Climate Change & Fish Populations

Every day, we hear something in the news about the effects of climate change — warming oceans, an increasing number of severe storms, melting polar ice caps. But we also know that life on this planet has adjusted to climate changes in the past. Marine ecosystems can be altered dramatically, partly in response to these changes. As we consider the future of our fisheries, we ask ourselves: How does climate change influence fish populations? What changes can we expect to see over the next several decades?

cli•mate \'klī-mət\
1: the average course or condition of the weather at a place over a period of years as exhibited by temperature, wind velocity and precipitation.

What makes fish populations change?

Fish populations change for many reasons. These reasons can be grouped into two categories:

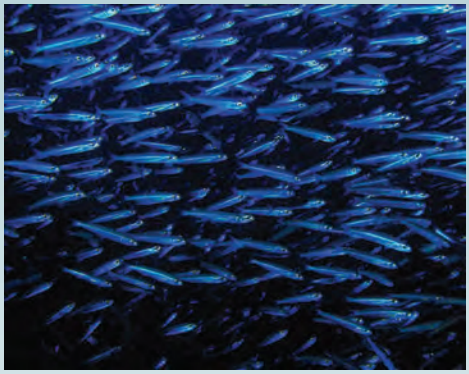
Bottom-up changes:

Factors that affect the growth and development of young fish.

Top-down changes:

Changes that impact the number of predators (including fish of the same species and fishermen) or competition for food.

Because climate influences the environment in which young fish grow, our current understanding is that climate is responsible mostly for bottom-up changes in fish populations. However, a changing environment also alters predator behavior and populations, so top-down changes should also be expected.



Left: Young fish are susceptible to bottom-up changes.

Below: Fishing pressure is an example of a top-down change.

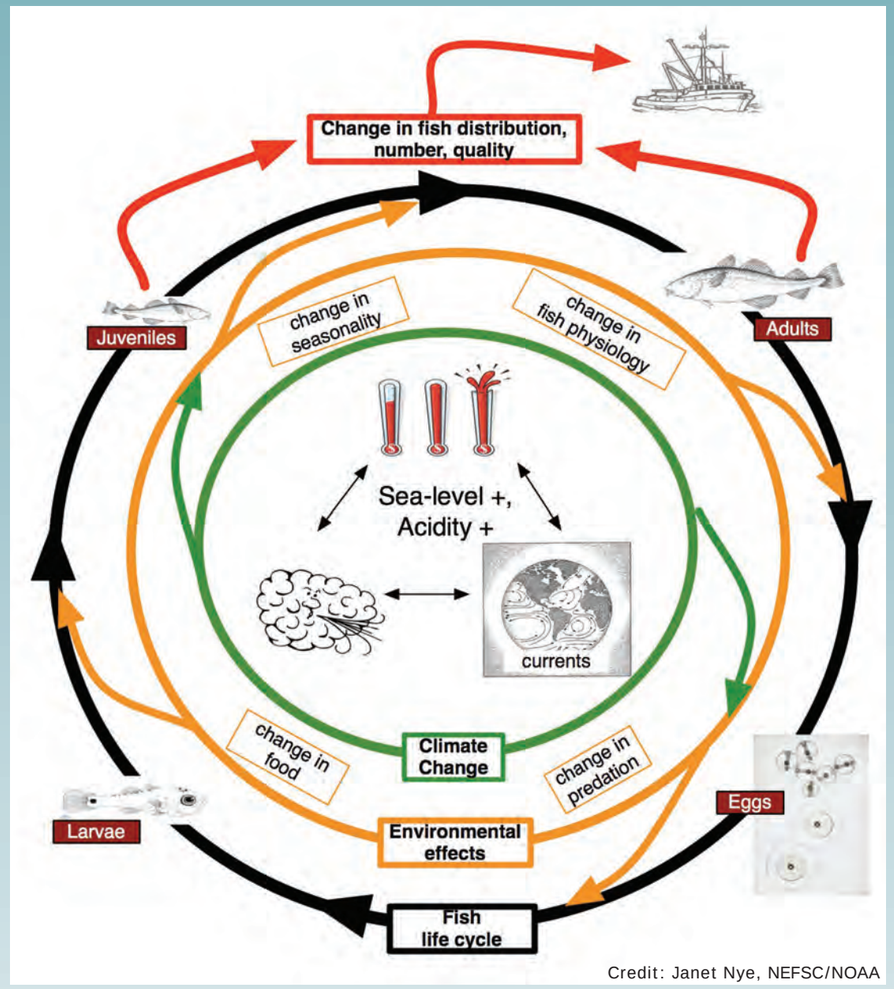
How does climate affect fish populations?

1. Temperature Effects

Climate change can alter water temperatures, which in turn affects where certain fish will be found. Just like animals on land, each species of fish has a range of temperatures that it can withstand. When temperatures rise, species may shift their location. In the Northern Hemisphere, fish respond to increasing temperatures by either moving further north or into deeper water to avoid overheating. For example, researchers have found that American shad, alewife, red hake and yellowtail flounder have shifted their distribution further north as ocean temperatures have warmed.

Changes in species home range may have important implications for our fisheries. As more southern species shift their distribution northward, fishermen will need to adapt their techniques to catch the new species and fishing markets will, in turn, have to adapt. For example, Atlantic croaker, a common fish off the southeast U.S. coast, is moving north and may soon be targeted by New England fishermen. If that happens, we may be asking our local grocer: "What does croaker taste like and how should I prepare it?"

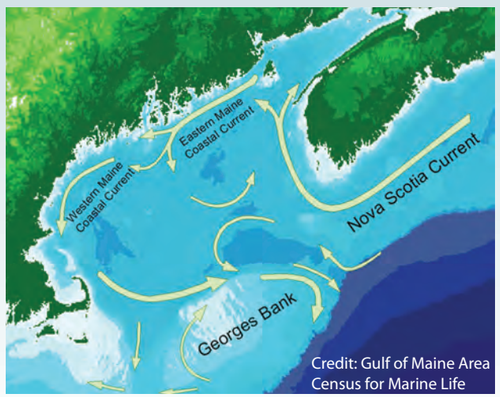
If fish do not shift their distribution north, they will experience warmer water temperatures. Since fish are cold-blooded, their metabolism depends in part on the temperature of their environment. This means that in warmer water, young fish and larvae will grow faster because the water is warmer and because their food is more plentiful. One benefit may be that fish speed through a period when they are small and more likely to be eaten by larger animals. As a result, more of them would survive. However, increased water temperatures may also benefit their predators, so the end result for fisheries is not easy to predict.



Credit: Janet Nye, NEFSC/NOAA

Above: The linkages between climate change effects (green), the biological and physical fish environment (orange), the fish life cycle (black) and fisheries (red).

Right: Major currents of the Gulf of Maine.



Credit: Gulf of Maine Area Census for Marine Life

2. Wind Power

Changes in wind patterns are also expected as the climate changes. Winds are driven by differences in density between adjacent air masses that have different air temperatures and moisture content. With climate change, differential heating and cooling of land and water will influence the intensity, frequency and seasonality of climate patterns (such as El Niño) and extreme weather (like droughts and storms) that influence current. As a result, the speed and direction of the dominant wind patterns may be altered due to climate change. Because wind pushes surface waters, these changes will affect currents that carry larval fish as they develop, and thus may impact the survival of young fish. For example, if a species depends on currents that keep larvae in warmer, predator-free waters, a change in climate that disrupts this pattern can cause serious problems for that stock with obvious implications for fishermen.

3. Ocean Acidification/Sea Level Rise

Increased atmospheric carbon dioxide will also increase the ocean's acidity. Increased acidity could mean that marine organisms, such as coral and lobsters, will be unable to draw the calcium carbonate from the water that they need to survive and grow. While changes in the ocean acidity are predicted to be slight, these changes may have important impacts on marine fisheries.

Sea level is also expected to rise because water expands as it warms. Melting glaciers and sea ice will add more water to the ocean as well. This will impact marine fishing communities as well as altering coastal habitats that are critical to the life cycle of commercially valuable fish populations.

4. Timing is Everything

Climate change can also influence fish populations by altering the timing of phytoplankton blooms. Warming and changes in wind patterns can influence rainfall, glacial run-off and evaporation patterns that determine ocean salinity and density. Phytoplankton need the right combination of sunlight, nutrients and a stable lens of lighter (warmer or fresher) water near the surface of the ocean in order to grow. Thus, changes in the ocean density may influence this lens and alter the timing and amount of phytoplankton growth. In ocean ecosystems, timing is critical. Zooplankton and fish carefully time their movements and spawning periods according to when and where there will be dependable, high-quality food. Changes in the availability of phytoplankton shifts the abundance and distribution of zooplankton, or fish food. Ultimately, this influences fish movements, spawning and population size, and the quality and quantity of fish caught by fishermen.

Combining Climate and Fishing Effects

Today's fish populations are being affected by climate changes and fishing pressure. Intense fishing pressure has caused fish populations to mature at younger ages and at smaller sizes, while larger, older fish are removed from the population. When fish are not harvested, adult fish have more opportunities to spawn over the course of their lifetime. These longer-living adult fish can prevent younger fish from suviving by competing for food. This is an example of top down population control. In contrast, for heavily fished populations that are dominated by younger, smaller fish, adult fish only have a limited number of opportunities to reproduce and every year is an important year for reproduction. These populations are more vulnerable to the bottom-up influence of climate change and their numbers vary dramatically as they closely track year-to-year environmental variability. This can be problematic for fishermen trying to provide a stable, dependable supply of fish to market.

Uncertainty and the Way Forward

We still have a lot to learn about the Earth's climate and how it will respond to changes in the atmosphere. But we do have climate change computer models that are linked with marine ecosystem information. These models provide the best guesses that experts can provide about what the future holds for fisheries.

Scientists are making great strides in improving our understanding of the Earth's climate system, and climate change computer models are continuing to improve. With the help of fishermen, these scientific studies will improve our ability to manage fish populations in ways that will benefit fish and fishermen alike. Despite the challenges ahead, fishermen and scientists will collectively find positive solutions.

Climate change affects fish populations by:

- Shifting fish distributions as they adjust to new ocean temperatures.
- Affecting ocean temperatures that change growth and survival of young fish.
- Determining dominant currents, which affect growth and survival of young fish.
- Shifting the timing of ecosystem events that fish depend on for survival and reproduction.

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