workgroup, similar to the conceptual model technical workgroup, will be comprised of staff from the Council, NEFSC, GARFO, ASMFC, NOAA Fisheries, state agencies and members of the SSC and academia. In general, this workgroup will: 1) help develop MSE materials and products, 2) identify stakeholders and outreach opportunities, 3) work closely with and support the contract analyst and independent facilitator, and 4) work with the Council and stakeholders in communicating the goals and outcomes of the MSE. The MSE technical/steering workgroup membership will be finalized in mid-April. Shortly after finalizing membership, the workgroup will meet via webinar to begin planning next steps, timelines, and developing materials for stakeholder engagement and input. It is anticipated the MSE process will take approximately 2 years to complete and provide final results and management alternatives to the Council for consideration. The table below provides a very general overview of MSE tasks/activities and the associated timelines.

Task/Activity	**Timeframe** (subject to change)
Finalize technical/steering committee workgroup membership and initial meeting	April – May 2020
Initial stakeholder meeting(s) and surveys to elicit objectives/performance metrics/uncertainties; data synthesis, initial model development and linking existing models, interim stakeholder meetings	June – December 2020
Simulation testing of management strategies, model refinement as necessary, deliver interim results at stakeholder meetings	January – July 2021
Continue with MSE analysis and stakeholder meetings, as needed; deliver final results	August – December 2021
Council considers potential management alternatives and actions to address recreational summer flounder discards	2022

Short-Term Projections Project:

Council staff are co-investigators with a team of scientists (Dr. Malin Pinsky and Dr. Alexa Fredston-Hermonn) from Rutgers University on a research project funded by the Lenfest Ocean

Program that will test new methods and models to predict short-term (the next one to ten years) climate-induced movements of diverse species that better align with management timescales. Project investigators provided an overview of the project methods and potential outcomes to the Ecosystem and Ocean Planning (EOP) Committee and Advisory Panel (AP) in December 2019. The EOP Committee and AP provided a great deal of feedback on the utility of these types of models, candidate species, data availability, and potential outcomes for consideration by research team.

Since that time, limited analysis and base model development (i.e. no candidate species information) has continued as Dr Fredston-Hermonn completed her dissertation and began her post-doctorate work full-time at Rutgers. These efforts will begin to increase over the next several months. In the meantime, a number of other planning activities have taken place and the research team continues to receive additional feedback from stakeholders and Council members, including input from the South Atlantic Council on potential candidate species and data sources. Given some of the feedback from the EOP Committee and AP and in working with the Lenfest Ocean Program, a new outreach flyer was developed to inform the public about the project[3]. As noted in the flyer, the research, including potential candidate species, will be evaluated and updated to reflect feedback and will get underway more earnestly in spring 2020. The research team will continue to look for opportunities to keep the Council, EOP Committee and AP members up to date on project progress and development. An in-person stakeholder meeting in New Jersey was initially being planned for late April; however, given the current national situation with the coronavirus, that meeting has been postponed. The research team is still considering an appropriate time and venue to hold the stakeholder meeting and solicit final initial feedback and it's also planning for a larger in-person meeting with a more diverse group later in year to present some initial models runs and analysis. It is anticipated this project will conclude sometime in mid-2022.

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[3] The new outreach flyer is included behind Tab 1 of the April 2020 Council meeting briefing book.

LENFEST OCEAN PROGRAM

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

Ricardo Esquivel, Pexels

PROJECT SUMMARY: SHORT-TERM FORECASTS OF SPECIES DISTRIBUTIONS FOR FISHERIES MANAGEMENT

BACKGROUND: As water temperatures increase along the U.S. east coast, fish and invertebrate species are shifting their ranges, presenting challenges for managers tasked with setting catch limits and, in some fisheries, spatially allocating harvest.

PROJECT GOAL: This research will test a new method for predicting warming-induced movements of diverse species over short timescales (the next one to ten years) that better align with management timescales.

THE METHOD: Unlike previous approaches that use only environmental factors to predict distribution, the new method, called dynamic range modeling, will also factor in the unique population dynamics of individual species, since warming temperatures could affect a species' growth, mortality, movement patterns, and reproductive success. By modeling how these life-history parameters vary geographically along the U.S. Atlantic coast, the researchers may be able to more effectively predict species movements and productivity. The raw data used to fit the models will include species abundance data from state, regional, and federal surveys, as well as high-resolution coastal temperature and dissolved oxygen hindcasts. To validate whether the approach is effective, the team will simulate species distributions from previous years and compare those predictions with actual observed distributions and with predictions that relied only on environmental data.

FOCAL SPECIES FOR THIS RESEARCH: The research team has initially identified four candidate species for which to test the model's effectiveness. The team has solicited feedback from the Mid-Atlantic and South Atlantic Fishery Management Councils and stakeholders regarding other potential candidate species; therefore, the final list of candidate species may change. The researchers selected these species because they represent a broad diversity of life-history strategies, have supporting data available, and are likely susceptible to distribution shifts as a result of changing environmental conditions. *The team did not select these species in order to utilize the outcomes of this research to directly inform current management efforts and actions for those species*.

The four species are:

1. Shortfin squid (*Illex illecebrosus*): Pelagic, short-lived, highly productive, an important forage species, and have a very high potential for distribution change (Hare et al. 2016);
2. Spiny dogfish (*Squalus acanthias*): Demersal, long-lived, low-productivity, seasonal north-south migrations, an important predator, and have a very high potential for distribution change (Hare et al. 2016);
3. Summer flounder (*Paralichthys dentatus*): Demersal, highly productive, seasonal inshore-offshore migrations, and a well-documented northerly range shift since the 1960s; and
4. Grey triggerfish (*Balistes capriscus*): demersal and structure-oriented, and historically present in the Gulf of Mexico and South Atlantic but appearing to shift into the Mid-Atlantic region.

MANAGEMENT RELEVANCE:

At its core, this is a scientific study, meant to evaluate and test the use of a new modeling approach for predicting changes in species distribution in the short term. Eventually, depending on how the model performs, movement predictions derived from this technique or similar techniques *could* be used to help inform management discussions concerning:

- Spatial allocation of harvest;
- Advancing an ecosystem approach to fisheries management considerations, since species assemblages and relative abundance may change;
- Population reference points and catch levels; and
- Spatial planning considerations for offshore energy development, by incorporating projected species distributions (not just current distributions).

PROJECT TIMELINE:

The three-year project is scheduled to conclude in the spring of 2022, although results and progress will be shared with stakeholders, scientists, managers, and the interested public as they become available.

THE RESEARCH TEAM:

- Principal Investigator: Dr. Malin Pinsky, Rutgers University (malin.pinsky@rutgers.edu)
- Co-Principal Investigator: Brandon Muffley, Mid-Atlantic Fishery Management Council (bmuffley@mafmc.org)
- Post-Doctoral Researcher: Dr. Alexa Fredston-Hermann, Rutgers University (fredstonhermann@ucsb.edu)

Questions, comments, or suggestions? *Please email Emily Knight of the Lenfest Ocean Program at eknight@lenfestocean.org.*

Black Sea Bass, NOAA

REFERENCE:

Hare, J., et al. (2016). A vulnerability assessment of fish and invertebrates to climate change on the northeast U.S. continental shelf. PLoS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756.