Low-oxygen 'dead zones' in North Pacific linked to past ocean-warming events

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Credit: Tiago Fioreze / Wikipedia

A new study has found a link between abrupt ocean warming at the end of the last ice age and the sudden onset of low-oxygen, or hypoxic conditions that led to vast marine dead zones.

Results of the study, which was funded by the National Science Foundation, are being published this week in the journal *Nature*.

Large-scale warming events about 14,700 and again 11,500 years ago occurred rapidly and triggered loss of oxygen in the North Pacific, raising concern that low-oxygen areas will expand again as the ocean warms in the future. Anomalous warmth occurring recently in the Northeastern Pacific Ocean and the Bering Sea - dubbed "The Blob" - is of a scale similar to the events documented in the geologic record, the researchers say. If such warming is sustained, oxygen loss becomes more likely.

Although many scientists believe that a series of low-oxygen "dead zones" in the Pacific Ocean off Oregon and Washington during the last decade may be caused by ocean warming, evidence confirming that link has been sparse.

However, the new study found a clear connection between two prehistoric intervals of abrupt ocean warming that ended the last ice age with an increase in the flux of marine plankton sinking to the seafloor, ultimately leading to a sudden onset of low-oxygen conditions, or hypoxia.

"Our study reveals a strong link between ocean warming, loss of oxygen, and an ecological shift to favor diatom production," said lead author Summer Praetorius, who conducted the research as part of her doctoral studies at Oregon State University and is now a postdoctoral researcher at Carnegie Institution for Science.

"During each warming event, the transition to hypoxia occurred abruptly and persisted for about 1,000 years, suggesting a feedback that sustained or amplified hypoxia." Praetorius added.

Warmer water, by itself, is not sufficient to cause diatom blooms, nor hypoxia, the researchers note. Just as warming soda pop loses its fizzy gas, warmer seawater contains less dissolved oxygen, and this can start the oxygen decline. But it isn't until there is accelerated blooming of microscopic diatoms - which have large shells and tend to sink more efficiently than other smaller types of plankton - that deoxygenation is amplified.

Diatoms are known to thrive in warm, stratified water, but they also require sources of nutrients and iron, according to Alan Mix, a professor in Oregon State's College of Earth, Ocean, and Atmospheric Sciences and co-author on the Nature study.

Surface warming also reduces upward mixing of nutrients from the deep sea. "So there are some competing effects," Mix said, "and the final story depends on which effect wins."

"The high-latitude North Pacific is rich in the common nutrients such as nitrate and phosphate, but it is poor in iron and this seems to be the key," Mix said. "A partial loss of oxygen causes a chemical reaction that releases iron previously trapped in continental margin sediments - and this iron then fuels the diatoms, which bloom, die, and sink toward the seafloor, consuming oxygen along the way."

The concern is just how rapid the ocean can respond, the researchers say.

"Many people have assumed that climate change impacts will be gradual and predictable," Mix said, "but this study shows that the ecological consequences of climate change can be massive and can occur pretty fast, with little warning."

Because the competing effects of mixing and iron may happen on different timescales, the exact sequence of events may be confusing. On the scale of a few years, mixing may win, but on the scale of decades to centuries, the bigger effects kick into gear. The geologic record studied by Praetorius and colleagues emphasized these longer scales.

The new discovery was the result of a decades-long effort by numerous researchers at Oregon State to collect marine sediment cores from the North Pacific, creating comprehensive, high-resolution records of climate change in the region. The temperature records come from trace quantities of organic molecules, called biomarkers, produced by plankton. This method of temperature sensing from sedimentary records was developed and tested by Fred Prahl, a professor emeritus at OSU.

"We tested many different strategies for reconstructing past temperature and looked at the imperfections of the geologic record, but these temperature records emerged as the most precise available," Prahl said.

In addition to "The Blob" - the unusually warm ocean temperatures seen across the North Pacific - this year has seen a record-breaking algal bloom dominated by a certain species of diatom, Praetorius noted.

"While it's too soon to know how this event ties into the long-term climate patterns that will emerge in the future, the current conditions seem eerily reminiscent of the past conditions that gave way to extended periods of hypoxia," she said.

More information: North Pacific deglacial hypoxic events linked to abrupt ocean warming, nature.com/articles/doi:10.1038/nature15753

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