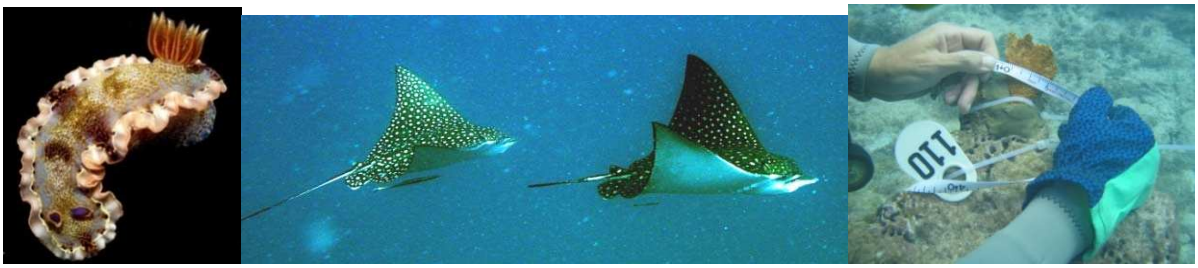

Marine Science Month Research Report

Guana Island

2006 - 2008

Prepared and Compiled by
Lianna Jarecki, PhD
H. Lavity Stoutt Community College, BVI

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Introduction

Restoring damaged coral reefs, tracking populations of fish, corals and sponges, monitoring the vital signs and pathogens of coral reefs, discovering new species—these are the works and passions of scientists participating in Marine Science Month (MSM) on Guana Island, British Virgin Islands. MSM is an annual marine research and education program funded by The Falconwood Foundation. Each year since 1992, a small group of university professors, professional scientists and students have come to Guana Island to investigate questions of marine ecology, hoping to find solutions to the rapid decline of coral reefs occurring world-wide.

To date, Guana's Marine Science Month program has produced 49 papers published in peer-reviewed journals, including notable titles such as PNAS, Ecology, Marine Ecology Progress Series, Limnology and Oceanography, Bulletin of Marine Science, Coral Reefs and others. MSM has helped graduate students complete their field research and move on to successful careers in marine biology. The program has also hosted local students of all ages, exposing them to a level of academic research that does not otherwise exist in the BVI.

Findings from the past three years of Marine Science Month research are highlighted in this summary. Six scientific teams participated in MSM during this period, and four of these teams returned each year to ensure continuity of their research. Newly published papers and correspondences that report data and findings from MSM investigations can be requested as PDF files by emailing ljarecki@hlscc.edu.vg.

Dr. Caitlin O'Connell-Rodwell transplanting a fragment of Elkhorn coral to the White Bay finger reefs.

New Publications from the MSM research teams

The following citations refer to recently published scientific papers based wholly or in part on data and collections acquired during the MSM program on Guana. PDF files of the published papers can be requested from ljarecki@hlscc.edu.vg. A complete list of MSM publications, which includes all those stemming from the MSM program since its inception in 1991, can also be requested from the same address. Papers in press will be available after publication.

Alejandrino A, Valdes A. 2006. Phylogeny and biogeography of the Atlantic and Eastern Pacific *Hypselodoris* Stimpson, 1855 (Nudibranchia, Chromodorididae) with the description of a new species from the Caribbean Sea. Journal of Molluscan Studies 72: 189-198.

Forrester GE, Finley RJ. 2006. Parasitism and a shortage of refuges jointly mediate the strength of density dependence in a reef fish. Ecology 87(5): 1110-1115.

Forrester GE, Steele MA, Samhouri JM, Vance RR. 2008. Settling larvae of a small coral-reef fish discriminate reef features at large, but not small, spatial scales. Limnology and Oceanography 53(5): 1956-1962.

Haney TA, Martin JW. 2004. A new genus and species of leptostracan (Crustacea: Malacostraca: Phyllocarida) from Guana Island, British Virgin Islands, and a review of leptostracan genera. Journal of Natural History 2003: 1-23.

Heard, R. W., J. W. Martin, T. J. Hansknecht, and D. B. Cadien. 2006. New records for *Cubanocuma gutzi* Băcescu and Muradian, 1977 (Crustacea: Cumacea: Nanastacidae) from the western Atlantic. Gulf and Caribbean Research 18: 47-51.

Jarecki, L, Burton-MacLeod SM, Garbary DJ. 2006. Ecology of algal mats from hypersaline ponds in the British Virgin Islands. Algae 21(2): 1-10.

Jarecki L, Walkey M. 2006. Variable hydrology and salinity of salt ponds in the British Virgin Islands. Saline Systems 2:2.

Martin, J. W., and T. L. Zimmerman. 2007. Color variation in the Caribbean crab *Platypodiella spectabilis* (Herbst, 1794) (Decapoda, Brachyura, Xanthidae). Gulf and Caribbean Research 19: 59-63.

Sikkel PC, Nemeth D, McCammon A, Williams EH Jr. in press 2009. Habitat and species differences in prevalence and intensity of *Neobenedenia melleni* (Monogenea: Capsalidae) on sympatric Caribbean Surgeonfishes (Acanthuridae). Journal of Parasitology 97(7): ---.

Martin, J. W. In press. Cephalocarida and Mystacocarida of the Gulf of Mexico. In: D. L. Felder (editor), Volume III -- Gulf of Mexico: Biota. Texas A & M University Press. (submitted December, 2004).

Martin, J. W., and T. A. Haney. In press. Leptostraca of the Gulf of Mexico. In: D. L. Felder (editor), Volume III -- Gulf of Mexico: Biota. Texas A & M University Press. (submitted February, 2005)

Martin, J. W., K. Wishner, and J. R. Graff. 2005. Caridean and sergestid shrimp from the Kick'em Jenny submarine volcano, southeastern Caribbean Sea. Crustaceana 78(2): 215-221.

Muller E, van Woesik R. *in press*. Shading reduces coral-disease progression. Coral Reefs.

McLaughlin, P. A., D. K. Camp, L. G. Eldredge, D. L. Felder, J. W. Goy, H. H. Hobbs III, B. Kensley, R. Lemaitre, and J. W. Martin. 2005. Order Decapoda. In: Crustaceans. D. Turgeon, editor, Common and Scientific Names of Aquatic Invertebrates from the United States and Canada. American Fisheries Society Special Publication 31: 1-545.

Paddack MJ, Reynolds JD, Aguilar C, Appeldoorn RS, Beets J, Burkett EW, Chittaro PM, Clarke K, Esteves R, Fonseca A, Forrester GE, Friedlander AM, García-Sais J, González-Sansón G, Jordan LKB, McClellan DB, Miller MW, Molloy PP, Mumby PJ, Nagelkerken I, Nemeth M, Navas-Camacho R, Pitt J, Polunin NVC, Reyes-Nivia MC, Robertson DR, Rodríguez-Ramírez A, Salas E, Smith SR, Spieler RE, Steele MA, Williams ID, Wormald CL, Watkinson AR, Côté IM. 2009. Recent region-wide declines in Caribbean reef fish abundance. Current Biology 19: 1-6.

Wishner, K. F., J. R. Graff, J. W. Martin, S. Carey, H. Sigurdsson, and B. A. Seibel. 2005. Are midwater shrimp trapped in the craters of submarine volcanoes by hydrothermal venting? Deep-Sea Research I, 52: 1528-1535.

Coral reef restoration

Dr. Graham Forrester, University of Rhode Island, Rhode Island

Dr. Caitlin O'Connell and *Dr. Timothy Rodwell*, Stanford University, California

Dr. Lianna Jarecki, H. Lavity Stoutt Community College, BVI

This team initiated a project in 2005 to restore coral life on the shallow finger-reefs of White Bay. These reefs had died gradually between the 1980s and 90's as an epidemic of white band disease and later white pox disease swept through the Caribbean, destroying approximately 80% of known Caribbean Elkhorn coral (*Acropora palmata*) populations. Prior to this epidemic, growth of Elkhorn coral's massive skeleton formed nearly all shallow coral reefs in the Caribbean. In response to its rapid demise, Elkhorn coral was added to the U.S. list of endangered species in 2006. It continues to be threatened by emerging diseases, marine pollution and physical damage from anchors, boat groundings and storms.

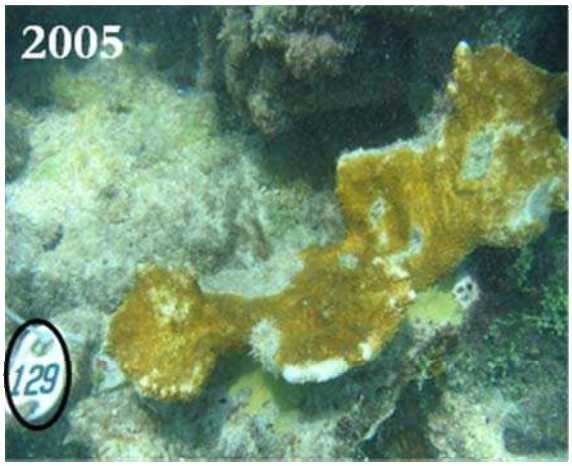
An initial biological survey in 2005 showed that Guana's finger reefs consisted of the remaining dead skeletons of large Elkhorn corals. Only 10% of the reef in 2005 was covered by living coral, and 50% of this was fire coral (a thin, brittle-skeletoned colonial hydroid carrying a painful sting). Less than 1% of the finger-reef coral was Elkhorn coral, the original reef-builder. In fact, there were no living Elkhorn corals on the three finger reefs closest to the White Bay beach house. This survey showed that Elkhorn has not returned to Guana's finger reefs, though established colonies were present along the rock walls to the east and west of White Bay. Elkhorn coral reproduces primarily by asexual fragmentation of branches that reattach to the substrate rather than by producing planktonic embryos. Recovery of a population of Elkhorn coral is therefore greatly enhanced by the presence of at least a few large, established colonies, which are missing from the White Bay finger reefs.

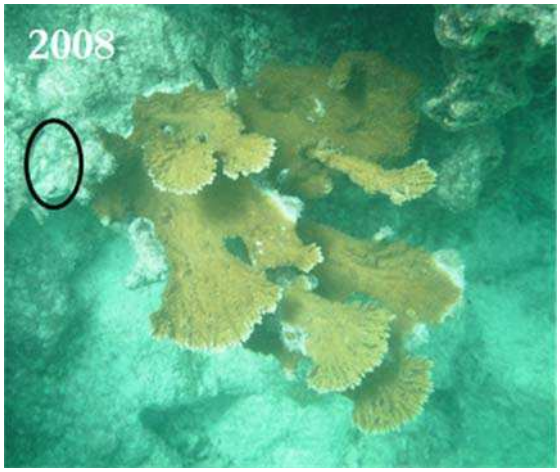
This research team began a project to restore the corals of White Bay's finger-reefs in 2005 by relocating 35 Elkhorn coral fragments found lying loose on sand bottom on the south side of Guana. Nine additional fragments were planted in 2006. The fragments were fixed with underwater epoxy to the old, dead finger reef structures. Surveys in 2006 and 2007 showed that 80% of the transplanted corals survived their first year. Second year-survival of the 2005 transplants was 100%, and on average transplanted corals grew 15cm per year, which is on par with published growth rates for this species under optimal natural conditions.

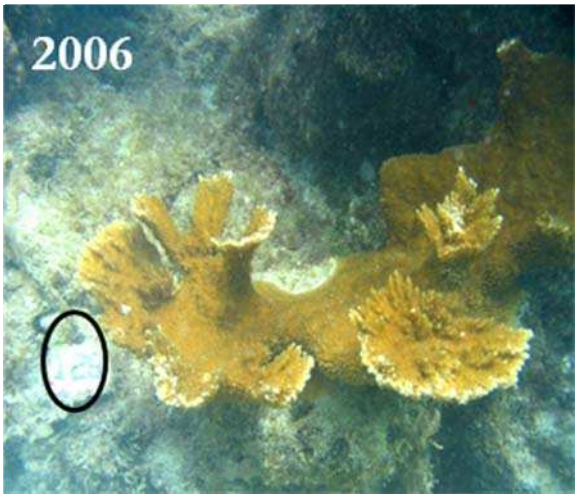
Coral restoration work was stepped up in 2007 and 2008, when Dr. Forrester brought a team of students to Guana for this purpose. They planted an additional 176 coral fragments in the past two years. Dr. Forrester and his students designed this work such that they could measure the success of the different transplant methods and compare growth of transplants with naturally-established coral colonies (outside of the finger reefs). They found that transplanted corals grew more slowly than naturally-established coral colonies, but that the transplant location did not impact rate of growth. They also found no difference in growth rates between groups of

transplants that were attached with different methods, including underwater epoxy, hydraulic cement, and cable ties.

2008 was an unfortunate year for the transplanted corals and for shallow reefs in general. A record ground sea hit the BVI in March of 2008. People on Guana at the time described enormous waves in White Bay that broke up parts of Guana's main dock and scoured much of the sand off of White Bay beach. Approximately 50% of the replanted corals died as a result, and many fragments and their tags were found washed up on the beach. However, those corals that withstood the wave forces, remaining attached and intact, appeared healthy and showed continued growth when surveyed in August 08 (see figures below). Interestingly, Muller's research team, engaged in tracking growth of naturally-established Elkhorn corals in Muskmelon Bay, also reported a death toll of 50% after the storm swell. Comparing these independent results suggests that the Guana's transplanted corals fared as well as nearby natural populations during the destructive forces of high ground seas. These findings lend support for the value of coral restoration projects in general.







Growth of Elkhorn coral fragment number 129, which was first planted on the east side of the 3rd finger reef in 2005. This fragment survived a large-scale coral bleaching event that occurred later in 2005 and also survived the record ground swell in March 2008.

(cm)	2005	2006	2008
Length	40	45	52
width	22	28	47
height	15	15	29

Elkhorn coral population monitoring

Erinn Muller, PhD candidate, Florida Institute of Technology

Dr. Caroline Rogers, U.S. Geological Survey, St. John, USVI

Elkhorn coral, *Acropora palmata*, is the major shallow-water reef-building coral in the Caribbean. Elkhorn reefs are present in the geological record for the past 200,000 years. Their reef-building capabilities can exceed the rate of sea-level rise and thus create fringing reefs, protected bays, and enclosed lagoons. In the past 30 years, however, the majority of Elkhorn coral populations throughout the Caribbean have succumbed to disease epidemics. Around Guana, large areas of dead Elkhorn reefs exist in White Bay and Muskmelon Bay. The dead skeletons of the Elkhorn coral still stand in upright position, indicating that they were killed by disease rather than physical damage such as from storms.

Erinn Muller and Caroline Rogers have monitored existing Elkhorn coral populations in Crab Cove and along the western rock wall of White Bay since 2004. They tracked coral density, growth, disease, physical damage and predation on each of several hundred Elkhorn corals that create a combined reef area of approximately 8,000 square meters. After determining that the major coral bleaching event of 2005 (see last MSM report) had little impact on Guana's Elkhorn populations, this team documented an increase in the total number of Elkhorn colonies at the monitored sites over the successive two years. They showed that 6 to 10% of Elkhorn corals at these sites were affected by White Pox and White Band disease. This measured rate of infection is lower than that recorded at shallow reef sites in the U.S. Virgin Islands, but that the incidence of White Pox disease has increased each year, according to data gathered by this team. Muller and Rogers also showed that predation on Elkhorn corals, especially by coral-eating snails, fireworms and damselfish, is relatively low on Guana. Their results showed that the Elkhorn coral populations around Guana were stable and perhaps increasing up until 2008.

A historically large ground swell came through the Virgin Islands in March 2008, producing wave heights of 20 to 30 feet. When this team returned to Guana in August, they found only 50% of the previous years' population remaining (see figure below). Many individuals had been so cleanly broken apart that no evidence of their original form remained. Erinn Muller intends to continue tracking the remaining corals in future years, which will show us in the future if and how Guana's shallow reefs recover from this damage.

A highly destructive ground swell in March 08 killed 50% of the Elkhorn populations on the south and west sides of Guana. These photos show:

Left: an Elkhorn coral colony in Crab Cove photographed in August 2007;

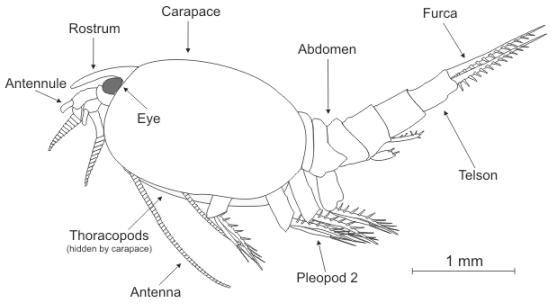
Right: the same colony photographed in August 2008.

In 2007, Erinn began her PhD studies at the Florida Institute of Technology, intending to contribute to a growing body of evidence showing corals become more susceptible to disease as their health is compromised by changing environmental conditions . As part of her doctoral research, she proposed a study of the relationship between intensity of solar radiation and the prevalence of disease in Elkhorn coral. She implemented her study during MSM of 08, in Muskmelon Bay, using a large species of brain coral (*Colpophyllia natans*) infected by White Plague disease as her study organisms. White Plague disease is currently epidemic throughout the Caribbean and affects 33 species of hard corals.

Marine Invertebrate diversity and taxonomy

Dr. Todd Haney, Sage Hill School, CA

Dr. Chris Irwin, University of California Los Angeles

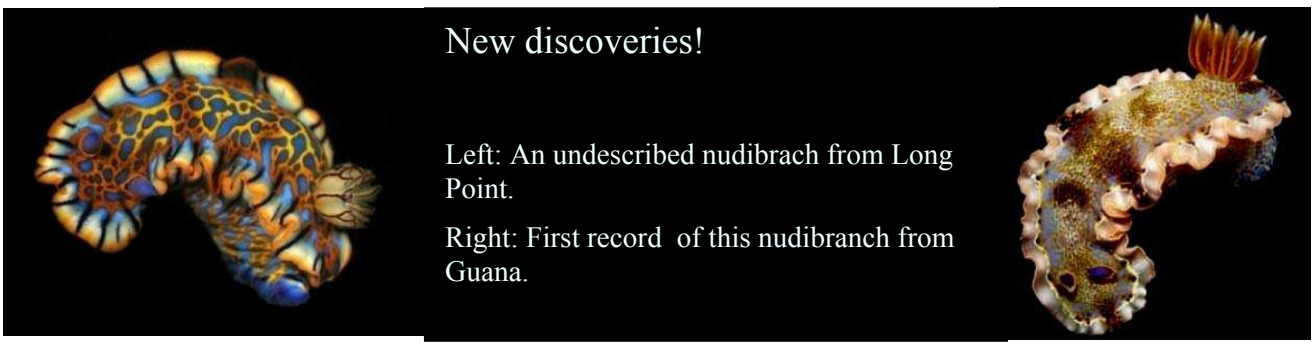


This team's work in 2008 was aimed at following up research by the Los Angeles County Museum of Natural History (LACMNH) from 1999 to 2001 on Guana. One of their specific goals was to collect additional samples of a thin-shelled shrimp that was discovered by the LACMNH team in 2001. This shrimp was described as belonging to both a new genus and species. The species was named for Guana (*Saronebalia guanensis*), having never been previously recorded in the scientific literature (Haney & Martin 2004). Dr. Haney is planning to assess the relationship between this genus and its closest relative, *Paranebalia*, by applying molecular genetic analyses with the specimens he collected during MSM 08.

Another goal of this research team was to collect additional specimens of a new but as-yet undescribed species of *Paranebalia*. The specimens collected will be used to publish a formal scientific description of this new species. The team also collected additional species of a small skeleton shrimp in order to describe the female characteristics of this species, which have never been adequately illustrated since the naming of this species in 1968.

In addition to achieving their stated goals, this team discovered two additional species of skeleton shrimp. They also amassed evidence that some hydroid-associated crustaceans are highly specific to the species of hydroid on which they live—an indication that these crustaceans and their hydroid hosts have a long and tightly-linked history of co-evolution.

A most pleasant reward of this team's work was the discovery of three species of nudibranchs that have not previously been reported from Guana. One of these is new to science and will be sent to an opistobranch expert for formal description.



Coral disease survey

Longin Kaczmarsky, PhD candidate, Florida International University

Dr. Mathew Draud, Long Island University

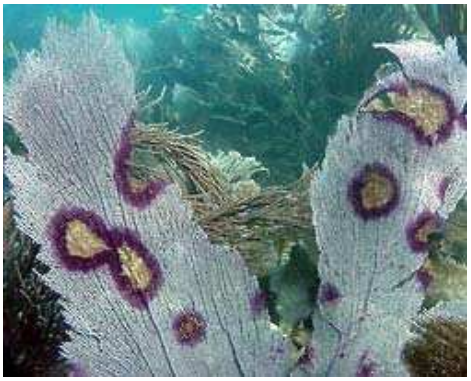


Photo right: Sea fan with aspergillosis infection (photo by E. Weil, from Cornell Chronicle Online, Feb 20, 2007)

This team assessed the prevalence of known diseases infecting corals around Guana and other sites in the Virgin Islands. They first surveyed Guana's reefs in 2004, and in 2008 they expanded their surveys to an additional eight sites at depths between 1m and 15m. Using a belt-transect methods, they visually assessed more than 21,000 coral colonies over 1,380m^2 and found infections of 12 different coral diseases and syndromes. The team found significantly lower rate of coral disease on Guana's reefs in 2008 than they recorded in 2004. However, they noted that the overall abundance of corals has declined, and their results have not been corrected for relative coral abundance

The most common disease they found was aspergillosis, caused by an infection of soil fungus in sea fans and soft corals. Of the hard corals (scleractinians), Elkhorn coral (*Acropora palmata*) was most affected by disease, especially white pox disease.

Mr. Kaczmarsky took water samples from Guana's reefs back to Florida for nutrient testing. The laboratory analyses showed that Guana's waters, for the most part, were clean and had normal, low nutrient concentrations. Only Bigelow Bay showed elevated nutrient concentrations, which may be coming from up-current pollution sources like sewage runoff from Scrub Island and Beef Island. The results also showed that White Bay had a higher concentration of total organic carbon than other sites around Guana. The latter may be linked to the prevalence of silt-laden suspended mucus (coral snot) that we often observe while diving at the White Bay study sites.

Interactions between ectoparasites, their fish hosts and cleaner organisms on coral reefs

Dr. Paul Sikkel, Center College, KY

Whitney Sears, student at Center College

In 2008, Sikkel's team expanded their ongoing studies of parasitic flatworms (monogeans) on Blue Tang and Surgeonfish to include other parasites on the reef. They studied the behaviour of gnathid isopod parasites, including the sensory mechanisms that help these parasites locate their fish hosts, the activity of the parasites at different times of day, and whether shelter under the reef affects the risk of parasite infection on the fish. In continuing their original work looking at the rate of monogean infection of Blue Tang, they now included a survey of cleaner shrimps to determine which species may be effective at controlling these infections. Their work on Guana complements studies that the team conducts on St. John. National Geographic took an interest in the application of Dr. Sikkel's work to climate change and produced a feature episode on National Geographic's Wild Chronicles. Information about this episode can be accessed via the web at:

http://news.nationalgeographic.com/news/2008/12/081219-fish-missions-video-wc.html

Microbial symbionts of corals

Dr. Kim B. Ritchie, Mote Marine Laboratory, Sarasota, Florida.

Dr. Ritchie visited Guana for only a few days during MSM of 2006, but she was building on her groundbreaking work of the previous year in which she showed that some microbes residing in coral mucus have a mutually beneficial relationship with their host corals. The corals provide a carbohydrate-rich slime (mucus)for the microbes and the microbes produce infection-fighting antibiotics that help corals resist infection from other, pathogenic microbes (*Ritchie KB. Regulation of microbial populations by coral surface mucus and mucus-associated bacteria. Mar Ecol Prog Ser 322:1-14*). This groundbreaking work made the cover of Science News (feature article "Slime Dwellers", June 2nd 2007).

Dr. Ritchie's goal on Guana was to collect mucus from the surface of Guana's Elkhorn corals. She returned with these samples to her laboratory, where she isolated and identified and diversity of microbes residing within the coral mucus. Her work on Guana was part of a much larger study in the Florida Keys, where Dr Ritchie investigated the role of coral mucus and its accompanying microbial flora in the lives and health of corals.

Long-term monitoring of reef communities

Dr. Graham Forrester, University of Rhode Island
Dr. Lianna Jarecki, H. Lavity Stoutt Community College, BVI
Elizabeth Kintzing, University of New Hampshire
Linda Forrester, University of Rhode Island

This team has assessed eight coral reef sites at 30m depth around Guana every year since 1992. The team has produced one of the largest and longest-term data sets showing the changing conditions of coral reef communities in the Caribbean, and it has recorded these conditions through a period of major global reef declines attributed to climate change and other anthropogenic impacts. The study is highly detailed in that it includes identification of all observed species of fish, corals and sponges, as well as quantification of live cover and algal cover. Although the full data set is yet to be published, the data on fish populations have been incorporated into a large-scale study showing a recent decline in reef fish abundance over the entire Caribbean region (Paddack et al. Current Biology 2009). In 2009, the team intends to analyse the full data set and describe long term trends and relationships between corals, sponges and fish populations on Guana's reefs.

Population assessment of Caribbean whelks

Dr. Graham Forrester, University of Rhode Island

Linda Forrester, University of Rhode Island

Katherine & Fiona Forrester

Dr. Tom Good, National Marine Fisheries Science Center, Seattle

Whelks (West Indian Topshells) are large intertidal snails that are considered a delicacy throughout the Caribbean. Recently, the price of whelk meat has transcended the price of more well-known seafoods such as lobster, conch and fish. This research team counts and measures whelks around Guana. It is hypothesized that the greater the fishing pressure, the fewer large whelks will occur, since larger whelks are preferentially taken.

The team monitors 6 sites around Guana every year. When opportunities arise, the team conducts their surveys elsewhere in the BVI in order to compare size distributions of other whelk populations with Guana's. This research may contribute important information that can guide government planning for conservation of the BVI's valuable whelk fishery.

Rebecca Karis

Experimental fish ecology

Dr. Graham Forrester, University of Rhode Island

Dr. Forrester's student assistants:

Lindsay Harmon

Jason Helyer

William Holden

Dr. Forrester has conducted long-term experimental studies aimed at determining what factors control the size of fish populations. His work focuses on gobies, a small bottom-dwelling fish that is common on sand and rubble bottoms like that of White Bay. Dr. Forrester tags individual gobies and tracks their growth, longevity, parasite loads, and reproduction. He has been able to manipulate habitat quality and availability by building new rubble reefs over sand bottom and by providing special nesting containers for mating gobies.

Through Dr. Forrester's and his students' work, we have learned a great deal about the effects of available habitat space, parasite loads, and predator abundance on fish populations. His work has contributed to studies that show how fishes choose which reefs to occupy at the end of their planktonic larval stage. Dr. Forrester's most recent experiments on Guana tested the effects of crowding on reproduction in both male and female gobies. Much of Dr. Forrester's research contributes on a larger scale to our understanding fish ecology, which and can be used in the development of effective methods to conserve fisheries resources.

Outreach and Education

Guana's MSM program hosted groups from Tortola's Youth Empowerment Project and The BVI's Environmental Camp. The groups each numbered around 20 youths accompanied by several adults. They were given presentations of the work of the scientists and the natural history of Guana Island. Afterwards, they were taken on a walking tour of the salt pond, the sugar mill ruins, North Beach and White Bay. Each participant was given a worksheet to reinforce learning objectives. The participants brought lunch, which they ate under a tent near the beach, and Guana provided drinks. After lunch, the participants spent an hour enjoying the beach before Guana's boats returned them to Tortola.

Reporters from the BVI Beacon were also invited to visit the MSM program, and the resulting news articles are available in PDF format by request from ljarecki@hlscc.edu.vg.