Warm Waters, Bleached Corals

Throughout the Caribbean, the corals are bleaching again, turning a ghostly white—a sign of severe stress. Though it is still early, it looks as if this current episode may rival or even surpass the one in 1987, which affected huge numbers of corals all around the Caribbean (*Science*, 27 November 1987, p. 1228). Most of those corals recovered, but this year some are already dying, raising fears for the future of the reefs themselves.

The cause of the 1987 bleaching is still mysterious, but most marine scientists suspect elevated seawater temperatures, either singly or in concert with other factors. So far, however, proof has eluded the researchers, as reliable long-term temperature data for the Caribbean are scarce or nonexistent.

Now two researchers, Tom Goreau of the Discovery Bay Laboratory in Jamaica and Raymond Hayes of Howard University, have evidence that they think nearly cinches the temperature connection. In the past few weeks they have been making the rounds on Capitol Hill, presenting their data and arguing that corals may be the canary in the mine—an indicator of greenhouse warming. They've caught the ear of Senator Albert Gore (D–TN), who is holding a hearing on 11 October to consider their evidence.

But Goreau and Hayes' as yet unpublished analysis is receiving mixed reviews from some of their colleagues. No one doubts that temperature is at least partly to blame, but they don't think Goreau and Hayes have nailed it down yet. And if temperature is at fault, there is no evidence that it is global warming and not some regional phenomenon, which Goreau and Hayes readily admit.

Bleaching occurs when corals expel their zooxanthellae, the single-celled photosynthetic algae that live within their tissues and provide them with nutrients. It can be triggered by a number of stresses, including disease, pollution, and changes in ultraviolet light and temperature. After one bout, at least, corals usually recover, but while they are bleached, they stop growing, leaving the reef vulnerable to erosion.

Although scattered bleaching episodes have been reported around the Caribbean for decades, they now seem to be increasing in both intensity and severity. Indeed, the 1987 episode took people by surprise because it was so widespread, occurring at distant sites at roughly the same time, which would seem to rule out disease or local pollution. Because it occurred during particularly hot weather, with calm waters, marine biologists began speculating that warm waters were to blame. Many corals thrive at a threshold temperature of about 29° C but begin to bleach if the temperature rises just a degree or two.

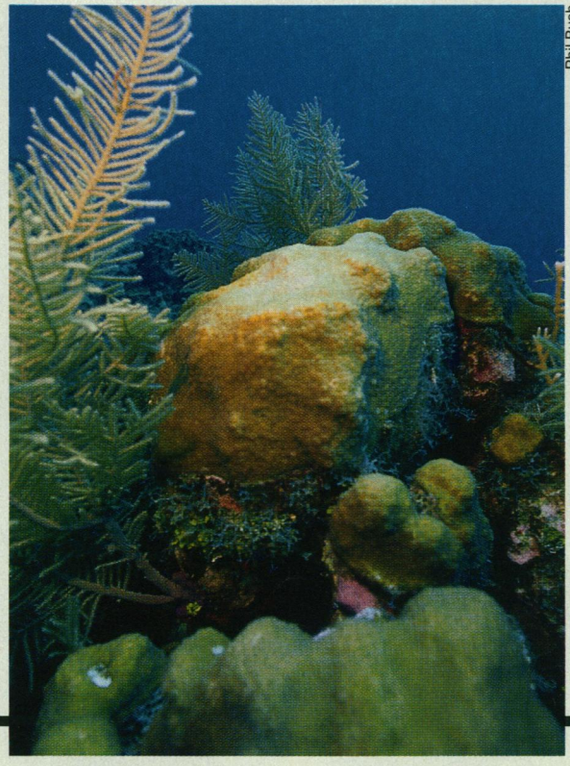
What Goreau and Hayes have now done is reconstruct the temperature record for the past decade, from May 1980 until May 1990, using high-resolution satellite data from the National Oceanic and Atmospheric Administration. They focused on seven sites in the Caribbean and Atlantic: northern Puerto Rico, north central Jamaica, Grand Cayman, eastern Cozumel, the Florida Keys, Nassau, and Bermuda. Everywhere except Puerto Rico and Cozumel, there was a statistically significant warming trend over the decade of 0.4° to 1°C, says Goreau. Not only did temperatures climb higher, but they stayed up longer. And most significantly, adds Hayes, "Whenever the temperature reached an extreme, there was bleaching. There is an absolute correlation there."

What's more, new satellite data for August and September show the water is now "really hot," says Goreau. "Last month the water was over 31° or 32°C in every satellite image for Jamaica and Cayman" which is why he is predicting massive bleaching for this year.

But Don Atwood of NOAA's Atlantic oceanographic and meteorological lab is not convinced by their analysis. "No one has been able to demonstrate a statistically significant regional increase in sea-surface temperatures. I haven't looked at their numbers, but I am extremely skeptical." Following the 1987 bleaching event, Atwood also analyzed sea-surface temperature data, though a different set, looking for any anomalies that might explain it. He found none. Although the water was warm in 1987, it was also warm plenty of times earlier when there was no bleaching. Sea-surface temperatures fluctuate so widely, he contends, that a decade is simply too short to discern a trend.

At the Caribbean Marine Research Center in the Bahamas, director Robert Wicklund is also leery of the satellite data, which measure the temperature of just the top few millimeters of the water. You can't tell what happening on the reef, some 60 or 100 feet down, by measuring what's on top, he says. Nevertheless, Wicklund has data of his own to support the temperature hypothesis. Following the 1987 bleaching, he installed temperature recorders on the reefs at about two dozen sites. Wicklund has yet to analyze the data but took a quick look at the readings 2 weeks ago—after he noticed that the corals off Lee Stocking Island in the Exuma Cays are bleaching at a startling rate. He found that for this past August and September, the water was 1° to 1.5°C warmer than it was in either 1988 or 1989, when only minimal bleaching occurred. The high this September was 30.5°C.

"We can say there is some pretty warm water down there and the corals are bleaching more extensively than at any time since 1987," says Wicklund. But to him it is still an open question whether the culprit is "temperature, temperature in combination with something else, or something else entirely." ■ LESLIE ROBERTS



Phil Bush

Under stress. *This star coral colony of the west side of Grand Cayman began bleaching this August.*