East Coast Climate Change Scenario Planning

Exploration Webinar #1: Oceanographic Drivers of Change

February 14, 2022

New England Fishery Management Council

MID-ATLANTIC

NOAA FISHERIES

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 1, outlining the **oceanographic** 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 oceanographic drivers of change been captured that might affect east coast fisheries over the next 20 years?
- Are there important oceanographic 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 Oceanographic Drivers of Change

Geography of the Region

The U.S. Atlantic Coast spans a wide temperature gradient that defines its habitats and ecosystems, from subtropical coral reefs in southern Florida to kelp forests in the much cooler Gulf of Maine. The coastline includes numerous small and medium size estuaries in addition to Chesapeake and Delaware Bays, and a barrier island ecosystem that extends from Florida north to New York. The gradually sloping shelf of the South and Mid-Atlantic regions consists mostly of sandy substrates with swales and shoals, punctuated with hard bottom patch communities, ship wrecks, and artificial reefs. Moving north, the substrate changes to mud, sand, gravel and cobbles with a range of bathymetric features including rocky ledges and boulders.

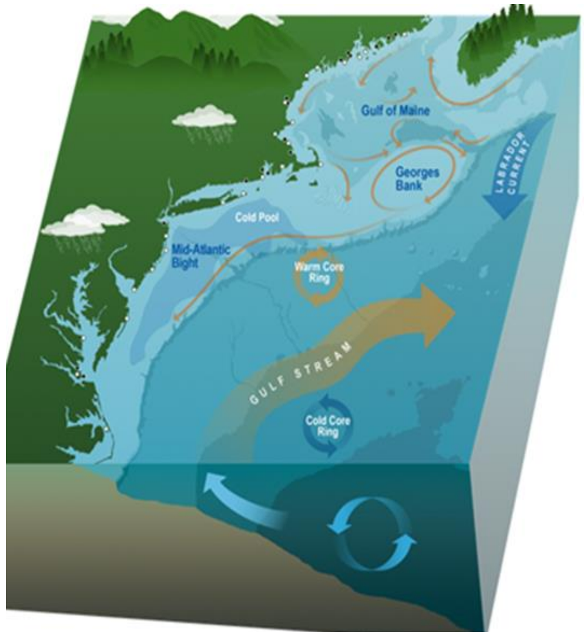

Figure 1: Major oceanographic features of the Mid-Atlantic and Northeast regions of the U.S. Atlantic coast. Source: [Northeast Integrated Ecosystem Assessment](#).

Figure 2: Major oceanographic features of the Southeast region of the U.S. Atlantic coast. Source: [Ecosystem Status Report for the U.S. South Atlantic Region.](#)

For the purposes of this project, Atlantic coast ecosystem information will often be organized into three regions: the South Atlantic Bight extending from Florida to Cape Hatteras, North Carolina; the Mid-Atlantic Bight/Southern New England from Cape Hatteras to Cape Cod, Massachusetts; and Northern New England from Cape Cod to Canada (including Georges Bank and the Gulf of Maine). We recognize that there are distinct subregions within each of these broad regions where there will be localized effects of the oceanographic drivers described below.

Temperature

East coast ocean waters are warming from Florida to Maine, with marked increases over the last decade. Recent research indicates the Gulf of Maine is warming faster than 99.9% of the global ocean.

Seasonality is an important factor affecting primary productivity and migration timing for a wide range of species. Along the east coast, the timing of seasons is changing. In the Northeast, summers are becoming warmer and longer, with warmer conditions persisting later into the fall. In the Mid-Atlantic, summers are also increasing in length, though less rapidly than in the Gulf of Maine. Similarly, the Mid-Atlantic is experiencing earlier spring warming. Southeast ocean water temperatures are warming, particularly during the winter-spring time period.

Key Uncertainties: Climate change is expected to cause generally warmer ocean temperatures. The major uncertainty relates to the speed of future increases. Will ocean temperatures rise more quickly than in previous decades? Also, to what extent will temperature changes vary across locations or seasons? Will increases be uniform, or could we see some locations or seasons that experience lower ocean temperatures in the next 20 years?

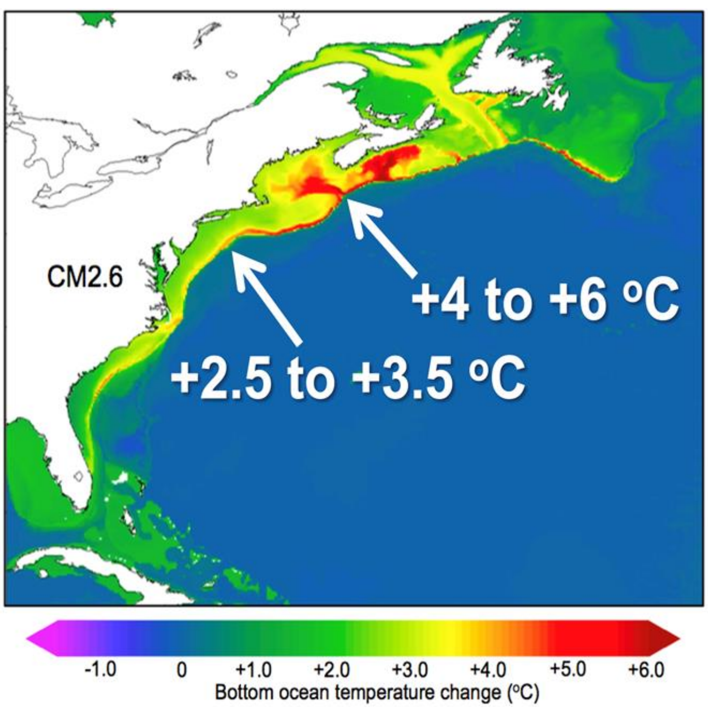

Figure 3: Global climate models can project how ocean conditions will change over time. This figure shows how ocean bottom temperatures are projected to increase, especially north of Cape Hatteras, NC, by the 2060s to 2080s under a scenario where carbon dioxide (CO2) increases by 1% per year and doubles after 70 years, representing a "high CO2 emissions" scenario. Source: Saba et al. 2016.

Currents

The Gulf Stream and the Labrador Current are major oceanographic drivers along the Atlantic coast. The Gulf Stream flows north carrying warm water along the southeast coast and up to the Northeast. The Labrador Current brings cool, fresher water down from Canada. The strength, position, and interaction of these two currents impact the temperature, salinity and nutrient content of water along the east coast.

The Gulf Stream's proximity to shore along the Southeast coast varies, influencing upwelling dynamics and primary productivity. In the Northeast, the position of the Gulf Stream varies north and south. When it is further north, warmer, saltier water is found on the Northeast shelf impacting the abundance and seasonality of plankton and higher trophic level species. Since the 2010s, the Gulf Stream has moved northward, pushing warmer, saltier water onto the Northeast shelf and through the Northeast Channel. There has been a decrease in colder Labrador slope water entering the Gulf of Maine.

Key Uncertainties: We cannot be sure what will happen to the Gulf Stream in future decades. Will it continue to push warmer water further north, or will we see change in its speed, position or some form of collapse? Will the impacts of any Gulf Stream changes be felt in all parts of the Atlantic Coast, or will some areas be affected far more than others?

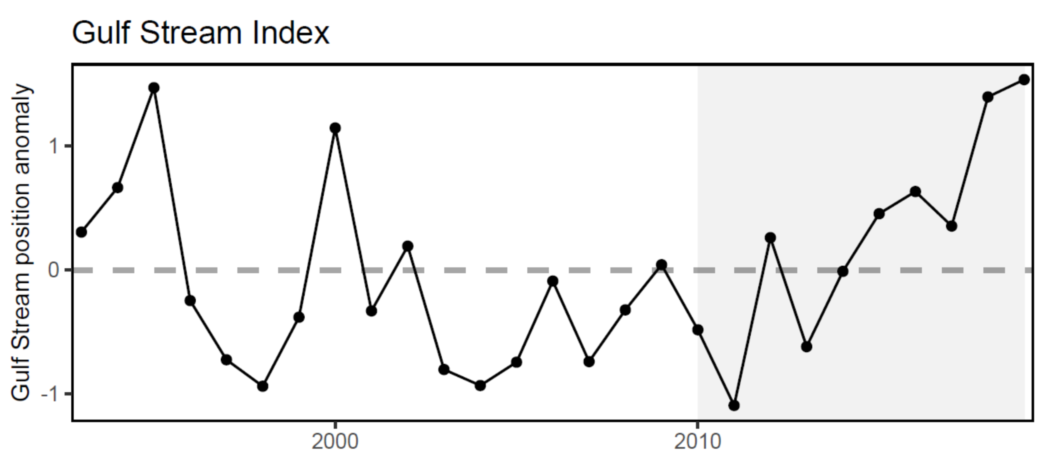

Figure 4: Index representing changes in the location of the Gulf Stream north wall. Positive values represent a more northerly Gulf Stream position. Source: [2021 State of the Ecosystem Report, New England.]

Long Term Cycles

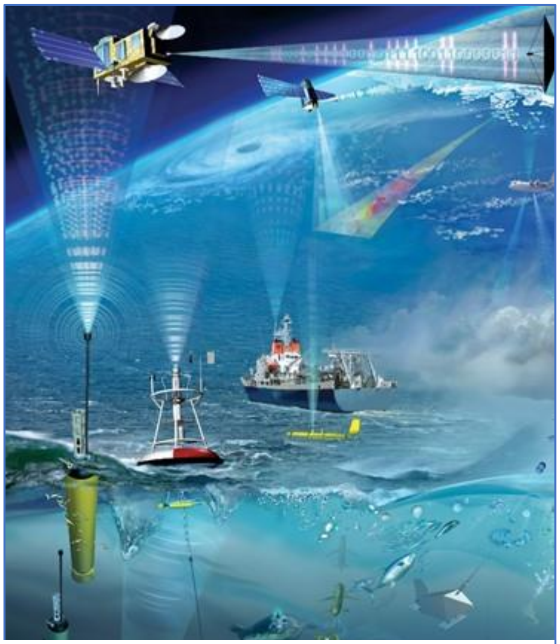

Figure 5: Ocean observing systems utilize satellites, radar arrays, weather buoys, survey vessels, and autonomous and remotely operated vehicles to collect data needed to understand how seasonal and long term cycles may be changing. Artwork by Glynn Gorrick.

Long term cycles such as the Atlantic multi-decadal oscillation (AMO), the North Atlantic oscillation (NAO) and El Niño are large scale coupled oceanographic-atmospheric features that typically vary on decadal scales. Changes in these cycles have strong effects on weather patterns, and ocean temperatures along the east coast. The AMO has been in a warm phase for several decades while the NAO has become more variable recently. These long-term cycles, on top of human driven climate change affect hurricane development, precipitation patterns and ocean temperatures which in turn impact species abundance and distribution.

Key Uncertainties: Will the long term cycles continue to oscillate, or will they increase in variability or become fixed in one phase in the next 20 years?

Cold Pool

The cold pool is a large reservoir of cold, winter water on the Mid-Atlantic continental shelf that forms as surface waters warm in spring and summer months. During the summer this region has one of the world's largest top to bottom temperature differences. This intense stratification, with much colder (less than 45°F) water held below very warm surface waters historically persists into the fall. The cold pool is a significant oceanographic feature affecting diverse processes including defining habitat size and structure for diverse living marine resources and driving coastal upwelling events and plankton blooms. The cold pool is also a major factor influencing hurricane strength via downwelling or mixing, depending on the direction of the surface winds. The size and position of the cold pool varies annually and it is significantly smaller and less persistent during warmer years.

Key Uncertainties: Will the volume and position of the cold pool persist within historical ranges?

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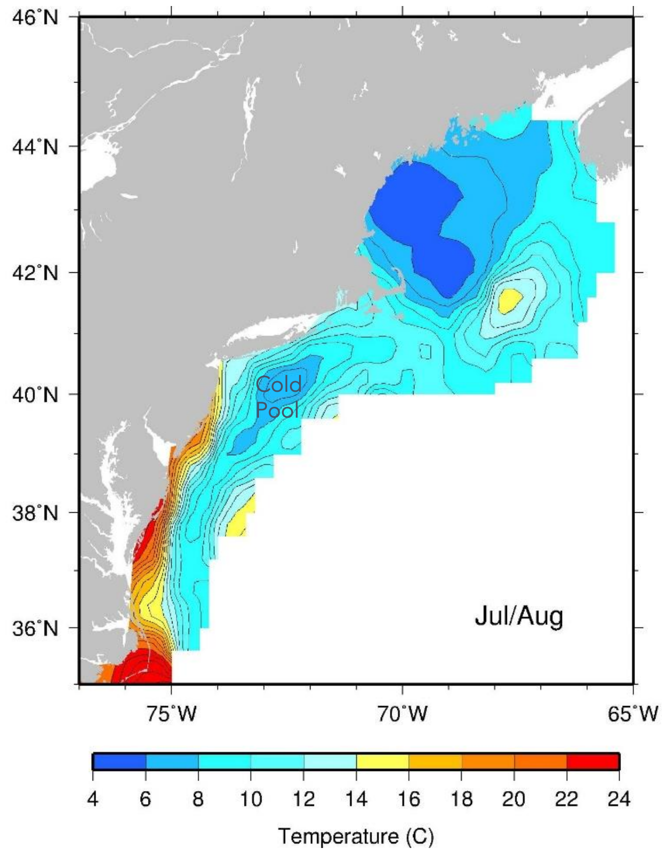

Figure 6: Average bottom temperature distribution on the Northeast U.S. Shelf for July-August, showing the Mid-Atlantic Bight cold pool. Source: NOAA Northeast Integrated Ecosystem Assessment.

Water Chemistry

Nutrient supply of nitrogen and phosphorus to east coast coastal and marine ecosystems is provided by deep ocean water flowing over the continental shelf break as well as by river runoff, stormwater runoff, and wastewater treatment plant outfalls from Maine to Florida. Although much progress has been made in reducing nutrient loading to estuaries and coastal habitats since the 1970s, hypoxic zones with oxygen levels too low to support most life are still frequent events along the east coast.

Ocean acidification is occurring on the east coast and is being documented through recently expanded monitoring efforts networks developed by all three of the Atlantic coast's Regional Ocean Observing Systems. While low pH (more acidic) conditions can impact nearly all marine life, animals with calcium based shells including corals, scallops, clams, and oysters are particularly vulnerable. Although documentation of present day impacts is limited, there is a high level of concern regarding potential impacts to coral reefs in Florida and future potential impacts to shellfish as well as other species including finfish and diatoms.

Key Uncertainties: It seems likely that coastal and ocean ecosystems will experience more hypoxia due to rising temperatures. Will these zones become more problematic? Which areas are most susceptible? Will human intervention succeed in limiting dead zones in important areas? Will ocean acidification begin to impact east coast species in major ways? Could some species adapt to gradual changes in ocean acidification?

Figure 7: Hypoxia driven by increased nitrogen levels and resulting algal blooms was a major cause of several fish kills in the Peconic River (NY) in the summer of 2015. Source: Investigation of Fish Kills Occurring in the Peconic River - Riverhead, N.Y., Spring 2015.

Primary Production

In the Southeast and up through the Mid-Atlantic, waters are generally nutrient poor. Primary productivity is associated with shelf break upwelling, coastal nutrients from runoff, and Gulf Stream eddies. The Gulf Stream intensity and proximity to shore is an important driver for primary productivity, along with nutrient supply and other factors, depending on the location and season. Although published information indicates primary productivity is relatively stable, there has recently been suggestion of changes in upwelling dynamics.

In the Northeast, waters are highly productive, in nearshore waters as well as adjacent to bathymetric features such as Georges Bank and Stellwagen Bank.

The Atlantic coast's major phytoplankton blooms typically occur in the winter-spring with a smaller bloom in the fall. These blooms are largely driven by seasonal dynamics including stratification, upwelling, and nutrient availability. Primary productivity has been increasing in the Northeast and Mid-Atlantic, likely due to warming waters. This increase is mostly in summer production of smaller phytoplankton species making relatively small contributions to the diet needs of predators higher in the food chain. Primary production in Southeast waters is variable and changing, and its interaction with Gulf Stream position and upwelling dynamics is a research priority.

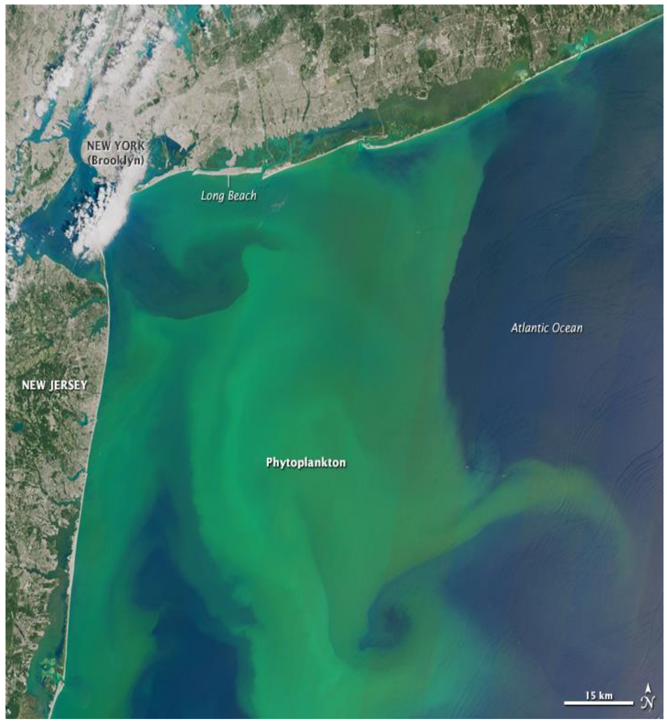

Figure 8: A phytoplankton bloom off the coast of New Jersey and New York, August 3, 2015. Source: NASA Earth Observatory.

Key Uncertainties: As primary production is affected by several interacting factors, future trends are difficult to discern. Will rising ocean temperatures continue to cause higher primary productivity? Will changing runoff patterns make a difference? How will Gulf Stream changes affect productivity? Will productivity changes happen in a similar fashion coastwide, or will there be more variability in specific locations?

Extreme Weather Events

Figure 9: Chief Petty Officer Mark Fisher places an Assessment Sticker on a vessel displaced by Hurricane Irma in the area of Dinner Key, near Miami, October 2017. Source: U.S. Coast Guard photo by Chief Petty Officer Nick Ameen.

Increased frequency of extreme weather events are one of the most concerning impacts of climate change. The 2020 hurricane season included thirty named storms that caused over $42 billion in Atlantic coast damages. In addition to catastrophic damage from high winds and flooding, increased extreme precipitation events and freshwater inflow are driving increased nutrient loading and pollution in coastal areas. While these impacts are particularly acute in the Southeast region, this is a coastwide issue.

Marine heatwaves are defined as events when sea surface temperatures exceed 90% of past observations for a particular place and time and these conditions persist for more than five days. The marine heat wave of 2012 on the Northeast shelf lasted 56 days, one of the largest ever documented. The event disrupted the timing and productivity of phytoplankton and zooplankton at the base of the food chain. Mid-Atlantic species were seen north of their typical ranges and a temporary new fishery for longfin squid opened in the Gulf of Maine. This heat wave affected several harvest species, with major impacts to the lobster fishery disrupting timing, supply chains and markets. The Northeast continues to see an increase in marine heat waves.

Key Uncertainties: We are already observing more frequent and intense storms. Over the next 20 years, will this pattern continue, reverse or accelerate? Will extreme weather events become more frequent and intense, and will they last longer? Will they become more disruptive to coastal habitats and infrastructure? What impacts might more frequent marine heatwaves have on east coast ecosystems and fisheries? Will we learn to better predict and adapt to such extreme events, or will they continue to surprise us?

Sea Level Rise

Sea level along the Atlantic coast is rising three to four times faster than the global rate and exacerbating impacts of other drivers such as extreme weather events and coastal habitat loss. There has been a large increase in nuisance flooding (high tide flooding) up and down the coast with a greater increase in the Southeast and parts of the Mid-Atlantic.

Key Uncertainties: As sea levels are predicted to rise, the main uncertainty relates to the rate of increase. Sea level rise is often seen as a development that happens gradually over many decades. Will that assumption hold, or might we see faster rises in sea levels in the next 20 years? How might these rises combine with storms and tides, and what might be the consequences for damage to coastal infrastructure? Will there be impacts on the distribution and productivity of key species?

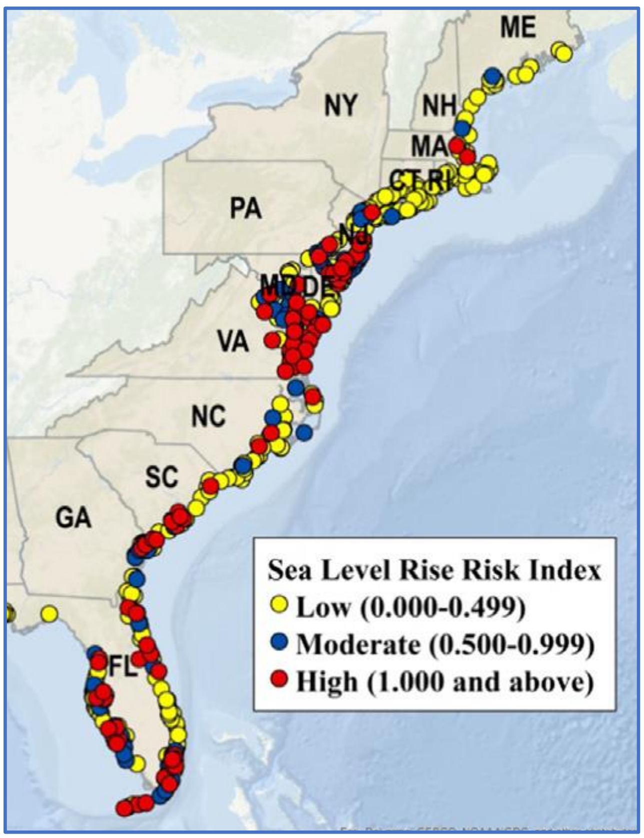

Figure 10: Community sea level rise risk based on area lost at 1-6 feet. Source: [Colburn et al. 2016.]

References and Further Reading

- 2021 Ecosystem Status Report | Southeast
- 2021 State of the Ecosystem | Mid-Atlantic
- 2021 State of the Ecosystem | New England
- Northeast Regional Association of Coastal Ocean Observing Systems
- Mid-Atlantic Regional Association Coastal Ocean Observing System
- Southeast Coastal Ocean Observing Regional Association
- Climate Change in the Northeast U.S. Shelf Ecosystem (NEFSC)
- OceanAdapt (Rutgers University)
- Fourth National Climate Assessment (Oceans & Marine Resources)