East Coast Climate Change Scenario Planning

Summary of Exploration Phase Webinars: Drivers of Change in East Coast Fisheries

February-March 2022

New England Fishery Management Council

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

NOAA FISHERIES

1. 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.

The Exploration Phase of the initiative looks in detail at the future - at the *drivers of change* that are likely to shape conditions facing East Coast fisheries over the next 20 years. These factors will provide the building blocks for the construction of a set of scenarios in the next phase of the process.

Exploring the future of East Coast fisheries in an era of climate change is a complex task, with many drivers of change. These drivers were clustered into three broad categories:

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)

For each of these categories, we created a set of briefing materials that described component drivers of change - these briefing materials are contained in the appendices to this document.

We also organized a series of three webinars involving speakers and panelists discussing their views on the drivers of change that they felt were most meaningful. Each webinar was attended by over 175 participants. This document provides a summary of each of the three webinars. Recordings of each webinar are available at: https://www.mafmc.org/climate-change-scenario-planning.

The themes and ideas raised in the briefing materials and during the webinar conversations will be used to shape the scenarios in the next phase of the initiative.

2. Webinar 1: Oceanographic Drivers of Change

The briefing material (Appendix 1) outlined a number of oceanographic **drivers of change** - factors that have the potential to shape East Coast fisheries over the next 20 years. These include:

- Ocean temperature changes
- Currents
- Long term cycles
- Cold pool
- Water chemistry
- Primary production
- Extreme weather events
- Sea level rise

To look in detail and discuss these and other drivers, a 1.5 hour webinar was held on February 14, 2022. The webinar was attended by 269 people. Speakers and panelists were as follows:

Main Speaker: Dr. Charlie Stock, Research Oceanographer, NOAA's Geophysical Fluid Dynamics Laboratory

Panelists:

- Zack Klyver: Science Director, Blue Planet Strategies
- Dr. San-Ki Lee: Oceanographer, NOAA's Atlantic Oceanographic and Meteorological Laboratory
- Dr. Shannon Mesek: Research Chemist, NOAA's Northeast Fisheries Science Center
- Capt. Chris Roebuck, Owner and captain of F/V Karen Elizabeth; Cooperative research participant *(invited; unable to attend)*
- Dr. Vince Saba: Research Fisheries Biologist, NOAA's Northeast Fisheries Science Center, Ecosystem Dynamics and Assessment

Charlie Stock provided a presentation that focused on some of the key oceanographic drivers of change. Some of the main messages from Charlie's talk were as follows:

- We are experiencing both climate change and climate variability. The interaction between them leads to some uncertainty in predicting oceanographic conditions over the next 20 years.
- The Northwest Atlantic is one of the fastest warming areas of ocean. Sea surface temperatures have risen rapidly in New England and Mid-Atlantic but less so in

the South Atlantic. This pattern of rapid warming in the Northwest Atlantic could plausibly continue, but different, alternative trends could emerge:

    - The Atlantic Multidecadal Oscillation (AMO) and other modes of natural climate variability might swing toward a "cooler" state, counteracting greenhouse gas warming and temporarily stalling the warming trend.
    - The AMO and other variability modes might remain "warm," allowing greenhouse gases to continue warming, though likely at a reduced rate relative to when variability was shifting from "cold" to "warm."
- CO2 induced ocean acidification is not expected to be a problematic issue due to emissions in a 20-year time frame. However, water saturation of calcium carbonate will affect species' ability to form shells. Levels of water saturation are affected by a combination of circulation, warming and other coastal processes.
- The impact of primary production is hypothesized to vary with latitude. Warming water is expected to lead to reduced mixing and an increase in plankton in surface waters in higher latitudes. But at lower, tropical latitudes, ocean warming will create lower nutrient supplies and a decrease in plankton near the surface.
- Ocean conditions could also be affected by some "wildcards" – for example, major Harmful Algal Blooms, or regime shifts from a loss of a critical food resource.

Each of the panelists commented on Charlie's talk and added their own perspectives on important oceanographic drivers of change.

Sang-Ki Lee emphasized the different experiences of changing ocean temperature in New England compared to the South Atlantic. Northerly waters have seen a large build up in heat over time. But in the South Atlantic, change is seasonal, with warmer waters in summer, but colder waters in winter. This is suspected because of increases in cold fronts, which are expected to increase in frequency with further warming.

Shannon Mesek drew attention to bottom water. Much data refers to sea-surface temperature, but bottom water contains valuable fisheries. For example, the cold pool is a critical habitat for many species in the mid-Atlantic bight. Vince Saba added that the cold pool has gotten smaller and persisted for less time in recent years. We can expect this trend to continue in future.

Vince Saba also commented on the difficulty of using global climate models to assess coastal ecosystems. The interaction between temperatures, AMOC, acidification and other factors gets very complicated. We now have a lot of data, but applying this at a suitable resolution is critical.

Zach Klyver relayed his experiences in running whale watching trips off the New England coast. He has had to adjust his business model, going farther offshore and with longer trips. The types of species he is seeing are changing significantly. In 2000, over 150 trips saw finback, but in recent years, almost no trips have done so. Contrast this with Ocean sunfish – the abundance in the Gulf of Maine went from very rare to 60 in one trip.

Workshop participants contributed questions and comments via an online chat function. Some of the key questions referred to:

- Storms, stratification and primary productivity: Sang-Ki Lee explained how models currently suggest that we might see fewer cyclones off the Florida coast, but many storms will be much stronger, with rainstorm levels increasing by 10%. Charlie Stock suggested that any increased frequency of storms will not be a big driver of integrated productivity. However, such storm activity could have an impact on harmful algal blooms, a possibility that is worth exploring further.
- Will non-co2 pollution (such as nutrient run-off) have an impact on productivity? As such run-off moves into offshore water, we can expect nutrients to have less impact. While the East Coast does not have the features of a Mississippi, it still contains sizeable rivers and critical estuaries. Chesapeake Bay, for example, will need to look at policies to prevent the worst effects of pollution and nutrient run-off over the next 20 years.
- Do we think that predicting future ocean conditions will be more straightforward than those on land? How confident are you that we can get the science to actually help us plan ahead? It will be important to bound the range of possibilities. If we can do this, then it's possible to identify robust management strategies. We can hope for the best, but plan for the worst. More generally, the ocean has a long memory, so things generally tend to be more predictable over longer timescales. Looking at things in an optimistic way, I hope that we can get the science in place to put some odds on different outcomes. We are not there yet, but I'm hopeful.

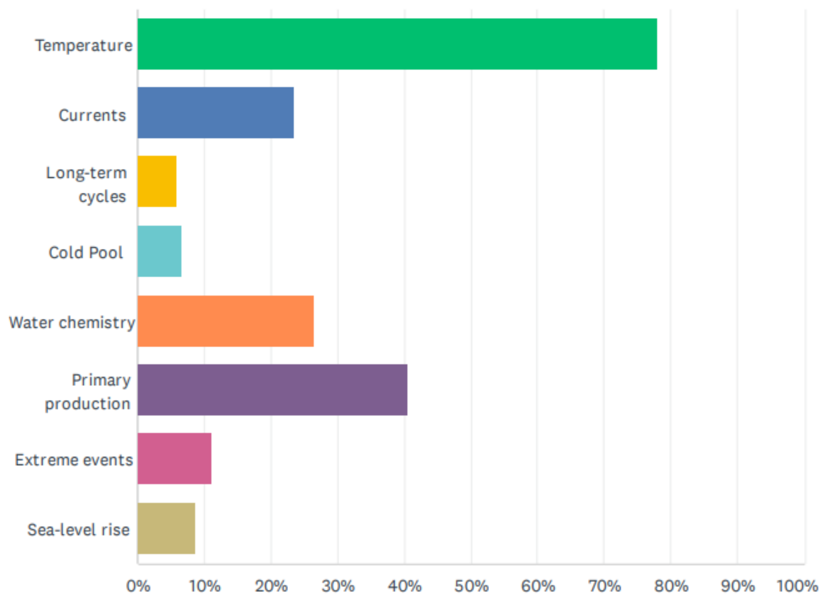
Drivers of Change Poll

Following the presentation and panel discussion, webinar attendees were asked to respond to two poll questions. These questions asked respondents to select those oceanographic drivers of change that they think (i) will have the greatest impact on East Coast fisheries in the next 20 years, and (ii) are most uncertain / unpredictable over the next 20 years.

136 participants responded to the poll, with the results as follows:

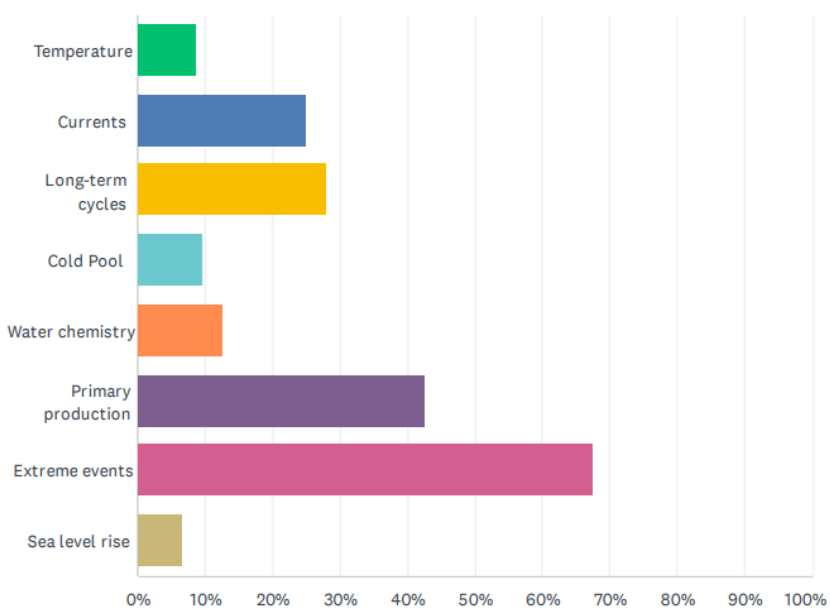
Q1 Of these oceanographic drivers of change, which do you feel will have the most impact on East Coast fisheries / your activities over the next 20 years?* (Please select TWO answers)

Answered: 136 Skipped: 0



Q2 Of these oceanographic drivers of change, which do you feel are the most unpredictable over the next 20 years? (Please select TWO answers)

Answered: 136 Skipped: 0



The poll results showed that participants assessed that temperature changes will have the most impact on fisheries, with relatively low levels of unpredictability. Water chemistry and primary production are also seen as very important drivers of change – i.e. most likely to have a sizeable impact on shaping east coast fisheries.

In terms of unpredictability, extreme events score highest. But people also see primary production as significantly uncertain. Currents and long-term cycles are seen as unpredictable by a quarter of respondents.

3. Webinar 2: Biological Drivers of Change

The briefing material (Appendix 1) outlined the following as important biological drivers of change:

- Distribution changes
- Productivity changes
- Seasonal timing
- Habitat changes
- Diseases
- Harmful Algal Blooms
- Invasive Species

To look in detail at these and other drivers, we held a webinar on February 23, 2022. The webinar was attended by 215 people. Speakers and panelists were as follows:

Main Speaker: Dr. Janet Nye, Associate Professor, University of North Carolina

Panelists:

- Dr. Mandy Karnauskas, Ecosystem Science Lead, Southeast Fisheries Science Center
- Capt. Ira Laks, Charter and commercial fisherman; Chairman of SAMFC Mackerel Cobia Advisory Panel
- Dr. John Manderson, Principal Consultant, OpenOcean Research, Blue Hill Partners
- Dr. Malin Pinsky, Associate Professor, Rutgers University

Janet Nye presented an overview of many of the biological drivers of change expected to affect fisheries in the next 20 years.

- She explained how organisms respond to climate change through both direct and indirect effects. Direct effects include spatial shifts, population productivity, phenology and changes in community assemblages. The indirect effects emerge through changes in food availability, habitat availability, trophic interactions, disease incidence and emergent properties of food webs / ecosystems.

- Temperature drives species shifts through two mechanisms: movement/migration and population productivity.
- Some species move faster, and others slower, than what would be expected by water temperature
- Models predict decreases in primary productivity, while changes in many stock productivity are already evident, with greater impacts on overfished populations.
- We should expect to see smaller body sizes "shrinking of fish" in the coming years due to warming and reduced oxygen.
- Disease could increase with climate change. One example with corals has seen in an increase in diseased tissue but not an increase in mortality.

Each of the panelists commented on Janet's talk and added their own perspectives on important oceanographic drivers of change.

Dr. Karnauskas explained how the most important changes in distribution are not uniform, and instead they vary by region and species. The biggest challenge is to detect responses at population levels, and then determine which drivers are most influential. Dr. Karnauskas described the difficulties of explaining population declines in dolphinfish (Mahi Mahi) in the South Atlantic region. There have been significant changes in temperature, upwelling and primary productivity, but the data on landings is limited due to unreported catch and the fact that Mahi Mahi is a highly migratory species.

Captain Laks relayed the frightening experience of being in the Southern end of ranges and seeing species moving away/ Important species (Mahi Mahi, Spanish Mackerel) seem to be going farther North and not coming back as early. It also seems that forage fish are disappearing from many fishing waters.

Dr. Manderson prefaced his remarks by stating "the future is now." Predictions about changes shouldn't be thought of as predictions – they are already happening in our waters. Like Dr. Karnauskas, he also acknowledged the difficulty of monitoring, and recognized that we need to better understand how our observations are changing what we see. For example, it is difficult to assess whether changes are a distribution problem or a productivity problem. A general concern is that information and action is way behind actual changes in our ecosystems. Academic science is 2-3 years behind the ecosystem. Applied science is 5-7 years behind, and then governance is two years behind that. The process needs to be speeded up, mostly by working more directly with the fishing industry.

Dr. Pinsky reinforced the message about the limitations of today's data in a situation where the ecosystems are non-stationary. The fundamental problem is that the ecosystem is changing, and by the time we get information to management it can be too late. There is a need for more real-time monitoring and forward looking projections. Could near-term projections (10-20 years) for ocean and species be more useful for guiding fisheries management decisions that are getting more difficult each year?

Workshop participants contributed questions and comments via an online chat function. Some of the key questions referred to:

Effects of coastal habitat loss from climate and non-climate stressors: Capt. Laks recognized the problem and explained that they are now feeding manatees due to lack of seagrass. This is a major problem and there is little expectation that things will improve. Dr. Karnauskas agreed, and highlighted that changes in habitat feed into changes in productivity in a gradual and lagged fashion. Hence tracking and accounting for the impacts in stock assessments is difficult.

Dr. Pinsky drew attention to the importance of estuarine conditions. The question becomes: will the habitat conditions be suitable when species move to an area? For example, pollution abatement should not be focused on where we need it now, but on where we will need it in the future. Dr. Manderson agreed that estuaries are critical and sea level rise is endangering shallow water habitats.

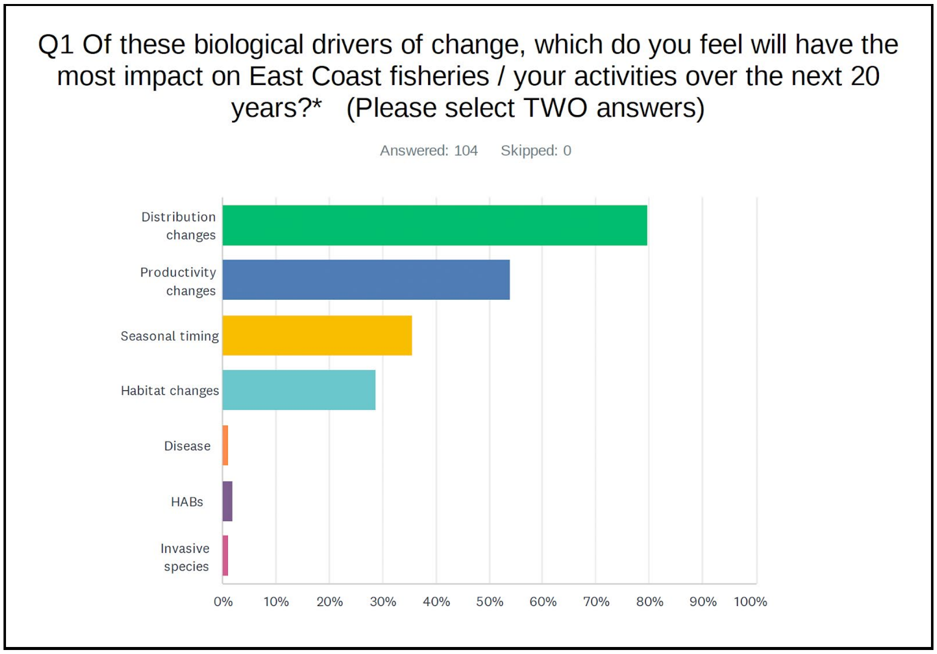
Are species shifting climate the same "invasive species"? Dr. Pinsky looked to reframe the concept of 'invasive species.' It's better to think about the whole process of adaptation. We have species leaving and others moving in. We are no longer managing for a stationary ecosystem and instead need to manage for active transition.

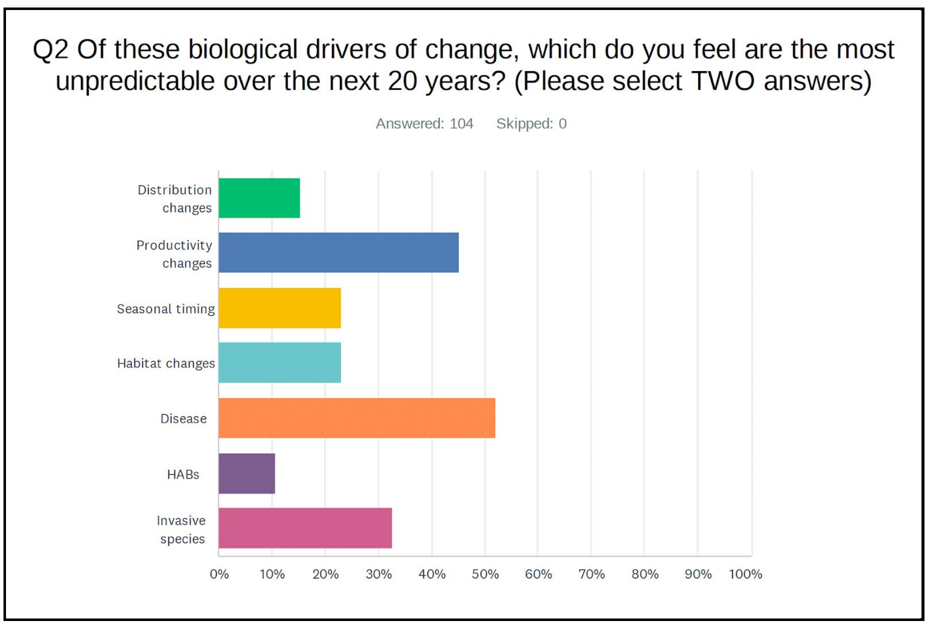
Discussion about trailing / leading edges of stocks on the move. The problem with the trailing edge is that people don't want to let go. Our governance structures are based on land-based viewpoints. It is not built for a liquid situation. Trailing edges might have genotypes that are most adaptive to changing conditions, so we need to be careful at the trailing edge. In the leading edge, fishing at this edge might slow down the range expansion. Dr. Nye commented on how we are not collecting the right data to assess this.

Drivers of Change Poll

Following the presentation and panel discussion, webinar attendees were asked to respond to two poll questions. These questions asked respondents to select those biological drivers of change that they think (i) will have the greatest impact on East

Coast fisheries in the next 20 years, and (ii) are most uncertain / unpredictable over the next 20 years. 109 participants responded to the poll.





Around 80% of attendees agreed that distribution changes were one of the top biological drivers of change that would shape east coast fisheries in the next 20 years. More than half also suggested that productivity changes would have a high impact. Changes in seasonal timing and habitat conditions are also noted as high impact.

In terms of uncertainty, attendees highlighted disease as an unpredictable driver of change. There was less uncertainty in distribution changes, while almost half of attendees felt that future productivity changes have a significant degree of uncertainty attached to them. Over a third of attendees also highlighted invasive species as an uncertainty to watch.

4. Webinar 3: Social & Economic Drivers of Change

The briefing material (Appendix 1) outlined a number of **drivers of change** - factors that have the potential to shape East Coast fisheries over the next 20 years.

- Population growth and demographics
- External cost factors
- Waterfronts and infrastructure
- Consumer demand and market dynamics
- Technological change
- Competing ocean uses
- Social Vulnerability and Environmental Justice

To look in detail and discuss these and other drivers, we held a 1.5 hour webinar on March 2, 2022. The webinar was attended by 176 people. Speakers and panelists were as follows:

Main Speaker: Dr. Doug Lipton, NOAA Fisheries

Panelists:

- Dr. Matt Cutler, Social Scientists, NOAA Fisheries Northeast Fisheries Science Center
- Dr. Matt McPherson, Director, Social Science Research Group, NOAA's Southeast Fisheries Science Center
- Dr. Kathy Mills, Research Scientist, Gulf of Maine Research Institute
- Rick Robins, Marine Affairs Manager, RWE
- Capt. Tom Roller, WaterDog Guide Service; NC At-Large Seat, SAFMC

Doug Lipton provided a presentation overview of some of the major social and economic drivers likely to shape east coast fisheries over the next 20 years.

- His remarks began with two critical questions that are relevant to the overall scenario planning exercise. First, how will fishing and related sectors respond to changing fish distributions, and second, how will external factors influence their ability to make those decisions?
- Looking at the external factors, fish are part of a larger food system that depends on demand, trade and technology. The shocks of the past couple of years (e.g. pandemics and wars) will have impacts on trade, while technology

advances (e.g. aquaculture) may lower seafood prices due to market saturation. Alternatively, wild caught seafood might become more of a premium market in contrast to farmed seafood.

- Cost pressures are another major factor that will shape fisheries, and these costs will be affected by fuel prices, distances to port, crew wages, port facilities etc.
- Offshore wind is another major driver of change, creating competition for port space, competition for crew and affecting fishing grounds.
- The most critical question is what can we do now to stabilize and support fishing industries through this time of transition. If this requires capital investment, who will provide that? Will it be existing industry, new investors or government? And what management policies create the flexibility to incentivize adaptation?

Dr. Matt Cutler highlighted the importance of identifying underserved communities at this time of transition. We need to identify vulnerabilities and options to offset risks to these communities. Also critically important to this task will be meaningful engagement with underserved communities and co-production of knowledge through stakeholder partnerships and participation in research to better understand community vulnerabilities.

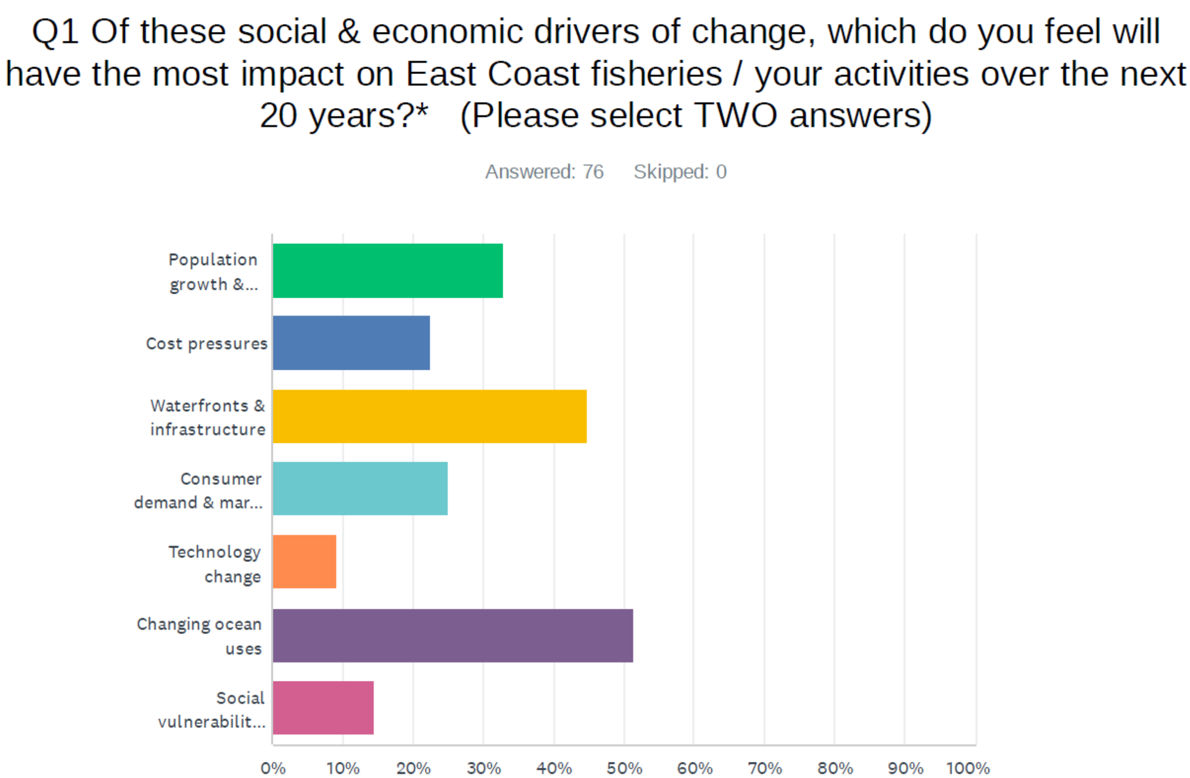
Kathy Mills focused on the potential for adaptation. The core question is: how well will fisheries be able to buffer changes from climate? What will it mean to adapt to changes in fish availability? Looking at today's situation, adaptive capacity varies between and within fleets, and these differences can reflect and impact equity. It's also important to mention how sea level rise poses risks for waterfronts. The scenarios should consider what changes may happen in the ecosystem, as well as how humans will adapt to those changes. Fishermen have shown time and time again they can adapt, but the regulatory systems, markets, etc. may not be able to adapt as effectively.

Capt Tom Roller outlined the main risks facing recreational anglers and for-hire businesses. There are important interplays between federal and state fisheries, and we must expect that there will be a shifting of effort across different jurisdictions. He expects that the lag between changes on water and management is poised to get worse. Coastal communities are growing rapidly and creating challenges for dock / water access. He commented that damages from coastal storms is a major threat and our ability to respond to damages needs to be faster to help fishing businesses get working again following storm events and other climate driven disasters.

Rick Robins explained how offshore wind is sure to be a big factor in the next 20 years, and stressed the importance of thinking strategically about the intersection of fisheries and offshore wind development. The need for mitigation will be a function of the siting and project development process. Siting is critically important and impacts can there are encouraging signs of cities taking a broader planning perspective that takes ocean change and fisheries into account. We need to spend more time understanding the factors that have led to both effective and ineffective community resilience. Also, this whole scenario planning initiative is about trying to encourage more 'proactive adaptation' by creating scenarios that imagine the future, it is hoped that communities and fishery managers are better prepared for future shocks.

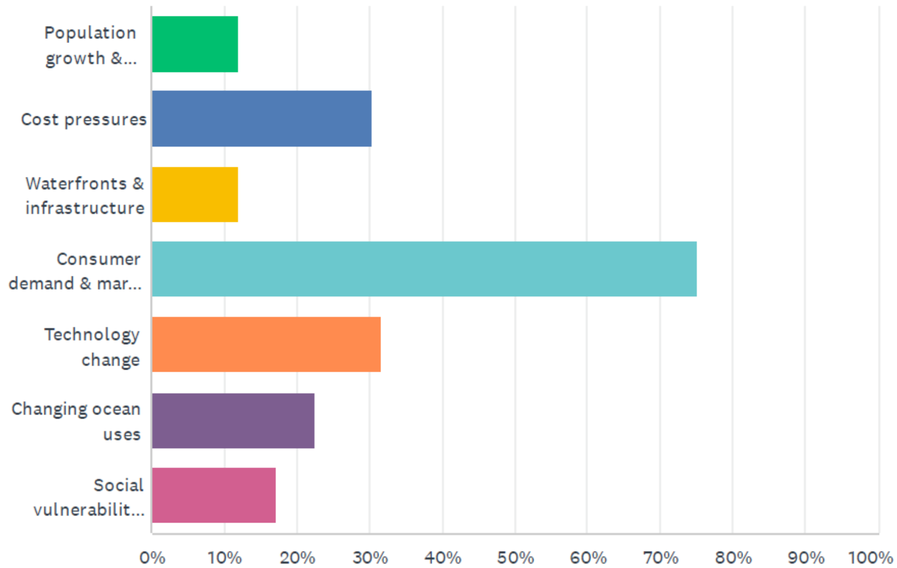
Drivers of Change Poll

Following the presentation and panel discussion, webinar attendees were asked to respond to two poll questions. These questions asked respondents to select those biological drivers of change that they think (i) will have the greatest impact on East Coast fisheries in the next 20 years, and (ii) are most uncertain / unpredictable over the next 20 years. 109 participants responded to the poll.



Q2 Of these social & economic drivers of change, which do you feel are the most unpredictable over the next 20 years? (Please select TWO answers)

Answered: 76 Skipped: 0



Around half of respondents voted for *changing ocean uses* as one of their most important social & economic drivers of change, most likely reflecting the potential impact of wind power installations on fisheries. 45% of respondents selected changes in waterfronts & infrastructure as particularly significant, while over a third highlighted demographics and a changing population as very relevant.

In terms of unpredictability, around three-quarters pointed to consumer demand and market dynamics as a highly uncertain factor that will shape conditions over the next 20 years. We have seen how the market dynamics have been affected (through shocks such as Covid-19), and given levels of global instability, it is not surprising that trade and supply chains are likely to be highly unpredictable for years to some. Shifts in consumer demand might also be uncertain. Cost pressures and technology changes were also mentioned as unpredictable by 30% of respondents.

5. Final Reflections on Exploration Phase

The exploration phase was designed to educate, engage and focus attention on some of the most important factors that are expected to shape East Coast fisheries over the next 20 years.

The primary takeaway from the webinars was an acknowledgement that we are in a time of significant change in ocean conditions, ecosystems and fishery resources. Change will continue, and we can and should expect to be affected by more shocks or "inevitable surprises".

Some of the changes - at a big picture level - are broadly predictable. We can expect ocean temperatures to increase, primary productivity to decline and extreme weather events to become more intense and destructive. But these trends are unlikely to be entirely predictable: patterns will vary across an area as large and diverse as the US Atlantic Coast.

We can expect that stock distribution changes will be an essential feature of the next 20 years, with a broad trend towards species' moving north and into deeper waters. However, distribution changes are by no means uniform and will vary by species and region. Habitats are expected to degrade, but the impact of such changes will most likely happen in a gradual and lagged fashion.

The complexity of changes to our oceans, ecosystems and fishery resources is difficult to track. As conditions change and become 'nonstationary,' our scientific information is instantly outdated. Management/governance decisions based on such information will always struggle to reflect an accurate picture of the real-time situation. Faster, more effective and collaborative ways of collecting data - and acting upon it - will be required for being better prepared for the future.

Ocean users - commercial vessels, recreational charters, whale-watching trips etc. are all experiencing changing conditions, concerned about species moving north, forage fish disappearing and more problematic habitats. These kinds of changes will likely continue, and new developments such as wind power installations will offer new challenges and some opportunities. It is evident that people are becoming more accustomed to change - willing to accept that conditions in the future will be different than those of today. Communities are reacting and adapting to major changes (such as storms), but there is still a need for more collaboration and long-term thinking, to deliver 'proactive adaptation.'

The purpose of the next phase of this initiative is to create a handful of stories - scenarios - that "make sense" of all this complexity and change. We cannot predict the future, but if a broad group of stakeholders imagine several different plausible ways that the next 20 years could play out, we can all be better prepared for whatever occurs next.

Amidst this change, complexity and "inevitable surprises", one thing is indeed certain. Even though we cannot know exactly what future conditions will be, that should not stop us from being prepared and suggesting important changes now - suggestions about how fishery management and governance could evolve, or suggestions for how fishing communities can become more resilient and successful. Creating scenarios and suggesting ways to be prepared for the future are the tasks ahead in Phases 4 and 5 of the scenario planning process.

Appendix 1: Exploration Webinar Briefing Materials

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New England Fishery Management Council

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

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?

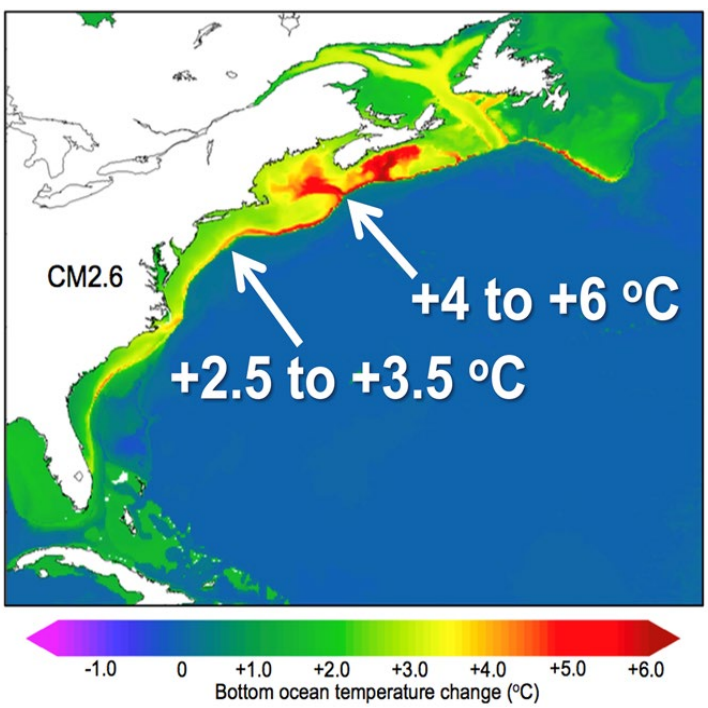

Figure 3: Global climate models can project how ocean conditions will change over time. This figure shows how ocean bottom temperatures are projected to increase, especially north of Cape Hatteras, NC, by the 2060s to 2080s under a scenario where carbon dioxide (CO2) increases by 1% per year and doubles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

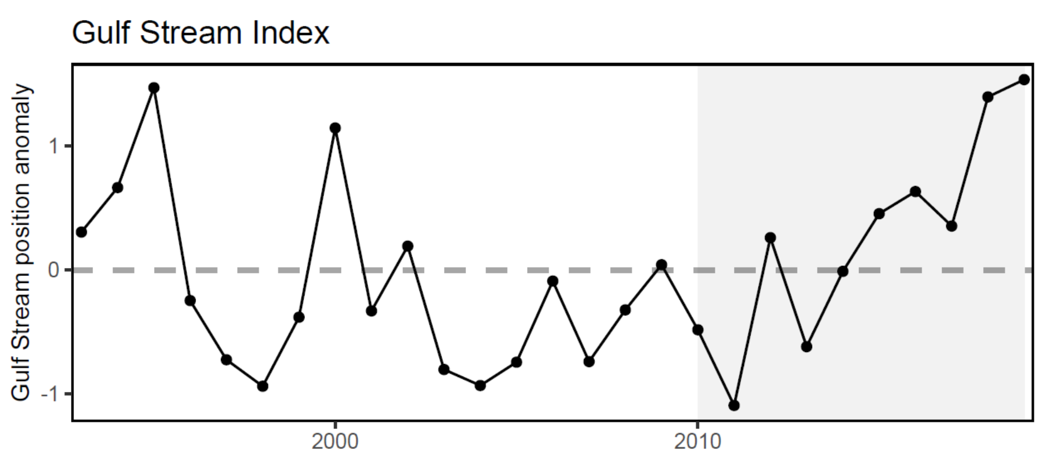

Figure 4: Index representing changes in the location of the Gulf Stream north wall. Positive values represent a more northerly Gulf Stream position. Source: [2021 State of the Ecosystem Report, New England.]

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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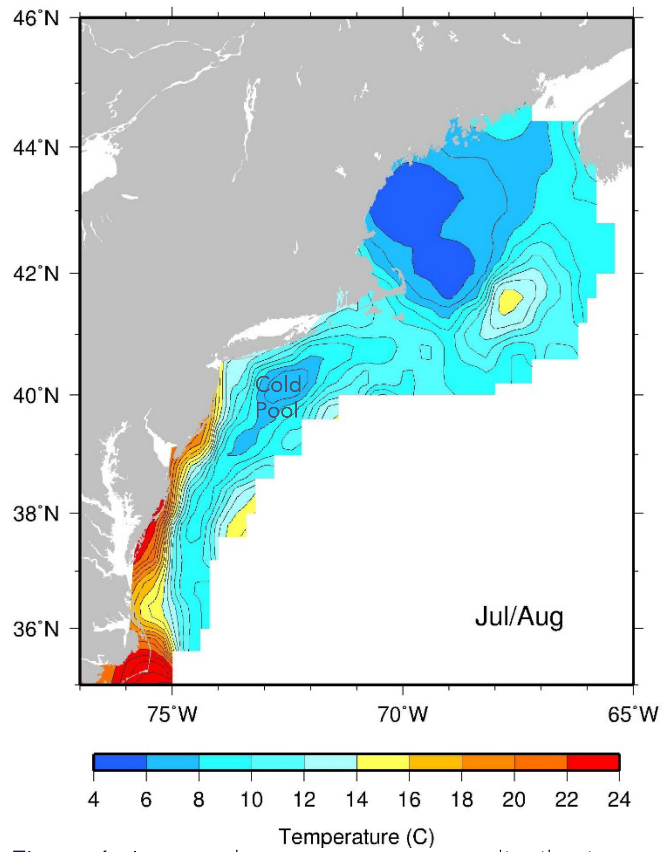

Figure 6: Average bottom temperature distribution on the Northeast U.S. Shelf for July-August, showing the Mid-Atlantic Bight cold pool. Source: NOAA Northeast Integrated Ecosystem Assessment.

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.

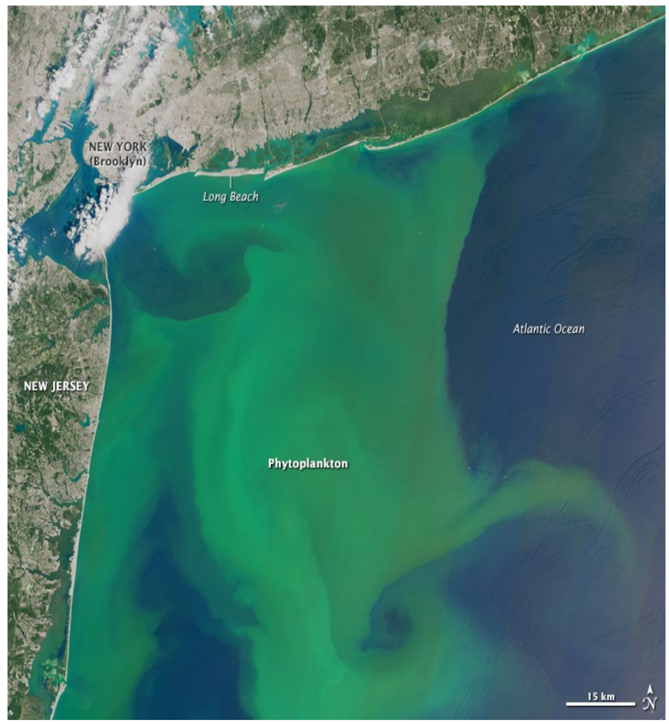

Figure 8: A phytoplankton bloom off the coast of New Jersey and New York, August 3, 2015. Source: NASA Earth Observatory.

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?

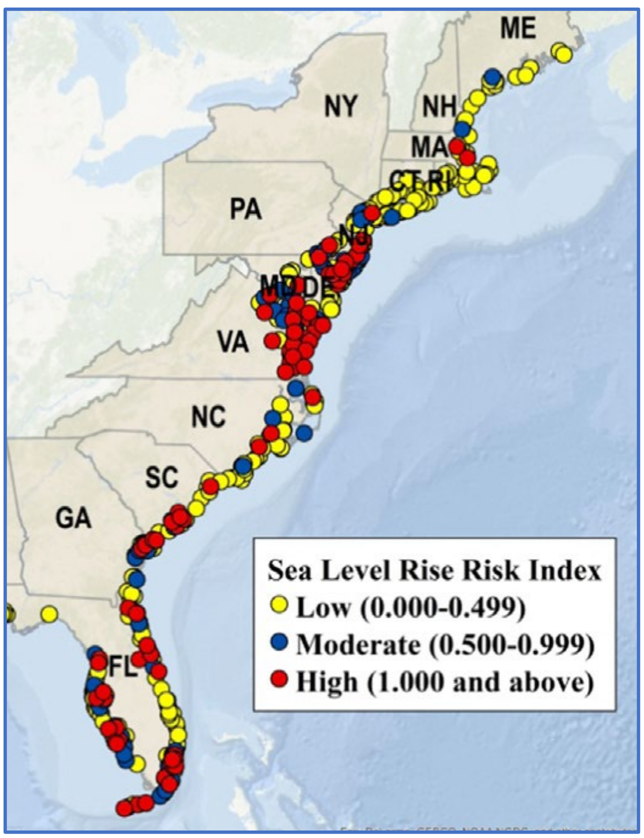

Figure 10: Community sea level rise risk based on area lost at 1-6 feet. Source: Colburn et al. 2016.

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)

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.

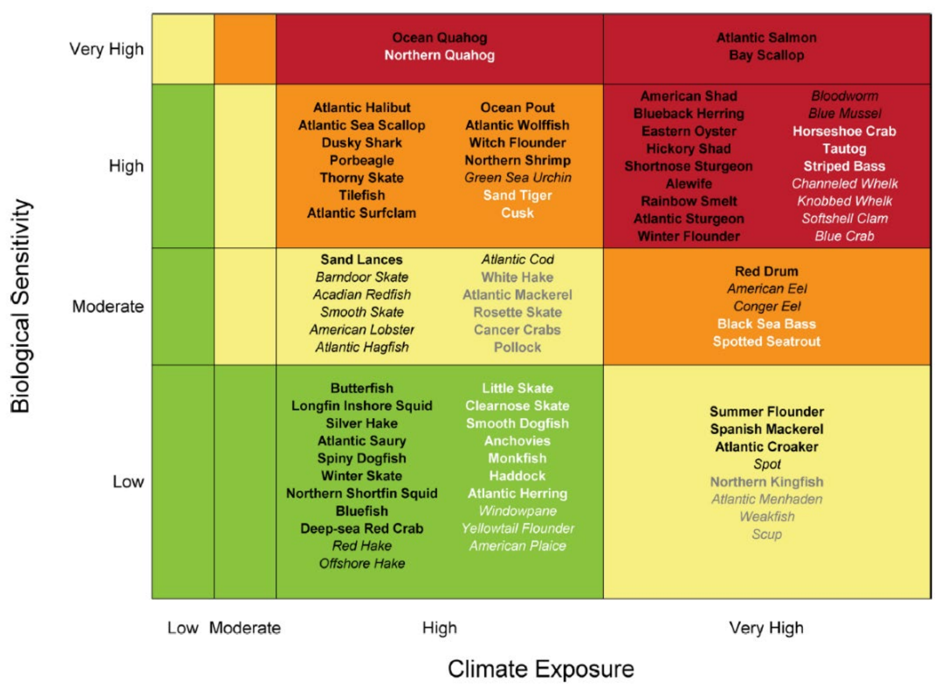

Figure 11: An evaluation of species vulnerability to climate change in the Northeast and Mid-Atlantic regions considered both the exposure and biological sensitivity of various species to climate stressors. Overall climate vulnerability is indicated by color: low (green), moderate (yellow), high (orange), 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 12: 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 13). 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.

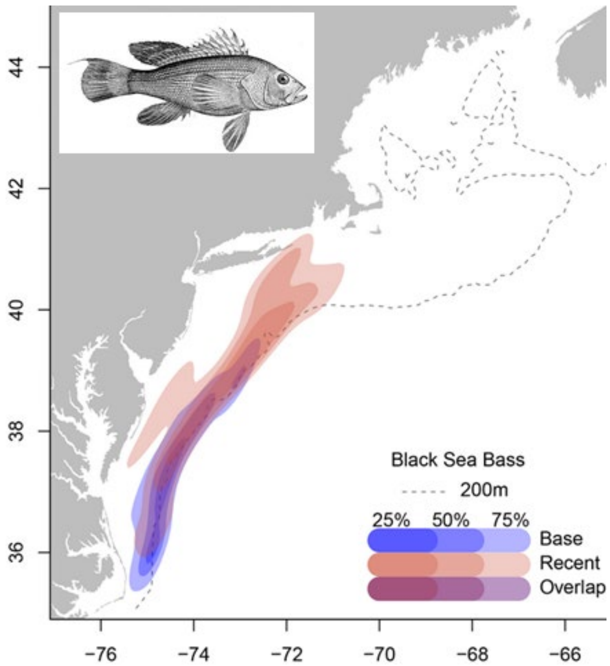

Figure 13: Plot of spring distribution of black sea bass (northern stock) in the 1970s (blue) vs. 2014-2016 (red). Percentages represent probability densities of a species being found in that location, with 25% defining the core area of distribution and 75% defining the broader use of the ecosystem. Source: [NOAA Northeast Fisheries Science Center.]

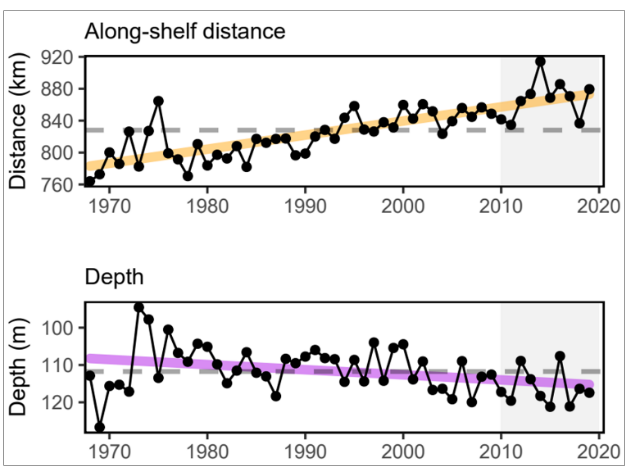

Figure 14: Analysis of Northeast and Mid-Atlantic aggregate stock distribution shows average movement trends to the northeast and into deeper water. Source: [2021 State of the Ecosystem Report, New England.]

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 15: 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.

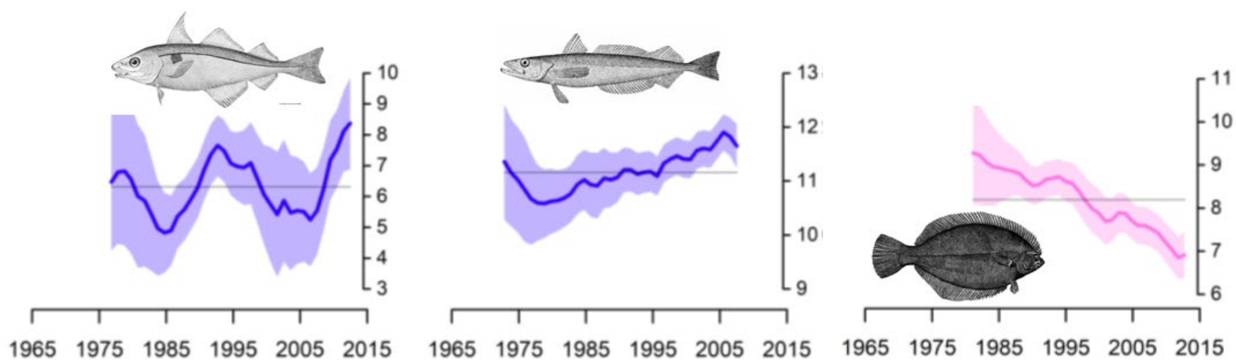

Figure 16: Changes in stock productivity for Gulf of Maine haddock, silver hake, and southern New England/Mid-Atlantic winter founder. Source: [Tableau et al 2018.]

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 17).

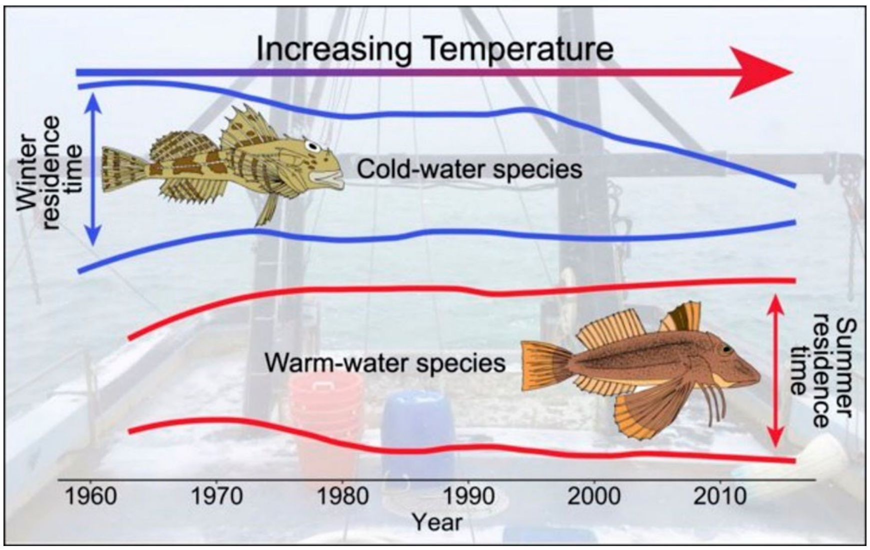

Figure 17: The number of days that migratory fish species spend in Narragansett Bay, Rhode Island has been changing, likely due to warming waters. Image: Lauren Fish and Joseph Langan.

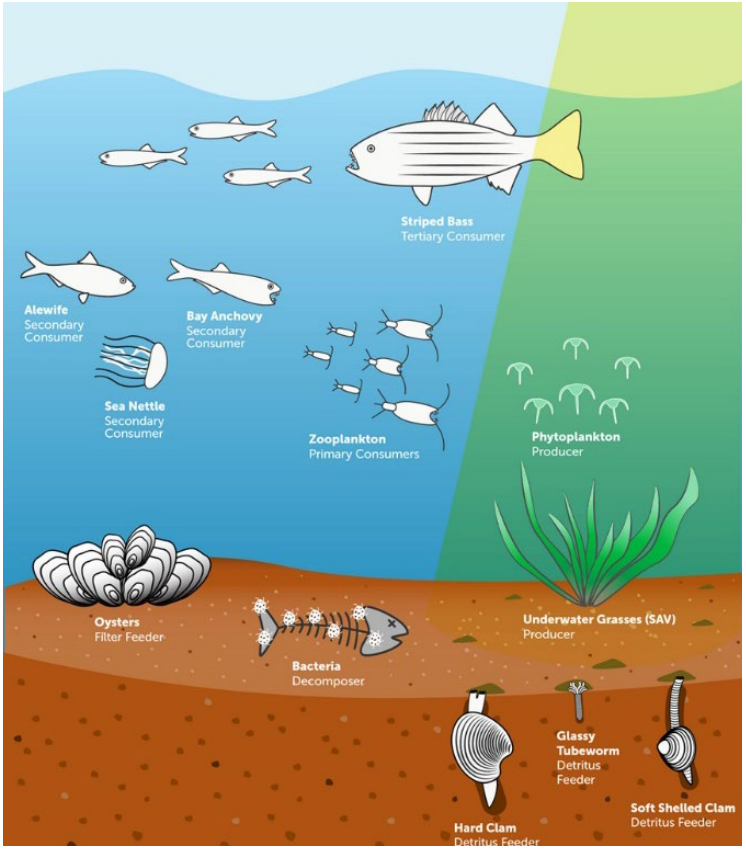

Figure 18: Conceptual model of Chesapeake Bay food web. Actual food webs are more complex, for example including larval forms of finfish as zooplankton predators. Source: [Chesapeake Bay Program.]

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.

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 19: 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 20: 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 21: 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)

East Coast Climate Change Scenario Planning

Exploration Webinar #3: Social and Economic Drivers of Change

March 2, 2022

New England Fishery Management Council

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

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 3, outlining the **social and economic** 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 social and economic drivers of change been captured that might affect east coast fisheries over the next 20 years?
- Are there important social and economic 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 Social and Economic Drivers of Change

In addition to the combined effect of oceanographic and biological drivers, diverse social and economic factors interact to either constrain or enhance the ability for communities to achieve and sustain profitable and rewarding commercial and recreational fisheries. Some of the most important factors likely to shape East Coast fisheries over the next 20 years are briefly characterized below, by no means an exhaustive list.

Figure 22: Live blue crab in a bushel. Photo: Jason Houston.

Overview of East Coast Fisheries

Coastal tribes along the Atlantic coast harvested shellfish and finfish for sustenance and trade income for millennia. This was followed by several waves of intensive harvest by European and domestic flagged vessels and technological advances during the last 400 years. Since then, advances like steam powered trawling, onboard freezers, fish finders, outboard motors and other innovations sharply increased fishing power and helped drive development of today's fisheries. Current Atlantic coast fisheries have persisted, evolved and expanded through constant adaptation by individual fishermen, communities, and fisheries management agencies. It should be noted that fisheries are reliant on substantial coastwide investment in shoreside infrastructure and diverse supply chain businesses; for example, seafood dealers, processors, gear manufacturers, and thousands of shops selling bait and tackle from Maine to Florida. The economy, culture and quality of life for coastal states and communities and the nation as a whole is tightly linked to future prospects for Atlantic coast fisheries.

In the New England (Maine through Connecticut) and Mid-Atlantic regions (New York through Virginia), total landings are dominated by commercial fisheries, while in the South Atlantic region (North Carolina through Florida), the majority of landings are from recreational fishing.

Atlantic coast commercial fisheries have produced landings of about 1.2 billion pounds annually since 2011 (Figure 2), about 40% of total US commercial landings. The seafood industry along the Atlantic coast supported nearly half a million jobs in 2018. Commercial landings and revenue for most continental shelf species have generally been flat or declining since the 1980s. However, total annual landed value has been relatively stable, largely due to high prices for lobster and sea scallops. Recent average landings of select commercially important species by region are shown in Figure 3.

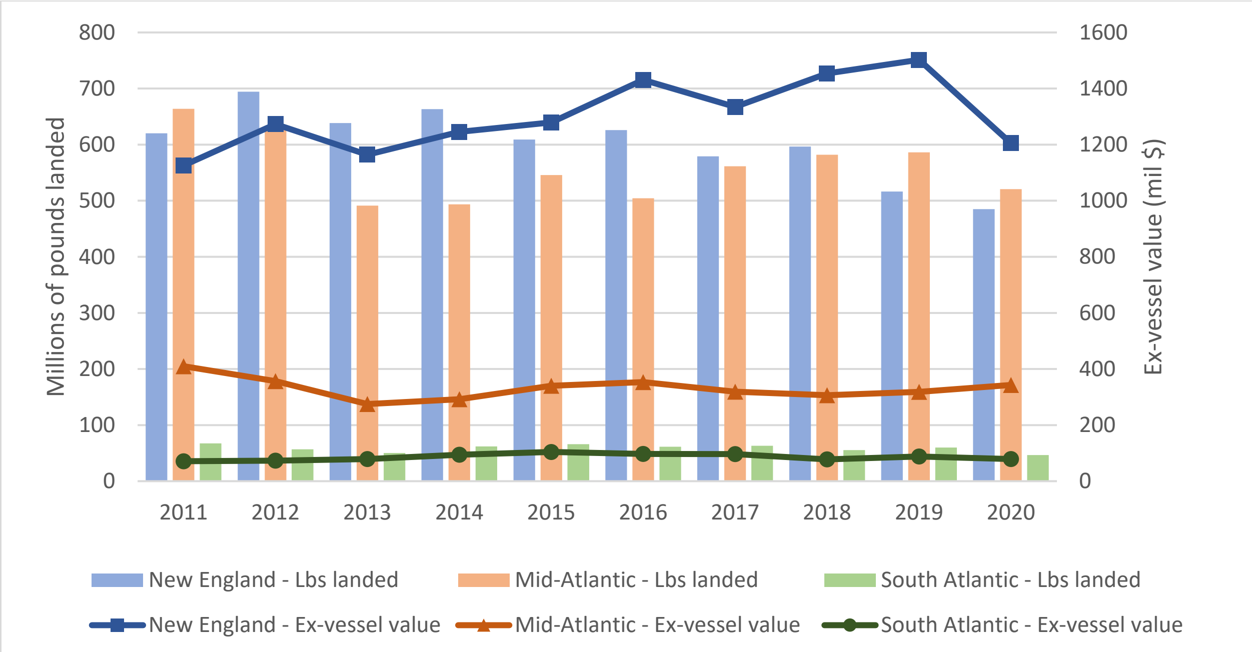

Figure 23: Commercial pounds landed (all species; meat weight for shellfish and whole weight for finfish) and ex-vessel value by region, 2011-2020. New England = ME-CT, Mid-Atlantic = NY-VA, South Atlantic = NC-East Coast of FL. Source: ACCSP Data Warehouse.

New England (Maine-Connecticut)			Mid-Atlantic (New York - Virginia)			South Atlantic (North Carolina - East Coast of Florida)		
	Sea Scallop	311 mil lb		Menhaden	422 mil lb		Blue Crab	30 mil lb
	American Lobster	138 mil lb		Sea Scallop	121 mil lb		Northern White Shrimp	18 mil lb
	Ocean Quahog	103 mil lb		Atlantic Surf Clam	107 mil lb		Marine Shrimp	13 mil lb
	Atlantic Surf Clam	87 mil lb		Eastern Oyster	71 mil lb		Eastern Oyster	8 mil lb
	Atlantic Herring	76 mil lb		Blue Crab	63 mil lb		Northern Brown Shrimp	5 mil lb

Figure 24: Average annual commercial landings for the top 5 harvest species by weight (total poundage as whole weights for finfish and shellfish, including shell) in each Atlantic coast region, 2016-2020. Source: Pers. Comm., ACCSP.

East coast waters also support a variety of important recreational fisheries, with an estimated 5.2 million anglers making 129 million fishing trips in 2018. At well over 100 million fishing trips each year, about 70% of all recreational angler fishing in the US takes place along the Atlantic coast. In recent years (2016-2018), total annual estimated recreational trips have averaged about 16 million per year in New England, 45 million per year in the Mid-Atlantic, and 75 million per year in the Southeast Atlantic. Recent average harvest of the top recreationally harvested species by region are shown in Figure 4.

Recreational fishing effort in New England and the Mid-Atlantic regions has generally declined since its most recent peak in 2010, with total estimated recreational fishing trips dropping by 28% and 19%, respectively. In the Southeast region, recreational fishing effort has been stable, with indication of increased participation in recent years. Recreational anglers in all regions participate in fishing from shore, from private boats, or by paying for trips on for-hire (party/headboat or charter) vessels. Recreational fisheries have considerable economic impact via sales of recreational fishing vessels, bait and tackle and other fishing trip expenses including fuel, ice, and lodging. Total spending on recreational fishing trips and durable goods for east coast fishing is estimated to be nearly $15 billion each year, led by $8.6 billion of expenditures in the Southeast region. In 2018, the recreational fishing industry supported approximately 154,000 jobs along the East coast.

New England (Maine-Connecticut)			Mid-Atlantic (New York - Virginia)			South Atlantic (North Carolina - East Coast of Florida)		
	Scup	7 mil lb		Striped Bass	17 mil lb		Bluefish	8 mil lb
	Striped Bass	6 mil lb		Summer flounder	7 mil lb		Dolphin	7 mil lb
	Atlantic Mackerel	5 mil lb		Bluefish	7 mil lb		Red Drum	5 mil lb
	Black Sea Bass	4 mil lb		Scup	7 mil lb		King Mackerel	5 mil lb
	Tautog	4 mil lb		Yellowfin Tuna	7 mil lb		Spotted Sea Trout	5 mil lb

Figure 25: Average annual recreational harvest for the top 5 recreational harvest species by weight in each Atlantic coast region, 2017-2021. Source: NOAA Fisheries Recreational Fisheries Statistics Queries.

Population Growth and Demographics

Human population growth in coastal states is driving development that negatively impacts estuarine and coastal ecosystems as a result of increased impervious surfaces, inadequate wastewater treatment, shoreline armoring in response to sea level rise, and other factors. While past and ongoing coastal development stresses drive coastal habitat damage and loss in all regions, the 2020 census revealed that population growth in southeastern states over the last decade exceeds all other U.S. regions, heightening concerns for the future of fisheries that depend on vulnerable habitats.

A recent assessment of demographic trends in saltwater recreational fishing found that participants were mostly white (79%) and male (64%) and do not mirror the much more diverse demographics of coastal counties. There is an indication of increasing participation in saltwater recreational fisheries by hispanic men and women, and women overall.

Figure 26: East coast waterfronts currently support diverse industries and activities. How will population growth and changing social values impact working waterfronts ? Artwork: Glynn Gorrick.

Fishing communities across the U.S. are experiencing 'the graying of the fleet' as fewer young people choose commercial fishing careers. This is a coastwide issue and recent studies in Maine reveal a long term steady increase in the average age of lobster harvesters. As the average age of fishermen increases, generations of accumulated traditional ecological knowledge can be lost, potentially diminishing the ability for community adaptation to changing ocean conditions and opportunities.

Key Uncertainties: Will more people move to coastal areas in the next 20 years, and will faster population growth across the Southeast region continue? Will sea level rise, coastal inundation etc. mean that coastal living becomes less attractive and less safe as expenses and hazards rise? How will the make-up of fishing communities change in the next 20 years? How might the appeal of commercial or for-hire fishing as a career choice change as climate change continues?

External Cost Factors

Labor, fuel, and other input costs are major drivers of commercial and for-hire recreational profits, and future fluctuations in these costs are expected to continue to drive fishery effort, investment, and fishing behaviors. Rising costs of labor and fuel are exacerbated for vessels that may need to steam longer distances to search for target species as the distribution and abundance of traditional harvest species changes.

Changing conditions may require some fishermen to learn new fishing methods, purchase new gear, or upgrade fishing vessels in order to sustain profitable businesses. Prospects of sea level rise are likely to affect lenders' assessment of real estate values, and impact insurance costs for coastal facilities, which could affect processing facilities, moorings and marinas. Regulatory responses to dynamic ocean conditions with rapidly shifting opportunities can change the number of days available for recreational and commercial fishing. A wide range of regulatory actions in response to climate and other factors could change fishing industry costs for labor, gear and vessels. Depending on how a particular stock is managed, access to permits and/or quota may have associated costs that change over time as management evolves. This may also represent a cost barrier for fishermen without access to capital or affordable financing.

Figure 27: Crew member unloading sea scallops at Atlantic Cape Fisheries, Cape May, NJ. Photo: Jason Houston.

Processors and infrastructure developed to support historic commercial fisheries may no longer be located adjacent to fishing areas. Home port locations and existing port facilities may need to be modified and upgraded to accommodate new mixes of species and product categories. These factors may increase business costs and constrain adaptation. Similarly, recreational anglers may choose to travel further or purchase different fishing gear for better fishing opportunities.

Key Uncertainties: How will costs associated with fishing change over the next 20 years? Will cost increases be steady and predictable, or sudden and unpredictable? What specific cost increases are most damaging to the livelihood of fishing communities? Will such cost increases affect both commercial and recreational fishing?

Working Waterfronts and Infrastructure

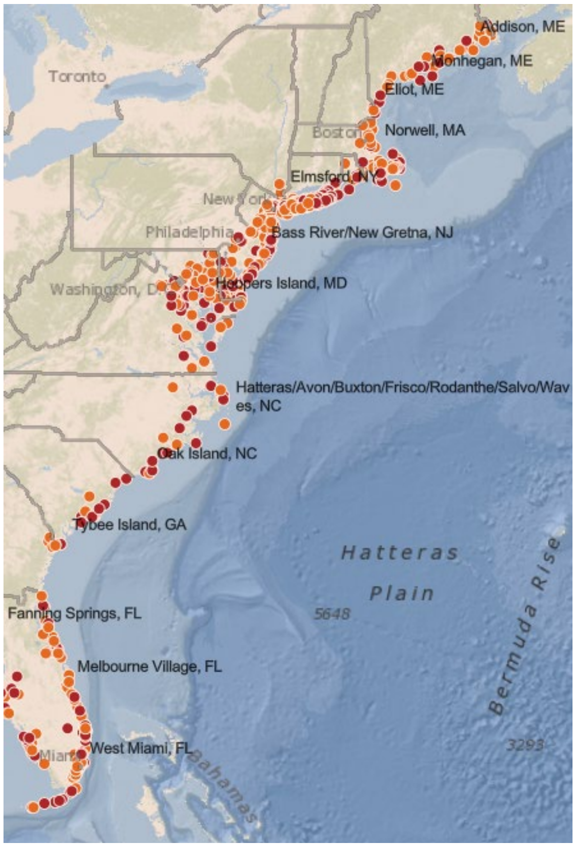

Figure 28: Fishing communities with medium-high or high housing disruption, an indicator of gentrification pressure, in 2018. The housing disruption metric tracks housing market data on home values, rents and mortgages. Red and orange dots indicate communities with the highest housing disruption ranks and potentially higher risk for gentrification of working waterfronts. Source: NOAA Community Social Vulnerability Indicators Toolbox.

Physical damage to ports and marinas caused by extreme weather events will be exacerbated by continued sea level rise. In some ports increased flooding during fair weather high tide events will hinder effective operations and increase costs. One hurricane in 2018 (Florence) caused an estimated $38 million in damages to vessels and businesses, $56.5 million in lost revenues and 3,500 fishing related job losses in one state (North Carolina). However, available federal fishery disaster funds for Hurricane Florence were just $7.7 million. Fishery disaster declarations have been increasingly attributed to extreme environmental events with over 80% of 71 declarations from 1989 to 2020 partially or entirely attributed to events such as marine heatwaves, hurricanes and harmful algal blooms.

These climate and weather related pressures are coupled with persistent trends towards gentrification of working waterfronts in response to cultural and economic drivers as developers seek to maximize profits from waterfront property. Loss of working waterfronts can lead to shifts in cultural identity for coastal communities.

Figure 29: Working waterfront in Portland, ME. Photo: Jay Odell.

Key Uncertainties: How will the locations and physical infrastructure of commercial fishing ports change over the next 20 years? Will we see investment in new infrastructure to support fishing activity? How will population growth and gentrification impact recreational and commercial fishing ports and communities? Will the siting and purpose of shoreside support and infrastructure change as climate change continues?

Consumer Demand and Market Dynamics

Changes in consumer demand and market dynamics for seafood are major drivers of fishery effort, and shifts in societal values can drive consumer demand. U.S. per capita fish consumption has steadily increased since the 1990s, increasing 27% between 1990 and 2019. A 2021 study found that sales of fresh seafood in the U.S. over the last two years increased by over 30%, with increases of about 20% for frozen and shelf-stable product categories. Consumer preferences have changed over time such that today seafood landings and value are dominated by invertebrates including lobster, scallops, clams, shrimp, and squid.

Figure 30: The Maine Avenue Fish Market in Washington, DC, originally opening in 1805, is the oldest continuously operating fish market in the country. Photo: Jason Houston.

Multiple factors can impact market dynamics, including unexpected supply gluts (for example, high lobster landings in 2012) and competition with lower priced international imports, often from countries with fewer regulatory requirements. Periodic harvest restrictions to reduce seafood consumption health risks (e.g. paralytic shellfish poisoning) can impact supply. Consumer perceptions of risk concerning a range of contamination issues (e.g. heavy metals in tuna, *Vibrio* in oysters) can impact consumer confidence and demand, with potentially large effects following poisoning incidents that result in serious injury or death.

Figure 31: Fishadelphia, a pilot community seafood program, was designed to connect low-income consumers in Northern Philadelphia with neighboring New Jersey harvesters. Photo: NOAA Fisheries/Talia Young.

Many fisheries identified vulnerabilities in their supply chains during the COVID-19 pandemic that may be relevant for the future. Adaptive responses included some fishermen developing methods (in person and by mail) for direct sales to consumers when markets were lost due to widespread restaurant closures. This shift was met by seafood consumers who were exploring new ways to shop more locally, avoid grocery stores, and prepare more seafood at home. Some of the recent changes in consumer purchasing patterns may persist, and some fishermen may choose to take on the significant additional processing and marketing costs required for direct sales. Additional changes within supply chains that move seafood from producers to consumers will evolve in response to diverse external factors, including changes driven by the larger and tightly linked food service industry.

Consumer surveys reveal that environmental sustainability is commonly cited as an important factor in food purchasing decisions, and younger generations appear more likely to believe that individual food choices can have at least a moderate impact on the environment. Generational shifts in values regarding sustainability and animal welfare as well as an apparent increase in rates of vegetarianism, veganism, and pescatarianism may shift market trends and demand levels over the next 20 years.

Figure 32: Charter vessels in the Florida Keys. Photo: ASMFC.

Demand for recreational fishing trips and equipment also fluctuates in response to a number of economic and social factors. While recreational trips on the East coast have seen a generally decreasing trend in recent years, there are indications that the COVID-19 pandemic drove an increase in nature-based recreation including recreational fishing activity. Climate change may impact how people spend leisure time, driven by changes in temperature, precipitation and wind. The influence of climate change linked weather factors on recreational fishing behavior will likely vary by coastal location, and potentially alter recreational harvest patterns.

Key Uncertainties: How will demand, consumer preferences, and supply chains for East Coast seafood change over the next 20 years? Will there be significant changes in local, national and/or international markets? Will consumers become more concerned with overfishing or environmental damage from fishing? Will advances in food technology such as plant-based seafood or tissue culture affect market demand for wild-harvest products? How might markets respond to other future unknown stressors (pandemics, global crises, etc.)?

Technological Change

Advances in technology have often impacted fisheries, in some cases dramatically, for example the shift from sail powered hook and line commercial fishing to steam engine powered bottom trawlers. Many companies are actively developing new types of fishing gear, including increasingly powerful fish finders. Gear technology is also evolving to improve catch rates of target species while avoiding bycatch of non-target species and protected resources.

Technological advances may improve fisheries management outcomes via development of expanded at-sea monitoring and reporting systems that deliver timely and accurate data streams to support nimbler decision making. For example, the Northeast region's Study Fleet includes about 50 fishing vessels whose captains and crews provide high resolution data for uses such as developing thermal niche models and stock assessments. Future information technology advances could enable extension of this approach to a coastwide network with thousands of vessels.

Figure 33: Captain Jimmy Ruhle reviews monitoring and navigation systems on the F/V Darana R while conducting the Northeast Area Monitoring and Assessment Program (NEAMAP) cooperative inshore trawl survey. Photo: Jay Odell.

Effective integration of fishing vessel based ocean sensing networks with next-generation ocean observing system assets (e.g. satellites, buoys, gliders, etc.), and with next-generation stock assessment technology (e.g. sonar, robotic camera systems, e-DNA, etc.) could significantly improve ocean model performance, reduce stock assessment uncertainty, and provide short term forecasts to flag bycatch hotspots and optimal fishing locations.

Southeast region states have for many years operated hatchery programs for red drum and other marine fish to supplement natural population growth and provide additional fishing opportunities. Potential technological advances that significantly improve cost effectiveness of hatchery production and/or enable successful culture of new species may drive increased use of hatchery produced fish and invertebrates to enhance wild harvest stocks.

Advances in food technology may also impact demand for wild-harvest seafood as new product types are emerging, including plant-based imitation seafood which is already being produced and sold by at least ten different brands. At least two firms have each raised over $100 million to launch commercial scale production of tissue culture seafood. There is high uncertainty regarding future economic viability of producing seafood with bioreactors as estimates of current production costs range as high as $9,000 per pound.

Several firms are currently developing electric powered fishing vessels, including electric outboard motors for recreational fishing. All of these types of technological change could shape the future of Atlantic coast fisheries, in combination with other factors.

Key Uncertainties: To what extent will new monitoring systems be broadly adopted and widely available? How accurate will such technology be? How will investments in any forms of new technology be funded? Will subsidies or regulations be required to encourage/ensure the adoption of new technologies?

Changing Ocean Uses

There are many other ocean uses that overlap with fish habitat and areas of fishery operations along the East Coast, in both nearshore and offshore areas. Development of offshore wind projects and the potential for offshore aquaculture are perhaps the most significant known examples of non-fishing ocean uses expected to affect fisheries on the East Coast.

There are over twenty wind projects currently proposed for the East coast, mostly clustered offshore in New England and the Mid-Atlantic. There is currently a high level of fishing community concern regarding impacts to fisheries, particularly in locations where fishing with mobile gear (trawls and dredges) coincides with wind development areas. Many impact categories are currently being studied pursuant to the Bureau of Ocean Energy Management's permitting process, with ongoing efforts to develop mitigation measures for environmental impacts (e.g. threats to North Atlantic right whales) and impacts to fisheries (e.g. displacement from traditional fishing grounds). Some fishing communities may benefit from addition of new structured habitat in wind development areas (e.g. scour protection at base of turbines), especially those utilizing hook and line gear, generally expected to be recreational anglers.

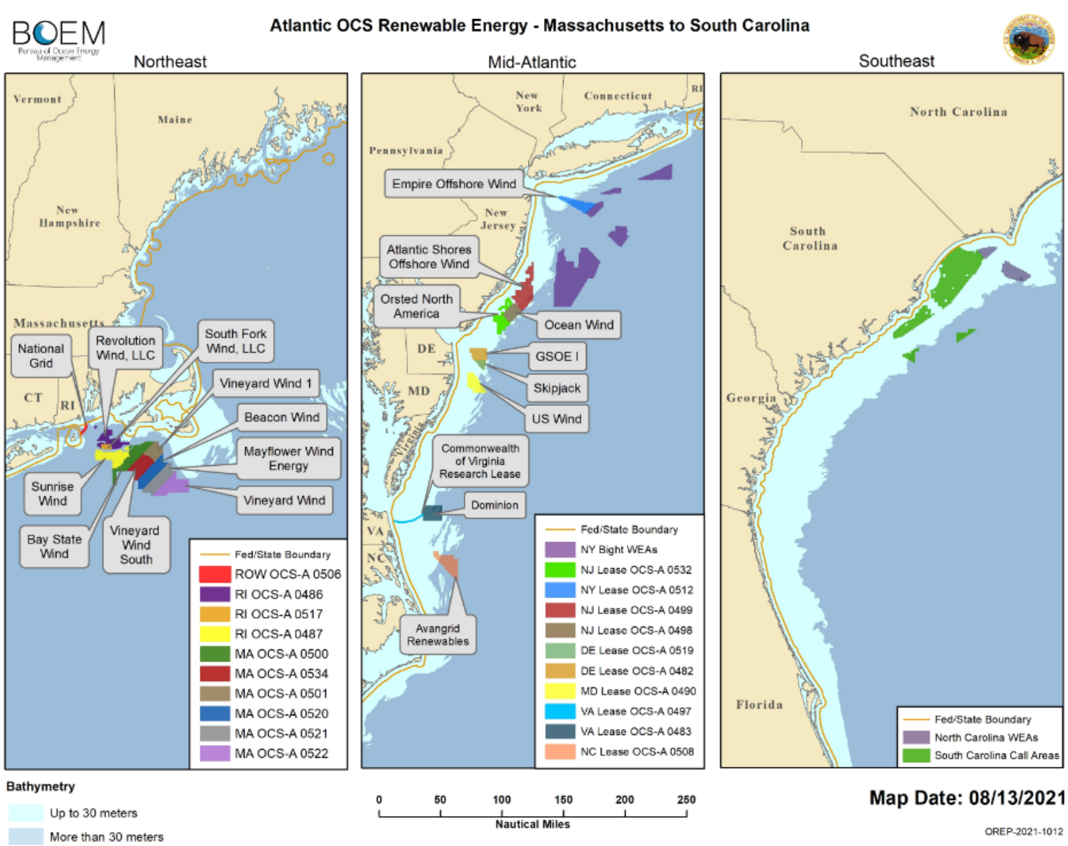

Figure 34: Atlantic outer continental shelf (OCS) Renewable Energy Areas as of 8/13/21. Source: BOEM.

The US Atlantic coast currently supports different aquaculture operations for finfish, shellfish, and marine algae, with commonly farmed species including oysters, clams, mussels, Atlantic salmon and kelp. Aquaculture landings rank third for the East coast in terms of economic revenue, after sea scallops and American lobster. While mariculture on the East coast is currently conducted primarily in inshore or nearshore areas, there is demonstrated interest in developing offshore aquaculture facilities. Changes in the extent of aquaculture or the areas in which it's conducted could impact future seafood market dynamics and may also affect wild caught fishery access in some areas.

Figure 35: Sugar kelp, a marine algae grown and harvested for a variety of uses from food to potential biofuels. Photo: NOAA Fisheries.

Key Uncertainties: What will be the scope of offshore wind development, aquaculture, and other non-fishing ocean uses? How will these projects be sited, and using which technologies? What other industries or interests will use East Coast waters? What effects will competing ocean uses have on fishing effort, coastal infrastructure, marine resources and ecosystems, and research surveys? How will new ocean uses affect stock distribution or stock productivity?

Social Vulnerability and Environmental Justice

NOAA has developed a set of Community Social Vulnerability Indicators (CSVIs), that characterize and evaluate a fishing community's vulnerability and resilience to disturbances. A subset of these indicators addresses environmental justice issues, or the disproportionately high and adverse human health and environmental effects that some actions can have on minority and low-income populations. These include measures of poverty, population composition (the demographic makeup of a community), and personal disruption (capturing unemployment status, educational attainment, poverty, and marital status). Higher rankings in each of these indices indicate a more vulnerable population that may be less resilient to climate change. Many East coast fishing communities rank medium-high to high in these indicators. The CSVIs also provide indices of gentrification pressure, fishing engagement and reliance, economic factors, and climate change risk (to sea level rise and storm surge). Many of the communities along the East coast that have high reliance on commercial or recreational fishing are also associated with high economic and climate change vulnerability.

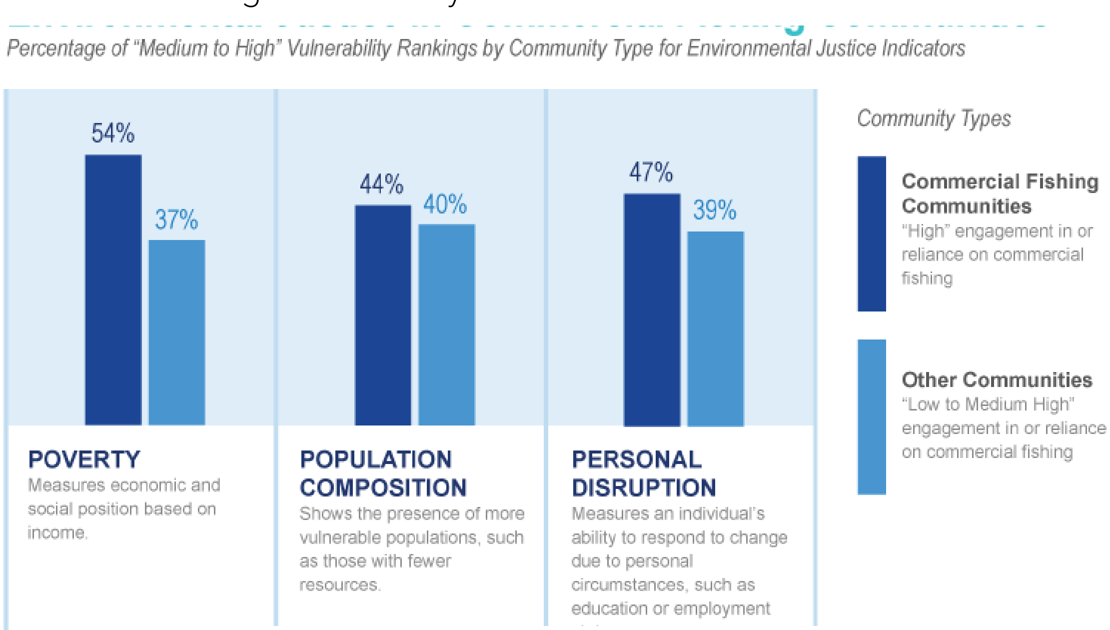

Figure 36: NOAA's indicators of environmental justice for US commercial fishing communities vs. other communities. Communities dependent upon commercial fishing are far more likely to be poor, have a larger percentage of minority and tribal populations, and/or have residents with less 'personal capacity' to respond to change, e.g., higher unemployment rates or lower educational attainment.

Key Uncertainties: How will social and economic vulnerability characteristics of East coast fishing communities change over time? Will communities become more vulnerable or more resilient to change? Will some communities become less reliant on fishing?

References and Further Reading

- Fisheries of the United States, 2019
- Fisheries Economics of the United States, 2018
- 2021 STATE OF THE ECOSYSTEM| Southeast
- 2021 STATE OF THE ECOSYSTEM | Mid-Atlantic
- 2021 STATE OF THE ECOSYSTEM| New England
- NOAA Fisheries Social Indicators for Coastal Communities

Appendix 2: Exploration Webinar Agendas

Exploration Webinar #1: Oceanographic Drivers of Change, February 14, 2022

Connection

Webinar registration information is available at: https://www.mafmc.org/council-events/ecsp-webinar-1-oceanographic-drivers

Briefing Materials

A background document for webinar #1 is available at: https://www.mafmc.org/s/ECSP-Exploration-Webinar-1-Oceanography-Briefing_Feb2022_final.pdf

Agenda

3:00pm Welcome and Overview

3:10pm Oceanographic Drivers of Change: **Dr. Charlie Stock**, Research Oceanographer, NOAA's Geophysical Fluid Dynamics Laboratory

Dr. Charles A. Stock is a Research Oceanographer at NOAA's Geophysical Fluid Dynamics Laboratory, where his work for the past 15 years has focused on understanding interactions between climate and marine ecosystems. He is one of the developers of GFDL's Earth System Models, projections from which are used to inform international and national climate assessments and subsequent policies. He has also collaborated extensively with fisheries scientists and managers to apply climate and earth system models to help meet living marine resource challenges in a changing climate.

3:30pm Panel Responses:

- **Zack Klyver**, Science Director, Blue Planet Strategies
- **Dr. Sang-Ki Lee**, Oceanographer, NOAA's Atlantic Oceanographic and Meteorological Laboratory
- **Dr. Shannon Mesek**, Research Chemist, NOAA's Northeast Fisheries Science Center, Aquaculture Systems
- **Capt. Chris Roebuck**, Owner and captain of F/V Karen Elizabeth; Cooperative research participant
- **Dr. Vince Saba**, Research Fisheries Biologist, NOAA's Northeast Fisheries Science Center, Ecosystem Dynamics and Assessment

4:00pm Audience Questions & Discussion

4:20pm Polling questions

4:25pm Next Steps

Exploration Webinar #2: Biological Drivers of Change, February 23, 2022

Connection

Webinar registration information is available at: https://www.mafmc.org/council-events/ecsp-webinar-2-biological-drivers

Briefing Materials

A background document for webinar #2 is available at: https://www.mafmc.org/s/ECSP-Exploration-Webinar-2-Biological-Briefing_Feb2022_final.pdf

Agenda

3:00pm Welcome and Overview

3:10pm Biological Drivers of Change: **Dr. Janet Nye**, Associate Professor, University of North Carolina

Dr. Janet Nye is an Associate Professor at UNC Chapel Hill based at the Institute of Marine Sciences in Morehead City, NC. Her research centers around fisheries oceanography and ecology. Her lab uses mathematical and statistical methods to study fish populations, marine food webs and coastal ecosystems. Her past research has documented shifts in spatial distribution of fish in response to warming water temperatures and fishing and sought to determine the mechanisms behind changes in distribution and abundance. Janet's current research seeks to understand how climate influences fish populations, trophic interactions, and the emergent properties of marine ecosystems.

3:30pm Panel Responses:

- **Dr. Mandy Karnauskas**, Research Fishery Biologist, Southeast Fisheries Science Center
- **Capt. Ira Laks**, Charter and commercial fisherman based out of Jupiter, FL; Chairman of SAFMC Mackerel Cobia Advisory Panel
- **Dr. John Manderson**, Principle Consultant, OpenOcean Research, Blue Hill Partners
- **Dr. Malin Pinsky**, Associate Professor, Rutgers University

4:00pm Polling questions

4:05pm Audience Questions & Discussion

4:25pm Next Steps

Exploration Webinar #3: Social and Economic Drivers of Change March 2, 2022

Connection

Webinar registration information is available at: https://www.mafmc.org/council-events/ecsp-webinar-3-socioeconomic-drivers

Briefing Materials

A background document for webinar #3 is available at: https://www.mafmc.org/s/ECSP-Exploration-Webinar-3-Social-and-Economic-Briefing_Feb2022_final.pdf

Agenda

3:00pm Welcome and Overview

3:10pm Social and Economic Drivers of Change: **Dr. Doug Lipton**, NOAA Fisheries

Doug Lipton is the Senior Research Scientist for Economics at NOAA Fisheries (NMFS) and serves as Senior Economic Advisor to the NMFS Chief Scientist. Lipton received his Ph.D. from the University of Maryland College Park, Department of Agricultural and Resource Economics in 1989 where he was a faculty member until 2013, and still serves as Professor Emeritus. During that time he was also program leader for the Maryland Sea Grant Extension Program. Lipton's research focuses on a wide variety of marine economic issues including, commercial and recreational fisheries economics, non-market valuation of marine resources and aquaculture economics.

3:30pm Panel Responses:

- **Dr. Matt Cutler**, Social Scientist, NOAA's Northeast Fisheries Science Center
- **Dr. Matt McPherson**, Director, Social Science Research Group, NOAA's Southeast Fisheries Science Center
- **Dr. Kathy Mills**, Research Scientist, Gulf of Maine Research Institute
- **Rick Robins**, Marine Affairs Manager, RWE
- **Capt. Tom Roller**, WaterDog Guide Service, Beaufort, NC; NC At-Large Seat, South Atlantic Fishery Management Council

4:00pm Polling questions

4:05pm Audience Questions & Discussion

4:25pm Next Steps

Appendix 3: Summary of Webinar Chat Questions and Comments

Chat from Webinar 1: Oceanographic Drivers

The following paraphrased questions/comments were raised by participants on the webinar via the chat function:

- Do projections factor in changes in frequency and intensity of storms that can affect stratification and mixing in regards to net primary productivity? More strong storms could favor increased primary production locally.
- In the Gulf of Maine increased stratification and shifts in the spring phytoplankton bloom time and duration can lead to changes from the diatom-based grazing food chain to the microbial food web. This can lead to increased community respiration which decreases the yield of living marine resources at the top of the food chain. In deeper ocean waters this could alter vertical carbon transport from the surface waters to burial at depths. How would this affect the role of the ocean as an atmospheric carbon dioxide sink?
- In the panel discussion it was noted that Atlantic herring is subject to overfishing. While Atlantic herring is currently overfished, according to the last assessment it has not been subject to overfishing.
- Physical changes to coastal wetlands from sea level rise and increased coastal storm intensity will affect physical habitats, including intertidal sand, mud, and rocky habitats. A recent habitat climate vulnerability assessment identified these "non-living" habitats as highly vulnerable to climate change, and perhaps this should be addressed in the oceanographic theme. Increased erosion and sea level rise will likely have profound affects to fisheries that use these habitats for one or more life history stages.
- Some fishing industry members are concerned with subsurface warming due to massive offshore electrical substations servicing offshore wind facilities that cool their systems with open loop systems. One wind farm for example will have one substation discharging 8.1 million gallons of 90 degree water a day onto Cox's Ledge in New England, as well as the heat emitted from the underwater cables. Additionally there are also plans by Google to create underwater data centers to absorb the heat emitted from large web servers and asked whether the potential effects from that subsurface warming are being considering in a forward planning scenario.
- Is there a relationship between the changes in the Atlantic Multidecadal Oscillation (AMOC) that Sang-Ki referenced and the AMO and North Atlantic Oscillation (NAO)?

- Shouldn't we be also considering non-CO^2 pollution such as nutrient runoff in our models as it has a large impact on ocean chemistry and primary production?
- How well do newer models resolve the changing dynamics at the northeast shelf break such as changes in slope water intrusions onto the shelf and its influence on certain species?
- How do oceanographers plan on monitoring currents going forward since high frequency radar coverage (which measures surface currents along the coast) will be lost due to the radar interference of offshore wind farms, and the timeline for finding solutions is long?
- It sounds like radiative forcing and anthropogenic warming is the primary driver of North Atlantic warming broadly, but specific to the Gulf of Maine, can you comment on the physical drivers of the rate of warming there, specifically? In particular, comment on the hypothesis about the Gulf Stream "spreading out" in recent years (due to freshwater input from a melting Arctic)? How much of an influence is that vs, say, the geometry (shallowness) of the basin itself?

Chat from Webinar 2: Biological Drivers

The following paraphrased questions/comments were raised by participants on the webinar via the chat function:

- Since climate change affects ecosystem components of the environment (community primary production & respiration) and biodiversity that influence the "productive capacity" of Essential Fish Habitat of managed finfish and shellfish species, how will these ecosystem features be addressed in the Climate Change Scenario Planning? As we transition to an Ecosystems Approach to Fisheries Management to address climate change effects, it might be worthwhile to explore emergent ecosystem properties addressed in Dr. Eugene P. Odum's paper on the effects of succession on ecosystem structure and function on land and in the ocean.
- It's unsurprising that the pilot whales appeared to move faster than their prey. How good are we at determining distributions of mobile, patchily-distributed pelagic prey? What can we do to get better at measuring spatiotemporal distribution of prey at finer scales?
- How will the stressors of offshore development to fight climate change be incorporated into studies on how species are affected by climate change?
- The issue of identifying species interactions that influence abundance and distribution of managed species (including prey taxa) can aid decision-making. For example, small changes in temperature can shift competitive dominance. Shifts in distribution can produce novel communities with strong trophic interactions (like black sea bass in new areas preying on resident fish

and crustaceans). The key will be using existing data streams to infer process, such a gut contents, species co-occurrences, and changes at size at age and condition. This is more exploratory at this point but addressing such interactions at landscape scales could produce products useful for management advice related to Ecosystem Based Fisheries Management and multispecies alternatives.

- What about Caribbean species moving into South Florida?
- I'd like to hear the panel's views on the effects of coastal habitat loss from climate and non-climate stressors. For example, salt marsh wetlands and seagrasses were identified as very highly vulnerable to climate change from a combination of higher temperatures and sea level rise, and coastal development (e.g., hardening shorelines, pollution). If a majority of commercially-important fisheries depend upon these habitats (directly or through prey), we should expect to see declines in fish productivity even for warmer water species that may shift their distributions into more thermally-favorable areas.
- How do we speed up observation and interpretation of ecosystem and stock condition (in time to act on it)? Greater reliance on industry collected data was mentioned, but this could be expanded on as it is a key topic.
- What proactive efforts are being made to include vulnerable communities in not only the monitoring but the modeling and decision making based on the panelists experiences?
- An "Other" factor in the poll: Ecosystem Productivity to Respiration Ratio and yield of managed finfish & shellfish.
- How do we consider with ocean management regime will be that can incorporate these scenarios into decisions? This may not be a fisheries management problem.
- Climate change effects on ecosystem production and respiration ratios could also influence succession patterns and productive capacity of Essential Fish Habitat for managed species. In climax ecosystems the ecosystem production/respiration ratio approaches one, while in earlier stages production >> respiration which allows plant & animal biomass to increase. In old growth forest the tree/soil microbiome absorbs much more carbon dioxide from the atmosphere. Does this also occur in the ocean?
- How do we bridge the gap between our Ecosystem Status Reports and our mostly single species stock assessments, which tend to be the "drivers" of management change (and reinforce the single species/reactive approach)?
- Could any of the panelists talk about "trailing/leading" edges of stocks on the move? Is there science to support that management of either the pioneers on

the move or the laggards (or both) might need to be different than assessing/managing stocks as one unit?

- How are the early life history traits of varying species being accounted for considering that many of them have differing bio physical and chemical requirements (aka thermal limits)? How can you determine the future population sizes without in depth considerations of these life stages in relations to potentially different environmental conditions or physical environment?
- If species are moving into new areas and it is driven by changing climate conditions, is it appropriate to call them "invasives?"
- It's very important to see how limited entry prevents fishermen from taking advantage of a changing ecosystem.

Chat from Webinar 3: Social and Economic Drivers

The following paraphrased questions/comments were raised by participants on the webinar via the chat function:

- It is interesting that now this year New Jersey is harvesting surf clams again off Virginia and landing them in Cape Charles, VA.
- What socioeconomic and cultural tools are available to help coastal communities prevent the loss of working water fronts to tourism/other non-water dependent economic activities ?
- How do we account for both the monetary and biological effects of fishing down the food web? Is there a way to assess the sustainability of these practices to prevent a "race to the bottom" effect when it comes to the remaining fish stocks in particular areas as they shift locations?
- Are there lessons to be learned with regard to fleets adjusting to past (human-induced, climate-induced, or otherwise) "shocks" (e.g., ENSO and Peruvian anchoveta, F and Gulf of Maine cod, foreign policy and fuel prices)?
- A question for Capt. Roller: Have you seen client motivations change as a result of climate change, e.g., move from catching a fish to eat to catching for trophy motivations to catching for relaxation/nature, etc. and has that also influenced target species for clients?
- Highly Migratory Species recreational fishing contributes an estimated $510 million to the U.S. economy each year. Yellowfin tuna, managed by NOAA Fisheries' Highly Migratory Species (HMS) Division, is listed in the materials as one of the top 5 recreational species in the Mid-Atlantic region. To what extent will NOAA's HMS Division and species/fisheries within their management plan be included in this initiative as we consider potential future scenarios and management solutions?

- There is value in thinking not just about the concept of "underserved" communities, but also that many of the groups that typically refers to have also been historically excluded from the processes we are talking about as well and we need to be sure that future scenarios are considering groups that may have been excluded.
- To Tom's point about the interconnectivity of state and federal fisheries, how might this scenario planning effort consider governance of state and federal fisheries in tandem? Thinking about Kathy's point about challenges related to access to permits and quota as species shift, and Matt highlighting the need to focus on equitable distribution of risks and benefits, both which cross state and federal boundaries.
- Fisheries can adapt, but can science provide them information on fish species changes in distribution and abundance quickly enough and can management provide access/permits and quota? Will wind power companies in the mid-Atlantic make efforts to hire and train fishermen?
- Capt. Roller’s comments are on point about a more complex interactions between state and federal fisheries in the future. This process should be deliberate about consideration of coastal (often not federally permitted) fishermen. These fishermen may find that their diversified coastal fisheries change because of climate change and that access to the newly available species may “belong” to fishermen from other areas. These fishermen do not operate within individual quota systems in many areas. Their communities are well-documented in NOAA’s community profiles. They have very different adaptation capacity and options than more centrally located federal fleets
- The country with the second largest EEZ in the world imports 92 to 94 % of seafood consumed due to a policy enacted by U.S. Department & U.S. Department of State. Coastal Area Management & the Army Corp of Engineers conspire to limit docks. NOAA & NMFS policies leading to harvest of large fish are contrary to “big old fat fecund fish” theories. All Councils have polices that limit the supply of fish to increase prices thus giving imports an advantage of market share. All council regulations of closed seasons increase market share to imports. As for climate change a simple action could be to allow vessels a dollar amount to land so all product must be sold. NOAA, NMFS, and the Councils are not following Magnuson guidance from 2006 to require saltwater angler registration. Climate Change is a scapegoat. Aquaculture is also being blocked by NOAA.
- It seems like there are several events (hurricanes, brown tide, heatwave) that forced coastal communities to adapt that we can learn from. How do we adapt proactively or does it take an "event" to make adaptation happen?
- How can managers create a system that reduces the importance of capital when adapting to climate change?

- As the scenarios are explored, how will they treat the investment in understanding the systems? We've spent a lot of time and money working to understand the fish and the "natural" environment, but in truth we are managing people and not fish. How do we ensure that we are investing as much in understanding the human element as we are in understanding the fish? How do we entrain even more social scientists from a range of expertise to focus more in addressing the questions raised in these scenarios? I think about for example the level of investment by USDA in understanding farming economic and social factors, versus in the fisheries and aquaculture world.
- Offshore wind energy will help stem the tide on these climate impacts being discussed, however, it has enhanced recreational fishing at Block Island even though fishing pressure has increased there over 200 percent. Wind energy can and will have a profound positive impact on recreational fishing especially if natural artificial reef designed are added to the base of pylons. Can we encourage enhanced structure?
- As various agencies, departments, and specialists commence in scenario planning, what are the mechanisms that allow these activities to work in synergy?
- It seems that further integration between planning and activities at a state and federal level under the Coastal Zone Management Act are better integrated and thought about in concert with Magnuson Stevens and state fisheries discussions too. It seems at times those two worlds exist separately, but they are both part of the future.