UC SANTA BARBARA

THE Current

July 15, 2024

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Expanding marine reserves will redistribute global fishing effort

Earth is facing a biodiversity crisis. Fueled by human activity, species are going extinct, habitat is disappearing, and ecosystems are breaking down. In response, the countries of the world have committed to expand protections over the land and sea.

A new study in the Proceedings of the National Academy of Sciences, led by researchers from UC Santa Barbara, aims to understand how the expansion of marine protected areas (MPAs) will affect global fishing effort — a measure of fishing activity or intensity

“Evaluations often simply assume that fishing effort inside new MPAs either disappears or moves elsewhere,” write the study’s authors, including Gavin McDonald, a scientist at UCSB’s Environmental Markets Lab (emLab). “We find that neither assumption is true.” Instead, their model predicts that fishing activity will decrease both within and adjacent to marine reserves. Understanding this dynamic is important for properly planning ocean conservation and fisheries management.

Expanding protections in the ocean

Fully protected marine reserves currently cover less than 3% of the world’s oceans, but ongoing international discussions suggest they will expand over the coming years. For instance, in 2022, 196 countries adopted the Kunming-Montreal Global

Biodiversity Framework. This non-binding agreement calls for the effective protection and management of 30% of the world's terrestrial, inland water, and coastal and marine areas by the year 2030, informally referred to as "30x30."

As the coverage of MPAs expands, governments, scientists and NGOs want to ensure these efforts are effective and long lasting. This requires understanding how fully protected marine reserves impact global fishing effort. Gaps in our knowledge can have real consequences.

"Phoenix Islands Protected Area and Palau National Marine Sanctuary were recently reopened due to their perceived negative effects on the fishing industry. Losing these protections demonstrates the importance of economics in marine spatial planning, " said co-author Jennifer Raynor, an assistant professor at the University of

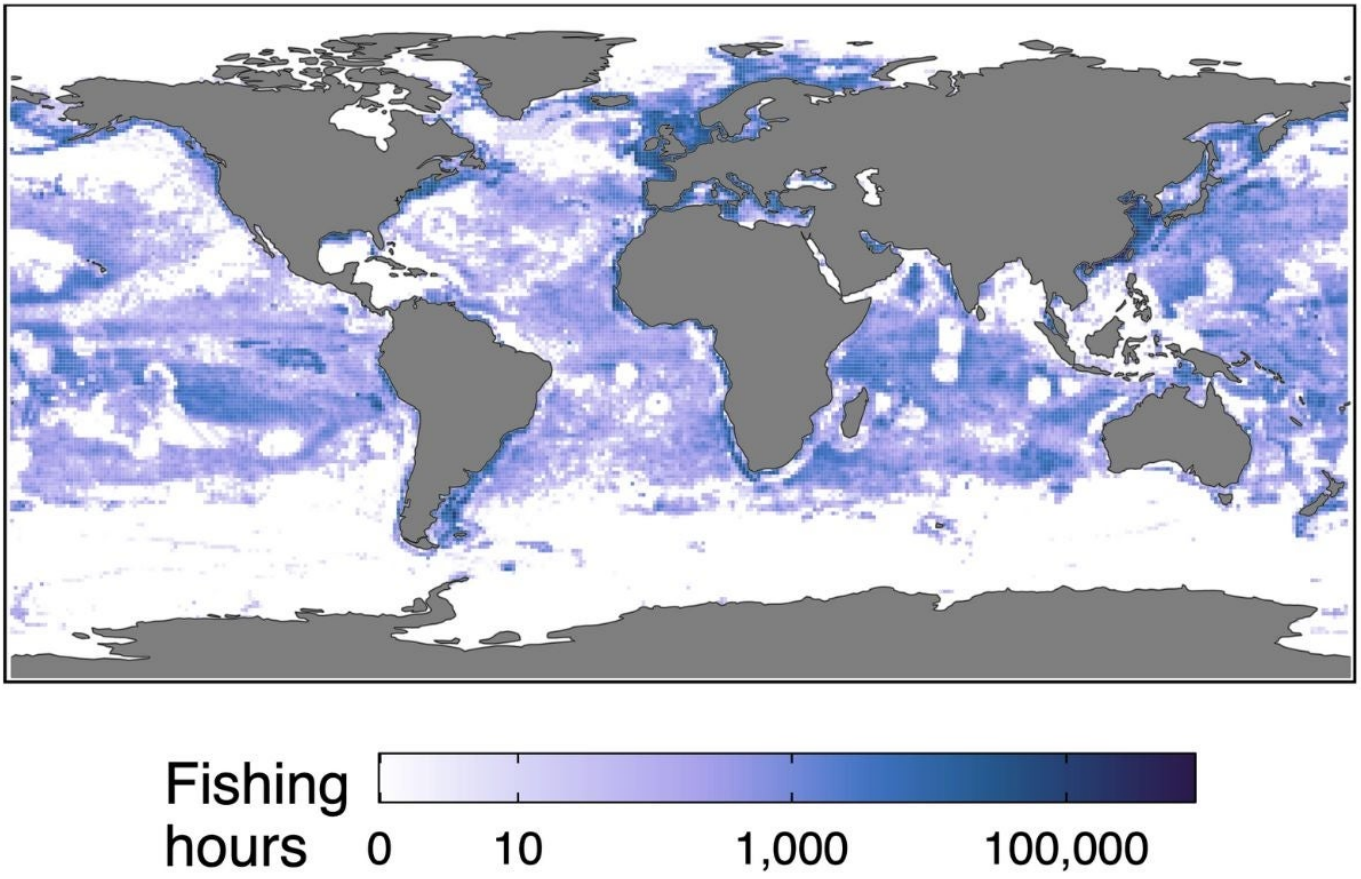

Photo Credit
McDonald et al.
Fishing effort varies widely across the ocean.

Modeling an international industry

The authors designed a data-driven, predictive model to investigate how fishing effort will respond following large-scale closures of fishing grounds. Fishing “effort” refers to the time or energy expended on fishing. “So this is different from the fisheries outputs, such as fish catch, revenues or profits,” said lead author McDonald.

Using historical fishing data, the team trained a machine learning model to compare the industry’s response if governments increased MPA coverage to upwards of 30% of the ocean, versus the current 3%.

The researchers began by compiling global datasets of industrial fishing effort courtesy of Global Fishing Watch. This NGO provides open source, publicly available and nearly real-time information on fishing activity. Data like this has only recently become available due to the Automatic Identification System, which uses satellite and land-based receivers to track more than 110,000 fishing vessels. “This data source has fundamentally changed the way we do research and is now a major part of much of the fisheries-related research we do,” McDonald said.

The team combined fishing patterns with the locations of existing and proposed marine protected areas gleaned from MPA Atlas and the scientific literature. They then added geographic and environmental data from the National Oceanic and Atmospheric Administration; information from the Marine Regions and Global Fishing Index, which characterizes the strength of fisheries management; and fuel price data from the Bunker Index that captures economic conditions.

Taking a global perspective

After crunching the numbers on a variety of scenarios, the models consistently predicted that large-scale protection will drive down fishing effort throughout the globe — both within and outside of protected areas. And the magnitude of this decline depended primarily on the location of new MPAs in relation to the current distribution of fishing activity.

The team found it encouraging that fishing inside reserves was predicted to decline. However, it rarely went to zero globally when they aggregated MPAs together, which suggests that realizing the full conservation potential will require improved enforcement and better engagement with fishing communities.

Fishing effort within MPAs fell by at most 87% after three years, although compliance depended on network design and where the network boundaries were placed in relation to current fishing effort. “Importantly, fishing doesn't just move from inside to outside marine protected areas,” said Raynor. “Fishing effort outside marine protected areas also falls.”

“This goes against the commonly discussed idea of ‘fishing the line,’” McDonald added, “where fishing effort that was previously inside the new MPA is displaced to areas just outside the MPA's boundaries.” This behavior is often assumed in analyses of new marine protected areas.

The effect that expanding MPA coverage had on global fishing heavily depended on how it overlapped with current fishing effort. The smallest decline (6%) came from increasing protections on areas that aren’t currently fished. In the scenario on the opposite end of the spectrum — protecting the areas that are currently most fished —the model predicted a 55% decline in fishing effort around the world. “Most of the scenarios fall between these two extremes,” McDonald said, “resulting in 10% to 20% reductions.”

Considering the driving factors

The researchers didn’t focus on the mechanisms behind their results, but they have a few hypotheses. MPAs may serve as a reservoir for increasing fish stocks, which then spill over into the unprotected areas surrounding them. This would enable fishermen to get more bang for their buck, landing a similar sized catch with less effort.

Alternatively, there might not be a strong spillover effect, and MPAs could simply close off the most productive fishing grounds. In this case, it may no longer be as profitable to fish outside the MPA in the remaining open areas. And MPAs in remote locations, that are expensive to travel to, might not be worth the expense to visit, even to fish outside the reserves.

“It's also really important to note that, while our analysis found that fishing effort will likely go down, this does not mean that catch, profit, revenue or food provisioning will go down,” McDonald explained. “Depending on which of these underlying mechanisms is at play, decreased fishing effort could correspond to increases or decreases in these other important outcomes.”

While previous studies have looked at the effect individual MPAs have on fishing in a specific region, this is the first to consider the question on a global scale, accounting for complex interactions between fleets. Indeed, the group is also interested in using their model to explore how other large-scale changes could impact fishing effort, like the climate crisis.

“The success or failure of these new marine protected areas — and the impacts they will have on biodiversity and socioeconomics — will largely hinge on how fishing activity responds to them,” McDonald said. So understanding this is critical to those who hope to implement these changes.”

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