Bleached Reefs

Is a warm-water cycle stripping corals of their lifeblood?

By ROBERT N. LANGRETH

Jaap

Pale blotches show 1987 bleaching at Sand Key Reef, Fla.

They look like snowfields under the Caribbean Sea. After weeks of abnormally warm water temperatures, the usually colorful Puerto Rican corals have expelled the algae that give them their hues.

At first, in the middle of last summer, only a small percentage of the coral polyps lost their algal contents, exposing blotches of white limestone skeleton amidst the rainbow of colors. But by October, the coral shone so uniformly white that the fishermen who work near the reef couldn't help but notice.

"Some people say that this is normal," says Ivan López, a former commercial fisherman who now assists marine botanists at the University of Puerto Rico in Lajas. "I'm 42 and I've been [working] in the water all this time, and I've never seen something like this before."

Many scientists share his concern. Far from being normal, "bleaching" means the reefs are in peril, they say. Corals of the order Scleractinia, deprived of their symbiotic algal partners, are slowly starving in many parts of the world – perhaps, many believe, because of rising temperatures in tropical waters. If prolonged bleaching eventually kills enough of these so-called "stony corals" – the oceans' primary reef builders – entire ecosystems of reef-dependent organisms could topple.

Scientists have known about coral bleaching for at least 75 years, but the phenomenon became widespread only in the last decade. Marine biologists noted bleachings at several Pacific, Atlantic and Caribbean reefs in 1980, and again in 1983, but not until the summer and fall of 1987, which brought the world's most extensive bleaching on record, did they realize that the individual incidents might be related.

Last summer, corals bleached again, mainly around the Florida Keys and in the Caribbean, but also at several Pacific reefs. "There are some indications that it may be even more extensive [than in 1987]," says Ernest H. Williams of the University of Puerto Rico. A specialist in aquatic animal health, Williams has collected bleaching reports from around the world since the 1987 episode.

In past years, most of the faded reefs recovered during the winter. But this year, many researchers worry that many corals, weakened by repeated bleachings, may actually die. "Although the bleaching episode is not yet complete, we have seen more deaths than in the past," coral expert Raymond L. Hayes told SCIENCE NEWS.

As of late November, many of the Caribbean reefs were still faded, although Florida reefs had largely recovered. Hayes, of Howard University in Washington, D.C., says it will be at least four to six months before enough reports trickle in to reveal the full extent of the damage.

Already, however, the issue has drawn the attention of the Senate Committee on Commerce, Science and Transportation. At an Oct. 11 subcommittee hearing, Hayes, Williams and other reef researchers offered their assessments of the situation and ventured the disturbing prediction that the current coral fadeout may signify the beginning of the expected global greenhouse warming.

The stony corals – a motley pastiche of greens, browns and yellows, sprouting branch-like shoots and sporting names like lettuce coral or golden seamat – bear a striking resemblance to plants. But like all corals, they're actually collections of tiny, immobile animals called polyps, which live together in colonies of millions anchored to the surface of the reef skeleton. Each polyp, several millimeters in size, sucks in even smaller organisms called plankton that happen to drift by, but these nutritious tidbits fulfill only part of the polyp's energy needs.

Thousands of one-celled algae known as zooxanthellae (Greek for "little yellow creatures") make their home in the stomach of each polyp. The transparent polyp provides the pigmented algae with a sheltered site for photosynthesis, and in turn uses the algae's waste products as an energy source and as a raw material for producing reef-building limestone, or calcium carbonate. The major frame builder for the Caribbean and Florida reefs – a Scleratinia species called star coral, or *Montastrea annularis* – takes 100 years to construct a limestone frame 1 meter in height, Hayes notes.

In the nutrient-poor waters of tropical regions, a reef's nooks and crannies create an oasis supporting hundreds of fish, shellfish and other organisms – probably more species than live in the rest of the ocean waters combined, according to Thomas J. Goreau, who heads the Global Coral Reef Alliance, a public awareness project based in Chappaqua, N.Y.

"The reef represents a sponge that maintains and allows for the recycling of nutrients between organisms," Hayes explains. "The entire reef system is a very complex and [delicately] balanced ecosystem where one organism's waste becomes another's food."

When a reef dies, many species sheltered in its crevices lose their hideouts and face possible death, he adds.

Even the slightest stress can threaten the coral habitat. Abnormally high or low water temperatures, salinity increases, sediments from nearby shores, scraping by boats and trampling by divers – all of these can strain the fragile polyps, resulting in the loss of zooxanthellae. For instance, bleaching can result from summer water temperatures rising 2° to 3°C above the usual seasonal highs and lasting for more than a couple of days, says Walter C. Jaap of the Florida Marine Research Institute in St. Petersburg.

While a number of different stresses may contribute to local bleaching episodes, most marine biologists now think high water temperatures led to the mass fadeouts of 1987 and this year. The bleaching of reefs in so many places at about the same time seems to rule out pollution or disease as the primary culprit. Another potential suspect – increased levels of harmful ultraviolet rays penetrating the sea surface – can, in laboratory experiments, cause zooxanthellae pigments to fade, but

it does not make the coral eject the algae, Williams says. Therefore, he and others reason that warmer-than-usual water temperatures – which have generally preceded or accompanied widespread bleaching – are the answer.

"Although we cannot say with certainty that water temperature is the cause of coral bleaching, the evidence definitely points to its playing a major role," marine biologist Robert I. Wicklund told the Senate subcommittee in October. Wicklund directs the Caribbean Marine Research Center in Riviera Beach, Fla.

Confirming the warming-water theory has proved difficult, since temperature statistics for reef waters have not been extensive or detailed enough to establish a true trend. But Goreau and Hayes say they have unpublished data that may settle the issue. Using sea-surface temperature measurements made by National Oceanic and Atmospheric Administration satellites, they charted a 0.4° to 1°C rise in Caribbean and Floridian waters over the last decade.

"We have found a precise correlation between high temperatures and bleachings," Goreau testified at the hearing, adding that "all increasing trends were statistically significant."

Some researchers remain unconvinced. "[Arguing that] temperature is the cause of bleaching is very seductive, but as of yet there is no evidence. The elevated temperatures and incidence of bleaching are merely correlative," marine biologist Leonard Muscatine of the University of California, Los Angeles, told SCIENCE NEWS.

Adding to the uncertainty, Wicklund told the subcommittee, is the likelihood that sea-surface temperatures do not precisely match those of the waters directly above reefs, which typically lie 10 to 100 feet underwater.

Muscatine maintains that scientists cannot assign a cause to the bleaching until they truly understand the cellular mechanisms behind it. Some researchers think the phenomenon results when warmer temperatures and more sunlight increase the rate of algal photosynthesis, but no one agrees on the exact nature of the bleaching process.

One theory holds that the rapidly photosynthesizing algae deplete the polyps' energy reserves, says Peter Glynn of the University of Miami's Rosenthiel School of Marine Science.

Ian Sandeman, a biologist at the University of Trent in Ontario, offers another explanation. He proposes that at high temperatures and sunlight levels, the algae produce too much oxygen, which reacts with chemicals in the polyps to form high levels of poisonous oxides. This overwhelms the coral's normal defenses, killing its stomach cells, which drift out of the polyp along with the zooxanthellae, Sandeman says.

Viewing reef deterioration on a broader scale, Williams and several others speculate that it may provide an early sign of greenhouse warming.

"The first proof of global warming may come from the bleaching of the fragile and highly sensitive coral reef system," he told the Senate subcommittee. "But unfortunately, we do not have enough data to evaluate this intriguing suggestion, because this gigantic series of disturbances has been understudied and virtually ignored."

Williams has developed a theoretical model for current and future bleaching events, using data from his worldwide surveys. In his model, a gradual warming of the world's oceans combines with El Niño-Southern Oscillations (periodic warmings of tropical waters, which coincided with bleaching episodes in 1983 and 1987) to push the reefs beyond their temperature tolerance. As reefs undergo repeated bleachings, their resilience diminishes. This paves the way for even more extensive bleaching, with potentially lethal results.

Williams used his model to predict the latest mass fadeout months in advance. In the July 19 NATURE, he noted that each widespread bleaching episode in the past occurred the year after moderate bleaching had struck several locations. "In 1989 we recognized the preceding event as severe bleaching in Jamaica" and moderate bleaching in several other places, he told SCIENCE NEWS. Williams says he based his prediction on this clue combined with scientists' expectations that the summer of 1990 would bring an El Niño warming, which now appears to be in its early stages.

Scientists first documented this year's bleaching in late July, noting fadeouts near Florida's Looe Key and the Cayman Islands of the Caribbean. In August, similar reports came from Jamaica. By October, dozens of areas in the Florida Keys, the Caribbean and the Flower Garden Banks off the coast of Texas – as well as reefs off Hawaii and Okinawa – had bleached extensively. Williams says he thinks additional Pacific reefs are bleaching this year, although reports from the Pacific remain too sketchy to tell.

If the water temperatures – or whatever fluctuation has provoked the coral imbalance – return to normal in the next few years, most of these reefs will probably endure, say coral specialists. But few experts count on this. "A lot of people are getting very pessimistic," Williams says.

Goreau, as pessimistic as anyone, compares the plight of the reefs with the rapid shrinking of the Amazonian rain forest. "There will still be some rain forests left in 50 years," he says, "but at the rate the coral reefs are going now, they won't be around anywhere near that long."

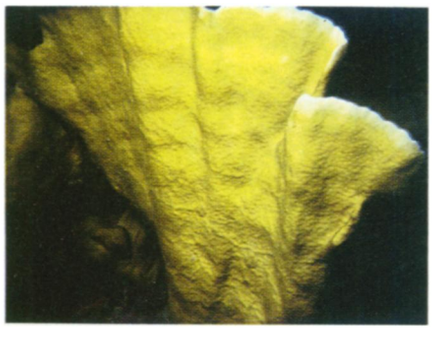
In Glynn's worst-case scenario, the reefs nearest the equator would die out and the rest would "migrate" to higher latitudes formerly inhospitable to corals. In any event, Glynn says his studies of Pacific corals suggest that the fastest-growing species would die first.

As researchers await future developments, they struggle to keep track of existing episodes and to confirm (or debunk) the high-temperature hypothesis. By alerting the public and gaining additional funding, they hope to find a way to prevent further harm.

Billy Causey, who manages the Looe Key National Marine Sanctuary, has watched some of the area's most colorful underwater life dwindle over the past decade. Besides facing stress from warming waters, Florida reefs in particular must cope with human intrusions, including many small craft that run aground and people who break off chunks of coral as souvenirs. Causey has struggled to explain the decline to tourist divers, who wonder why these famed reefs – which form spectacular "fingers" protruding several hundred yards into the ocean – look so drab.

"Man is probably creating the problem that causes the imbalance," he says. "We have to become conscious of it globally. If we continue to heighten public awareness of the threat of losing a major ecosystem, then maybe we can change things." □

Healthy fire coral (Millepora complanata).



Bleached specimen of the same species.