Survivors. This coral-mangrove ecosystem in the U.S. Virgin Islands is thriving despite ocean conditions that killed nearby reefs.

CREDIT: CAROLINE ROGERS/USGS, ST. JOHN, U.S. VIRGIN ISLANDS

MARINE CONSERVATION

As Threats to Corals Grow, Hints of Resilience Emerge

Some reefs are showing a surprising ability to resist or bounce back from damage. Could such resilience help corals survive in a rapidly changing ocean?

Eight years ago, a blistering heat wave sent local sea temperatures soaring in the eastern Caribbean, killing more than one-half of the region's coral reefs. Many have yet to recover. But in Hurricane Hole, a sheltered bay off St. John in the U.S. Virgin Islands, one vibrant coral ecosystem survived unscathed. "We've identified more than 30 coral species" that avoided the catastrophe, says Caroline Rogers, a marine biologist with the U.S. Geological Survey (USGS) in St. John. "The diversity is astounding."

Rogers has been trying to understand what made the corals in Hurricane Hole so resilient, and she has plenty of company. Around the globe, a growing corps of scientists is searching for resilient reefs and then trying to identify what enables them to resist or bounce back from severe environmental stress. They've found tantalizing hints that heat-resistance genes, the proximity of other reefs, and even the presence of plant-eating sea life that scrub corals free of weedy algae can play a role. But they're also discovering that the factors that promote resilience can vary greatly from reef to reef.

Still, coral researchers are trying to extract some general, widely applicable lessons from their studies of resilience, partly in hopes of developing smarter conservation strategies, such as better designed marine reserves. It's a task that is taking on increased urgency, as climate change threatens to wipe out corals and remake ocean ecosystems. "We in the environmental community look for points of hope," says ecologist Stephanie Wear of the Nature Conservancy in Arlington, Virginia. And in identifying possible ways to boost reef resilience, she says, "We see opportunity."

Stressful developments

Coral reefs weren't always considered fragile. When Rogers was working on her doctorate in the late 1970s, many researchers believed that reefs were intrinsically stable ecosystems, threatened mainly by local storm damage. But by the early 1980s, it was obvious that corals were in trouble. In the Caribbean, reefs took a noticeable hit after disease led to a massive die-off of spiny sea urchins, which had helped to keep reef-smothering algae in check after another group of herbivores, parrotfish, had been overexploited. In the Pacific and Indian oceans, unusually high seawater temperatures linked to the large-scale weather pattern known as El Niño caused massive "bleaching" events in 1982 and 1998 that turned reefs a ghostly, skeletal white. Bleaching happens when heat-stressed corals expel the symbiotic algae—known as zooxanthellea—which live in their tissues and supply nutrients in exchange for protection. And it is often fatal: the 1998 event killed 16% of the world's reefs overall and up to 95% in some locations, says Robert Steneck, a biologist at the University of Maine's Darling Marine Center in Walpole.

But here and there, reefs have shown the ability to resist or rebound from such shocks. In an oft-cited example, the extensive reef system off Palau, in the western Pacific, charged back within a decade after suffering extensive bleaching losses in 1998. Similarly, reefs off the Cocos Islands in the eastern Pacific, which were virtually destroyed by bleaching during the 1980s, experienced up to fivefold increases in coral cover within 20 years. These recoveries sparked widespread interest in understanding the underlying "drivers" of resilience, with an eye toward developing better reef protection plans.

Scraping by

One focus has been on understanding the role of herbivorous fish and plant-eating invertebrates such as sea urchins. Ecologists have long known that these grazers play an important role in reef health by mowing down weedy algae and clearing attractive settling spots for young corals. Now, many believe that those tasks are essential to enabling some damaged reefs to recover from ecological stress.

For example, when Steneck visited Palau's bleached reefs in 2000, he was heartened by the abundance and diversity of herbivorous fish that were still patrolling the coral skeletons. "The reefs were extremely well-grazed," he recalls. "I thought the conditions for coral recovery were great because young corals would have a chance to settle." The subsequent recovery of those reefs reinforced Steneck's belief that protecting herbivorous fish is one of the most effective means of boosting reef resilience. A number of studies appear to back his view, including experiments published in *Current Biology* in 2007 conducted on Australia's Great Barrier Reef in which researchers deliberately removed grazing fish; the corals were soon overwhelmed by algae.

At the same time, in other parts of the

Published by AAAS