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Global Warming May Boost Dead Zones in Oceans

Ice Age evidence suggests rising temperatures could boost areas of ocean water with little oxygen for life

ClimateWire

By Niina Heikkinen and ClimateWire | February 10, 2015 |

Scientists are finding clues about how climate change could affect marine life by looking deep into the global ocean's past experiences with warming.

The findings raise concerns about whether warming conditions will make certain parts of the ocean uninhabitable for a wide range of marine life that needs oxygen to survive.
Credit: Travis Wise/Flickr

Through analysis of ocean sediment data, researchers at the University of California, Davis, found that the last time the planet underwent a major temperature change at the end of the last ice age, ocean oxygen levels fell sharply along the continental margins in the eastern Pacific Ocean. The findings raise concerns about whether warming conditions will make certain parts of the ocean uninhabitable for a wide range of marine life that needs oxygen to survive.

The researchers focused specifically on regions called oxygen minimum zones (OMZs), which are naturally occurring low-oxygen regions in the intermediary waters just below the oxygen-rich surface.

During the glacial period around 20,000 years ago, these zones did not exist. But in modern oceans, they occur in intermediary waters all over the world. Over several millenia after the ice age ended, the low oxygen expanses of water began expanding until they peaked midway through the deglaciation period about 14,000 years ago. In some locations, the expansion took place much more quickly, over less than a hundred years.

The researchers analyzed archived sediment core sample data to chart ocean oxygen concentrations from four regions in the eastern Pacific—from the sub-Arctic region down to the equatorial Pacific.

The largest oxygen minimum zone appeared along the Humboldt Current on the western coastline of Central and South America. The extremely low oxygen region had a huge vertical range, from 110 to more than 3,000 meters (360 to 10,170 feet) below sea level. Today's oxygen minimum zones in the same region are much less extensive, extending from about 100 to 500 meters (128 to 1,640 feet) below sea level.

Expansion of the zones coincided well with the peak in deglaciation, according to the study.

Are dead crabs an early sign of warming?

The research could signal future environmental and economic trouble for areas near modern-day oxygen minimum zones, said Sarah Moffitt, a postdoctoral researcher at the Bodega Marine Laboratory at UC Davis and lead author of the study.

"We wanted to present the [research] in a way that was meaningful for people looking at ocean systems in the modern world," she said, adding that researchers had already documented changes in oxygen concentration in the ocean interior. "We want to understand these systems—are they stable or are they reactive? We need information on how sensitive these types of environments are to global scale change."

The study's authors were amazed by how sensitive the oceans were to past changes in the global climate, suggesting that current ocean systems are not as stable as they may appear, she said.

Previous research in 2008 estimated that the amount of hypoxic (very low oxygen) water could increase by 50 percent by 2100, with overall declines in oxygen ranging from 1 to 7 percent.

"It's very well accepted that climate change will change oxygen concentration in the ocean," said Francis Chan, an assistant professor in the Department of Integrative Biology at Oregon State University who studies ocean oxygen concentration levels closer inland, off the coast of Oregon. The oxygen minimum zones he studies are somewhat different than those in Moffitt's study—their upper ranges are 600 meters deep, not 100 meters.

According to Chan, the jury is still out on whether current changes in ocean oxygen concentrations are early signs of the effects of climate change, though there may already be some impacts on marine life. He has heard reports from crab fishermen that their catches are lower, and they are pulling up more dead crabs. There is also come anecdotal evidence that fish are moving farther up in the water column than they used to, perhaps because of expanded oxygen minimum zones.

"This is something we are paying very close attention to," he said.

Deciphering the mystery behind the ocean 'layer cake'

The complex mix of factors that lead to lower ocean oxygen levels make studying the phenomenon even more challenging.

"The problem with this kind of science is that it's really messy because there is a whole suite of physical processes that impact the interior of the ocean," said Moffitt, adding that the study did not analyze in detail the mechanisms driving modern oxygen loss.

The simple way to think about how oxygen is distributed in the ocean is to compare it to a layer cake, Chan said. At the very surface, the ocean is in intimate contact with the atmosphere, and the waters are oxygen-rich, but progress deeper into the ocean and the oxygen levels drop lower and lower.

Periodically, the poorly oxygenated waters blend with those on the surface. This can happen through subduction, when especially cold and salty surface waters become dense enough to sink into the low oxygenated waters. This process is often driven by the formation of sea ice and ocean surface currents.

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Other times, oxygen-poor waters will rise up into surface waters through a process called upwelling, which is driven more by atmospheric processes, according to Moffitt.

Oxygen levels are also affected by photosynthesis from marine plants, algae and phytoplankton, said Francisco Chavez, a senior scientist at the Monterey Bay Aquarium Research Institute, who also studies oxygen minimum zones. Long-term climate cycles like the Pacific Decadal Oscillation, are thought to have an impact, as well.

Problems with the ocean's water mixing system begin as temperatures warm. With higher temperatures, the surface ocean acts like a

cap that prevents oxygen from getting into deeper layers. As temperatures increase, that cap gets stronger and stronger, according to Chan.

The stratifying phenomenon is familiar to anyone who has jumped into a lake in the middle of the summer. Even though the surface of the water is relatively warm, closer to the bottom there is a distinct drop in temperature.

Multiple threats to the Calif. coast

Paleoceanographic research like Moffitt's study is just one of the ways researchers are trying to understand today's oceans.

Moffitt noted that it is important to recognize the differences between the end of the last ice age, which occurred because of a change in the Earth's orbit around the sun, and current warming that is driven by human-caused greenhouse gas emissions.

Chan said the study is interesting because it focused on the near geological past.

"One thing the study doesn't tell us a lot about is what is going on near shore. It's more focused on the continental margin; that's 65 to 75 nautical miles out," he said.

Researchers hypothesize that upwelling in the California coastal region is essentially piping deep ocean hypoxic water into coastal areas, making the area especially hypoxic, or low in oxygen.

"Because we are starting from a low number already, any changes that go lower than that can have very serious consequences," Chan said.

The Pacific coastline is at risk not just from low oxygen levels but also from higher concentrations of dissolved CO_2, which are increasing the water's acidity.

"I think for a long time we were talking about the vulnerability of coral reefs. Actually, it's turning out that places like the U.S. West Coast are vulnerable because of currents and low oxygen," he said.

Others researchers, like Chavez are more skeptical of the short-term risks of low ocean oxygen levels.

"Because of these dynamic processes, with atmospheric highs and lows that intensify in a warmer world, you can override some of the stratification," he said.

While oxygen levels may have been declining off California's coastline for more than a decade, Chavez said imminent results of the decrease are unlikely in the next 10, 20 or even 50 years.

"If we continue down this path now, in several hundred years, we will have serious problems," he said.

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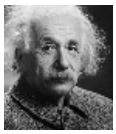
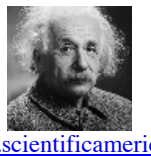

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