Population dynamics of *Acropora palmata* at Guana Island, British Virgin Islands

Erinn Muller

Florida Institute of Technology

Department of Biological Sciences

2010 Report

Introduction

Thirty years ago, *Acropora palmata* reefs helped define the shallow Caribbean seascape. With their complex branching morphology and large size (some reached several meters across), *Acropora palmata* colonies grew in dense, sometimes interlocking stands on reef crests and in the forereef zones of fringing and barrier reefs. In May 2006, this species was listed as threatened under the Endangered Species Act (71 Federal Register 26852). White band disease, first described by Gladfelter (1982) from the US Virgin Islands (USVI), is thought to have caused extensive losses of *A. palmata* in the late 1970s, 1980s and 1990s throughout the Caribbean region (Beets et al. 1986; Aronson and Precht 2001; Bruckner 2003). In the Virgin Islands, a series of tropical storms and hurricanes in 1979, 1984, and 1989 caused further declines of this important reef-building species. Now many shallow zones in the Virgin Islands have "standing dead" *A. palmata* colonies interspersed with piles of storm-generated rubble.

From 2000 to 2002, informal surveys around St. John and Buck Island Reef National Monument, off St. Croix, indicated that *A. palmata* coral was becoming more abundant at least on some reefs (Rogers et al. 2003). In 2003, a systematic study began to determine the factors (including disease and physical damage) that could influence the potential for *A. palmata* recovery on reefs around the USVI (Rogers 2005). To compliment these studies in the USVI, annual monitoring of *A. palmata* on two reefs along the shoreline of Guana Island, British Virgin Islands, was also established. Monitoring of *A. palmata* at Guana Island began in 2004 and has been conducted annually in August up to the present year, 2010 (except in 2009).

Additional stressors continue to limit the recovery of *A. palmata* in waters of the Virgin Islands, the most common being a disease called white pox (Muller et al. 2008, Rogers and Muller in prep). Predation from snails, fish, and firworms, as well as physical damage from large swells, bleaching from warm water temperatures, and sedimentation from runoff continues to impact colonies of *A. palmata* causing significant tissue loss and damage. The impact of these stressors on select reefs in the USVI has been quantified; however, the variability of each stressor among reefs throughout the Caribbean is presently unknown. The objective of the present study is to determine the impact of stressors on *Acropora palmata* within two sites around Guana Island:

White Bay Wall and Crab Cove. These surveys will also quantify the distribution of colonies within each site, colony density, and size-frequency distribution of the population of *A. palmata* around Guana Island.

Methods

Survey sites

Guana Island is a privately owned island that consists of 850 acres and is located within the British Virgin Islands. Fringing reefs surround most of the island while several fingers reefs extend from the shoreline in the more protected bay along the southern shore. Crab Cove is located on the western side of the island within Muskmelon Bay. This site was historically dominated by colonies of *Acropora palmata* (Figure 1 (A)) and is now dominated by exposed carbonate. The second site, White Bay Wall, is located along the western side of the southern tip of the island (Figure 1(B)). This site is not a well established reef, but instead consists of a vertical wall of volcanic rock exposed to the settlement of benthic organisms. Large colonies of *A. palmata* are located along the wall making this site an area of interest for monitoring purposes. This site is also used as a donor site for the collecting of *A. palmata* fragments to re-establish colonies within the finger reefs of nearby White Bay.

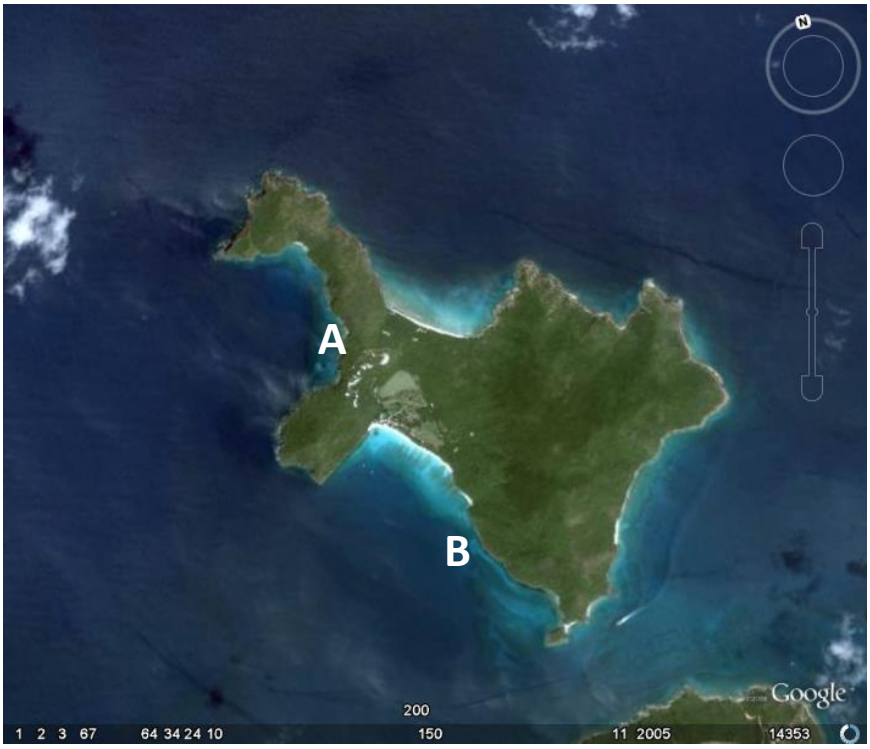

Figure 1. The study location, Guana Island in the British Virgin Islands. The two study sites are identified: (A) Crab Cove and (B) White Bay Wall.

Data collection

Crab Cove has been monitored annually in August since 2004 to 2010 and White Bay Wall has been monitored annually in August from 2006 to 2010. During each survey, every individual colony of *A. palmata* was given a waypoint (i.e., geo-referenced) using a hand-held global positioning survey unit in a waterproof bag. Data recorded included the size class of each colony (0 – 10 cm, 11 – 50 cm, 51 – 100 cm, or >100 cm). If recent mortality was present, the cause was identified as either i) predation by snails, fish, or fireworms, ii) physical damage, iii) disease or iv) unknown. Recent mortality was defined as recently exposed white skeleton devoid of any settling benthic organisms. The presence of ciliates within the area of recent mortality was also noted. The type of disease was further recorded as white band, white pox, or unknown disease. Every colony was photographed and linked to the geo-referenced waypoint for potential colony comparisons over time.

Results

Population Structure

Crab Cove

The size-frequency distribution of *A. palmata* colonies each year at Crab Cove showed that the most of the individual reside within the 11 to 50 cm size class (Figure 2). From 2004 to 2007 there was an increase in larger-sized individuals, likely a result of smaller-sized individuals growing over time. However, between 2007 and 2008 there was a substantial decline in the overall number of colonies (Figure 3). Density drops from approximately 0.052 colonies per m^2 to 0.035 colonies per m^2. Although the colonies were not monitored frequently enough to determine direct cause of death, in early 2008 large waves were observed hitting the northwest side of Guana Island. Colonies that were alive in 2008 were typically crusts with very few branches. The abnormally large swell likely caused significant fragmentation within the population at Crab Cove, resulting in a population that was more susceptible to tissue mortality from predation and disease, probably leading to an overall decline in colony density. Between 2008 and 2010 the only size class that increased in number was within the 51 and 100 cm range. Density, however, remained relatively stable within this time frame.

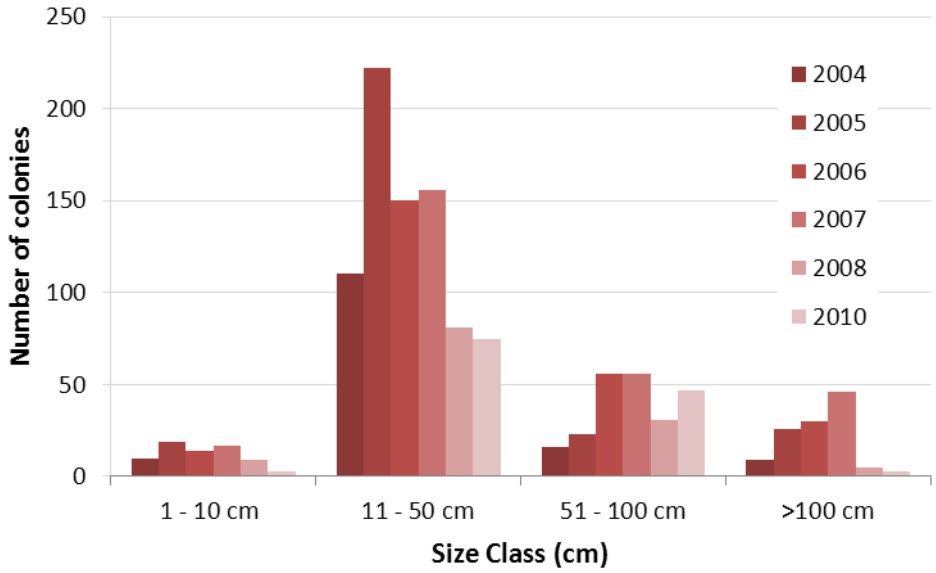

Figure 2. Size-frequency distribution of *Acropora palmata* colonies at Crab Cove, Guana Island from 2004 to 2010

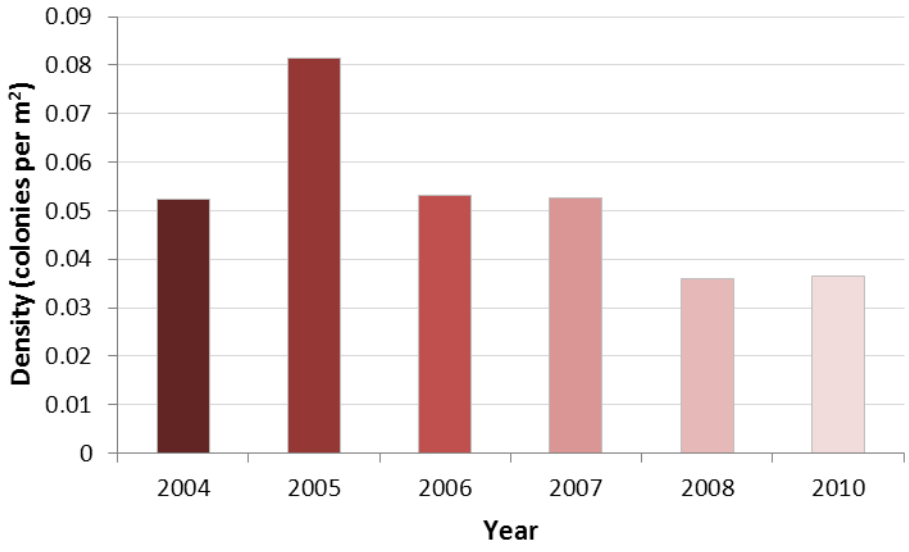

Figure 3. Density of *Acropora palmata* at Crab cove, Guana Island from 2005 to 2010.

White Bay Wall

The size-frequency distribution of colonies surveyed along the White Bay Wall showed a similar pattern to those in Crab Cove except more large-sized colonies were present (Figure 4). White Bay Wall is generally more protected than Crab Cove so larger individuals may be related to lower fragmentation rates at this location. Colony density values were also similar to Crab Cove (Figure 5) and followed a similar pattern. Density decreased from 2006 to 2008, while between 2008 and 2010 there was a slight increase in the population density. The increase in density appears to be a result of more colonies within two different size classes : (i)the 10 to 50 cm range, and (ii) the 51 to 100 cm range.

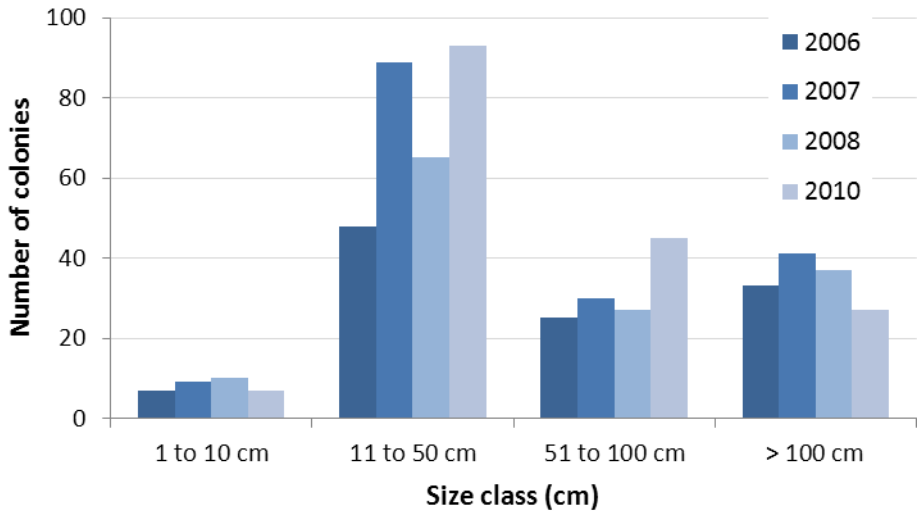

Figure 4. Size-frequency distribution of *Acropora palmata* colonies at White Bay Wall, Guana Island from 2004 to 2010.

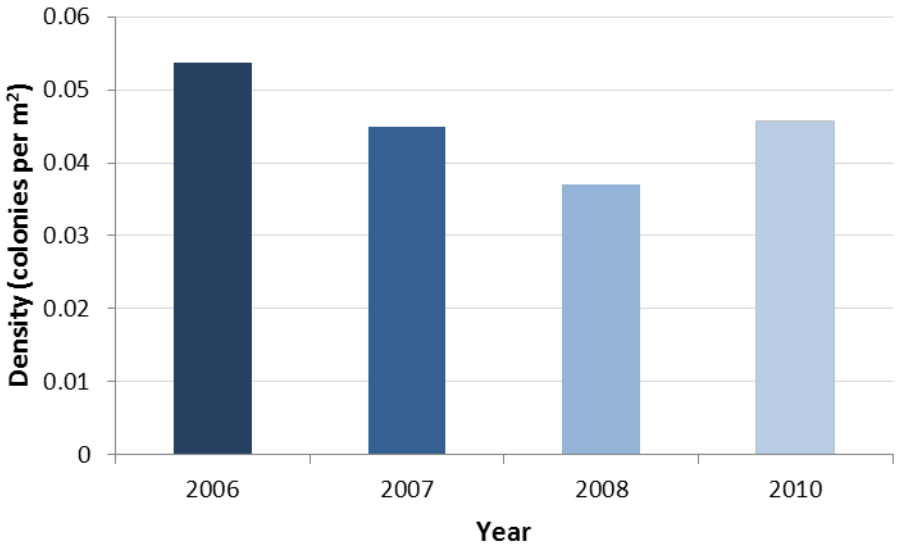

Figure 5. Density of *Acropora palmata* along White Bay Wall, Guana Island from 2004 to 2010.

Colony Survival at White Bay Wall

In 2010 an attempt was made to follow colonies along White Bay Wall over time. This was conducted by trying to match up photographs of colonies taken in 2008 with those taken in 2010. Some difficulty was found in matching up photos between years since angle and distance from colony differed. Also, since dead structure is not photographed the only way to confirm colony death is the lack of a photo in subsequent years. A total of 30 colonies identified in 2008 could not be found in 2010. Eight of these 'colonies' were fragments that were either moved by G. Forrester (see Discussion) or died. These data show that a potential 22 colonies may have been lost between these two years, which is equivalent to a 15.8% mortality rate between 2008 and 2010 (7.9% mortality rate per year). All of the colonies that were not found in 2010 were within the first two size classes, revealing that smaller colonies at White Bay Wall may be more vulnerable to complete colony mortality than larger ones. Additionally, a total of 21 colonies were identified in 2010 that were not photographed in 2008. An addition 28 fragments were identified, 14 of which clearly came from G. Forester's study. Therefore, although there was a potential loss of 22 colonies between time periods there was a gain of 21 colonies, making the total population stable between these two sampling periods.

Stressors

Predation, Ciliates, and Physical Damage

All stressors were observed at both sites throughout the study period, but the prevalence of each stressor differed. At Crab Cove fish and fireworm predation were frequently observed within the first several years; however the prevalence of these two stressors declined over time (Figure 5). On the other hand snail predation and ciliates became more common. At White Bay Wall every stressor became more common and all were most frequently observed in 2010 (Figure 6).

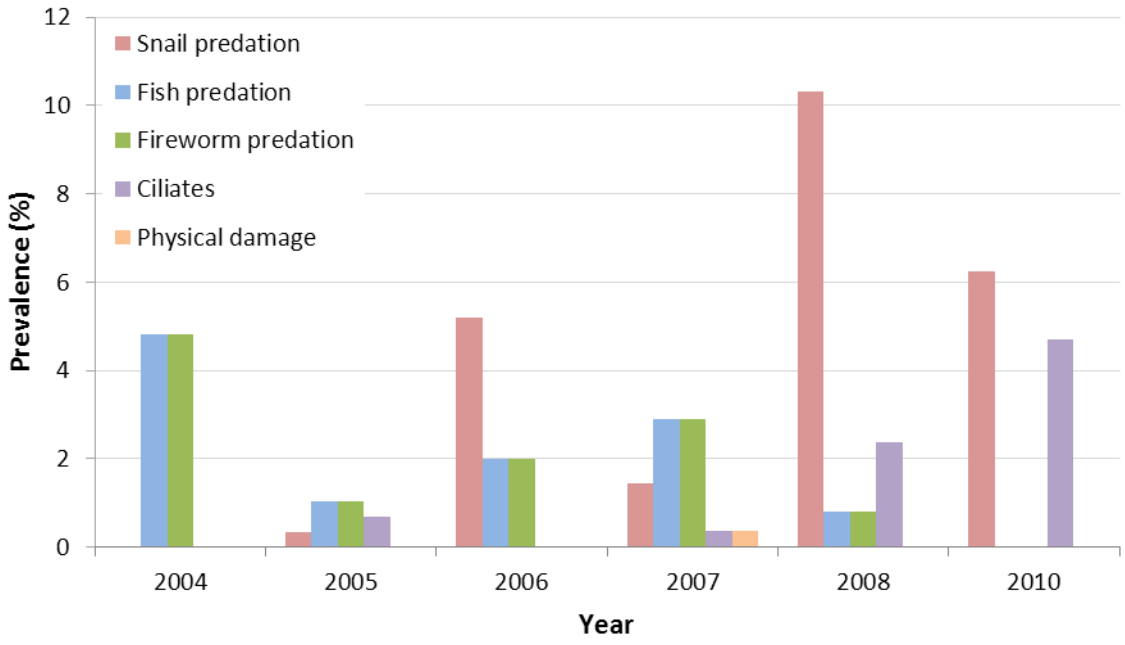

Figure 5. Prevalence of stressors causing recent mortality at Crab Cove from 2004 to 2010.

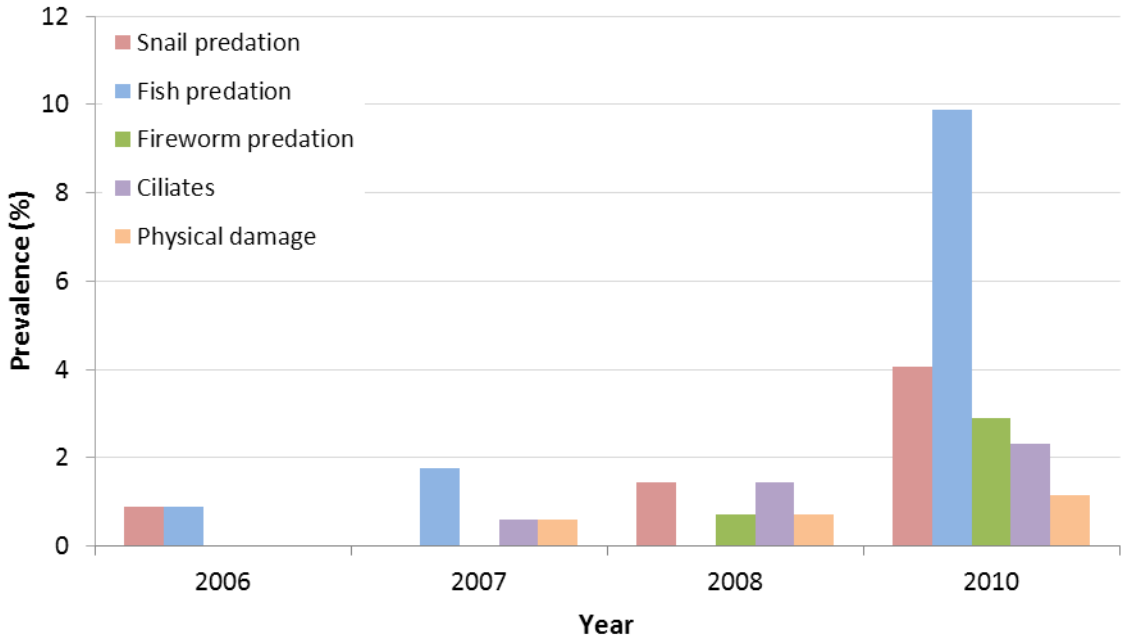

Figure 6. Prevalence of stressors causing recent mortality at White Bay Wall from 2006 to 2010.

Disease

Overall, disease was the greatest contributing factor to tissue loss observed at both sites over time. At Crab Cove, white-pox prevalence increased between 2004 and 2007, but declined significantly when the population declined in 2008 (Figure 7). White-band disease was observed only between 2006 and 2010 at Crab Cove, but remained at relatively low prevalence levels. White-pox prevalence also increased at White Bay Wall over time although at this site the increase was continuous (Figure 8). White band was also observed at White Bay Wall, but with low prevalence.

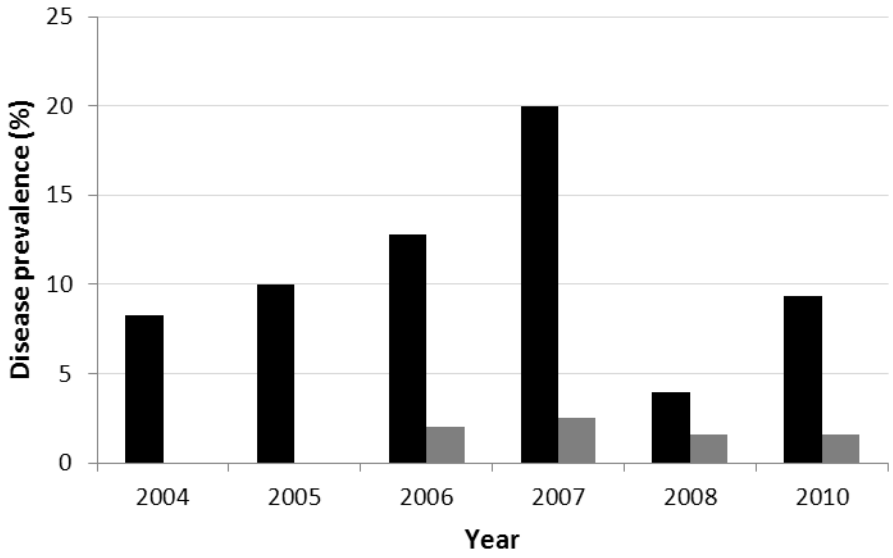

Figure 7. Prevalence of white-pox and white-band disease on *Acropora palmata* at Crab Cove, Guana Island from 2004 to 2010

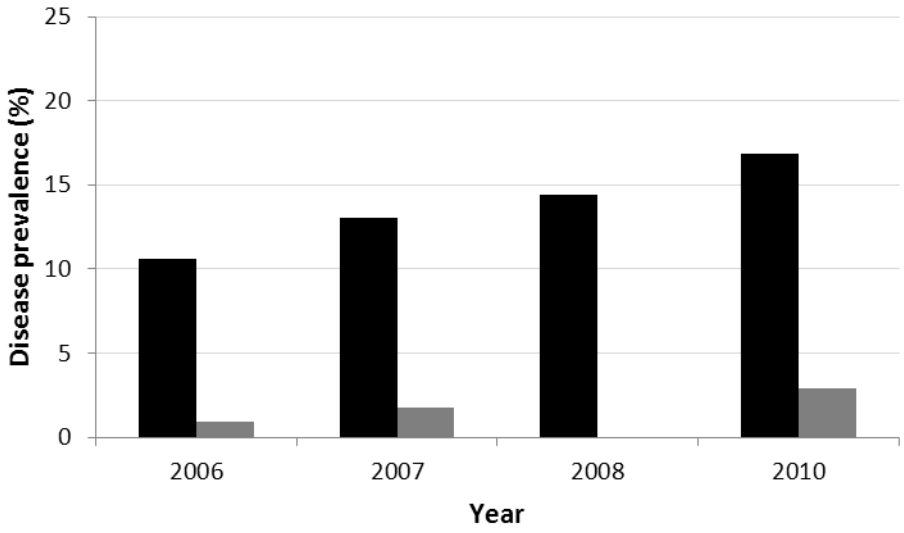

Figure 8. Prevalence of white-pox and white-band disease on *Acropora palmata* at White Bay Wall, Guana Island from 2006 to 2010

Discussion

The *Acropora palmata* populations at the two study sites appear to be fluctuating over time. The decline in the population at Crab Cove was likely a result of large swells in early 2008, which resulted in high rates of fragmentation and subsequent mortality. In 2010 the population remains relatively stable with some increases in one of the larger size classes. In the absence of further disturbances the population at Crab Cove may be able to show signs of recovery in the future.

Although White Bay Wall showed a decline in density for the first several years, between 2008 and 2010 there is some indication that the number of colonies is increasing. Even some colonies appear to be growing into the larger size classes. Additionally, following colonies through time shows that several colonies were lost between 2008 and 2010, but an equal amount of colonies were gains as well as additional fragments. These results are encouraging in spite of the increase in white-pox prevalence observed at this site over time. Population stability and potential growth of colonies suggests that *A. palmata* along White Bay Wall may have the ability to recover significantly from disease outbreaks. These results, however, may be somewhat biased. Dr. Graham Forrester from the University of Rhode Island has been taking fragments from this location as well as zip-tying naturally occurring fragments to the substrate to encourage reattachment and growth. Therefore, the success of this site may be from the additional maintenance provided by researchers rather than natural resilience. Further study and collaborative efforts between the present research and that of Dr. Forrester will also provide greater insight into the natural and artificial population growth within the White Bay Wall site.

As other studies have shown (Muller et al. 2008, Rogers and Muller (in prep)), white-pox disease has become a significant threat to *A. palmata* within the Virgin Islands. White pox was the greatest threat to the populations of *A. palmata* at both sites around Guana Island and was also the most frequent cause of tissue mortality. Further understanding of white-pox disease dynamics over space and time is essential for potential mitigation of future disease outbreaks. Although several other causes of mortality (stressors) were observed, tissue loss associated

with each cause was limited. The increase in ciliate activity over time, however, calls for further study of these organisms to determine whether they are causing mortality through predation or opportunistically feeding on diseased tissue.

Acropora palmata has declined precipitously over the last few decades and population growth is essential for the recovery of this species. The surveys conducted in Guana Island suggest that the population at the two study sites are fluctuating or remaining stable. There is some indication that *A. palmata* has the potential to recovery if given enough time between disturbance. White pox is the greatest threats to the colonies of *A. palmata* at Guana Island and further understanding how this disease impacts the populations are essential for the prevention of further outbreaks and a reduction of mortality through time.

Literature Cited

Acropora Biological Review Team. 2005. Atlantic /Acropora/ Status Review Document. Report to National Marine Fisheries Service, Southeast Regional Office. March 3, 2005. 152 p + App.

Aronson RB, Precht WF (2001) White-band disease and the changing face of Caribbean coral reefs. Hydrobiologia 460: 25-38

Beets J, Lewand L, Zullo E (1986) Marine community descriptions and maps of bays within the Virgin Islands National Park/Biosphere Reserve. Biosphere Reserve research report no. 2. VIRMC/NPS.: 118 pp

Bruckner, A.W. (editor). 2003. Proceedings of the Caribbean *Acropora* workshop: Potential application of the US Endangered Species Act as a Conservation Strategy. NOAA Tech. Memorandum NMFS-OPR 24. 199 pp

Gladfelter WB (1982) White-Band Disease in *Acropora palmata*: Implications for the Structure and Growth of Shallow Reefs. Bulletin of Marine Science 32: 639-643

Muller EM, Rogers CS, Spitzack AS, van Woesik R. 2008. Bleaching increases likelihood of disease on *Acropora palmata* (Lamarck) in Hawksnest Bay, St John, US Virgin Islands. Coral Reefs 27:191-195

Rogers, C. 2005. Will the major reef-building species *Acropora palmata* (elkhorn coral) recover in the US and British Virgin Islands? Proc. of the 5th Annual Gulf and Caribbean Fisheries Institute. British Virgin Islands (2003). 439-452

Rogers C, Gladfelter W, Hubbard D, Gladfelter E, Bythell J, Dunsmore R, Loomis C, Devine B, Hillis-Starr Z, Phillips B. 2003. *Acropora* in the US Virgin Islands: a wake or an awakening? Pages 99 – 122 in A.W. Bruckner (editor). Proceedings of the Caribbean *Acropora* workshop: Potential application of the US Endangered Species Act as a Conservation Strategy. NOAA Tech. Memorandum NMFS-OPR 24. 199 pp