

PREVENTING ANOTHER NEW ENGLAND COD CRISIS

STUDY OFFERS WAYS TO PREPARE FOR CLIMATE IMPACTS ON FISHERIES

In October 2015, a study in the journal *Science* demonstrated a clear link between warming ocean waters and the depleted state of cod in the Gulf of Maine. It also provided a forecast for the fishery and practical ideas to avoid a similar crisis elsewhere.

Background

The story of New England cod has been told many times, and it is grim. In the Gulf of Maine, total catch has fallen by 80 percent since 1991, and the population is estimated to be about 4 percent of what's needed for maximum sustainable yield. Overfishing is a primary cause, but recently, warming has emerged as another major challenge.

The story of climate change and fisheries is just starting to unfold, and it is potentially troubling. Recent studies have shown that warming has for decades been causing fish stocks to move to cooler water. This could reduce or even eliminate fisheries like Gulf of Maine cod, which is at the southern edge of the species' range.

What the study found

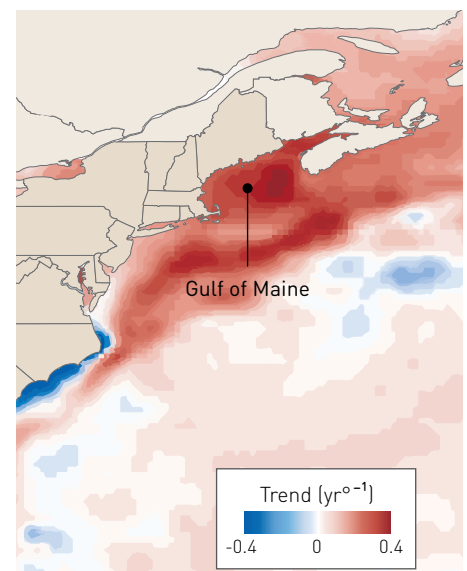
The new study, led by Andrew Pershing at the Gulf of Maine Research Institute, describes a causal chain between climate and the cod crisis for the first time:

- **Three climatic patterns led to rapid warming:** Between 2004 and 2013, the Gulf of Maine surface temperature increased by 0.23°C per year, one of the largest 10-year temperature swings ever experienced by a large marine ecosystem. The study linked this warming to three well-known patterns: the Gulf Stream, the Atlantic Multidecadal Oscillation, and the Pacific Decadal Oscillation. It found that these patterns explained 70 percent of the variation in summer temperatures between 1982 and 2013. This suggests it may soon be possible to predict average temperatures in the Northeast several years in advance, which would help set realistic expectations for fisheries.
- **Warmer water increased cod mortality:** By adding temperature to a traditional stock assessment model, the researchers found two impacts of warming: reduced spawning and lower survival of young cod. The causes are unclear but could include reduced food availability, stress due to water temperature, and more hospitable conditions for predators. The study projected the future potential for the fishery based on three climate scenarios and found that warming will likely prevent the cod stock from recovering to the levels seen before the decline (see figure 2, back page).
- **Management did not reduce catch enough to account for high mortality:** Managers are charged with setting catch limits based on the estimated abundance of cod. The stock assessment model used to make such estimates assumes reproduction and survival of cod do not depend on temperature. According to the paper, this led managers to set quotas that were too high. The frustrating result was that fishermen stayed within their quotas but still took more fish than the population could sustain.

Figure 1

RAPID WARMING

Sea surface temperature trends (degrees C per year), 2004-2013. The Gulf of Maine warmed faster than 99.9 percent of the global ocean.



Source: Pershing et al. (2015)

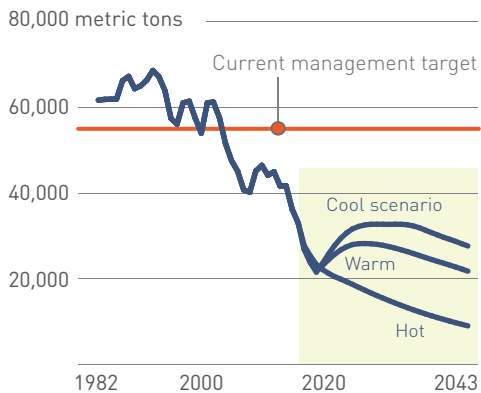
“ **FAILURE TO RECOGNIZE THE IMPACT OF WARMING ON COD CONTRIBUTED TO OVERFISHING.** ”

Pershing et al. (2015)

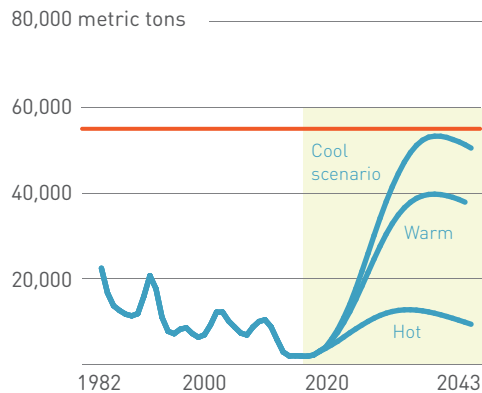
Figure 2

POTENTIAL FOR REBUILDING

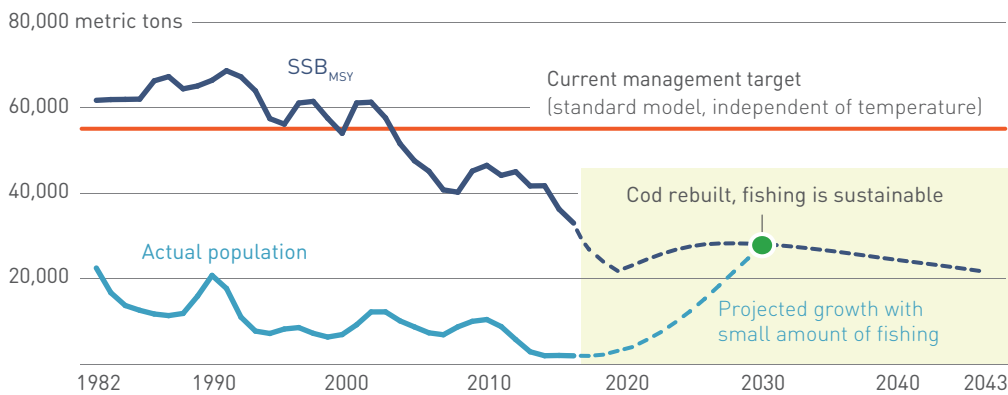
Biomass of a hypothetical population producing maximum sustainable yield (SSB_{MSY})



Actual and projected biomass of Gulf of Maine cod



Combined SSB_{MSY} and actual biomass, projected for warm scenario only



Source: Pershing et al. [2015]

Tools for preventing another crisis

The study offered the following ideas for responding to changing temperatures, for cod and for other fisheries:

- **Use temperature and other environmental indicators in fishery models.** As this study shows, this step toward ecosystem-based management can improve accuracy without the need to change the overall modeling framework. Such indicators are likely to be particularly reliable for stocks that are near the edge of the range for their species.
- **Use long-term climate forecasts.** Fishery models that include temperature can be combined with climate forecasts to provide a more realistic picture of the potential size of fish stocks and their associated fisheries. Multi-year forecasts are becoming available for many climate indices, including the Atlantic Multidecadal Oscillation. These could be used to make contingency plans for the major shifts in fishery productivity that are expected in a changing climate.

The graph at left shows how warming water reduced the potential productivity of cod. In technical terms, this is reflected in a decline in the spawning stock biomass that would produce maximum sustainable yield (SSB_{MSY}). The graph at right shows the actual biomass of Gulf of Maine cod, which was lower than SSB_{MSY} because of the added effect of overfishing. The shaded areas show projections for three climate scenarios with a small amount of fishing.

The bottom graph shows both SSB_{MSY} and actual biomass for only the “warm” scenario, which is based on the average temperature predictions from climate models. With a small amount of fishing, Gulf of Maine cod would be rebuilt by about 2030. However, because of warming, its potential productivity would be much lower than before the population collapse, according to the study.

CITATION

Pershing, A., M.A. Alexander, C.M. Hernandez, L.A. Kerr, A. Le Bris, K.E. Mills, J.A. Nye, N.R. Record, H.A. Scannell, J.D. Scott, G.D. Sherwood, A.C. Thomas. “Slow Adaptation in the Face of Rapid Warming Leads to Collapse of the Gulf of Maine Cod Fishery” *Science* [2015], doi 10.1126/science.aac9819

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Lenfest Ocean Program was established in 2004 by the Lenfest Foundation and is managed by The Pew Charitable Trusts