Should we inject carbon dioxide into the deep ocean?

One proposed strategy to offset rising levels of greenhouse gases in our atmosphere is to capture carbon dioxide (CO_2) emissions from fossil-fuel-burning power plants and pump them into the ocean depths. Under the pressure of the deep sea, the CO_2 would remain sequestered, proponents say—out of the atmosphere, out of sight, and out of mind.

But some tiny but critical denizens of the seafloor might be out of luck.

Joan Bernhard, a geobiologist at Woods Hole Oceanographic Institution, and colleagues at Monterey Bay Aquarium Research Institute investigated how a proposed geoengineering technique—direct injection of CO_2—might affect deep-sea life. Under pressure below a certain depth, the gas forms a dense mixture called a hydrate. Scientists think it would remain in depressions in the seafloor, not mixing with upper water layers and returning to the air.

In experiments conducted on the seafloor in Monterey Bay off California, they found that some organisms survived exposure to high concentrations of CO_2, but others were killed. The researchers published their results in the November 2009 issue of the journal *Global Change Biology*.

Bernhard studies the ecology and biogeochemistry of some of the ocean's smallest inhabitants: single-celled organisms called foraminifera, which play a central role in the marine food web. The research team—Bernhard and Victoria Starczak at WHOI and MBARI colleagues James Barry and Kurt Buck—used a remotely operated deep-sea vehicle to push specially made cylinders into the seafloor mud and injected pure CO_2 hydrate directly into them. After a few weeks, they also injected a fluorescent dye that labels live cells, but not dead ones.

"We found that foraminifera react [to injected CO_2] in two ways—some did not appear affected in the slightest, but others are just gone," Bernhard said.

Some species of foraminifera that make their protective coverings (called "tests") out of calcium carbonate displayed no green fluorescence, showing that they had not survived. But other foraminiferal species that make coverings out of proteins and sand still had a green glow.

The explanation? Higher concentrations of CO_2 in waters make them more acidic, creating more hydrogen ions that bind with carbonates. That leaves fewer carbonates available for carbonate-forming (or "calcifying") foraminifera to make their tests.

"It's not doomsday for some species, but for others it may be," Bernhard said. "If we're serious about pumping CO_2 to seafloor, we need to think about it. The seafloor is one of the biggest habitats on the planet."

Bernhard and WHOI colleagues, geochemist Dan McCorkle and postdoctoral investigator Anna McIntyre-Wressnig, have done similar experiments on foraminifera with photosynthetic symbionts living on coral reefs at shallower depths, which are also threatened by increasing CO_2 levels in the ocean due to the atmospheric CO_2 rise caused by human activities. They are analyzing those data and hope to secure more funds to conduct further studies at sites where CO_2 naturally vents from the seafloor to reveal more about how the smallest sea life will cope with changing and challenging climate and ocean conditions.

—Kate Madin

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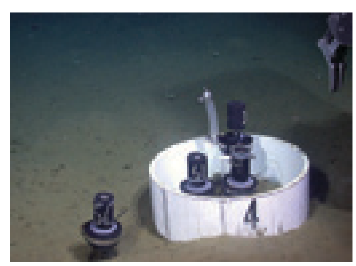
Monterey Bay Aquarium Research Institute



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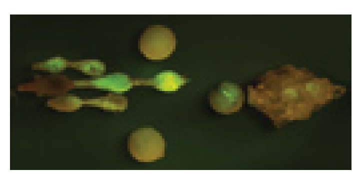

Joan Bernhard, WHOI

One proposed strategy to combat the buildup of carbon dioxide in the atmosphere is to pump it to the seafloor. To find out how that might affect life on the seafloor, WHOI geobiologist Joan Bernhard (above, green jacket) and Kurt Buck of Monterey Bay Aquarium Research Institute used the MBARI robotic vehicle *Tiburon* to push cylinders (right) into seafloor sediments more than 3,000 meters deep in Monterey Bay, Calif. They injected a carbon dioxide hydrate slurry into the sediments and retrieved the samples a month later. Organisms collected from the sediments were stained with a green fluorescent dye that appears (under ultraviolet light) only in living specimens. Microscopic images (at right, bottom) showed that some shell-less organisms survived high levels of carbon dioxide, but no species that form calcium carbonate shells survived.