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The Low-Oxygen Life

There's a lot to love about the Santa Barbara Channel. On the mainland side beautiful beaches abound, while the Channel Islands provide unique natural habitats to explore and enjoy. Then there's the channel itself, where fishing, sailing, diving and whale watching are some of the best in the world.

But if you ask UC Santa Barbara paleoceanographers Dorothy Pak and James Kennett, and geophysicist Craig Nicholson, the real treasure is deep below the surface, on the ocean floor.

"The Santa Barbara Basin is shaped like a bathtub," Kennett said, explaining that its concave shape, with well-defined eastern and western edges, or "sills," restricts water exchange that creates an "oxygen minimum zone" (OMZ) at depth. It's a place hosting life forms adapted to varying low levels of oxygen. And thanks to relatively low sediment disturbance by limited biological activity, the Santa Barbara Basin also contains remarkably well-preserved records of previous life forms (microfossils) that inhabited the area over millennia. Changes in these communities provide evidence for fluctuations in oxygen concentrations associated with past climate shifts.

General animal characteristics of the Santa Barbara Basin deep sea animal communities were already described in previous studies. But thanks to state-of-the-art underwater exploration technology in the form of the remotely operated underwater vehicle (ROV) Hercules, Kennett, Pak, Nicholson and colleagues at the University of Washington, including lead author Sarah Myrhe, recently got a rare,

comprehensive, real-time look at the basin's ecology.

Their resulting paper, "Oxygen minimum zone biotic baseline transects for paleoceanographic reconstructions in Santa Barbara Basin, CA," appears in the journal Deep-Sea Research II. The research was conducted with the partnership and generosity of the Ocean Exploration Trust, which operates Hercules, its research vessel E/V Nautilus and the Nautilus Live web access.

Perhaps better known as one of the submersibles used for exploring the wreck of the RMS Titanic under the aegis of explorer and UCSB alumnus Robert Ballard, ROV Hercules was deployed for this project to better understand the influence of upward increasing oxygen in the basin on the distribution of animal and microbial communities on the ocean floor and open water column. Nicholson noted that since observations and cores were taken in a vertical transect along the rising seafloor, "we were able to document the changes in communities up through the water column, and specifically the changing oxygen conditions associated with the transition from the OMZ into more oxygenated zones."

"With this study we are getting a glimpse of how the benthic ecosystem in Santa Barbara Basin responds to changes in oxygen and temperature today, because these factors change with depth in the basin and we were able to take samples along a depth transect," said Pak.

Using a suite of technology on the Hercules, including sensors, cameras, remote-controlled sampling tools and a live feed, the researchers were able, over two dives, to collect sediments, take measurements and observe the distribution and abundance of various organisms that call Santa Barbara Basin their home.

The teleconnected aspect of the project was "really special," according to Pak. The researchers were able to remotely observe how the fauna changed as the oxygen levels changed, and to make real-time decisions about where to collect samples and watch the ROV recover the cores, she added.

"The experience was very different than taking samples from a ship without an ROV, where you really don't know what you have until the samples are recovered on the deck of the ship," Pak said.

The deepest, most oxygen-poor sections of the transect belonged to the microbes, the tiny snail Alia permodesta and a restricted assemblage of single-celled

organisms called foraminifera. There was an almost complete absence of large burrowing benthic animals that reside at shallower basin depths. Hence sediments at these depths remain undisturbed.

Rising along the transect, the researchers observed an upward succession of different animal groups, including sea stars, more diverse assemblages of foraminifera, octopuses and sea hares (large sea slugs), which became more common. Then brittle and basket stars, urchins and sea cucumbers, and more abundant trails of burrowing organisms. “Certain species dramatically appeared at certain specific water depths and disappeared at others,” Nicholson noted, “showing just how sensitive these seafloor communities are to changing ocean conditions.” Unexpectedly, the results also demonstrate that the different animal groups living on the seafloor have evolved differences in tolerance to varying oxygen levels. The researchers also observed similar differences in tolerance in open water species including many colorful jellies and fishes.

Thanks to the sediment coring, researchers also are now able to compare the distribution of modern biological assemblages to those of the past for paleoceanographic reconstructions that reveal climate patterns and ocean oxygen changes over millennia.

“The oceans have risen before,” said Kennett, pointing to a period from about 18,000 to 10,000 years ago when global warming melted enormous ice sheets, causing sea levels to rise, accompanied by increases in atmospheric CO_2 and in sea surface temperatures. In the past, he said, such phenomena reduced the amount of oxygen permeating the ocean waters such as in Santa Barbara Basin, resulting in microfossil communities migrating up to even shallower depths than the present day.

The measurements and observations, with the possibility soon of even more, Kennett added, provide a baseline snapshot for comparison with future levels as the oceans respond to current climate trends.

“The relevance of this study is to anticipate future oxygen reductions predicted with ongoing global warming, including the waters of Santa Barbara Basin,” Kennett noted. His conclusion was echoed by Nicholson, who commented, “With the establishment of this baseline transect, we are well positioned to monitor how these various seafloor communities change, migrate and adapt to future changing climatic conditions, including global warming, ocean acidification and sea level rise.”

About UC Santa Barbara

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