News Release : In CO2-rich Environment, Some Ocean Dwellers Increase Shell Production

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In a striking finding that raises new questions about carbon dioxide's (CO_2) impact on marine life, Woods Hole Oceanographic Institution (WHOI) scientists report that some shell-building creatures—such as crabs, shrimp and lobsters—unexpectedly build more shell when exposed to ocean acidification caused by elevated levels of atmospheric carbon dioxide (CO_2).

Because excess CO_2 dissolves in the ocean—causing it to "acidify" —researchers have been concerned about the ability of certain organisms to maintain the strength of their shells. Carbon dioxide is known to trigger a process that reduces the abundance of carbonate ions in seawater—one of the primary materials that marine organisms use to build their calcium carbonate shells and skeletons.

The concern is that this process will trigger a weakening and decline in the shells of some species and, in the long term, upset the balance of the ocean ecosystem.

But in a study published in the Dec. 1 issue of *Geology*, a team led by former WHOI postdoctoral researcher Justin B. Ries found that seven of the 18 shelled species they observed actually built more shell when exposed to varying levels of increased acidification. This may be because the total amount of dissolved inorganic carbon available to them is actually increased when the ocean becomes more acidic, even though the concentration of carbonate ions is decreased.

"Most likely the organisms that responded positively were somehow able to manipulate… dissolved inorganic carbon in the fluid from which they precipitated their skeleton in a way that was beneficial to them," said Ries, now an assistant professor in marine sciences at the University of North Carolina. "They were somehow able to manipulate CO_2…to build their skeletons."

Organisms displaying such improvement also included calcifying red and green algae, limpets and temperate urchins. Mussels showed no effect.

"We were surprised that some organisms didn't behave in the way we expected under elevated CO_2," said Anne L. Cohen, a research specialist at WHOI and one of the study's co-authors. "What was really interesting was that some of the creatures, the coral, the hard clam and the lobster, for example, didn't seem to care about CO_2 until it was higher than about 1,000 parts per million [ppm]." Current atmospheric CO_2 levels are about 380 ppm, she said. Above this level, calcification was reduced in the coral and the hard clam, but elevated in the lobster

The "take-home message, " says Cohen, is that "we can't assume that elevated CO_2 causes a proportionate decline in calcification of all calcifying organisms." WHOI and the National Science Foundation funded the work.

Conversely, some organisms—such as the soft clam and the oyster—showed a clear reduction in calcification in proportion to increases in CO_2. In the most extreme finding, Ries, Cohen and WHOI Associate Scientist Daniel C. McCorkle exposed creatures to CO_2 levels more than seven times the current level.

Enlarge Image
Lead researcher Justin Ries works on CO2 study in WHOI lab. (Tom Kleindinst, Woods Hole Oceanographic Institution)

Enlarge Image
The conch shell at left was exposed to current CO2 levels; the shell at right was exposed to the highest levels in the study. (Tom Kleindinst, Woods Hole Oceanographic Institution)

Enlarge Image
The larger of these two pencil urchins was exposed to currrent CO2 levels; the smaller was exposed to the highest CO2 levels in the study. (Tom Kleindinst, Woods Hole Oceanographic Institution)

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This led to the dissolving of aragonite—the form of calcium carbonate produced by corals and some other marine calcifiers. Under such exposure, hard and soft clams, conchs, periwinkles, whelks and tropical urchins began to lose their shells. "If this dissolution process continued for sufficient time, then these organisms could lose their shell completely," Ries said, "rendering them defenseless to predators."

"Some organisms were very sensitive," Cohen said, "some that have commercial value. But there were a couple that didn't respond to CO_2 or didn't respond till it was sky-high—about 2,800 parts per million. We're not expecting to see that [CO2 level] anytime soon."

The researchers caution, however, that the findings—and acidification's overall impact—may be more complex than it appears. For example, Cohen says that available food and nutrients such as nitrates, phosphates and iron may help dictate how some organisms respond to carbon dioxide.

"We know that nutrients can be very important," she says. "We have found that corals for example, that have plenty of food and nutrients can be less sensitive" to CO2. "In this study, the organisms were well fed and we didn't constrain the nutrient levels.

"I wouldn't make any predictions based on these results. What these results indicate to us is that the organism response to elevated CO2 levels is complex and we now need to go back and study each organism in detail."

Ries concurs that any possible ramifications are complex. For example, the crab exhibited improved shell-building capacity, and its prey, the clams, showed reduced calcification. "This may initially suggest that crabs could benefit from this shift in predator-pray dynamics. But without shells, clams may not be able to sustain their populations, and this could ultimately impact crabs in a negative way, as well," Ries said.

In addition, Cohen adds, even though some organisms such as crabs and lobsters appear to benefit under elevated CO2 conditions, the energy they expend in shell building under these conditions "might divert from other important processes such as reproduction or tissue building."

Since the industrial revolution, Ries noted, atmospheric carbon dioxide levels have increased from 280 to nearly 400 ppm. Climate models predict levels of 600 ppm in 100 years, and 900 ppm in 200 years.

"The oceans absorb much of the CO2 that we release to the atmosphere," Ries says. However, he warns that this natural buffer may ultimately come at a great cost.

"It's hard to predict the overall net effect on benthic marine ecosystems," he says. "In the short term, I would guess that the net effect will be negative. In the long term, ecosystems could re-stabilize at a new steady state.

"The bottom line is that we really need to bring down CO2 levels in the atmosphere."

The Woods Hole Oceanographic Institution is a private, independent organization in Falmouth, Mass., dedicated to marine research, engineering, and higher education. Established in 1930 on a recommendation from the National Academy of Sciences, its primary mission is to understand the oceans and their interaction with the Earth as a whole, and to communicate a basic understanding of the oceans' role in the changing global environment.

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