NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

What’s the Catch?

Understanding and Managing Fisheries in Response to Climate Change

by
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Part I – Shifting Populations

It was 4:00 a.m. when Captain Joe Fraser left his house in Point Pleasant, New Jersey for his ship, the F/V Atlantis. He and his crew were setting out on their trip to haul for squid with trawl nets. This had been his routine for as long as he could remember, beginning in childhood when he used to assist his father and grandfather pull in their prey.

After loading up the supplies they needed for the two-day trip, he consulted the navigational charts and the satellite data showing sea surface temperature to identify areas and conditions he knew from his grandfather and father that squid favor. But, over the past few years, he had been finding a totally different mix of species on his fishing grounds. Squid were becoming a smaller portion of his overall catch. Newcomers like black sea bass often filled the nets, but he didn’t have the quota to land them. Joe wondered if he could continue the legacy that his father and grandfather began.

Joe ran into fellow fishers, Sydney Shipbottom and Bill Longshore. Bill had been fishing off Rhode Island and had also experienced big changes. Bill said, “We’re just loaded with black sea bass, overwhelmed with them. We used to catch them off New Jersey at the end of summer, but now they’re more up in Rhode Island. We can’t get away from that fish! We were going out for fluke, but we got black sea bass. We were going after squid, we got sea bass. At all depths. See, species don’t stay put in the ocean, like they do in a farm.”

Bill had a big fishing boat, and often went out for a week or more at a time. For him, going up to Rhode Island or further to find the fish he wanted was not a problem (though sometimes the cost of diesel fuel was expensive). Sydney and Joe had smaller boats, however, and stayed close to port. Following squid if they moved elsewhere was not a realisitc option for them. Sydney lamented, “It’s left us original squid fishermen with no squid to catch unless we travel 100 miles, and we’re not those types of wanderers.”

Months later, Joe attended a joint meeting set up by the the Mid-Atlantic Fishery Management Council (MAFMC). The MAFMC managed species that occur between 3 and 200 miles offshore (in federal waters) to make sure that species are not overfished and that the habitat is maintained. At this meeting, Joe spoke with other fishers and scientists, but of particular interest were the data presented by Dr. Steve Marlin of Coastal University (see figures on next page from Ocean Adapt, https://oceanadapt.rutgers.edu/). Dr. Marlin had been studying the movements of a variety of marine species over time and had identified numerous shifts in where they were found.

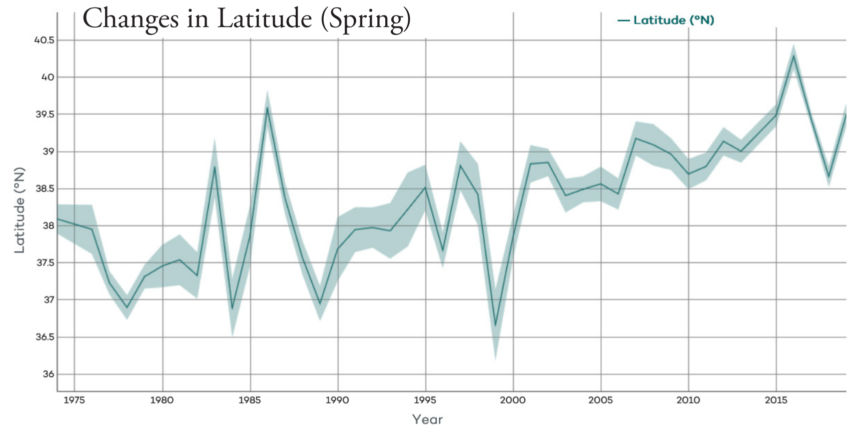

Figure 1(a). Population shift by latitude and season (spring) for black sea bass *(Centropristis striata)*. The solid line indicates the mean and the shaded area surrounding the mean is the standard deviation.

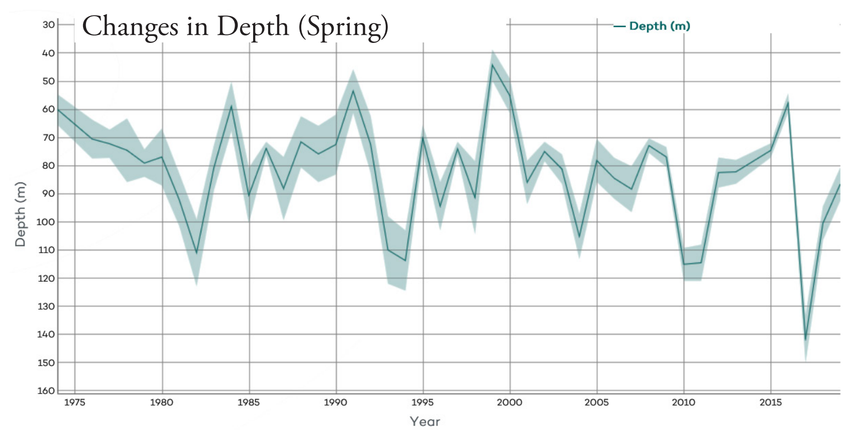

Figure 1(b). Population shift by depth and season (spring) for black sea bass *(Centropristis striata)*. The solid line indicates the mean and the shaded area surrounding the mean is the standard deviation.

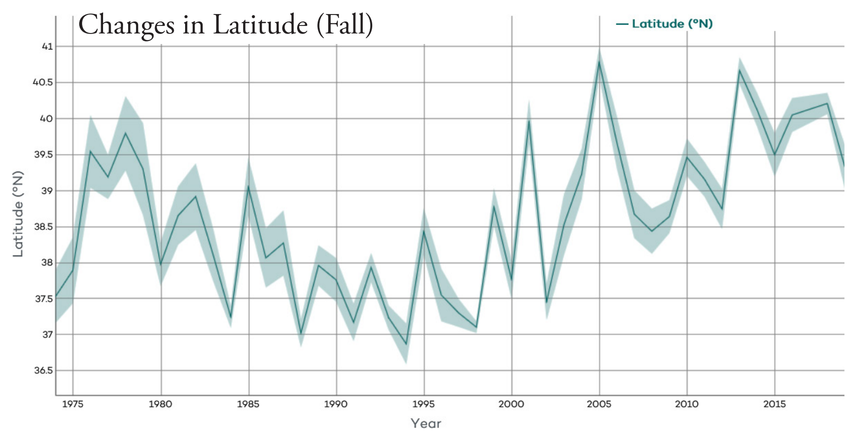

Figure 2(a). Population shift by latitude and season (fall) for black sea bass *(Centropristis striata).* The solid line indicates the mean and the shaded area surrounding the mean is the standard deviation.

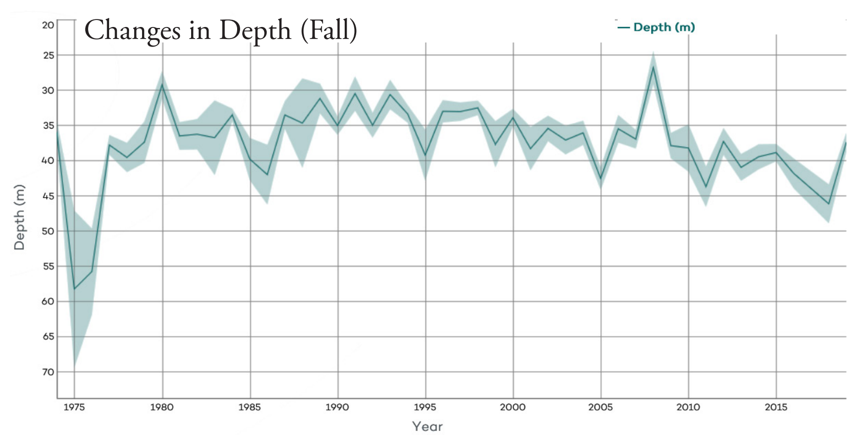

Figure 2(b). Population shift by depth and season (fall) for black sea bass *(Centropristis striata).* The solid line indicates the mean and the shaded area surrounding the mean is the standard deviation.

Questions

1. What changes have the fishers found when they go to catch their fish?

2. What patterns can you detect from studying Figures 1 and 2? How might this be relevant to the squid and your answer to Question 1?

3. What could be the potential causes of these changes?

4. What evidence would we need to collect to determine whether these potential causes are in fact the source of the changes? What will this evidence show?

5. The fishing industry is considered a "social-economic-ecological system."
   a. Why is it considered a social system?

   b. Why is it considered an economic system?

   c. Why is it considered an ecological system?

   d. In what ways do these subsystems interact?

6. What are the potential effects of the shifting fish populations on marine ecosystems and the fishing industry? Create a diagram that models all the potential causes and effects related to this case. In your diagram consider all the components that might be a part of the scenario besides the fishers and the fish. This is an initial diagram where you will have a chance to revise your diagram later in the case as more information becomes available!

Part II – Climate Velocity

While at the meeting, Joe listened intently as Dr. Marlin and others presented data about the fish Joe remembered as being abundant in the waters he fished over the years. The data described the shifts in species towards northern latitudes and deeper waters, although there were complications beyond these two movements.

Dr. Marlin presented his research first, which examined the shift in location of summer flounder *(Paralichthys dentatus*, also called fluke), black sea bass *(Centropristis striata)*, and scup *(Stenotomus chrysops)* towards cooler waters in the North Atlantic. He described these shifts as being related to climate velocity, which is the rate and direction that temperature shifts across space. "We are seeing overall shifts in species at a rate of 0.24–0.70° latitude per decade, or about 27–78 km per decade. However, our results also show that marine species shift at different rates and directions because they closely track the complex mosaic of local climate velocities."

Joe and other fishers in the audience were not surprised to hear about the shifts, but the concept of climate velocity was new. He raised his hand and asked, "Dr. Marlin, your data show locational shifts in a few species. Do you expect the shifts to occur in all marine species? What does it mean for the marine life that eat species living in different regions of the ocean?"

Dr. Marlin replied, "Great questions! We know that not all marine species are shifting at the same rate; however, there are optimal survival temperatures for each marine species, and if temperatures rise (see Figure 3), they will likely shift to cooler locations if they can. Regarding your second question, I'll defer to Dr. Susan Baleen, a marine ecologist from the Marine Eco-Center of the Atlantic."

Dr. Baleen, who had studied marine ecosystems of the western Atlantic for more than twenty years, addressed the listeners. "When species shift location, it is like they are moving into a new home. The new location may or may not have what is needed for the guests to survive. If the location is suitable for the arriving species, the resources available for those already living there may be reduced. This is called competition. In addition, the food web may change as new species enter, begin eating new prey, and begin to be eaten themselves. For example, we've seen this occur when black sea bass shifted north into lobster habitat and began to eat more lobster."

The information presented at the meeting resonated with Joe as he thought about all the changes he had witnessed over the years. He was concerned about the future of the fisheries he had relied on for more than 30 years; he had always just assumed they would be sustained into the future. Even more, he was concerned about the marine ecosystem as a whole, knowing that one small change could have an impact throughout the entire ecosystem.

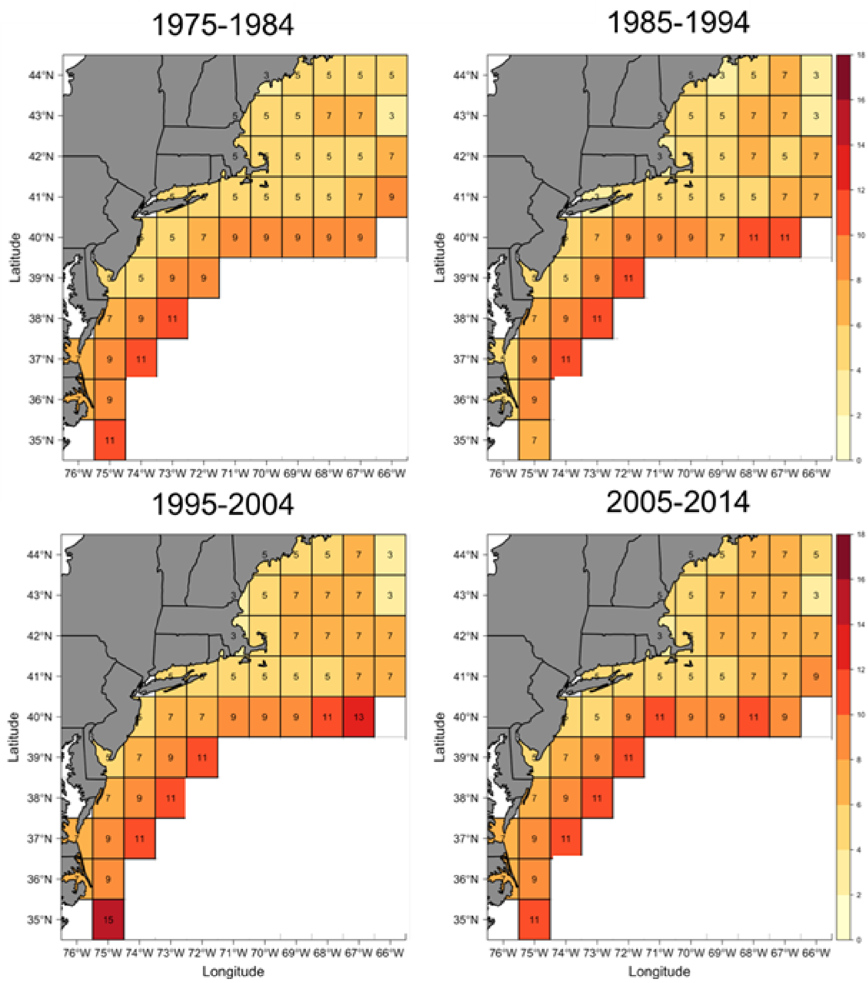

Figure 3. Ocean bottom temperature data (degrees Celsius) collected from NOAA Fisheries vessels during their spring fish surveys in 10-year blocks.

Questions

1. Identify the trends in temperature over time as represented in Figure 3.

2. In your own words, describe "climate velocity."

3. Note the data presented in Figure 3. Describe how marine species may respond to shifting temperatures as displayed in the figure. Consider the following questions in your response:
   a. When species are introduced to a new environment, what positive impacts might they bring to the new habitat?
   b. When species are introduced to a new environment, what harm might they cause to the new habitat?
   c. Since black sea bass have been introduced to new habitats, they have been impacting the lobster population. What other consequences can you envision stemming from this new species' arrival?

4. Ecosystems are complex. Identify the cause-effect relationships that may occur when species shift their locations.

Part III – Developing a Management Plan

Now that Joe understood why he might be seeing changes in his catch, his mind raced through the impacts that these changes might have on his fishery. "Do I find a new species to fish? Do I find a new line of work? If I do, what about the welfare of those working for me?" After grappling with all the what-ifs, he took a deep breath and began thinking about ways to move forward. The next speaker sparked his interest.

Sam Sharkman from the National Oceanic and Atmospheric Administration (NOAA) was the final speaker of the day, and he suggested an action plan for the fisheries of the East Coast. "With your assistance, we need a plan to ensure our fisheries are maintained into the future. This plan must not only consider our multi-million-dollar industry and the jobs it provides, but it must also consider the science. We know fish are leaving certain regions, but they are doing so at different rates and other species are moving in. We also know our current quota system for many species is based on data from the late 1980s and early 1990s, and it hasn't been updated to account for these shifts. Whatever management plan we adopt must be flexible enough to account for shifting fish populations now and into the future, and for the range in sizes of our fishing companies from small boats to large boats and fleets. Our regulations have been successful in rebuilding our fish stocks after years of overfishing. We've got to maintain this positive momentum."

Sam showed a slide on the screen (Figure 4), and then split the audience into diverse teams with stakeholders representing various entities involved in the fishing industry (e.g., big boat and small boat fishers), scientists, local fishing communities, etc. The teams were tasked to develop a fisheries management plan reflecting the shifts in marine species.

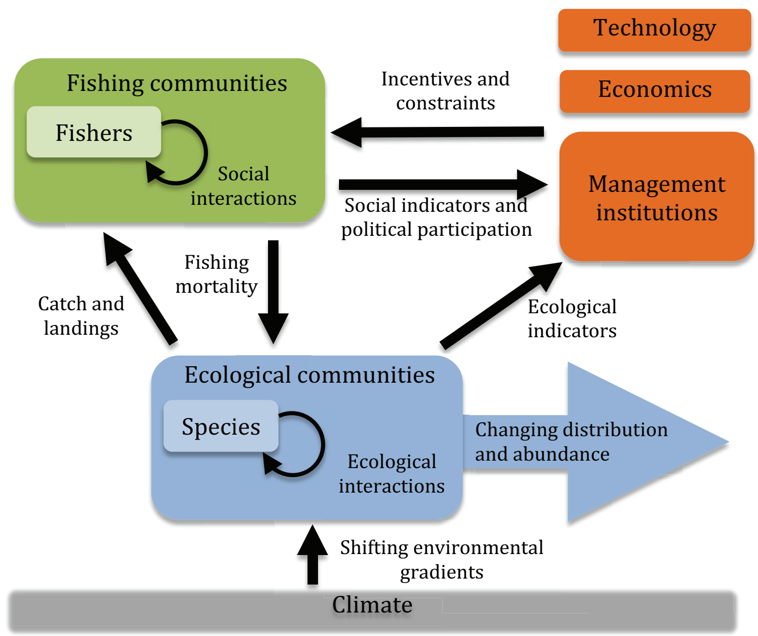

Figure 4. Conceptual diagram of the fisheries human-environment system. Climate and fishing impact species, while feedbacks through fishing link human communities and species. Management institutions respond to social and ecological information. Regulations, economics, and technology constrain or incentivize fishing behaviors.

Questions

1. How might the interactions of fishing, introduced species, and climate velocity affect the abundance and distribution of marine fish?
2. Fishing regulations place limits on the quantity and size of fish obtained in sectors of the ocean. Why is it so difficult to establish fishery regulations which ensure fish populations are sustainable?
3. Revise the model you created in Part I to account for the complexity of the issue presented in this case study. Be sure to identify positive and negative feedbacks that might add to the complexity of developing a sustainable fisheries management plan. Use Figure 4 as a guide when constructing your model to ensure all the components of the case are considered in your plan.
4. As one of the stakeholders, what is the best management plan from your perspective? Why? Be ready to defend your ideas with evidence-based arguments.