

East Coast Climate Change Scenario Planning

Exploration Webinar #2: Biological Drivers of Change

February 23, 2022



Introduction

The [East Coast Climate Change Scenario Planning](#) initiative is being conducted to explore governance and management issues related to climate change and fishery stock distributions. During a scoping process in 2021, stakeholders provided [input](#) on drivers of change that have the potential to shape the future of east coast fishing over the next 20 years. A series of three upcoming webinars will examine these drivers of change in more detail:

1. [Oceanographic Drivers of Change](#) (Monday, February 14, 3-4:30pm)
2. [Biological Drivers of Change](#) (Wednesday, February 23, 3-4:30pm)
3. [Social and Economic Drivers of Change](#) (Wednesday, March 2, 3-4:30pm)

This document provides background material for Webinar 2, outlining the **biological** drivers that are poised to shape east coast fisheries in the next 20 years.

In this document, the driver descriptions have been kept relatively short and simple. The material is not designed to be comprehensive or provide all the answers. Instead, it is meant to get us thinking creatively about what could unfold in the future.

As you review these drivers of change, please keep the following questions in mind:

- Have the main biological drivers of change been captured that might affect east coast fisheries over the next 20 years?
- Are there important biological drivers that have been missed?
- Do the Key Uncertainties sections contain the most important questions about the drivers?
- Which of the drivers of change do you see as most impactful in shaping the future and your work in fisheries?

Following the webinar discussions, the most important and impactful driving forces will be used to create a scenario framework in a Scenario Creation workshop scheduled to be held in late Spring 2022.

Thanks for your continued interest in this initiative.

Major Biological Drivers of Change

Introduction

The US Atlantic coast's diverse living marine resources have widely varying movement patterns, diets, reproductive strategies and specific requirements for estuarine, coastal and offshore habitats. All of these life history factors influence an individual species or group's vulnerability to the effects of ocean warming and other climate impacts.

Climate change impacts to living marine resources can be grouped into three categories: changes in a species range, altered productivity (up or down), and changes in seasonal life history event timing. The range of responses by many species to changing ocean conditions is beginning to result in the formation of novel communities of invertebrate and fish species that may not have historically co-occurred. Although negative or positive changes at the individual species or stock level are being observed and forecasted, the speed and magnitude of ecosystem level change is quite uncertain. It should be noted that many factors in addition to climate change affect the distribution and abundance of living marine resources, including coastal development impacts and fishing, and care must be taken to consider these effects.

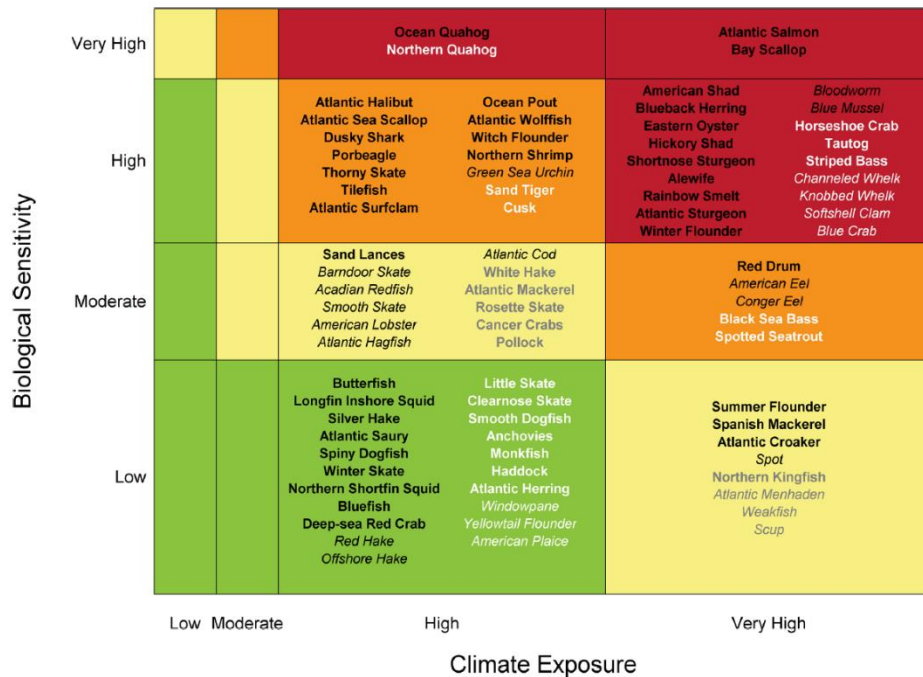


Figure 1: An evaluation of species vulnerability to climate change in the Northeast and Mid-Atlantic regions considered both the exposure and biological sensitivity of various species to climate stressors. Overall climate vulnerability is indicated by color: low (green), moderate (yellow), high (orange), and very high (red). Source: [Hare et al. 2016](#).



Finfish and invertebrates with very specific habitat and prey needs are predicted to be more vulnerable to climate impacts than 'generalists.' Diadromous fish like shad, river herring, and striped bass that require both freshwater and saltwater habitats are predicted to be highly vulnerable, as are shellfish like lobster, surf clams, and scallops, in consideration of ocean warming, disease and ocean acidification. Pelagic (water column) species like mackerels, menhaden, bluefish, spiny dogfish and mahi-mahi that can more easily remain within their optimal thermal habitats are more likely to be resilient to impacts. Some species create habitat that others in turn depend on and on the east coast these living habitats include coral, mangroves, saltmarsh, seagrasses, and oysters. Changes to the size, location and quality of these habitats can impact many other species.



Figure 2: Mangroves serve as critical habitat for many species.
Source: [NOAA Photo Library](#).

Complex interactions of multiple drivers underlie changes to distribution and abundance of individual species and the natural communities they form. While one driver of change may make a larger contribution than another, in most cases, changes are the result of multiple factors acting in combination. Several of the most prominent drivers are described on the following pages.

Distribution Changes

As the environment changes, the ranges of recreational and commercially important species are shifting, contracting, or expanding. Typically, range shifts or expansions are occurring northward, eastward (offshore), and to greater depths. Both short term shifts in response to specific events like heat waves and longer term more slowly developing changes are being observed, primarily at the leading and trailing edges of their historical distributions.

A clear range expansion for the northern stock of black sea bass (north of Cape Hatteras, NC) is well documented (Figure 3). Similarly, the distribution of surf clams and ocean quahogs has been shifting northwards from the Mid-Atlantic region, with increasing overlap in the ranges of these two species at least partially driven by climate change.

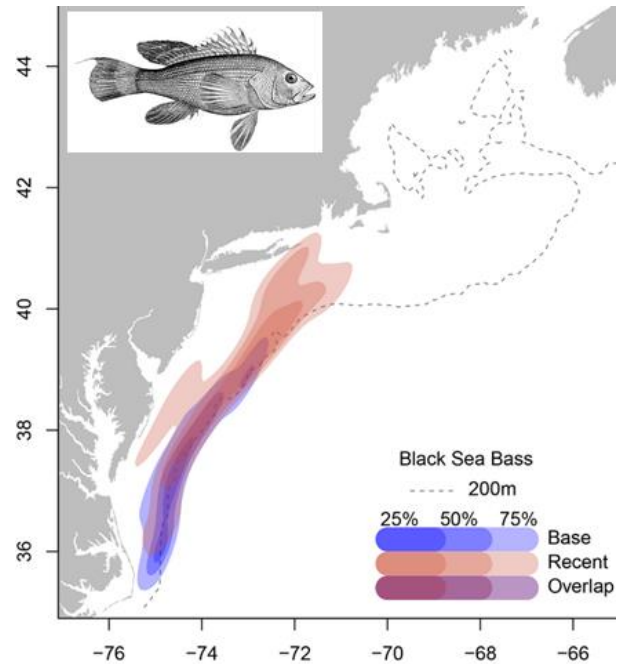


Figure 3: Plot of spring distribution of black sea bass (northern stock) in the 1970s (blue) vs. 2014-2016 (red). Percentages represent probability densities of a species being found in that location, with 25% defining the core area of distribution and 75% defining the broader use of the ecosystem. Source: [NOAA Northeast Fisheries Science Center](#).

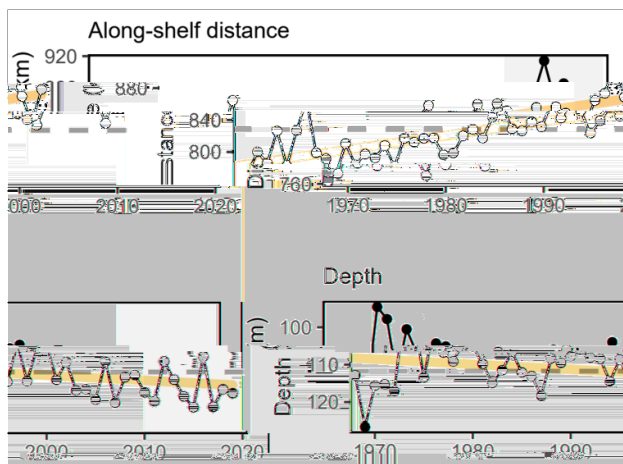


Figure 4: Analysis of Northeast and Mid-Atlantic aggregate stock distribution shows average movement trends to the northeast and into deeper water. Source: [2021 State of the Ecosystem Report, New England](#).

Distribution changes are occurring at multiple trophic levels, from top predators like cobia at the top of food webs to zooplankton like *Calanus finmarchicus* near the base. This relatively large cold-water copepod is shifting north, with warmer water plankton species taking its place. Copepod distribution changes are believed to be one of several drivers for recent shifts of North Atlantic right whales into new more northern foraging areas where they had rarely been seen before. Additionally, larvae of southern fish species are being observed more frequently in northeastern waters.

Warmer ocean temperatures over the last decade appear to be facilitating range expansion of white shrimp ('green-tails', *Litopenaeus setiferus*) from the Southeast region into the lower Chesapeake Bay. In 2017 the steadily increasing abundance led to actions by the Virginia Marine Resources Commission to authorize a limited new fishery. This species is a mainstay of the Southeast region's shrimp fishery and the observation of sharply increased white shrimp abundance in Chesapeake Bay is likely a range expansion, not a shift.

There are fewer clear examples of species distribution changes in the Southeast region. However, there has been a strong suggestion that blueline tilefish are becoming more abundant north of Cape Hatteras, based primarily on increased landings. Whether this is an actual range expansion, the result of changes in fishing behavior, or a combination of factors remains unclear. A Climate Vulnerability Analysis for Southeast region species is nearly complete and preliminary results indicate the majority of species evaluated have high or very high potential for distribution changes.



Figure 5: Live bottom habitat and community at Gray's Reef national Marine Sanctuary. Photo: Greg McFall.

Key Uncertainties: Over the next 20 years, will most fish distributions continue to exhibit generally northward and northeasterly shifts or will different patterns emerge? Will future changes be generally predictable or will changes be unpredictable and surprising? Will these patterns be similar up and down the whole Atlantic Coast? Will range changes result in large numbers of species crossing jurisdictional boundaries, or only a few species? Will changing distributions of diverse species lead to more bycatch concerns and interactions with protected species?

Productivity Changes

Environmental changes can impact the productivity of individual species and ecosystems. Changes in habitat or interactions within novel communities (via competition, predation, etc.) can alter the birth, growth, and/or mortality rates of a stock of fish. Warming waters and changing habitats appear to be impacting the productivity of a number of species along the east coast, altering rates of birth, growth, and/or mortality to drive changes in total population size. Water temperature is one of several factors that influences these rates, for example speeding up or slowing down metabolism and growth.

While all species have upper and lower lethal temperature limits, relatively small deviations from optimal temperatures can have significant effects on productivity at individual and population-wide levels. Several species at the southern extent of their range are exhibiting reduced productivity, for example lobster, northern shrimp, Atlantic surfclams and sea scallops, winter flounder, and Atlantic cod. The productivity of other species such as croaker, haddock, and Gulf of Maine lobster has been increasing, coincident with ocean warming; these species appear to profit from expansion of their thermal habitat size and quality.

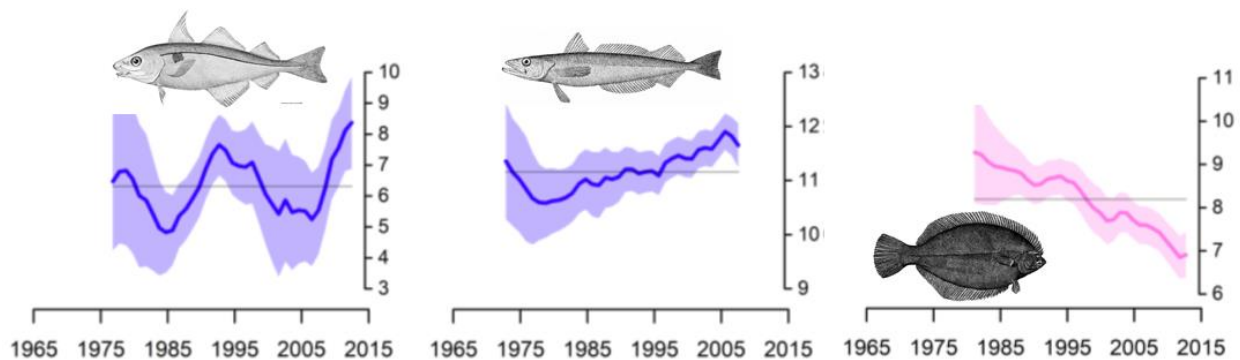


Figure 6: Changes in stock productivity for Gulf of Maine haddock, silver hake, and southern New England/Mid-Atlantic winter flounder. Source: [Tableau et al 2018](#).

Key Uncertainties: Over the next 20 years, which key species are likely to adapt and thrive, and which are likely to struggle to cope with changing conditions? What factors are important in determining if a species does well or poorly? How will changes in predation or competition impact stock productivities? How will changes in productivity impact the suitability of existing reference points, quotas and rebuilding?

Seasonal Timing

Warmer winters and summers, earlier spring warming and later cooling in the fall is impacting seasonal timing for many species, affecting predator-prey dynamics, seasonal migrations, overwintering survival and reproduction. These conditions are driving some cold water species to reduce time spent in bays and estuaries. For example, in Narragansett Bay a recent analysis of 60 years of weekly trawl data revealed significant changes in natural communities, with several cold water resident species (e.g. longhorn sculpin, ocean pout, red hake) spending up to 118 fewer days in the estuary while warm water transient species (e.g. scup, butterfish, summer flounder, longfin squid) are arriving earlier and leaving later (Figure 7).

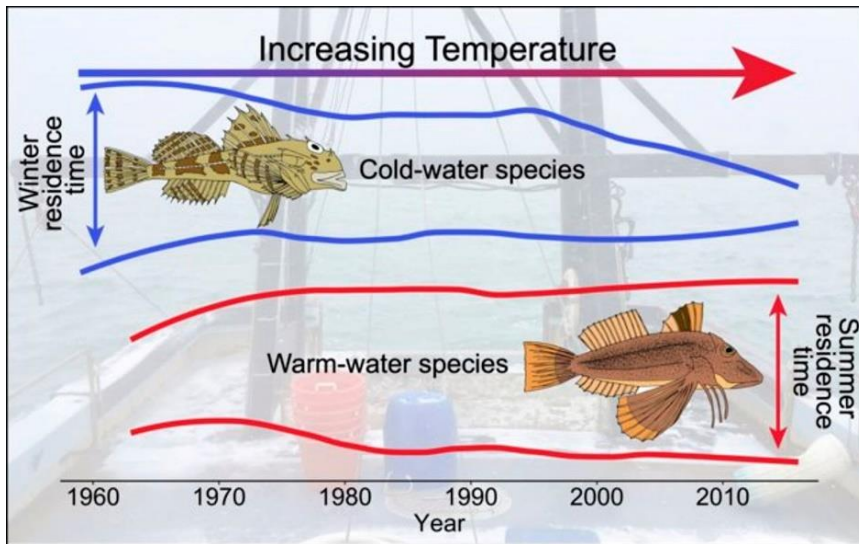
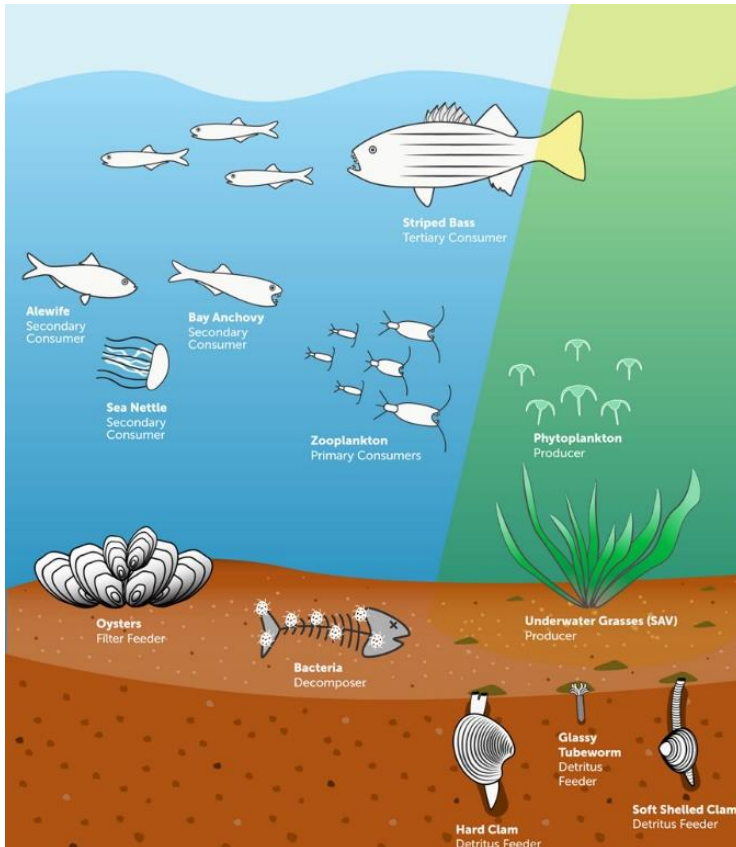


Figure 7: The number of days that migratory fish species spend in Narragansett Bay, Rhode Island has been changing, likely due to warming waters. Image: Lauren Fish and Joseph Langan.



Climate driven mismatches in seasonal timing of predator and prey life history events can result in negative impacts. For example, warmer winters in the Chesapeake Bay region drive earlier plankton blooms, resulting in copepods that are key prey for striped bass larvae dying before striped bass are present in the estuary. Warmer winters in the Chesapeake may also be increasing the survival of adult overwintering blue crabs, with the highest survival rate since surveys began twenty-five years ago recorded in 2020. Changes in the seasonal timing of fish and protected species migrations and reproduction can reduce effectiveness of seasonal closures and other time-area regulations, leading to changes in species-species and/or human-species interactions.

Figure 8: Conceptual model of Chesapeake Bay food web. Actual food webs are more complex, for example including larval forms of finfish as zooplankton predators. Source: [Chesapeake Bay Program](#).

Key Uncertainties: Will the observed effects of seasonal timing changes accelerate and become more pronounced over the next 20 years? In what ways might seasonal changes be beneficial to some species and damaging to others? Which types of species do well? How will seasonal changes affect migration patterns and predator-prey relationships? How will timing changes impact regulations based on locations and timing?

Habitat Changes

Sea level rise will 'squeeze' and reduce the extent of saltmarsh, seagrass, mangroves and other coastal habitats as rising waters outpace inland migration along paths often constrained by coastal development. In locations where these habitats are not constrained, there is potential for habitat migration and expansion. Rising water temperatures and changing ocean chemistry are predicted to impact several types of important coral habitat along the Atlantic coast. Concern over these impacts is particularly heightened for Florida's subtropical coral reefs, as well as for live bottom patch habitats with various species of hard and soft cold water corals (e.g., *Lophelia*, *Oculina*, *Astrangia*, *Leptogorgia*). Similarly, changes to ocean chemistry have the potential to place additional stress on remnant native oyster reefs and other habitats defined by dense shellfish populations.

It should be noted that seafloor habitats are defined by temperature as well as structure, for example the snapper-grouper 'complex' of the Southeast region is dependent on live-bottom patch reefs that coincide with preferred temperatures. Accordingly, future habitat for this large group of fishes could be gained or lost based on changes to either or both of these factors.



Figure 9: University of Miami diver transplants nursery-grown staghorn coral in the Florida Keys National Marine Sanctuary. NOAA and many partners are currently expanding efforts to restore this endangered species. Photo: Rachel Hancock Davis/The Nature Conservancy.

Rising temperatures are likely to drive changes to the current distribution and abundance of several seagrass species, with considerable uncertainty about the exact nature, timing, and ecological impact of these changes. For example, eelgrass is an important habitat for Mid-Atlantic and Northeast resident and migratory species that may experience loss at the southern portion of its range. Although it may be replaced over time by southern species like shoal grass, it's uncertain whether a different seagrass species would provide comparable habitat values.

Estuaries are critically important 'engines' for fisheries, with an estimated 68% of America's commercial seafood production and 80% of recreational catch coming from species that are estuarine dependent at some point in their life cycle. These values do not account for the indirect contributions of estuarine species like shrimps, menhaden, and many others as forage for diverse marine fish and wildlife from Florida to Maine. Accelerated loss and degradation of estuarine and coastal habitats due to climate driver interactions coupled with historic and ongoing stresses could have cascading food web effects that impact abundance of harvest species.



Figure 10: Tautog, winter flounder, seatrout, bay scallops, blue crab and many other species depend on seagrass habitats. Photo credits clockwise from upper left: Tautog-Paul Caruso; winter flounder-Cornell Cooperative Extension; seatrout-Kent Smith; bay scallop-Carl Lobue; blue crab-Jay Fleming.

A recent assessment of the vulnerability of riverine, estuarine and marine habitats (52 types) from Cape Hatteras to Canada to climate change impacts identified coastal and living habitats as particularly vulnerable, in part due to synergistic effects of non-climate stressors (e.g. pollution). The five habitats receiving the highest vulnerability scores were all living habitats in estuarine and marine systems.

Key Uncertainties: There is strong evidence that coastal and ocean habitats are increasingly vulnerable to the impacts of climate change. How quickly will vulnerable habitats degrade over the next 20 years? Will some habitats expand and shift? Will there be significant damage or loss to specific habitat types like corals, sea grasses, mangroves, oysters and salt marshes in specific locations or regions? To what extent will changes in habitat quality affect stock distribution and abundance? How will changes in coastal habitat impact resilience to storm events?

Diseases, Harmful Algal Blooms, and Invasive Species



Figure 11: Lobster infected with epizootic shell disease. Image: Jeff Shields, Virginia Institute of Marine Science.

Diseases impacting lobster, oysters, and coral appear to increase with both warmer waters and longer periods of warm water. Lobster shell disease was a key factor in the collapse of the formerly productive lobster fishery in southern New England. Harmful algal blooms (HABs) have historically impacted east coast fisheries, for example triggering harvest closures of specific areas to reduce paralytic shellfish poisoning risks, and seasonal bloom associated fish kill events. With increasing water temperature and other climate related factors there is the potential for an increase in HABs and the spread of disease pathogens.

Warming and other climate factors can also influence the distribution of non-native species. For example, non-native lionfish continue to expand their range in the Southeastern U.S. after being introduced to the area in the 1980s. One study estimates that suitable lionfish habitat could expand to cover 90 percent of the Southeast region continental shelf during the 21st century.

Key Uncertainties: Over the next 20 years, will HABs occur more frequently on the East Coast? Will they affect new locations, or cover a greater area? Will we see the emergence of new diseases that affect marine life on the East Coast? Will HABs and other diseases seriously affect fishing operations, either through regulatory restrictions, consumer concerns or reputational effects? Will there be new invasive species or will expansion of existing invasive species negatively affect ecosystems?

References and Further Reading

- [Climate Vulnerability Assessments | NOAA Fisheries](#)
- [An assessment of marine, estuarine, and riverine habitat vulnerability to climate change in the Northeast U.S.](#)
- [2021 Ecosystem Status Report | Southeast](#)
- [2021 State of the Ecosystem | Mid-Atlantic](#)
- [2021 State of the Ecosystem | New England](#)
- [Ocean Adapt](#) (Interactive visualization of observed changes in species ranges)