Hypoxia increases as climate warms

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A new study of Pacific Ocean sediments off the coast of Chile has found that offshore waters experienced systematic oxygen depletion during the rapid warming of the Antarctic following the last "glacial maximum" period 20,000 years ago.

The findings are intriguing as scientists are exploring whether climate change may be contributing to outbreaks of hypoxia - or extremely low oxygen levels - along the near-shore regions of South America and the Pacific Northwest of the United States.

Results of the study, by researchers at Oregon State University, are being published this week in *Nature Geoscience*. It builds on a series of field studies by researchers at OSU begun more than a decade ago through the Ocean Drilling Program, led by chief scientist Alan Mix, one of the study's authors.

The researchers focused their study on the influence of Antarctic Intermediate Water, a huge water mass that extends outward from the Antarctic, infusing Southern Hemisphere oceans with cold, highly oxygenated water - and extending all the way to the Northern Hemisphere.

Climate models suggest that these intermediate waters should have had higher concentrations of oxygen during the last glacial period, but scant evidence backed those assertions. However, the OSU researchers were able to use core samples through the Ocean Drilling Program to analyze sediments from three sites off the Chilean coast to calculate the dissolved oxygen on the seafloor.

They measured levels of manganese and rhenium to reconstruct oxygen levels, which they found began decreasing about 17,000 years ago, as warming accelerated and Antarctic glaciers began to recede.

"When there are high levels of oxygen in the water, there are higher levels of manganese in the sediments," said Jesse M. Muratli, a master's student in OSU's College of Oceanic and Atmospheric Sciences and lead author on the *Nature Geoscience*s study. "Rhenium is just the opposite. In highly oxygenated water, it become soluble and tends to dissolve. Together, they help paint a clear picture of oxygen levels."

The researchers say the waters off Chile could have become less oxygenated through two mechanisms - a reduction in the size and scope of the Antarctic Intermediate Water during warming associated with the end of the last ice age, or if those waters simply became less oxygenated.

"The water mass forms at the surface where it becomes enriched in oxygen," said study co-author Zanna Chase, an assistant professor of marine geochemistry at OSU. "Cold weather and wind saturate the water with oxygen and if it gets cold enough, it sinks and this tongue of cold water begins extending northward. Warmer temperatures could restrict oxygen penetration into the Antarctic Intermediate Water, or reduce the production of the water mass."

Mix said the position of mid-latitude winds, known as the Westerlies, plays a key role in the formation of these subsurface water masses. In a previous study, he and his colleagues documented movement of these wind belts, based on pollen from land and marine microfossils.

"These wind movements closely track the history of water mass oxygenation," Mix pointed out.

It is not yet clear what effect the findings may have on understanding of the offshore hypoxia events experienced intermittently in the Pacific Northwest over the past eight years. Other researchers from Oregon State University have documented patterns of low-oxygen waters - especially off the central Oregon coast. The worst of these happened in 2006, when oxygen in near-shore waters dipped almost to zero, killing thousands of crabs and other bottom-dwelling creatures.

Similar events occur annually off central Chile and the OSU research group is working with Chilean scientists to compare the two systems.

Changing wind patterns appear to be to blame for the 21st-century hypoxia - and wind may have played a role 20,000 years ago as well. Previous studies by Mix of sediment cores off Oregon revealed more oxygenation of subsurface waters during the last Glacial Maximum - and, as warming followed the last ice age, the Pacific Northwest region also experienced intervals of hypoxia, he said.

"Although this is similar to the effects off Chile, the impacts off Oregon were linked to regional ocean productivity," Mix said. "These contrasts underscore the importance of studying more than one system. Their differences and similarities allow us to understand the complexity of the ocean and its role in climate change - both in the past, and likely in the future."

Provided by Oregon State University

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