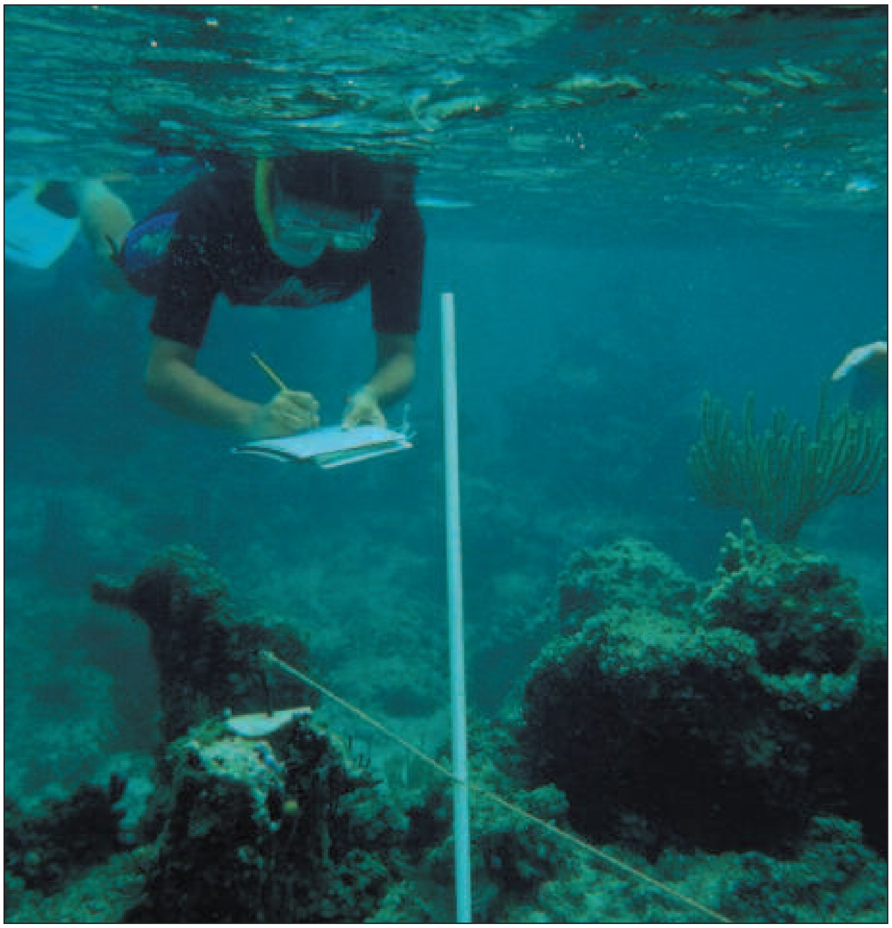
BAHAMIAN REEF SURVEY

UNDERSTANDING THE CAUSES OF CORAL REEF DECLINE



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On a sunny February morning, four people in wet suits walk into the clear, turquoise water that surrounds San Salvador Island in the Bahamas. It is a common enough sight on a Bahamian beach, except for one thing: these four carry pencils, dive slates, sample cups, and a thermometer. In a moment they will be snorkeling along a coral reef near shore, collecting data for one of the longest-running coral reef research projects in the world.

POLYPS WITH PARTNERS

Although they look like rocks or plants, corals are actually tiny animals that are closely related to sea anemones. Each coral animal, or **polyp**, has a clear, sac-like body and a ring of tentacles surrounding its mouth. The most commonly recognized corals are the **hard corals**. These secrete calcium carbonate to form a skeleton around their bodies. Most live together in colonies with their skeletons joined together. The soft parts of their bodies are connected as well, spreading out over the fused skeletons in a kind of crust. When a coral colony dies, its skeleton eventually gets crumbled by waves or broken apart by other animals. As the pieces pile up, they form a substrate (a bottom surface, like sand) upon which algae and other organisms can grow. In time, lots of time, this process

THE RESEARCH TEAM

Biologist Tom McGrath started exploring San Salvador's reefs back in 1979. Over the next ten years he made many trips to the island, bringing classes of college students to study its ecology. Though able to observe changes in the reefs, he wasn't in a position to study them intensively.

In the late 1980s, when a major coral bleaching event occurred throughout the world, McGrath witnessed its dramatic and sudden effects first hand. What had caused it? Theories were proposed, but none could be proven. Reliable information simply wasn't available. Frustrated by this situation, McGrath began a formal study of the reefs around San Salvador. He joined forces with Garriet Smith, who had been studying sea grass communities on the island, to launch the Bahamian Reef Survey in 1992.

John Rollino, a close friend of McGrath's, first came to San Salvador in 1994. An experienced open water diver, Rollino donned mask and fins within hours of arriving. As he swam amongst the reefs, he noticed curious white spots upon the corals — signs of coral bleaching. "I immediately knew that the island and the *Bahamian Reef Survey* project would become my second home," Rollino recalls. He has returned to San Salvador every year since and expects to continue; the studies he is now planning will take at least another decade to complete.

THE VALUE OF VOLUNTEERS

Volunteers who participate in the Bahamian Reef Survey are key members of the research team. The long hours they spend snorkeling along **transects** and inspecting tide pools yield fundamental data about coral reefs. Data must be reliable to be of any use, so volunteers need to take measurements with precision and analyze water chemistry accurately. They practice each procedure ashore, under the supervision of a scientist, before trying it out under water.

Good data is also based on the correct identification of marine organisms, so volunteers are given a crash course in reef ecology when they arrive on San Salvador. During "guided tours" of actual reefs, volunteers begin to distinguish algae, sponges, hard corals, soft corals, and other groups of reef-dwellers. On shore they study specimens, read books, view slides, and attend lectures. In two or three days, when they can identify about 15 different species of hard corals and spot symptoms of bleaching and disease, volunteers are ready to collect data in the field.

Despite hours of training and practice, volunteers face surprises. "As I was swimming along the reef," one recalls, "I saw a 5-foot barracuda - with its huge teeth - staring at me!" Since there is safety in numbers, she swam towards some other volunteers - only to find out that they were being circled by a lemon shark! Neither of the big fish caused any trouble. Waves and weather are more typical challenges. "It is certainly not easy making observations and recording data while currents and waves are bouncing you around," notes one volunteer.

may lead to the formation of a reef or island. Scientists calculate that corals reefs can grow about 5-8 millimeters a year.

Reef-building corals don't inhabit their skeletons alone. Within each coral polyp's body are **mutualistic** algae called **zooxanthellae**. The coral and zooxanthellae have a mutually beneficial relationship. The algae supply the polyps with carbon compounds manufactured through photosynthesis. Some corals receive more than half of their food in this way. In return, the algae get a nutrient-rich place to live. They algae use nitrogen and phosphorous from wastes that the polyps produce, nutrients that are otherwise very scarce in tropical waters.

Coral reefs are among Earth's most diverse communities, providing a host of living things with food, shelter, and a place to anchor. Algae, fungi, sponges, sea worms, mollusks, crustaceans, and colorful fish are among their inhabitants. In addition, reefs act as buffers between sea and land, protecting fragile shorelines from eroding waves. Coral reefs are found in warm, clear, shallow waters around the world.

REEFS IN DECLINE

Corals are sensitive to changes in their surroundings. Coastal development, toxic chemicals, hurricanes, global warming, and other stressors can damage or destroy coral colonies. One of the biggest problems corals face is **coral bleaching**. When coral animals bleach, they expel the algae that live in their bodies. They lose their color in the process, since their color comes from the algae. More significantly, they lose their in-house food supply. Bleaching can ultimately lead to coral mortality. When it does, reef ecology is disrupted, sometimes with devastating consequences. **Algae** overgrow the reef and prevent new coral polyps from establishing colonies. Marine biodiversity suffers, the number and diversity of species decreases and fisheries and tourism may deteriorate. Coral reefs also provide protection for beaches and dying reefs expose beaches to pounding waves.

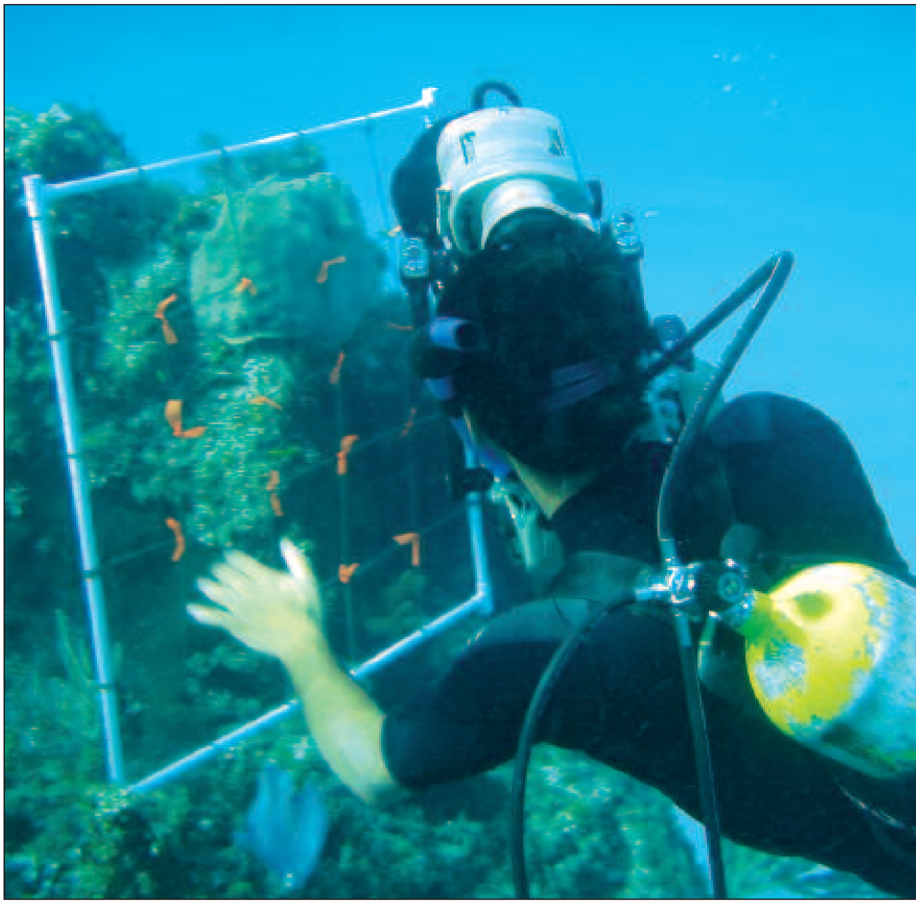
Coral bleaching was first described in the early 1900s, but it did not become a concern for many years. Then, in 1982-83, bleaching destroyed many corals off Panama, Costa Rica, and the Florida Keys. In 1987-88, a massive and prolonged bleaching event affected reefs around the world. Some scientists linked this episode to higher than average sea-surface temperatures and unusually calm water. They reasoned that the temperatures caused **thermal stress** while the calm water let excessive ultraviolet radiation reach the corals. Many episodes of bleaching, including the one in 1982-83, are associated with above-average sea temperatures.

The link between sea temperature and coral bleaching, combined with the fact that bleaching is increasingly common, has raised a concern. Is global warming threatening the world's reefs? Scientists are not yet certain. Not all episodes of bleaching can be linked to thermal stress or high levels of ultraviolet radiation. Researchers also note the rising incidence of coral diseases and wonder whether **pathogens** (viruses or bacteria that cause disease) play a role. To complicate matters further, bleaching occurs at low levels in healthy colonies that aren't under stress. Bleaching may be a natural phenomenon that is affecting larger and larger areas because of environmental changes.

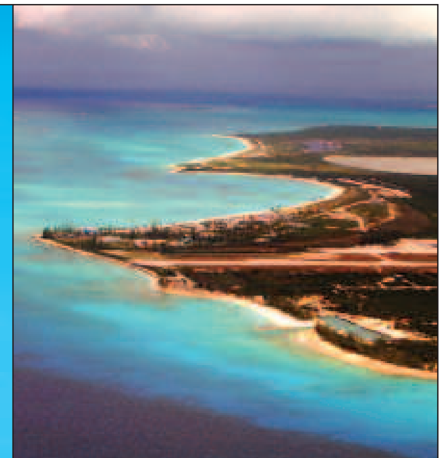
THE BAHAMIAN REEF SURVEY

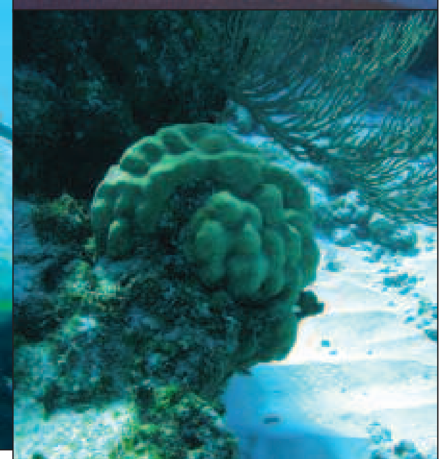
One reason scientists cannot pinpoint the cause of coral bleaching — or even know how seriously it threatens reefs — is that the phenomenon has not been studied thoroughly or for a long period of time. Most studies of bleaching have lasted just a few weeks or months, and site visits were infrequent. In addition, research began only after bleaching was underway, so prior environmental conditions were not observed and measured. On San Salvador Island, three researchers are taking a different approach. John Rollino (*Earth Tech, Inc.*), Dr. Garriet Smith (*University of South Carolina at Aiken*), and Thomas McGrath (*Corning Community College*) are conducting a long-term study of the island's reefs that involves ongoing data collection. It focuses broadly on the nature of coral reef decline in the region. More specifically, it looks at the origins and course of coral bleaching and disease.

Since multiple factors may be contributing to coral decline, Rollino, Smith, and McGrath must collect data about many aspects of the reefs and surrounding



Volunteer using a quadrat to collect data using the point-intercept method.





environment. Temperature, salinity, and water clarity are monitored before, during, and after bleaching events. Instead of relying on water temperature measurements taken from fixed points or from satellite sea-surface data, as most others have, Rollino, Smith, and McGrath take direct readings on the reefs. Using hand-held thermometers, they measure water temperature at different depths. They compare these measurements with data collected nearby to learn whether local habitat variations might be influencing bleaching, disease, and other changes in the coral.

Rollino, Smith, and McGrath also monitor the corals. When signs of bleaching are detected, the afflicted corals are tracked closely for several years. How do they vary over time? Do they recover or die? Is their fate associated with changes in the reef's flora or fauna? Systematic surveys can address these questions. Such surveys are quite labor-intensive, so researchers rely on volunteers to help carry them out. Volunteers regularly spend four hours a day snorkeling amonsgt the reefs. At the various study reefs, the researchers have permanent **transects.** At specific points along the transect line, they measure water temperature, chemistry, and clarity. They also inspect the area on either side of the line for signs of coral bleaching.

So as not to ignore other aspects of reef health as they seek causes for bleaching, Rollino, Smith, and McGrath use research techniques that allow them to focus on many kinds of change. For example, they have volunteers toss a large plastic frame with a grid of criss-crossed string onto the reef to collect data for **point intercept** and **quadrat** analyses. Volunteers note what kind of organism or substance is at each point, or intersection of strings, on the grid. (There might be hard coral at one spot, algae at another, and sand at a third.) The percentage of the entire frame, or quadrat, that is covered by each is also estimated. These techniques allow different locations to be compared. The researchers can then also compare coral density, species diversity, and changes in a reef's flora and fauna over time.

CLEAR WATERS

Because coral reefs are dependent on light for food, reef corals require clear water so light can penetrate the water. Clear waters are generally nutrient-poor and unproductive, making them poor places for many creatures to live. Paradoxically, coral reefs are some of the most productive marine environments.

STABILITY AND CHANGE

What are scientists learning from this long and intensive look at coral reefs? One thing they have discovered is that large coral colonies are most likely to survive bleaching and disease. Small colonies, which have not been growing for as long, are more vulnerable. They are continually being lost from the reefs and replaced by "new recruits."

In 1998, the biggest bleaching event in the history of coral reef study occurred. On the reefs off San Salvador, staghorn coral (*Acropora cervicornis*) was completely wiped out. Colonies of elkhorn coral (*A. palmata*) were also devastated, but some new ones did begin to grow. The 1998 bleaching event seems closely tied to the water temperature in the area, but the root cause of coral bleaching is still uncertain.

In July of 2000, a hard-coral disease called "white plague" appeared for the first time on a reef off San Salvador Island. Seven colonies were affected. The disease, which can kill an entire coral colony within a few days, had previously caused problems in some Florida reefs but had not occurred in the Bahamas. Fortunately, the damage it caused off San Salvador was limited. Over the course of five months, one of the affected colonies died, but the others resisted the disease. Though the incidence of coral disease has risen dramatically in the Caribbean in recent years, data collected off San Salvador shows that corals are resilient and can sometimes recover.

The observers who study San Salvador's reefs note many transformations over the course of a season and from year to year. Coral colonies begin to grow, but are soon lost to bleaching. Algae move in, then are torn away by severe weather. It seems the reefs are in a state of constant change, often for the worse. Should these impressions be trusted? Not entirely. While frequent, sudden, and sometimes devastating changes do occur on the reefs, they are often temporary, or balanced by other changes. A statistical analysis of data collected on the *Bahamian Reef Survey* project over the course of ten years showed little change in the diversity or distribution of coral species. Likewise, the percent of reef area covered by hard coral was fairly constant. When a decade's worth of numbers were analyzed, the picture of San Salvador's coral reefs that finally emerged was one of significant and dynamic changes in the short term, but remarkable stability over the long run. This is a hopeful note to those who have witnessed the devastating effects of bleaching, weather, and disease on coral reefs. It is also a statement about the value of long-term ecological research.

Rollino, Smith, and McGrath share findings from the *Bahamian Reef Survey* project with other scientists. They also provide the Bahamian government with information it can use protect its reefs.

GLOSSARY

coral bleaching: when coral animals expel the algae that live in their bodies.

algae: small aquatic plants

hard corals (also called stony corals): members of the Cnidarian subclass Scleractinia, these corals excrete a calcium carbonate skeleton around their bodies.

mutualistic: two species living together in a relationship in which both benefit from the association.

quadrat: a square of standard size, useful in ecological research.

pathogen: something that can cause disease, like a virus or bacterium.

point intercept analysis: a research technique that relies on data collected at each point on a square grid.

polyp: a sedentary or attached animal in the phylum Cnidaria.

thermal stress: extreme temperatures that cause a physiological response.

transect: a line along which data can be collected repeatedly.

zooxanthellae: photosynthetic algae that live in the body walls of coral polyps.

FIND OUT MORE

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Web Sites

Reef Relief
http://www.reefrelief.org/

Reef Base
http://www.reefbase.org/

Key Words

Coral reef, coral bleaching, Bahamas, zooxanthellae, cnidaria, global warming

Volunteers have joined this project through Earthwatch Institute. Read more about this study and other scientific field research at **www.earthwatch.org**.

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3 Clock Tower Place
Suite 100
Maynard, MA 01754-0075