January 22, 2021

Evolution & Behaviour

A rapidly changing ocean is alarming for fisheries sustainability

by **Andrea Bryndum-Buchholz**[1] | Postdoctoral Research Fellow

doi.org/10.25250/thescbr.brk457

[1]: Dalhousie University

This Break was edited by Akira Ohkubo, Scientific Editor - TheScienceBreaker

Climate change is affecting fisheries around the world. Fisheries managers need an innovative system to consider the climate-driven changes in their decision-making. A new ensemble model of marine ecosystems allows to forecast how climate change may alter North Atlantic fishing grounds for the next decades and to advise fisheries management for the sustainable future.

Image credits: Paul Einerhand on Unsplash

Our oceans support millions of people's livelihoods and well-being. Marine fisheries connect the vast ocean space and the world's fish markets, providing fish and other seafood on our tables. Today's drastic climate change is threatening fisheries worldwide, because the marine ecosystem is responding to climate-induced ocean changes: elevated water temperatures and acidification, oxygen depletion, and marine heatwaves.

Following climate change, many commercially fished species, such as mackerel or lobster, are shifting their distribution in time and space. This response directly impacts fisheries — some fisheries will increasingly lose traditional fishing grounds; other fisheries might encounter new harvestable species as they move into their current fishing grounds. To ensure future sustainable fisheries, managers, who essentially control how much to fish in a given region and time, now need an innovative system to take climate change into account while making decisions.

Forecasting future marine ecosystem responses to global change requires a modeling approach. Often, climate-change scenarios are used to predict possible future consequences dependent on the success of global efforts to reduce greenhouse gas emissions such as carbon dioxide. These scenarios simulate different future possible greenhouse gas emissions pathways, ranging from low to high emissions, indicating different degrees of ocean warming over the 21st century. Scientists combine these scenarios with a climate model that forecasts changes in key ocean factors, such as temperature, primary production, and ocean acidification. These climate models are then coupled to a marine ecosystem model. Scientists can use this final model—which enables to predict how marine ecosystem processes or species may respond to future climate change—to advise fisheries managers on climate-change adaptation.

In this research, we combined multiple marine ecosystem models rather than a single model to study how marine ecosystems and fisheries' resources will change under high and low greenhouse gas emissions scenarios. It allowed us to estimate potential future consequences for fisheries' production and management in the North Atlantic Ocean, which includes hot spots of climate-driven ecosystem changes and regions of lucrative fisheries for Atlantic cod, American lobster, and large Snow Crab. We expected to find regional differences in magnitude and direction of future changes, signaling different challenges for fisheries management across the region.

Using a single marine ecosystem model to analyze climate change effects has its limitations. Instead, we used a model ensemble where multiple models are combined. Each individual model has its own assumptions and structure that, when combined into a model ensemble, can give a much more complete picture of ecosystem processes compared to any single model alone. The model ensemble allows finding out differences between individual models, which is critical for informing fisheries management agencies which forecasted changes could be more likely. In our analyses, we combined data from six different marine ecosystem models, that were coupled with climate models under two possible future greenhouse gas emissions scenarios (high and low emissions pathways), into a model ensemble. Our new model ensemble revealed average trends in harvestable fish biomass for each year in the study region over the 21st century.

To understand future consequences for fisheries management more explicitly, we analyzed the relationship between historical fisheries landings and forecasted biomass changes within our case study of the Northwest Atlantic Fisheries Organization (NAFO) regulatory area. We found that climate change will have strong impacts on marine ecosystems and the future of fisheries resources in the North Atlantic Ocean, which will challenge fisheries management within the NAFO area. Here, ecosystem changes will differ regionally — future fisheries resources will increase in northern, historically less fished regions, but will decrease in southern regions that include traditional and current key fishing grounds, such as the Grand Banks of Newfoundland. When it comes to the greenhouse gas emissions, future declines in fisheries resources will be larger under the high-emissions scenario, threatening future fisheries' production and pointing towards the need to adapt the regulations that are in place. In contrast, all future biomass declines will be smaller under the low-emissions scenario, confirming that effective policies limiting global greenhouse gas emissions can benefit our oceans and societies.

Our study is the first to apply an ensemble model approach to a regional fisheries management context under different greenhouse gas emissions scenarios for the next decades. We found a strong relationship between areas of future fisheries resources and historically important fishing grounds in the Northwest Atlantic Ocean. Climate change demands proactive fisheries governance and management practices. If we are to achieve sustainable fisheries that will continue to support livelihoods and well-being, fisheries management must begin to adapt to climate-driven changes.