Climate change has likely begun to suffocate the world's fisheries

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Credit: Paul Einerhand

By 2080, around 70% of the world's oceans could be suffocating from a lack of oxygen as a result of climate change, potentially impacting marine ecosystems worldwide, according to a new study. The new models find mid-ocean depths that support many fisheries worldwide are

already losing oxygen at unnatural rates and passed a critical threshold of oxygen loss in 2021.

Oceans carry dissolved oxygen as a gas, and just like land animals, aquatic animals need that oxygen to breathe. But as the oceans warm due to climate change, their water can hold less oxygen. Scientists have been tracking the oceans' steady decline in oxygen for years, but the new study provides new, pressing reasons to be concerned sooner rather than later.

The new study is the first to use climate models to predict how and when deoxygenation, which is the reduction of dissolved oxygen content in water, will occur throughout the world's oceans outside its natural variability.

It finds that significant, potentially irreversible deoxygenation of the ocean's middle depths that support much of the world's fished species began occurring in 2021, likely affecting fisheries worldwide. The new models predict that deoxygenation is expected to begin affecting all zones of the ocean by 2080.

The results were published in the AGU journal *Geophysical Research Letters*, which publishes high-impact, short-format reports with immediate implications spanning all Earth and space sciences.

The ocean's middle depths (from about 200 to 1,000 meters deep), called mesopelagic zones, will be the first zones to lose significant amounts of oxygen due to climate change, the new study finds. Globally, the mesopelagic zone is home to many of the world's commercially fished species, making the new finding a potential harbinger of economic hardship, seafood shortages and environmental disruption.

Rising temperatures lead to warmer waters that can hold less dissolved

oxygen, which creates less circulation between the ocean's layers. The middle layer of the ocean is particularly vulnerable to deoxygenation because it is not enriched with oxygen by the atmosphere and photosynthesis like the top layer, and the most decomposition of algae—a process that consumes oxygen—occurs in this layer.

"This zone is actually very important to us because a lot of commercial fish live in this zone," says Yuntao Zhou, an oceanographer at Shanghai Jiao Tong University and lead study author. "Deoxygenation affects other marine resources as well, but fisheries [are] maybe most related to our daily life."

The new findings are deeply concerning and adds to the urgency to engage meaningfully in mitigating climate change, says Matthew Long, an oceanographer at NCAR who was not involved in the study.

"Humanity is currently changing the metabolic state of the largest ecosystem on the planet, with really unknown consequences for marine ecosystems," he said. "That may manifest in significant impacts on the ocean's ability to sustain important fisheries."

Evaluating vulnerability

The researchers identified the beginning of the deoxygenation process in three ocean depth zones—shallow, middle and deep—by modeling when the loss of oxygen from the water exceeds natural fluctuations in oxygen levels. The study predicted when deoxygenation would occur in global ocean basins using data from two climate model simulations: one representing a high emissions scenario and the other representing a low emissions scenario.

In both simulations, the mesopelagic zone lost oxygen at the fastest rate and across the largest area of the global oceans, although the process

begins about 20 years later in the low emissions scenario. This indicates that lowering carbon dioxide and other greenhouse gas emissions could help delay the degradation of global marine environments.

The researchers also found that oceans closer to the poles, like the west and north Pacific and the southern oceans, are particularly vulnerable to deoxygenation. They're not yet sure why, although accelerated warming could be the culprit. Areas in the tropics known for having low levels of dissolved oxygen, called oxygen minimum zones, also seem to be spreading, according to Zhou.

"The oxygen minimum zones actually are spreading into high latitude areas, both to the north and the south. That's something we need to pay more attention to," she says. Even if global warming were to reverse, allowing concentrations of dissolved oxygen to increase, "whether dissolved oxygen would return to pre-industrial levels remains unknown."

More information: Hongjing Gong et al, Emerging Global Ocean Deoxygenation Across the 21st Century, *Geophysical Research Letters* (2021). DOI: 10.1029/2021GL095370

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