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Applying New Methods to Diagnose Coral Diseases

Coral disease, one of the major causes of reef degradation and coral death, has been increasing worldwide since the 1970s, particularly in the Caribbean. Despite increased scientific study, simple questions about the extent of disease outbreaks and the causative agents remain unanswered. A component of the U.S. Geological Survey Coral Reef Ecosystem STudies (USGS CREST) project is focused on developing and using new methods to approach the complex problem of coral disease.

Mitigation of impacts from coral diseases and syndromes requires better diagnostic techniques to detect the onset of disease. Ideally, these techniques would be rapid and non-destructive. USGS scientists are working on such a diagnostic method that is based on fluorescence. Reef-building corals have symbiotic dinoflagellates (zooxanthellae) that contain chlorophyll and associated photosynthetic pigments. Chlorophyll, associated photosynthetic pigments, and some proteins within coral have fluorescent properties. Images of coral fluorescence can be captured in three colors with a multispectral camera: green, orange, and red (fig. 1). Analyzing the natural variability in fluorescence intensity for a given species, as well as the differences between diseased and healthy specimens, enables the development of an index relating fluorescence to disease. This diagnostic tool would provide researchers and resource managers with a rapid, non-invasive means to assess coral health. If successful, a towable camera system can be developed, allowing entire segments of the reef to be surveyed rapidly.

Prior research has indicated that coral diseases may be due to secondary opportunistic infections, rather than primary pathogens, making it imperative to understand the microbial shifts that occur from healthy to diseased corals. (Lesser and others, 2007; Sunagawa and others, 2009). USGS researchers, in collaboration with Lawrence Berkeley National Laboratory (Berkeley, California), will employ custom-designed microarrays to characterize microbial patterns on corals. These microarrays are small chips that are printed with DNA sequences representing 30,000 microbial groups, ranging from family to species. If bacterial DNA from a coral matches any of the microarray DNA spots, a signal is

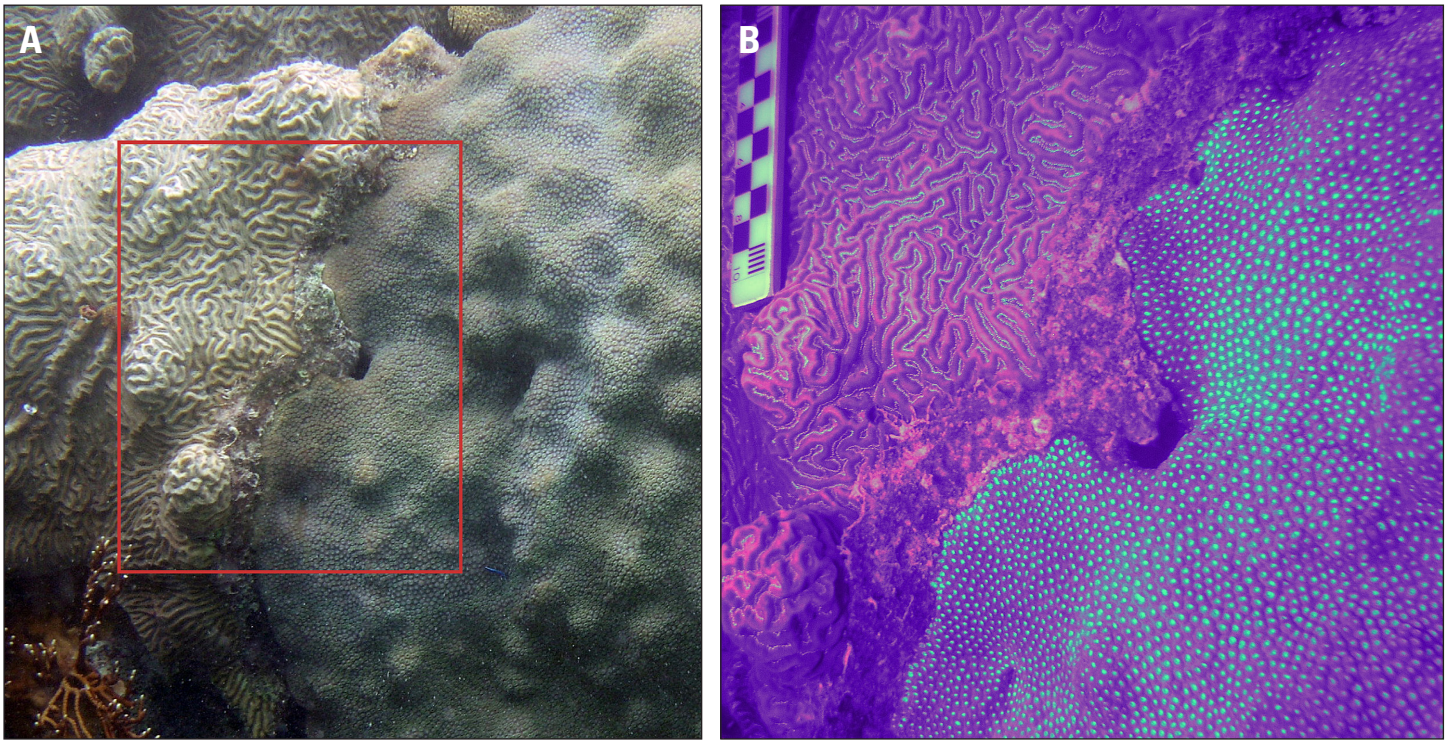

Figure 1. (A) Under natural lighting, both the knobby brain coral (*Diploria clivosa*) and the star coral (*Montastraea faveolata*) are tan or brown. When stimulated to fluoresce with blue light (B), ridges of the brain coral appear red and its valleys are green. The polyps of the star coral fluoresce green, punctuating a background of red. In both cases, chlorophyll and a green fluorescent protein are responsible for the red and green fluorescent emissions, respectively. Note the border zone between the two corals is dominated by a filamentous alga that fluoresces red due to its chlorophyll content. Ruler squares are 1 centimeter. The red box in (A) indicates the area shown in (B). Photo credit: David Zawada, USGS.

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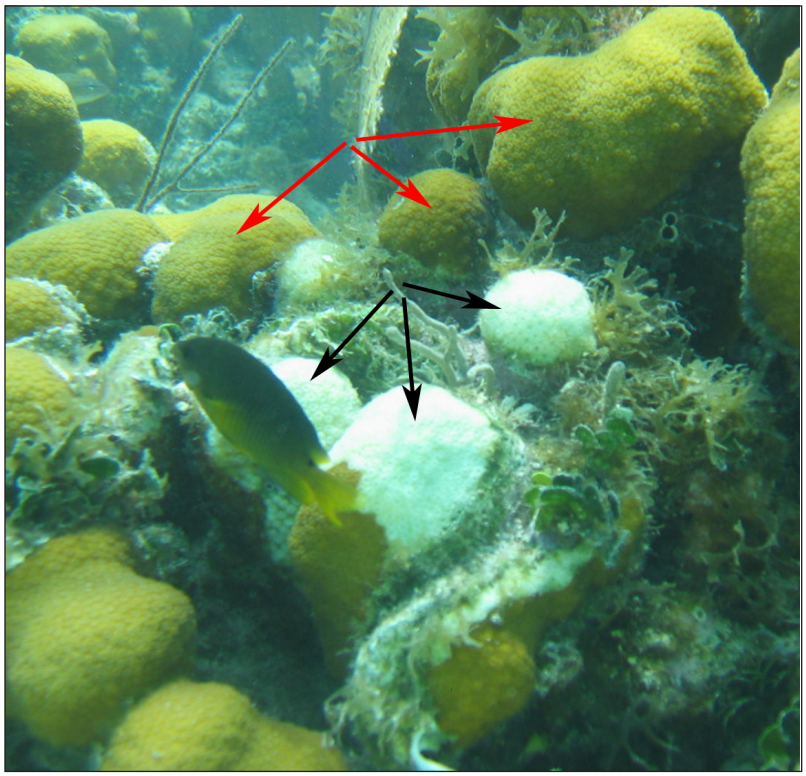

Figure 2. Boulder star coral (*Montastraea annularis*) affected by white plague. The white parts of the colony (indicated by black arrows) are dead. The disease has rapidly killed the coral, leaving bare white skeleton behind. The apparently healthy parts of the colony are indicated by red arrows. Photo credit: Christina Kellogg, USGS.

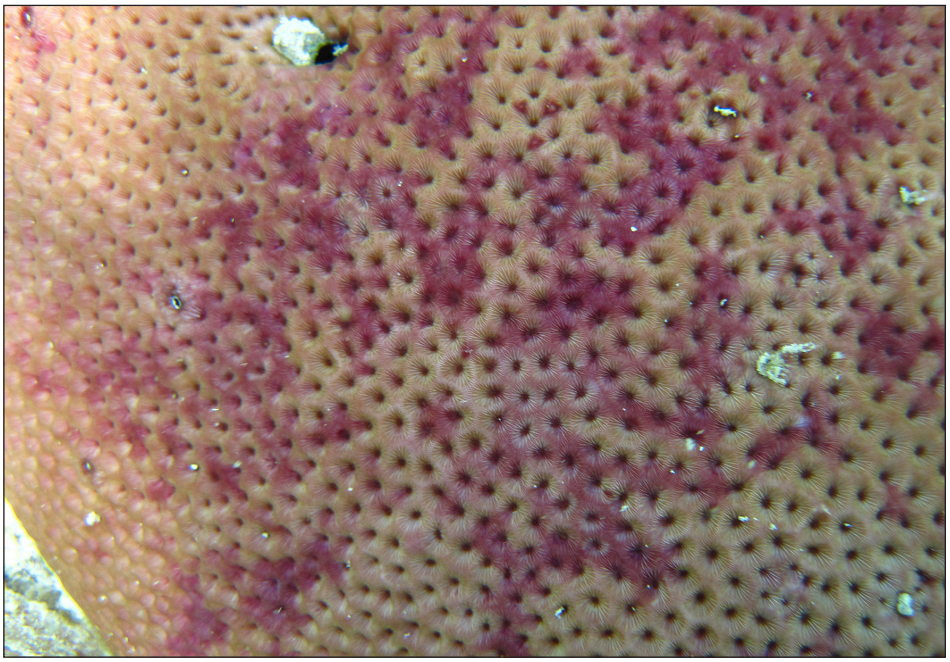

Figure 3. A closeup view of dark spot lesions (purple areas) on a colony of *Siderastrea siderea*, the massive starlet coral. Photo credit: Julie Olson, University of Alabama.

generated that can be used to determine the relative abundance of those microbes in the sample. Samples have been collected for this experiment from healthy and white plague-affected *Montastraea annularis* (boulder star coral; fig. 2) as well as from healthy and dark spot-affected *Siderastrea siderea* (massive starlet coral; fig. 3). This experiment will allow an unprecedented comparison of microbial communities between healthy and diseased corals, between species of coral, and between geographic locations. The microarray data generated by this experiment will provide a new baseline of information and may reveal previously unknown patterns underlying the diseased state.

Initial field tests and sample collection for these methods took place in the Virgin Islands National Park and the Dry Tortugas National Park in July and August 2009. Work will continue in the Florida Keys during the 2010 summer field season.

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