

CORAL REEFS

Calcification Rates Drop in Australian Reefs

Wall Street isn't alone in suffering a steep downturn. A large-scale study in Australia's Great Barrier Reef has revealed that the rate at which corals absorb calcium from seawater to calcify their hard skeletons has declined precipitously in the past 20 years, slowing coral growth. The report, on page 116, provides empirical data that fuels concerns that increased carbon dioxide in the air is putting these diverse marine ecosystems at risk (*Science*, 4 May 2007, p. 678). "This study has provided the first really rigorous snapshot of how calcification might be changing" as the ocean temperature and acidity rise, says marine biologist Ove Hoegh-Guldberg of the University of Queensland in Australia. "The results are extremely worrying."

Corals start out as soft-bodied larvae that settle on hard surfaces, take on algal partners, and begin pulling dissolved calcium compounds out of the water to lay down a hard skeleton. A reef arises from whole colonies of corals laying down these secreted skeletons. To keep ahead of erosion, they must calcify quickly enough to make up for what's being lost due to wave action and other forces. But some coral experts worry that the expected doubling of the carbon dioxide in the atmosphere over the next 50 years—and the subsequent ocean acidification—could make keeping up next to impossible. Several laboratory studies have suggested that as seawater pH declines, so do coral calcification rates, although one recent experiment has not shown this effect.

Glenn De'ath, an ecological modeler at the Australian Institute of Marine Science (AIMS) in Townsville, and his colleagues looked at

archived coral samples for signs of such a slowdown. Between 1983 and 1992 and between 2002 and 2005, AIMS researchers had collected coral cores from 69 reefs spanning the length and breadth of the Great Barrier Reef. The coral sampled, *Porites*, grows over many decades, even centuries, into 6-meter-tall mounds. It lays down annual growth bands, making it possible to count back to specific years and correlate growth with sea surface temperature and other environmental data for the same period.

The researchers sliced up cores and used x-rays and a technique called gamma densitometry to measure annual growth and skeletal density; from those two parameters they calculated annual calcification. In their first pass, De'ath, AIMS coral biologist Katharina Fabricius, and AIMS climatologist Janice Lough found a decline in calcification rates since 1990 in 189 colonies from 13 reefs. They then broadened the analysis to include a total of 328 colonies spanning coastal to oceanic locations, including 10 cores that dated back centuries.

They found that calcification rates increased 5.4% between 1900 and 1970, but have dropped 14.2% from 1990 to 2005, mainly due to a slowdown in growth from 1.43 centimeters per year to 1.24 centimeters per year. "The very fact that the effect is seen on inshore as well as offshore reef sites rules out [the chance that] the observed decline has been due to declining coastal water quality," says Hoegh-Guldberg.

In the 1990s, researchers had predicted that ocean acidification might one day become a problem for corals, and at the 11th Interna-

tional Coral Reef Symposium (ICRS) in July 2008, global experts suggested that humans had about a decade to "get our act together" to reduce carbon dioxide emissions, says Clive Wilkinson, global coordinator of the Global Coral Reef Monitoring Network in Townsville. But calcification decline is "here and now and over the past decade, not some time in the future, as we predicted," he notes. "This has been happening under our noses."

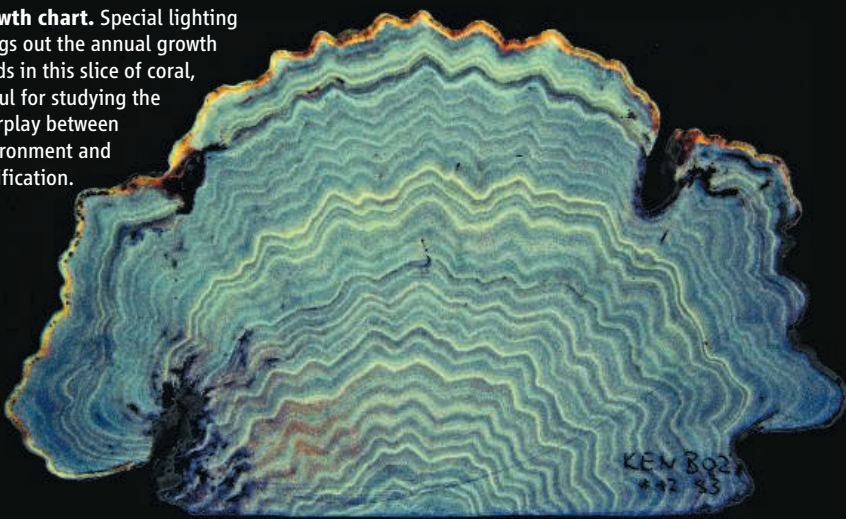
Problems are showing up beyond the Pacific. Anne Cohen, a marine biogeochemist at the Woods Hole Oceanographic Institute in Massachusetts, and her colleagues are using computed tomography scans to look at growth and calcification in Bermuda brain corals. There's been a 25% decline in both since 1959, they reported at ICRS. "On Bermuda, the change appears unprecedented at least through the past century," says Cohen.

However, the role of acidification in this decline is far from settled. In the laboratory, Alina Szmant, a coral physiological ecologist at the University of North Carolina, Wilmington, and her colleagues found that neither low pH nor a lowered calcium carbonate concentration (which results from increased acidity and is considered key to calcification) slowed coral growth. Instead, calcium bicarbonate proved key, her team reported at ICRS. She faults previous lab studies because they used hydrochloric acid, not carbon dioxide, to lower the pH of the water in the calcification studies. Hydrochloric acid and carbon dioxide have different effects on seawater chemistry and bicarbonate concentration, she says. Her conclusion: "It's not clear that carbon dioxide enrichment will have negative effects on calcification rates."

Cohen also has some reservations. Commenting on De'ath's work, she says "the timing is later, and the magnitude and rate of the calcification decline is greater than one might expect if seawater saturation state [acidification] were the primary driver." Temperature and other environmental factors likely come into play.

But whatever the cause, the new data are grounds for concern. In December, Wilkinson's group released a 4-year assessment, *Status of Coral Reefs of the World: 2008*, which said that 45% of the world's reefs were healthy with no significant threats from human activity on the horizon. But looks can be deceptive, says Cohen: "Even though the corals *look* healthy, some pretty dramatic changes are occurring beneath the surface." —ELIZABETH PENNISI

Growth chart. Special lighting brings out the annual growth bands in this slice of coral, useful for studying the interplay between environment and calcification.



CREDIT: GLENN DE'ATH