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Global Warming

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Coral reef communities are suffering the wrath of pollution and global warming, but a USF marine scientist is diving into the problem to come up with solutions.

By Michael Reich

ONE LOOK AT A boring sponge eating away at coral, and you know something is terribly wrong. The pit of fiery orange looks like an oozing abscess. And, in a sense, it is. When the environment is right, the boring sponge becomes the coral’s own flesh-eating virus, devouring it and destroying one of nature’s most precious treasures. The boring sponge is a deadly enemy, make no mistake about it. Yet, most of the time, coral and boring sponges can peacefully co-exist in the same waters.

So what happens to set off the sponge’s feeding frenzy? What makes it powerful enough to go from just a feared enemy to an unstoppable murderer?

According to Pam Hallock Muller, the trail ultimately leads back to people. It’s a twisted trail that goes as far away as the stratosphere and comes as close to home as an automobile in a garage. The cumulative impact of humans on the environment is changing the waters in which coral reef communities live and thrive. While reef communities often recover, the threats are getting more serious, the strikes are getting more frequent, and recovery may not be as likely in the future.

A biogeological oceanographer in USF’s College of Marine Science, Muller has studied coral reef communities throughout the world since the early 1970s. Since coming to USF in 1983, she has conducted most of her research in the Florida Keys. While most people dive around coral reefs for the beauty and pleasure in it, Muller and her team of graduate students are like environmental doctors, checking on patients, running tests and making diagnoses.

Beauty and the beast. Coral reefs like those off the coast of the Florida Keys, left, are among the treasures of the oceans. But changes to the environment have brought predators and competitors for space, such as boring sponges, above, which eat away at coral’s skeletons.
And while they discover ailments like voracious boring sponges, they have found that these are just symptoms of much larger problems like pollution and global warming.

Unwanted nutrients

Much of Muller's research into coral reef habitats involves foraminifera, single-cell protozoans that respond to changes in the environment the same way coral do. Healthy coral and foraminifera live in low-nutrient environments, something they are able to do because they have symbiotic relationships with algae, which live inside them and give them their color. Algae use the sun’s energy, carbon dioxide and water to produce sugars to use for energy. With enough sunlight, they produce enough sugar to share with their foraminifer or coral host. The sugar—which Muller calls “junk food”—is a welcomed addition to the host’s diet; they use it for energy while waiting for scarce food in the environment. In return, the hosts produce waste, which algae use to grow. It is a relationship that allows algae and foraminifera or coral together to have 10 to 1000 times more energy than they would have alone.

Muller focuses on two processes that upset this relationship and harm coral reef communities: nutrification and bleaching. Nutrification is the addition of nutrients—such as nitrogen and phosphate—to an environment, Muller says. Nutrients alone aren’t bad. They help some plants and animals grow. But since coral reefs live and thrive only in very clean, low-nutrient water, additional nutrients upset the balance of their environment. It is like adding chicken and noodles to broth; you end up with a different soup.

It’s in this environment that boring sponges grow enough to erode into—and ultimately destroy—the coral skeleton, Muller says. In the short run, nutrification may destroy coral and foraminifera, but it doesn’t destroy the environment, per se. It changes it. Nutrients feed plankton, stimulating their growth. More plankton means more food for other animals, including predators and competitors for coral’s space. Eventually plants and animals like seagrass and sponges—which couldn’t live in a low-nutrient reef community—take over where coral and foraminifera once lived. As nutrification continues, the fatal end result is an oxygen-depleted environment in which only bacteria can live.

And humans are doubling the amount of nutrients in the world, most of which end up in aquatic environments. So who are culprits who are sending their nutrients to the Keys and other reef communities? Start pointing fingers, and it begins to get controversial. Small amounts of nutrients come from lots of places, Muller says, including septic systems, boat bilges, sewage outfalls, storm runoff and rainfall polluted by automobile exhaust. Nutrients in the Keys may even come from as far away as the Mississippi River.

Then add bleach

But nutrification isn’t the only problem facing coral reefs. In 1991, Muller and her team of researchers discovered foraminifera were starting to lose their brown color, or “bleaching”—something she had never seen in her 20 years of research. An El Nino was developing, and Mount Pinatubo had erupted in the Philippines. By September, 80 percent of the adults had white or nearly white spots, and by November, foraminifera populations had crashed. Many foraminifera were damaged to the point their shells broke. It was a tragedy so devastating that it
took several years for the foraminifera population to recover. Since then, foraminifera have started bleaching in March every year, with peak bleaching near the summer solstice.

While Muller’s discovery in 1991 was the first time bleaching had been observed in foraminifera, bleaching had been seen in coral several times over the years. It was highly unusual prior to 1983, but during the El Ninos of 1982-83 and 1987-88, coral bleached all over the world.

Further research began to uncover what was happening. It seems coral and foraminifera bleach because of changes in the Earth’s atmosphere, particularly ozone depletion and global warming. Ozone depletion allows more ultraviolet light to penetrate the clear waters of the coral reefs.

“In essence, they get sunburned,” Muller says. She hypothesizes that algae were damaged by too much ultraviolet light and stopped producing sugars. Once the algae weren’t producing sugars, the foraminifera ate them. As Muller says, “These symbioses are not altruistic.” But algae contribute to the production of calcium carbonate, which makes up the foraminifera’s shells, so the shells are more prone to break without algae.

But what prompted foraminifera to bleach for the first time in 1991? According to Muller, Mount Pinatubo’s eruption put volcanic ash and aerosol into the stratosphere, which worked with chlorofluorocarbons to destroy ozone. There was about a 4 percent decrease in stratospheric ozone, which likely allowed more ultraviolet light to reach the reefs.
where coral and foraminifera live.

After that incident, Muller looked through her foraminifera samples from prior years to see if there were high incidences of broken foraminifera shells. There weren’t. Even though there had been other periods of decreased ozone levels and increased temperatures, something had changed by 1991.

That’s where global warming comes in. As people pump more carbon dioxide into the atmosphere, the Earth’s temperature rises. The amount of carbon dioxide in the atmosphere today is about 360 parts per million, according to Muller. Before the Industrial Revolution 150 years ago, it was 280 parts per million.

And it isn’t slowing down. Carbon dioxide levels are expected to reach 500 parts per million by the middle of this century. Behind those numbers is a frightening truth: The last time levels were that high was about 45 million years ago, and Earth was a greenhouse world—without any ice.

Fortunately, coral produce their own sunscreens, which protects them from ultraviolet light and staves off bleaching. But they can’t produce the sunscreens at high temperatures. So when ozone levels decrease and water temperatures rise—as they will if global warming continues—coral bleach.

In the Florida Keys, for example, coral bleach when the water temperature rises above about 31 degrees Celsius. As global warming increases, Muller says, there will likely be more periods of massive bleaching among foraminifera and coral, and it will take longer for them to recover.

But remember that bleaching isn’t the only concern. Add the effects of bleaching and nutrification together, and—unless something changes—coral reef communities are in trouble.

**Save the coral reefs**

Muller admits the prognosis for coral reef communities isn’t good. But she believes environmental programs could curb or even reverse the trend. She says we need look no farther than Tampa Bay for examples of programs that work. In the 1970s and 1980s, the bay was polluted. Plankton were the dominant sea life. But through sewage and stormwater treatment programs, the bay was cleaned up and the environment shifted. Today,
there is more seagrass and more animals like snook and spotted seatrout, which returned to the bay in abundance.

"It shows that environmental programs work," Muller says.

But the problems for coral reefs are worldwide, and they won't be solved overnight or without broad efforts. One of the ways to slow or stop nutrification, Muller says, is through sewage treatment and other recycling programs. But every community has to do it. As Muller says, "It's a global problem on a local scale."

Global warming, however, is a little more complicated. With global treaties, experts predict ozone depletion will level off within 20 years or so. But high levels of carbon dioxide—the most significant factor in global warming—will take a broader effort. People will have to turn off lights, drive smaller cars and reduce the amount of energy used from fuels that emit carbon dioxide.

In the meantime, coral reefs are changing. And they will continue to change unless people start taking action.

Yet, the real question may not be how coral reefs will fare in 20 to 50 years, but what those reefs are telling us about our own future.

"We need to either do something about it or plan for the future," Muller says.