Twilight zone at risk from climate change

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Life in the ocean's "twilight zone" could decline dramatically due to climate change, new research suggests. The twilight zone (200m to 1,000m deep) gets very little light but is home to a wide variety of organisms and billions of tonnes of organic matter.

The new study warns that climate change could cause a 20-40% reduction in twilight zone life by the end of the century.

And in a high-emissions future, life in the twilight zone could be severely depleted within 150 years, with no recovery for thousands of years.

"We still know relatively little about the ocean twilight zone, but using evidence from the past we can understand what may happen in the future," said Dr. Katherine Crichton, from the University of Exeter, and lead author of the study.

The research team, made up of palaeontologists and ocean modellers, looked at how abundant life was in the twilight zone in past warm climates, using records from preserved microscopic shells in ocean sediments.

"We looked at two warm periods in the Earth's past, about 50 million years ago and 15 million years ago," said Professor Paul Pearson of Cardiff University, who led the research.

"We found that the twilight zone was not always a rich habitat full of life.

"In these warm periods, far fewer organisms lived in the twilight zone, because much less food arrived from surface waters."

Animals in the twilight zone mainly feed on particles of organic matter that have sunk down from the ocean surface.

The study showed that in warmer seas of the past, this organic matter was degraded much faster by bacteria—meaning less food reached the twilight zone.

"The rich variety of twilight zone life evolved in the last few million years, when ocean waters had cooled enough to act rather like a fridge, preserving the food for longer, and improving conditions allowing life to thrive," said Dr. Crichton.

This led the researchers to ask what will happen to life in the twilight zone in a future, warmer world.

Combining the evidence on past warm periods with Earth System Model simulations, they simulated what might be happening now in the twilight zone, and what could happen in future decades, centuries and millennia due to climate warming driven by greenhouse gas emissions.

"Our findings suggest that significant changes may already be under way," Dr. Crichton continued.

"Unless we rapidly reduce greenhouse gas emissions, this could lead to the disappearance or extinction of much twilight zone life within 150 years, with effects spanning millennia thereafter.

"Even a low-emissions future may have a significant impact, but that would be far less severe than medium- and high-emissions scenarios.

"Our study is a first step to finding out how vulnerable this ocean habitat may be to climate warming."

The study's three emissions scenarios are based on total carbon dioxide emissions after 2010. "Low" is 625 billion tonnes, "medium" is 2,500 billion tonnes, and "high" is 5,000 billion tonnes.

For context, the Global Carbon Budget (led by the University of Exeter) estimated total global carbon dioxide emissions of 40.6 billion tonnes in 2022 alone.

Emissions have been close to 40 billion tonnes every year from 2010-22, so most of the carbon dioxide (about 500 billion tonnes) for the study's "low" scenario has already been emitted.

At the current rate, the "medium" scenario would be reached 50 years from now, and the "high" in just over a century.

Dr. Jamie Wilson, from the University of Liverpool, said, "The twilight zone plays an important role in the ocean's carbon cycle because most of the carbon dioxide taken up by phytoplankton ends up there as their remains sink down from the surface ocean.

"One of the challenges of predicting how this movement of carbon might change in the future is that there are many processes to disentangle in the modern ocean.

"By looking back at the twilight zone in past warm periods we can identify the most important processes and use those to predict the future.

"We found that this natural cycling of carbon is likely already changing and may be perturbed long into the future."

To increase our knowledge on the ocean twilight zone, a UN programme (JETZON) has been set up. It states: "It is poorly understood from almost any perspective. However, it contains possibly the world's largest and least exploited fish stock and recycles ~80% of the organic material that sinks out of the productive surface waters."

The new study was funded by the Natural Environment Research Council and includes researchers from the universities of Exeter, Liverpool, California Riverside, Bremen, Cardiff, and University College London.

More information: What the geological past can tell us about the future of the ocean's twilight zone, *Nature Communications* (2023). DOI: 10.1038/s41467-023-37781-6

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