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Keck Geology Consortium: Projects 2007-2008
Short Contributions – St Croix

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TEMPORAL AND SPATIAL DISTRIBUTION OF CORALS AT TAGUE BAY REEF AND BUCK ISLAND NATIONAL MONUMENT REEF ST. CROIX, USVI

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INTRODUCTION

Caribbean reefs have suffered a 40% loss of coral cover since the 1970s (Aronson and Precht, 2006). Many reefs are experiencing a shift from a coral dominated system to a one overwhelmed by algae, weedy corals and soft corals (Pandolfi et al., 2005; Hughes et al., 2003).

This study considered the condition of two reefs, one at Tague Bay and one in Buck Island National Monument, St. Croix, USVI. St. Croix is located in the northeastern Caribbean and is the largest of the U.S. Virgin Islands (Fig. 1; also see Fig. 1 in Hubbard et al, this volume). Tague Bay and Buck Island are located on the North coast of the island. Tague Bay is a 7.8 km bank-barrier reef which is never greater than 0.9 km off shore (Burke et al., 1989). Buck Island is located 2 km north of Tague Bay on a shallow shelf that extends from the mainland and is protected by a similar reef (Bythell et al., 1989). In 1961, Buck Island was declared a National Monument and is now under the jurisdiction of the US National Parks Services (Hubbard, 1991). The US National Park Service has enforced the "no take zone" surrounding the island (Bythell et al., 2000). Data on reef biology has been collected since 1976 along the north and south Buck Island reefs (Hubbard, et al., 2005). In contrast, Tague Reef has not been protected. By comparing the amount of coral on these reefs, we present a snapshot of the reefs in 2007. Examination of cores through the same reefs (Burke, et al. 1989; Hubbard, 1991) allows a longer-term comparison.

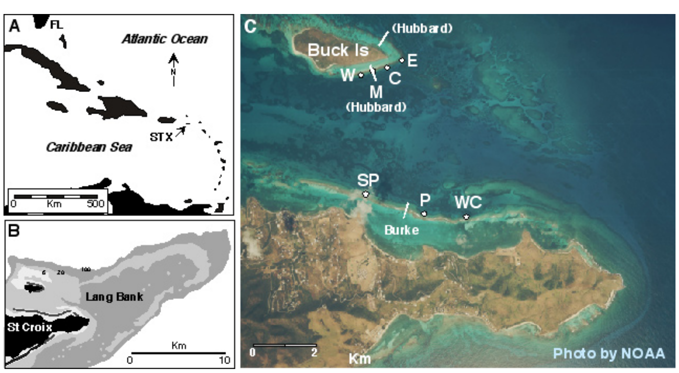

Figure 1. A) Map showing the location of St. Croix (STX) in the Caribbean Sea. B) Map of northeast St. Croix. C) Air photo showing the locations of the survey sites (white circles) and the cores (lines)

METHODS

Eleven dives at seven sites were to measure live versus dead cover on the modern reefs (Fig. 1). Three sites on Tague Reef and four sites at Buck Island were chosen because they are sites used for monitoring projects in the past. At each site, horizontal transects were established at depths of 3, 6 and 9 meters. Each transect was 20 m in length, and the substrate was measured using the chain transect technique of Bythell et al. (1989). The substrate was delineated based on five categories: live coral, dead coral, rubble, sand and pavement. Rubble was defined as dead coral fragments larger than 2 cm; sand was anything less than 2 cm. Dead coral was defined as in situ dead coral. Corals were identified to the species level where possible, otherwise to genus level.

Coring conducted by Hubbard et al (2005) included the North and South Buck Island reefs. I logged 5 cores by measuring each coral and identifying the corals to genus level. Coring in Tague Bay was conducted by Burke et al. (1989), using the same methods described above. Records for the 5 cores were acquired from Ian MacIntyre, from the Smithsonian Institution, Washington, DC (Fig. 1). The logs included length and identification to species level.

RESULTS

The percent of dead coral at 10 feet is consistently higher in Tague Bay than at the Buck Island sites (Fig. 2a; highest at Whaler's Cut). The highest amount of live coral was at Buck Island West with about 30% live coral (Fig. 2b). The overall average live coral is about the same (Tague Bay = 12.4%; Buck Island = 13.4%). At Buck Island, the dominant live species was *P. porites*, while on Tague Bay, it was *P. astreoides*. The highest amount of rubble was found at Buck Island East (Fig. 2c). Live coral cover has decreased from a high of 52.4% in 1976 to 13% in 2007 (Fig. 3). *A. palmata* decreased from 30.8% in 1976 to 0.3% in 1990 (Fig. 3). Figure 3 summarizes these patterns and the possible factors responsible.

The core data represents coral deposits throughout the Holocene (Hubbard et al., 2005). Both Tague Bay and Buck Island cores indicate an upward-shallowing trend, represented by the increase in branching coral species up core (Fig. 4). The amount of coral in the Tague Bay cores (16.62 %) was lower than that in the Buck Island cores (35.24%). For both reefs, there was much more *A. palmata* in the core than on the modern reef. In the Tague Bay cores, *A. palmata* represents about 4% of the core while in Buck Island it represents about 8%. *Montastraea* was the major coral component in the Buck Island cores (18%), while it made up 6% of the Tague Bay cores In the Buck Island cores, there was no recovery of *P. porites*, but in the Tague Bay cores, 4% of the cores was comprised of this species.

DISCUSSION

The higher amount of dead coral at shallower depths for the Tague Bay transects relative to Buck Island could be due to the reef being closer to mainland St. Croix, and therefore being affected by anthropogenic factors. These include overfishing, pollution, land use changes and increase human population

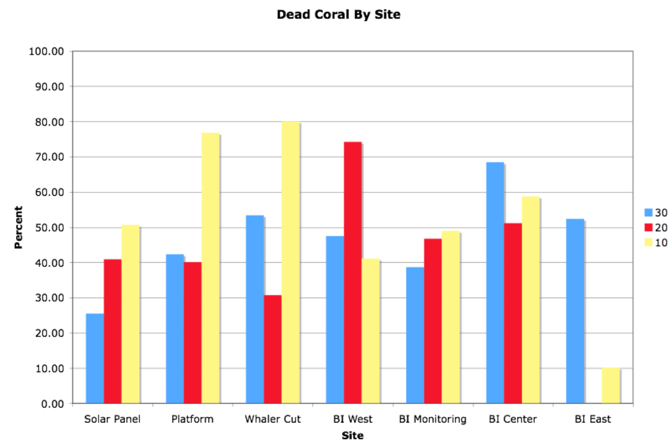

Figure 2a: Percent dead-coral substrate by site and water depth (ft)

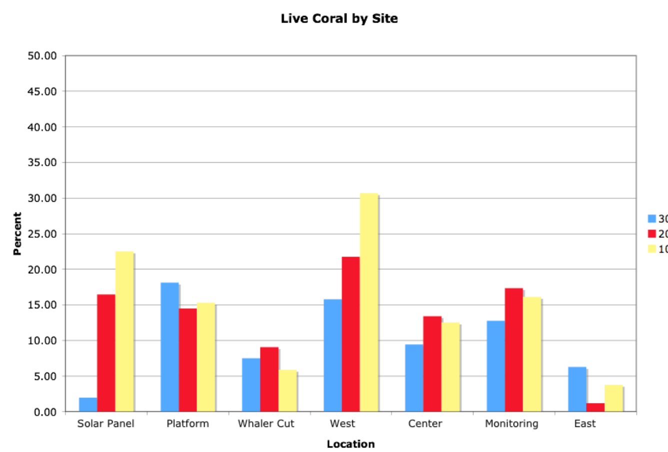

Figure 2b: Percent Live coral substrate by site and water depth (ft)

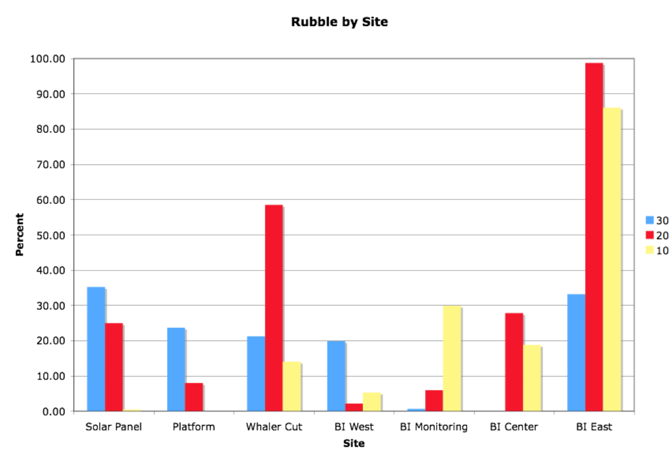

Figure 2c: Percent coral rubble substrate by site and water depth (ft)

(Hughes et al., 2003). Sedimentation, pollution and land use changes directly impact coral survival

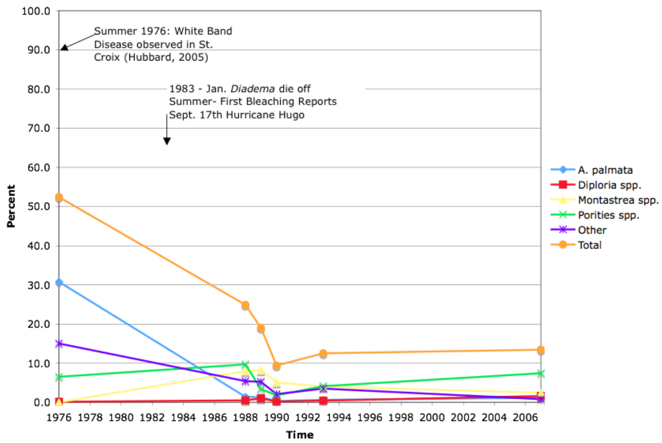

Figure 3. Percent live coral cover over time on the southern Buck Island forereef. Data from 1976-1993 from Hubbard et al. (2005). Note that the total cover from this survey is similar to the levels from the previous survey in 1993, and much lower than levels in 1976

(Hughes et al., 2003). Fishing greatly influences the natural dynamics of the reef (Hughes et al., 2003).

Both Buck Island and Tague Bay's easternmost sites, (E and WC), are dominated by low live coral and high amounts of rubble. In order for the coral to be broken and transported, a large source of energy is required, primarily through storms. Most of the rubble at these sites was comprised of *A. palmata* and *P. porites* which would be more easily broken by waves associated with strong storms like Hurricane Hugo.

Live coral at Tague Bay and Buck Island is mostly comprised of *P. asteroides* and *P. porites* respectively, the latter being a non-framework builder (Gardner et al., 2003). This trend to non-framework builders has been observed throughout the Caribbean reefs, and is a cause for concern because the reefs are less likely to keep pace with rising sea level (Gardner et al, 2003). Many of these species are also particularly susceptible to storm damage and temperature shifts (Gardner et al., 2003).

Over the last 30 years, decreasing coral cover has been documented throughout the Caribbean. The decline of St. Croix reefs has been attributed to Hurricane Hugo (1989), coral disease outbreaks and bleaching events (Hubbard et al., 2005). The greatest decrease in coral cover occurred from 1976 to 1988

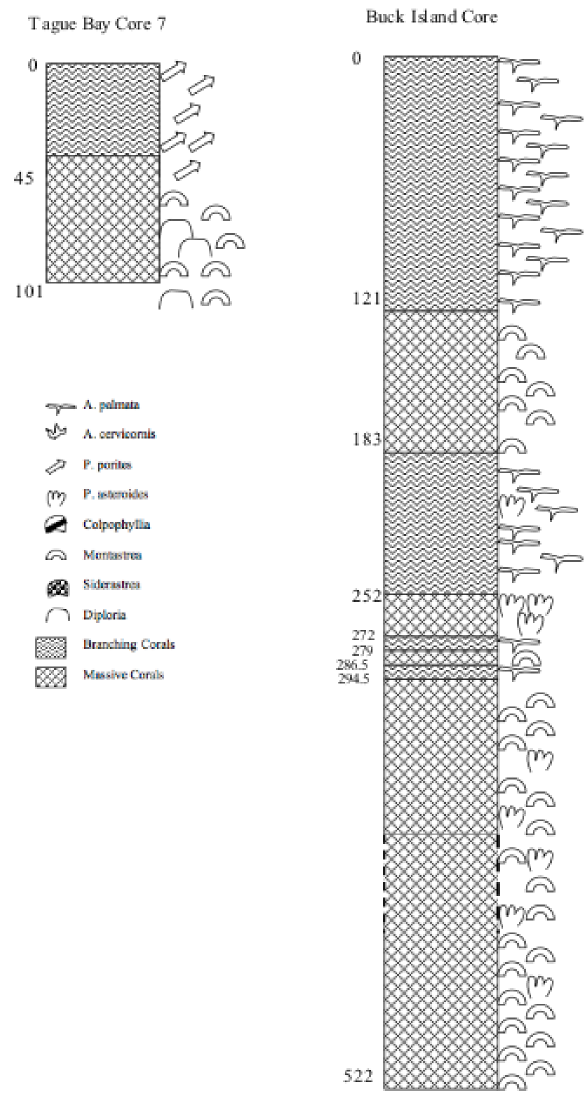

Figure 4. Representative core logs from Tague Bay and Buck Island reefs

(Fig. 3). The initial outbreak of White Band Disease was observed in 1976 with studies of St. Croix reefs indicating nearly half of the *A. palmata* being infected (Gladfelter, 1982). The outbreak of a host specific disease led to the Caribbean-wide mortality of *Diadema antillarum* in 1983, upsetting the natural balance of primary producers and grazing herbivores. More recently, bleaching has added to the problem.

Cores show that the internal structure of both reefs is comprised of sediment or voids within an overall coral framework of less than 30% coral (Burke et al., 1989; Hubbard et al, 2005). Coral abundance appears to have been greater at Buck Island than Tague

Bay (Table 2). This difference could reflect reduced coral-growth rates related to increased turbidity closer to the mainland (Burke et al., 1989). Another factor may be local wave regimes (Hubbard et al., 2005). It has been demonstrated with Carbon-14 dating that Tague Reef lagged behind Buck Island in reef development until 1,000 ybp (Hubbard et al., 2005).

The cores demonstrate natural changes in reef environments. The shift over time from massive to branching coral indicates the shallowing of the reef. *Montastraea* found near the base of the cores is known to grow in deeper water than *A. palmata* closer to the top. The rate of accretion is dependent on the productivity of the reef. If the reef demonstrates massive to branching corals, this indicates a "catch up" reef (Hubbard, 1997). This trend was found in Tague Bay core 7 and Buck Island core 7 and 5 (Fig. 4). This pattern also indicates that the reef was prograding seaward (Burke et al, 1989; Hubbard et al., 2005). The cores of Buck Island and Tague Bay are predominately mixed massive and branching (Hubbard et al., 2005; Burke et al., 1989).

The high amount of *A. palmata* present in the cores compared to the modern reefs may indicate that the current decrease in *A. palmata* is unusual. Alternatively, the high amount of *A. palmata* in the cores could be because *A. palmata* is well preserved in cores relative to other species. Other possibilities include different coral-growth rates: rapidly growing *A. palmata* and slower growing *Montastraea* annularis. Thus, equal abundance in the cores may not reflect equal coverage on the reef in the past (Hubbard et al., 1991). The low presence of *P. porites* within the Buck Island core is likely due to a lower potential for preservation and recovery in cores (Hubbard et al., 1991).

CONCLUSIONS

There are many factors to be considered when analyzing the "health" of a reef. Surveys conducted in 1976, prior to the outbreak of white band disease and Hurricane Hugo, indicate reefs with much greater abundance of *A. palmata* and *Montastraea* spp. relative to today's reefs (Hubbard et al., 2005). At present, the high amount of rubble documented in our transects, indicates that the reefs were once thriving, but now only remnants remain. In order for these reefs to survive a sea level rise due to global warming, an increase in framework building corals is necessary (Gardner et al., 2003).

The modern live coral cover at both Tague reef and Buck Island reef is low, due to both local and global stressors. Local stressors differ between Buck Island and Tague Bay (i.e., proximity to land and human populations). However, the greatest impact on both of the reefs studied was storm damage, as demonstrated by the much lower coral cover of Whaler's Cut and Buck Island East sites. Due to the location and the past storm history, these sites have been the most heavily impacted. Local stressors weaken corals and reduce coral's ability to regenerate and survive natural events (Hughes et al., 2003). The low percentage of live coral cover noted in all our transects is probably due to global stressors that cannot be controlled locally (Hughes et al., 2003).

The cores provides data on the development of the reefs over time. Both Tague Bay and Buck Island reefs were productive reefs as indicated by their upward shallowing and seaward progradation trends (Hubbard et al., 2005; Burke et al., 1989). The cores reflect a time when the reefs contained significant amounts of *A. palmata* and *Montastraea spp.,* and overall probably had a higher coral abundance compared to today's reefs. The absence or near absence of *A. palmata* on the modern reef and the reduction in *Montastrea spp.* is a cause for concern since they were important reef builders in the past.

Coral reefs are a resource that many coastal communities around the world rely on for survival. There are many instances of resource-use conflicts surrounding coral reefs through out the world (Hodgson, 1997). Through sustainable use that limits the negative effects, progress can be made, and the creation of parks and no take zones has proven to be a viable strategy for reef recovery (Pandolfi et al., 2005). The most successful marine parks are those that take into account terrestrial and aquatic ecosystems, the local inhabitants, and include enforceable regulations (Hodgson, 1997). Long-term funding and local and political supports are crucial for the survival and success of marine parks. However, Buck Island National Monument has been under the protection of the US government since 1961 and coral cover is also low, despite the protection. Continued success of the Marine Park will require continued funding to enforce regulations, and increased coastal management may reduce impacts, on these reefs. However, these local management schemes will have limited effectiveness on global stresses.

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