National Park Service
U.S. Geological Survey
U.S. Department of the Interior

Coral Bleaching and Disease Deliver "One – Two Punch" to Coral Reefs in the US Virgin Islands

Coral mortality continues as a result of 2005 coral bleaching-disease episode despite relatively normal 2006 summer water temperatures.

Diseased coral on Tektite Reef, Virgin Islands National Park (photo by Erinn Muller, USGS)

Historical Context

Coral reefs in the Virgin Islands have suffered the highest amount of hard coral mortality from severe bleaching that began in fall 2005 and subsequent outbreaks of coral disease than from any other stressor over the last 40 years. In the past, hurricanes have caused localized destruction, and white band disease caused losses of over 90% of the primary shallow water reef-building coral, *Acropora palmata*. In contrast, the bleaching and disease event of 2005-2006 has affected almost all species of coral over a depth range from the surface to greater than 30 meters.

Long-term and Episodic Monitoring

Monitoring programs that were in place before the bleaching began allowed NPS and USGS to quantify the effects of bleaching and disease. The NPS/ South Florida-Caribbean Inventory and Monitoring Network Program (SFCN) has permanent, randomly selected transects (=120) at 6 sites (up to 15 m deep) in St. John and St. Croix, including Virgin Islands NP and Buck Island Reef NM. An average of 90% of coral cover bleached at these sites in September and October 2005. Many corals began to recover their normal coloration but then suffered a "one-two punch" from disease (primarily white plague). Historically, sites were monitored annually using digital video, but frequency of monitoring increased to every 2-6 months to document the effects of the bleaching and disease event. Although bleaching was associated with record -warm seawater temperatures, some corals remain discolored and mortality from disease has continued despite cooler seawater temperatures in 2006. Coral cover has declined 48.7% at the long-term study sites as of July 2006.

Two New Approaches to Evaluate Change

In addition to the analysis of the digital videotapes for changes in percent coral cover over time, two other approaches are being used to examine the responses of corals to this event. First, the amount of disease affecting the coral reefs is being estimated on each sampling date by measurement of lesions (areas that have recently been killed by disease) on coral colonies one meter on either side of the permanent transects. Within our study sites, mortality from disease ranged from 4 to 80-times more extensive following bleaching than before bleaching began. Second, videotapes from successive time periods at each long-term site are being compared side-by-side to follow the condition and fate of 4153 selected coral colonies.

Monitoring the Continued Impact

The data reveal the largest and most important reef building corals, *Montastraea annularis* complex, experienced substantial recovery from bleaching at first; however high mortality due to disease followed with 68.5% of all colonies experiencing some level of mortality and 12.4% dying completely. *Agaricia spp.* suffered the most bleaching mortality of any species (94.6%). Major reef building species and those species that dominate reef cover (e.g. *Montastraea*, *Colpophyllia*, *Diploria spp*.) showed relatively low total mortality but suffered high partial mortality. Bleaching

These losses are especially alarming as these reefs took centuries to form and had some of the highest coral cover, diversity, complexity and management protection of any in the NE Caribbean.

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levels tracked mortality e.g.: corals with greatest color loss suffered greatest mortality. Those corals that had no color loss had lowest percent mortality. Approximately six months after the bleaching event, 34% of surviving corals still had not recovered completely.

Monitoring Elkhorn Corals, A New "Threatened" Species

In May 2006, elkhorn coral (*A. palmata*) was listed as threatened under the Endangered Species Act. USGS is monitoring over 400 elkhorn corals on reefs around St. John. Of these colonies, an average 50% bleached, and of those that bleached, 36% died partially, and 15% died completely. Fall 2005 was the first time that elkhorn coral bleaching had ever been observed in the Virgin Islands. In contrast to the deeper reefs described above, elkhorn reefs did not exhibit dramatic increases in disease following bleaching. White band is rarely seen on the reefs, although white pox and other un-described diseases are consistently present, usually with less than 10% prevalence rate.

Tissue Sampling and Molecular Techniques

To augment the efforts described above and to further our understanding of coral diseases, samples of healthy and diseased corals are being analyzed to determine if there are shifts in the associated microbial communities when corals become diseased. In August 2005, USGS scientists with the help of NPS personnel, sampled healthy and diseased *M. annularis* along transects at Tektite Reef, within Virgin Islands NP. Innovative noninvasive, nondestructive methods were used to get a statistically significant number of samples with minimal impact on the reef organisms. Sterile foam swabs were used to sample corals, and material was transferred to Whatman FTA cards for storage and transport to the laboratory. Bacterial 16S ribosomal genes and zooxanthellae ITS-1 genes were readily amplified by polymerase chain reaction (PCR) from card samples. PCR products were further analyzed to examine the diversity of bacteria and zooxanthellae colonizing the corals sampled. No obvious associations between disease status and zooxanthellae clades were noted, however investigations of bacterial associations were informative.

Collaborations between NPS and USGS, both field and laboratory units, during this event have advanced the knowledge of coral microbiology that may help protect the reefs of the future. (Photo by Tony Spitzack, USGS)

Exploring Microbiological Life within Corals

Members of the alphaproteobacteria are extremely diverse in form, function and ecological role. The sub-division includes symbionts as well as serious plant and animal pathogens. Several studies from multiple researchers have detected shifts in coral-associated alphaproteobacteria within the health/disease status. To further study this possible relationship, we developed a set of PCR primers that direct the amplification of a highly variable sequence stretch in the alphaproteobacterial gene that codes the 16S ribosomal RNA. Fifty-six of sixty-four *M. annularis* samples taken from apparently healthy colonies at Tektite Reef harbored a common, single type of alphaproteobacterium, while the remaining eight harbored either distinctly different single or multiple types of these microbes. This contrasts with the 31 diseased samples which all harbored alphaproteobacterial types that appear to be different from any of those found in the healthy colony samples. The species identifications of characteristic alphaproteobacteria associated with healthy and diseased coral colonies are currently being determined by genetic sequence analysis. Our data suggests that there may be an alphaproteobacterium that forms either a commensal or symbiotic relationship with *M. annularis* and that this relationship is disturbed in the disease process. The unusual alphaproteobacterial signatures found in eight of 64 apparently healthy colony samples may represent either rarely occurring normal flora, or alternatively, may be the first representation of the onset of disease in which case these sorts of analyses could be predictive in assessment of reef vulnerability. Similar analysis of microbial communities associated with elkhorn coral colonies is planned.

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