American lobsters feeling the heat in the northwest Atlantic

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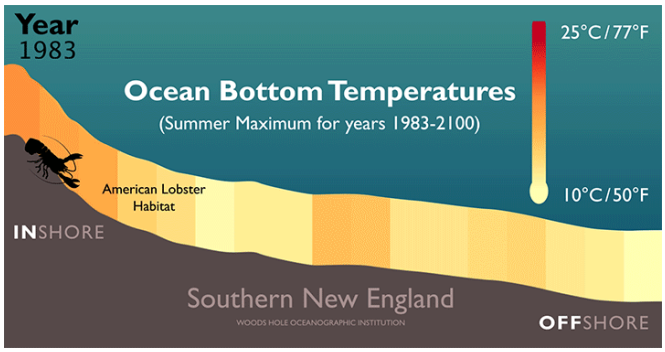

Rising temperatures along the bottom of the Atlantic Ocean will force American lobsters (H. americanus) farther offshore and into more northern waters, a new study finds. Credit: Natalie Renier, Woods Hole Oceanographic Institution

Rising temperatures along the bottom of the Atlantic Ocean will force American lobsters farther offshore and into more northern waters, a new study finds.

Climate models project that ocean bottom temperatures in the Atlantic along the U.S. East Coast may rise by up to 4.3 degrees Celsius (7.7 degrees Fahrenehit) by the end of the century. The new study's results show these rising temperatures will likely make conditions in the American lobster's southernmost range—less hospitable in the future for juveniles, pushing them farther north and into habitats farther offshore.

"That's a significant [temperature] change, and lobsters are particularly sensitive to warming water temperatures," said Jennie Rheuban, a researcher at the Woods Hole Oceanographic Institution (WHOI) in Woods Hole, Massachusetts and lead author of the new study published in the *Journal of Geophysical Research*: Oceans, a journal of the American Geophysical Union. "The species experiences physiological stress across all life stages when temperatures rise above 20 degrees Celsius (68 degrees Fahrenheit)."

Higher temperatures can affect lobster egg hatching and larval survival, Rheuban said. Females carry their eggs with them, and when the eggs hatch is largely determined by the temperature history the eggs have experienced.

Warming bottom temperatures can also reduce energy stores of overwintering invertebrates, such as lobster and copepods, and lead to more diseases, said Maria Kavanaugh, a former postdoctoral investigator at WHOI and now an assistant professor at Oregon State University in Corvallis and co-author of the new study.

The northeast U.S. continental shelf, which is home to a highly productive and commercially important marine ecosystem, has experienced some of the highest sea surface temperature warming rates in the world in recent decades.

The American lobster fishery—one of the most profitable, wild-caught fisheries—grossed more than $600 million in revenue in 2016. The fishery also employs thousands of people in the New England region. Credit: Derek Keats from Johannesburg, South Africa, CC BY 2.0, via

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"We wanted to find out specifically what was happening at the bottom, so that we could identify potential impacts to ecologically and commercially important species living there," says Rheuban. "We focused our analysis on the American lobster, but really the data could be used to look at impacts on other bottom-dwelling species, such as sea scallops."

In the new study, Kavanaugh analyzed 33 years of historical ocean temperature data from the Northwest Atlantic Ocean, ranging from Cape Hatteras through the Gulf of Maine.

"Bottom temperatures have increased throughout the region, including the deeper Gulf of Maine," Kavanaugh said. The iconic crustaceans are currently found in waters from southern New England up to Canada, but regional warming is already causing a decline in lobster catch in southern New England.

The research team then coupled these historical data with future projections of ocean temperatures from climate models from Intergovernmental Panel on Climate Change (IPCC).

Climate models use math and statistical methods to simulate how interactions among the atmosphere, oceans, land surface, and ice drive Earth's climate. But large-scale climate models don't have high-enough resolution to capture complex small-scale variations that occur in near-shore environments, such as on the continental shelf. So Rheuban and her colleagues needed to "downscale" the models to make better predictions of ocean temperatures at local scales and look at their impacts on marine life.

In the new study, the researchers downscaled projections from two different IPCC scenarios, based on possible future carbon dioxide emissions. One of the scenarios—known as the "business as usual" scenario—is based on unchecked emissions and taking no mitigating or policy action against climate change. The other scenario includes climate policy action and predicts roughly about half the warming as the other scenario.

Higher bottom temperatures can affect lobster egg hatching and larval survival, says WHOI researcher Jennie Rheuban, pictured here. Credit: Jennie Rheuban, Woods Hole Oceanographic Institution

In both cases, results showed that conditions in the southernmost range of the species—from Long Island Sound through Buzzards Bay, Massachusetts—will likely become less hospitable in the future for juveniles. The study also found that warming bottom temperatures may push lobsters farther offshore while the population will likely increase and expand northward in the Gulf of Maine.

Coastal environments act as a nursery habitat for both larvae and juveniles, providing them with a

protective area that is food-rich and relatively safe from predators.

"If adult females are forced into deeper water because the temperatures are more ideal, larvae may hatch outside of the nursery habitat and be less likely to survive," Rheuban said. "Juveniles also may be forced into offshore waters that are less safe from predators."

The increased temperatures could also lead to more cases of epizootic shell disease, which is linked to warmer waters. The bacterial disease impacts the behavior, growth and mortality rates, reproductive success, and marketability of lobsters.

The American lobster fishery is one of the most profitable, wild-caught fisheries and grossed more than $600 million in revenue in 2016. The fishery also employs thousands of people in the region and leads to substantial regional economic benefits.

"Maintaining a healthy, sustainable fishery in southern New England into the future will be increasingly challenging with further climate change and ocean warming," said Scott Doney, formerly of WHOI and now the Joe D. and Helen J. Kington Professor in Environmental Change at the University of Virginia in Charlottesville and a co-author of the new study. "An important next step, already under way, is to share our research findings with fishery managers and stakeholders from the northeast fishing community."

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