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THREATENED CORAL AT BUCK ISLAND REEF

Monitoring captures the devastating 2005 bleaching event of the barrier reef

- Learning center goes virtual
- The *Park Science* interview: Mike Soukup
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ON THE COVER

Tropical marine habitats of the U.S. Virgin Islands host reef communities such as the elkhorn coral (*Acropora palmata*) of Buck Island Reef National Monument. Elkhorn coral is one of the first coral species to be protected under the Endangered Species Act. Surveys in 2003–2004 determined the species' distribution and documented wave damage, predation, disease, and other stressors such as bleaching. Investigators continue monitoring the effects of the severe bleaching event of 2005 (see page 36).

NATIONAL PARK SERVICE/HANK TONNEMACHER

Science Feature

The decline of elkhorn coral at Buck Island Reef National Monument:

Protecting the first threatened coral species

By Ian Lundgren

BUCK ISLAND REEF NATIONAL Monument lies just north of the island of St. Croix in the U.S. Virgin Islands. When it was established in 1961, the park encompassed 176-acre (71 ha) Buck Island and 704 acres (285 ha) of marine habitat surrounding it. The park proclamation describes the monument and its "adjoining shoals, rocks, and undersea coral reef formations" as "one of the finest marine gardens in the Caribbean Sea," which are of "great scientific interest and educational value to students of the sea and to the public." Multiple use was prescribed in the original park purpose, allowing fishing in some areas but protecting others. In 2001 the relatively small national monument was expanded to 19,015 acres (7,695 ha), and all forms of resource extraction were completely prohibited (fig. 1).

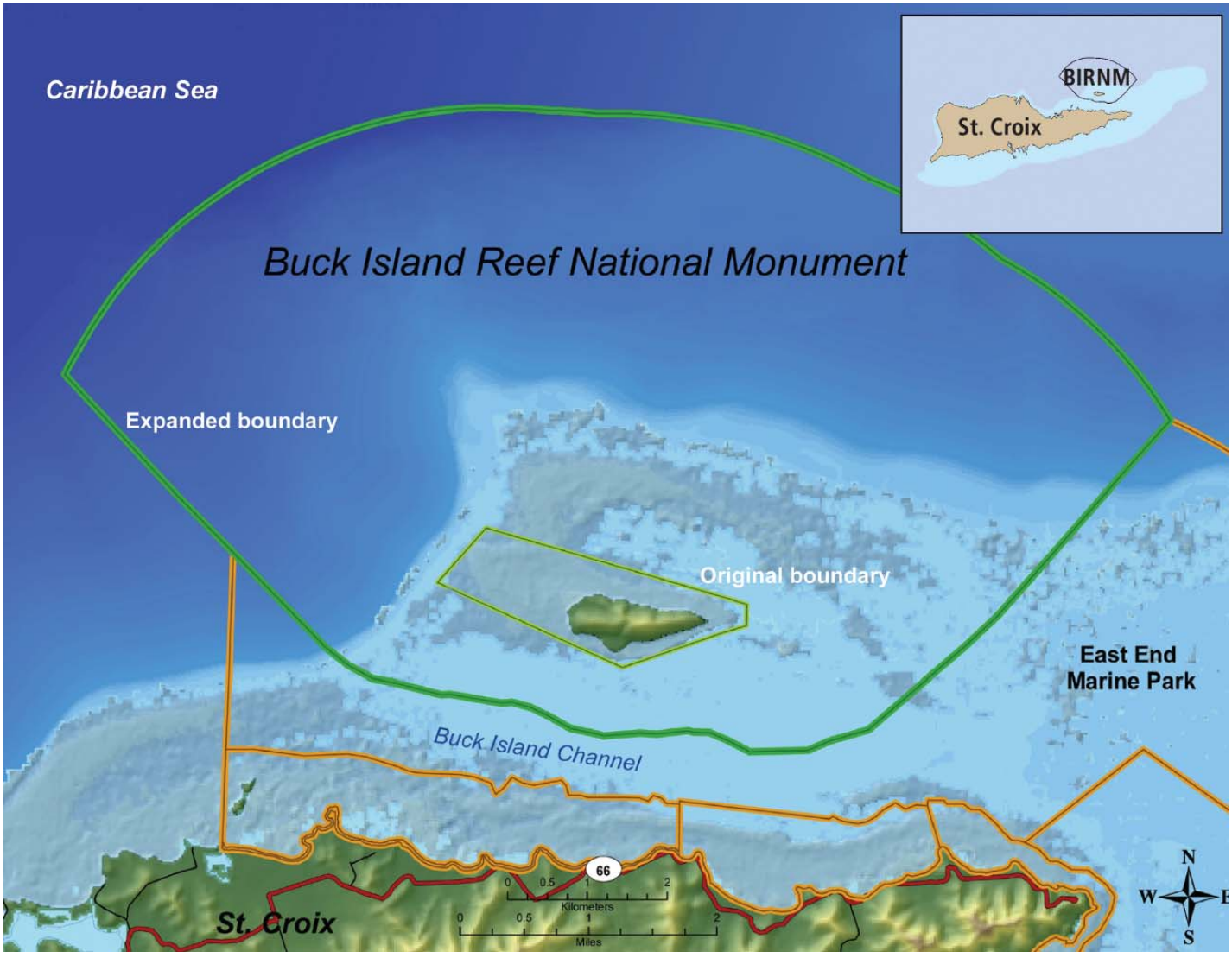

Figure 1. Map of Buck Island Reef National Monument; inset: St. Croix. SOUTH FLORIDA/CARIBBEAN NETWORK

In a tropical marine ecosystem, coral reef communities live in a fragile, interdependent relationship and include essential, interconnected habitats. The 2001 expansion of Buck Island Reef National Monument added coral reefs, sea grass beds, and sand communities, as well as algal plains, shelf edge, deep and dimly lit reefs, and deep oceanic habitats not originally within the monument boundary. These additional habitats preserve ecological links that help sustain the monument and its resources. Another important part of the boundary expansion was placing a vast reef shelf area of elkhorn coral (*Acropora palmata*), a major reef-building species, under management of the National Park Service (see fig. 1).

Elkhorn decline

Elkhorn was the dominant coral species in wave-exposed and high-surge reef zones throughout the Caribbean Sea before the 1970s (Adey and Burke 1976). Dense stands of elkhorn coral formed and dominated the barrier reef and unique "haystack features" (patch reefs that resemble haystacks) surrounding Buck Island (fig. 2). However, in the 1970s and 1980s this species drastically declined primarily because of a bacterial syndrome called white-band disease (see sidebar) (Aronson and Precht 2001). Since then, hurricanes, bleaching events, and outbreaks of predators have further decimated the populations of elkhorn coral (see sidebar) (Bruckner 2002). In 2006, elkhorn coral was listed as threatened under the U.S. Endangered Species Act (National Marine Fisheries Service 2006).

Managers' growing concern for elkhorn coral and the impending critical habitat designation under the recovery plan led to coral surveys in 2003–2004 (Mayor et al. 2006). Investigators determined the spatial distribution of the species (fig. 3) and the presence of disease, predation, and wave damage. The surveys estimated that between 97,232 and 134,371 large elkhorn coral colonies (at least a meter in length or height) were present at Buck Island Reef National Monument at that time. Investigators observed white-band disease on 11–12% of elkhorn colonies of all sizes and called for increased monitoring of this species to better understand the dynamics of other stressors, such as bleaching, predation, and severe storms, which can lead to its further decline (Mayor et al. 2006).

Figure 2. Divers enjoy an elkhorn coral haystack feature at Buck Island Reef.

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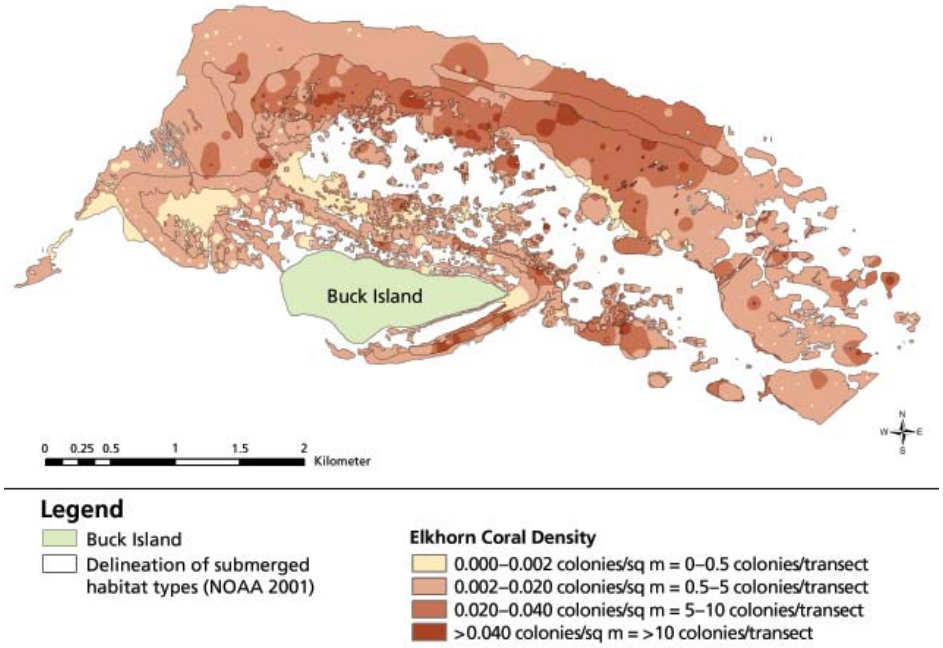

Figure 3. Distribution and density of elkhorn coral colonies at Buck Island Reef National Monument in 2004. PHILIPPE MAYOR

Bleaching event

A beneficial outgrowth of the 2003–2004 monitoring was the impetus to include elkhorn coral monitoring as part of the vital signs monitoring program being developed for Buck Island Reef National Monument by the South Florida/Caribbean Network of the National Park Service. Elkhorn coral monitoring began in March 2005, just before the onset of a major bleaching event, and focused on colonies in the three major types of elkhorn habitat: forereef, backreef, and reef shelf. Investigators monitored sites monthly for health parameters: presence and progression of disease, predation, bleaching, storm damage, and overall change in live tissue cover. This monitoring completely recorded the impact of the bleaching event in late 2005.

Elkhorn coral has anecdotally been known to be resistant to bleaching; however, in 2005, elkhorn reefs experienced the widest-scale bleaching ever reported in the U.S. Virgin Islands. According to the National Oceanic and Atmospheric Administration (NOAA), water temperatures in 2005 exceeded the bleaching threshold at Buck Island Reef National Monument for more than 12 weeks. Data loggers deployed by the National Park Service on both the forereef (33 feet [10 m] deep) and backreef (8 feet [2.5 m] deep) zones of the national monument showed that problematically high water temperatures seemed to be tri-phased during the bleaching event (fig. 4) (Lundgren and Hillis-Starr 2008). Initially temperatures in both the forereef and backreef habitats fluctuated above and below the bleaching threshold, exceeding the threshold 61% of the time on the forereef and 84% of the time on the backreef. By the first week in August, temperatures had exceeded the bleaching threshold at both reef habitats and remained lethal for 10 weeks. In the last phase, temperatures again fluctuated above and below the bleaching threshold as they had before August. The much higher water temperatures over a much longer period in 2005, as compared with historical records from 1991 to the present, explain why this event was so severe (see fig. 4).

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Biologists documented changes in elkhorn coral conditions by analyzing repeat photography (fig. 5). They preferentially photographed colonies from the planar view (i.e., from directly above) and in shallow water from a consistent oblique angle. They analyzed photos from August and November 2005 and January 2006 using the following categorical evaluation: live healthy tissue retained its normal brown coloration; bleached or mottled tissue was pale or white; and dead tissue had previously been alive but now was covered with algae. The change in live tissue from August 2005 to January 2006 (when bleaching was no longer evident) is the estimated loss as a result of the bleaching event. Of the colonies examined, 82% experienced bleaching, with maximum bleaching for all sites occurring in November 2005. Interestingly, colonies located on the backreef (at a medium depth among the three habitats) were impacted before colonies on the shallower forereef and much deeper reef shelf (fig. 6). More importantly, mortality was twice as high on the backreef and forereef as on the reef shelf (see fig. 6). Mortality on the backreef occurred sooner than on the forereef. The backreef experienced the highest average tissue mortality during the event (66%), followed by the forereef (58%) and the reef shelf (36%) (fig. 7). Overall, out of 44 colonies monitored, only 2 did not experience any mortality during the bleaching event.

Discussion and conclusion

Though shallow elkhorn coral habitat is present on the barrier reef and scattered haystack features surrounding Buck Island, the majority of elkhorn coral habitat

Figure 4. Buck Island Reef National Monument temp logger, 10 m depth forereef underwater trail.

Water temperatures during 2005 bleaching event and historical temperatures since 1991.

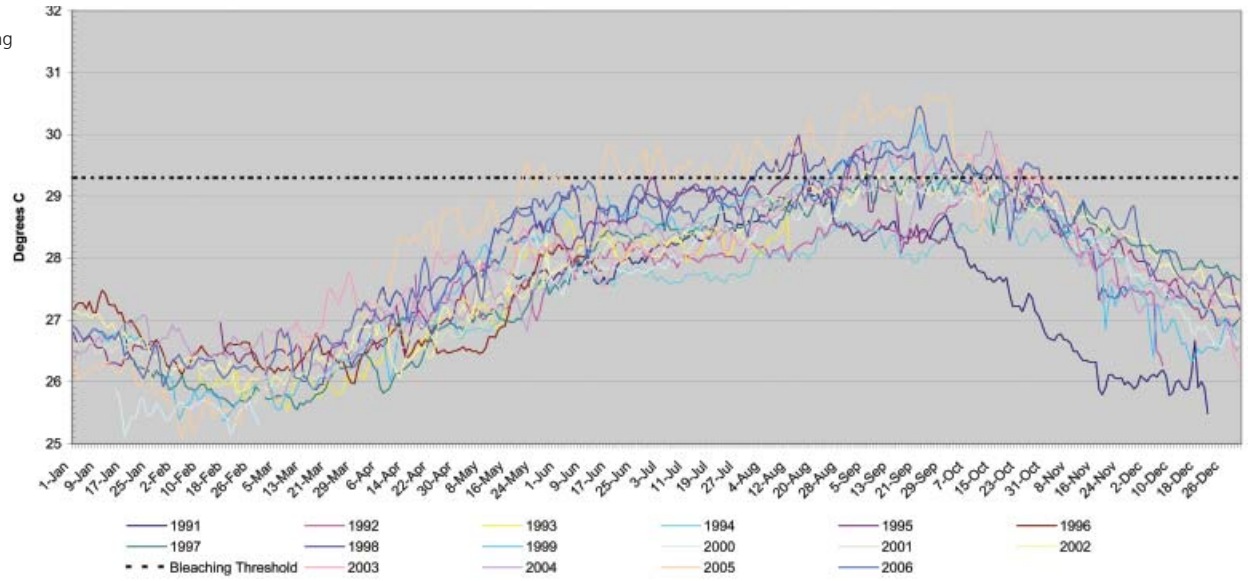

Figure 5. Progression of bleaching in elkhorn corals at two photo-monitored sites, August 2005 to January 2006.

Colony #130 (SFR)

August 2005
0% mottled/bleached
2% algae cover

November 2005
98% mottled/bleached
2% algae cover

January 2006
0%mottled/bleached
95% algae cover

△ bleaching = 98% — △ mortality = 93%

Colony #409 (NBar)

August 2005
0% mottled/bleached
0% algae cover

November 2005
100% mottled/bleached
0% algae cover

January 2006
10% mottled/bleached
10% algae cover

△ bleaching = 100% — △ mortality = 10%

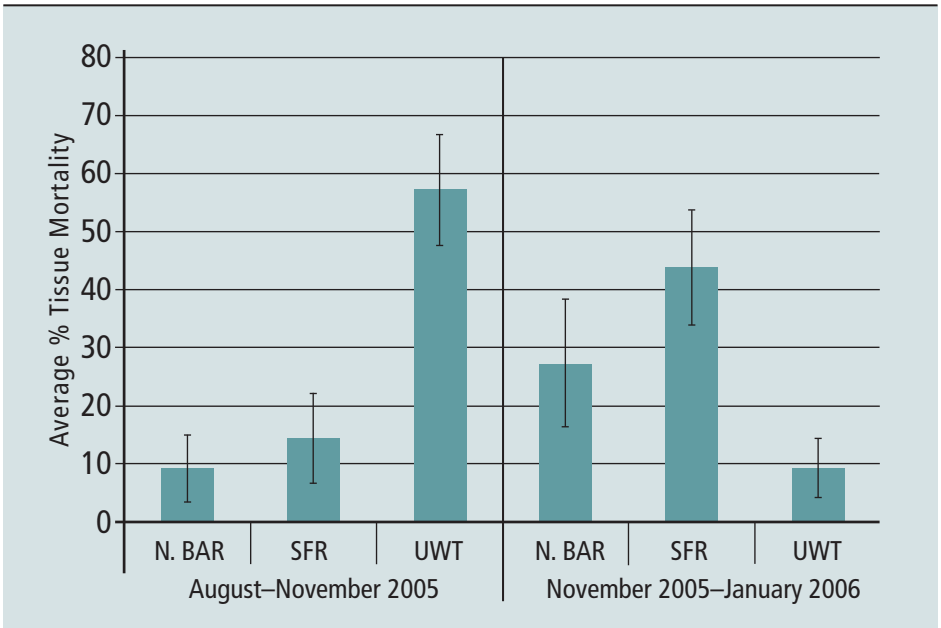

Figure 6. Temporal mortality of elkhorn coral at three monitored sites.

is on the reef shelf north of the island, and is typically deeper habitat (16–33 feet [5–10 m]) than the other elkhorn coral habitats in the national monument (Mayor et al. 2006) (see fig. 3). Rapid and severe bleaching and mortality of the backreef may be linked to restricted water flow and reduced wave action, which increase light penetration and stress, and slightly higher water temperatures (Nakamura and van Woesik 2001). One hypothesis for the greater mortality of the forereef and backreef corals is that the barrier reef was reseeded by coral colonies from the surrounding reef shelf after being destroyed by Hurricane Hugo in 1989 (Vollmer and Palumbi 2007). This would explain the lack of acclimation expected of colonies that are regularly exposed to extreme conditions on the shallow barrier reef (Rowan et al. 1997). Finally, disease could have contributed to mortality during the bleaching event without being detected. Bleached coral can appear identical to tissue affected by disease, especially white-band disease. Bacterial communities with antimicrobial properties normally present in healthy colonies have been known to disappear during bleaching events (Ritchie 2006).

Elkhorn coral colonies located in the backreef, where water flow is restricted and wave action is decreased, are less resistant to bleaching than at other sites and become hotter more quickly; therefore, the backreef would be a poor choice for critical habitat designation under the Endangered Species Act. However, bleaching in backreef colonies could effectively serve as an early detection mechanism, signaling managers to implement a specific monitoring protocol for bleaching events.

The National Marine Fisheries Service is the federal agency that administers the Endangered Species Act in the marine environment, and therefore is responsible for designating critical habitat. The act defines critical habitat as areas that contain "the physical or biological features essential to the species' conservation and which may require special management considerations or protection." The National Marine Fisheries Service is directed to establish critical habitat within one year of listing a species under the act.

Concurrently, Buck Island Reef National Monument is in the final stages of rewriting its general management plan. Under

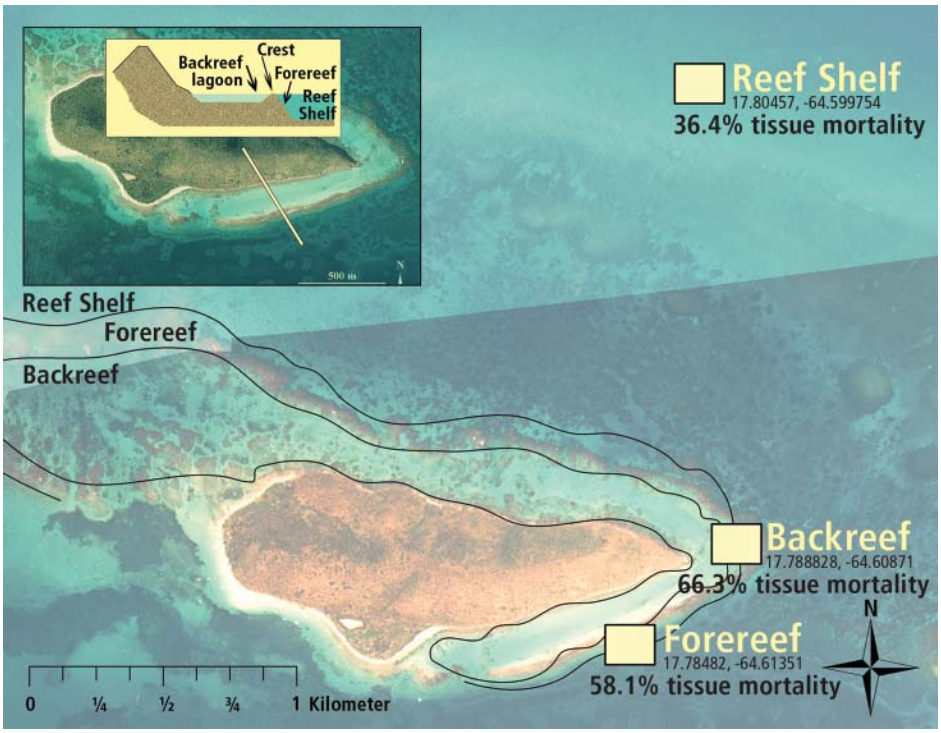

Figure 7. Map of Buck Island Reef National Monument showing monitored locations (forereef, backreef, and reef shelf), percentage of mortality experienced by elkhorn coral colonies as a result of bleaching in 2005, and an inset cross section of the described habitats.

the plan's preferred alternative, much of the elkhorn habitat north of Buck Island would be designated a marine hazard zone, limiting underwater use without permit. This would not affect the famous "underwater trail," though park managers anticipate increasing oversight of snorkelers in this area to ensure that elkhorn coral is well protected as it is being enjoyed by visitors.

Acknowledgments

The extent of our knowledge at Buck Island Reef National Monument is a result of all the researchers who have contributed to it over the past 30 years: Bill and Betsey Gladfelter, Denny Hubbard, Bob Stenek, Caroline Rogers, Philippe Mayor, and others. Zandy Hillis-Starr has dedicated much time and effort to managing elkhorn coral as chief of resource management. Of course, the contributions of staff and contractors such as Brendalee Phillips, Hank Tonnemacher, and Kimberly Woody are invaluable.

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