

CONSERVATION RESEARCH EDUCATION

Marine Science Month Program Report

Guana Island

2009 – 2011

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Guana Island

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ACKNOWLEDGEMENTS

The participating scientists wish to acknowledge the The Falconwood Foundation for its generous support of Marine Science Month. We are indebted to Henry and Gloria Jarecki, the extended Jarecki family, and the excellent management and staff of Guana Island for their continued support and enthusiasm for studying, enhancing and sharing Guana Island's matchless natural environment. We also acknowledge Dive BVI for providing, free of charge, our scuba tank fills, extra tanks when we needed them, and for their interest in our program.

I. INTRODUCTION

A. MSM Program Overview

Guana Island's Marine Science Month (MSM) is an annual gathering of scientists working to understand the intricate web of life in and around coral reefs. Initiated in 1992 and funded by The Falconwood Foundation, New York, the program's ultimate goal is to contribute knowledge that will improve environmental conditions for the many forms of life we depend on for food, recreation and protection of coastal land. Its focus is scientific research, and it includes strong educational and community outreach components.

The need for greater understanding of coral reef ecology has grown urgent with recent epidemic disease events, poor recovery rates, and reduced reef fish populations. Guana's marine scientists are engaged in restoring damaged coral reefs, understanding the lives and impacts of fish parasites, monitoring the vital signs and pathogens of corals, mapping ecosystems, discovering new species, and documenting the impacts of fishing on vulnerable animals such as the West Indian Topshell (whelk). Their results are published in peer-reviewed journals, including notable titles such as the Proceedings of the National Academy of Science (PNAS), Nature, Ecology, Marine Ecology Progress Series, Limnology and Oceanography, Bulletin of Marine Science, Coral Reefs and others. To date, Guana's MSM program has produced 77 published papers.

Education and community outreach are an important component of Guana's MSM research program. MSM program director Dr. Lianna Jarecki works with youth groups, educational institutions and government offices in the BVI to ensure that research on Guana reaches beyond the select scientific community to the local people whose lives are part of the BVI's ecology. Guana's scientists regularly receive local youth groups, present public lectures, and offer workshops and hands-on science activities to promote a better understanding of their studies and research findings. BVIslanders are actively recruited to ensure strong local participation in community outreach and educational programs on Guana.

The MSM program hosts BVI students of all ages, exposing them to a level of academic research that does not otherwise exist in their home country. It has helps international university and graduate students to complete their field research and move on to successful careers in marine biology.

Guana's Marine Science Month (MSM) activities and findings are reported bi-annually. The following report (2009-2011) provides overviews of each research team's activities since the previous report (2006-2008) and highlights new findings. The full MSM report also includes copies of the cited publications so that research findings from Guana are easily available to environmental managers and educators in the British Virgin Islands, where the data will be used to support regulatory decisions to manage the BVI's natural resources.

B. Scientific Contributions

Six scientific teams participated in MSM between 2009 and 2011, and four of these teams returned each year to ensure continuity of their research. Twenty-eight new papers have been published, each reporting on the findings of previous years' work.

Ecological studies account for most of scientists' field time on Guana. New ecological papers from Guana include Dr. Forrester's grand collaborative analysis of fish abundance throughout the Caribbean, which provides solid evidence of the region-wide decline in reef fish populations. In another study, Dr. Forrester collaborated with social scientists to produce a highly regarded scientific paper (Pollnac et al. 2010 in PNAS) describing the social and ecological criteria that make marine reserves effective throughout the Caribbean. Guana's MSM program provided the support needed to include the BVI in this analysis, which increased the value and applicability of the findings for the BVI government's marine management efforts.

Dr. Forrester, in collaboration with several other Guana scientists published the results of our coral restoration project in White Bay. This paper compared methods for "planting" corals and showed that stabilizing loose coral fragments by attaching them to a solid structure increases their chance of survival by about 75%.

Dr. Sikkel's team has published two papers describing their study of a particularly abundant fish parasite. These papers report differences in vulnerability to parasites depending on the quality of a reef fish's habitat, and they describe the parasite's nocturnal activity patterns the means by which the parasite finds its host fish.

Collections of tiny marine invertebrates made by the Los Angeles County Museum in 1999 and 2000 continue to contribute to our understanding of global biodiversity. A tiny shrimp, previously unknown to science, has been named after Guana Island (*Pseudoalpheopsis guana* Anker 2007). Several other new papers describe little-known polychaete worms and crustaceans from Guana, while other papers provide great overviews of evolutionary relationships between marine invertebrates. The latter includes contributions such as the Decapod Tree of Life (Bracken et al. 2009) and Arthropod relationships (Regier 2010 in Nature), with Guana's specimens providing a small part of the great global mass of the data compared.

C. Educational Contributions

The annual Jarecki kids "Science Week", normally run by the October terrestrial scientific group, was hosted in 2010 by the MSM program. Three local students, selected by the BVI government's Ministry of Education, were invited to participate. Science Week was a great success, enjoyed by the participants as well as by the scientists. In addition, the MSM scientists presented a "Reef Replanting Workshop" on Guana for the Tortola community of scuba divers and marine enthusiast, they hosted visiting local youth groups; and they presented lectures on

Tortola about research findings on Guana. During MSM 2009, a scientific internship was provided to Che Frederick a young member of the Carib Peoples Reservation in Dominica.

II. Research and Conservation Project Summaries

A. Long-term Reef Monitoring and the Rise of Lionfish

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

Photo left shows a typical Guana reef in the early 1990's; Photo right shows a typical Guana reef in 2011. Note the transect tape laid used for monitoring in photo left.

This team has produced one of the largest, most comprehensive and longest-term coral reef monitoring data sets in the Caribbean. Eight coral reef sites at 30m depth around Guana have been assessed every year since 1992. All observed species of fish, corals and sponges are identified, and live coral cover and algal cover are quantified. The research team has recorded the changing conditions of coral reef communities through a period of major global reef decline attributed to climate change and other anthropogenic impacts. 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 2010, a more specific project on the effects of changes in coral communities on fish populations focused on the Three-Spot Damselfish, *Stegastes planifrons*, a common and ecologically important species on Caribbean reefs. Like many species, Three-Spot Damselfish associate with certain species of live coral. These coral species have all declined to varying degrees on the Guana monitoring sites. This study seeks to determine whether declining fish populations can be explained as the cumulative effect of losing different usable habitat types (coral species). Dr. Forrester hypothesizes that as preferred coral species decline, fish can

compensate to some degree by switching to occupy less-preferred corals, but once all usable coral species become rare the fish populations will crash.

Reef surveys in 2011 showed that Lionfish have fully established themselves around Guana. Lionfish are related to Scorpionfish and are native to the Indo-Pacific region. They were accidently introduced to the Caribbean from the tropical Pacific years ago, and they have spread from the east coast of the US throughout the Caribbean to Trinidad. Densities of five Lionfish per square meter have been reported from reefs closer to Florida, such as the Keys and the Bahamas.

Lionfish eat small fish, including the juvenile stages of many reef fish. It is generally feared that their success in the Caribbean will reduce the number and diversity of native reef fish, exacerbating the existing crisis caused by overfishing and habitat loss.

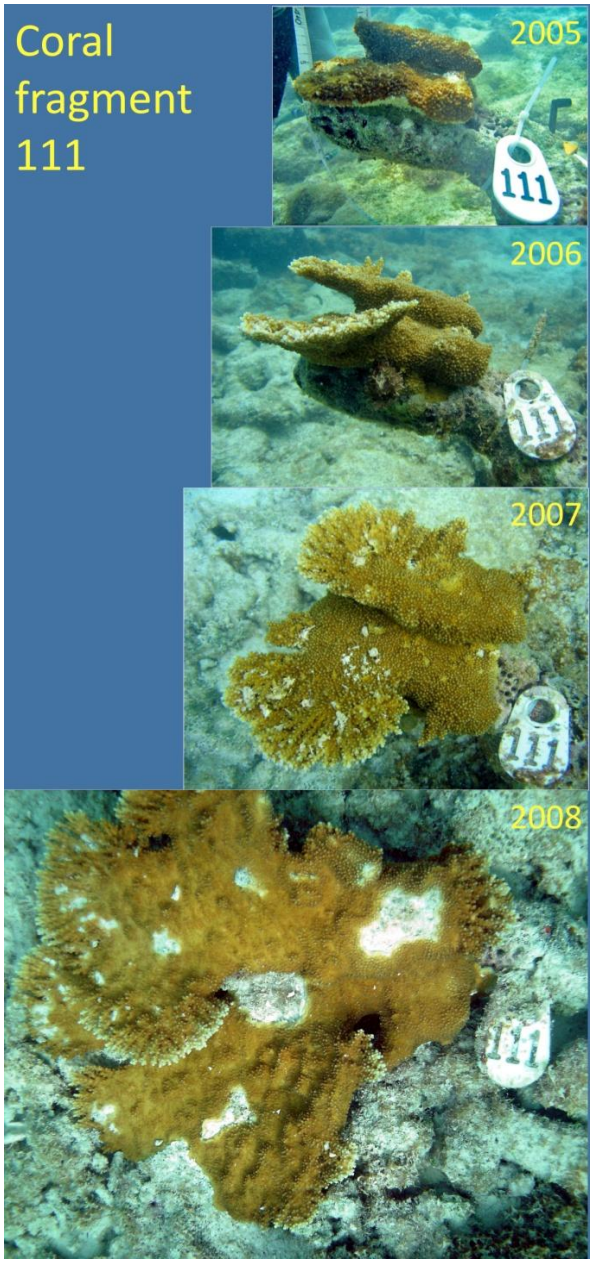
Guana was one of the very last holdouts, but in 2011 we documented numerous Lionfish on our monitoring sites all around Guana. The reef monitoring results show the Lionfish population density to be 14.3 lionfish/hectare as of August, 2011. Ongoing efforts in the BVI to manually control Lionfish by catching and killing them have so far been unsuccessful.

The Pacific Lionfish has spread throughout the Caribbean and is now abundant around Guana.

Guana's resort guests will surely notice the Lionfish on the White Bay finger-reefs as the fish are slow-moving and attractive. They are not large, but they sport venomous spines on their dorsal, anal and pelvic fins and thus are dangerous to handle. Despite this, Lionfish are not poisonous to eat and are allegedly delicious. They can be caught in the water with hand nets and they will enter fish traps, but they are not likely to bite bait on a hook. Once caught, the venomous spines can be snipped off, rendering them harmless. Even with their spines intact, cooking will denature the venom.

B. Coral Reef Restoration

Dr. Graham Forrester, University of Rhode Island, Rhode Island (URI)



- students MSM 2009:

  Dawn Kotowicz, URI
  Rebecca Karis, URI
  Ananda Fraser, URI

- students MSM 2010:

  Kerianne Taylor, URI
  Amy Maynard, URI
  Stephanie Schofield, URI

- students MSM 2011:

  Reuben Macfarlan, URI
  Megan Ferguson, URI
  Russell Dauksis, URI

Dr. Forrester and his team of students from the Natural Resources Institute at the University of Rhode Island are working to restore coral life on the shallow finger-reefs of White Bay. This project began in 2005 as a collaborative effort between several of our MSM scientists, including Caitlin O'Connell and Lianna Jarecki. The finger-reefs, which are the main snorkelling attraction on Guana's White Bay, 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 and destroyed approximately 80% of known Caribbean Elkhorn coral (*Acropora palmata*) populations. Prior to this epidemic, growth of Elkhorn coral's massive branching 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.

Graham Forrester's students have planted hundreds of coral fragments in White Bay over the past few years, and the reefs are now looking significantly more colourful, structurally diverse and vibrant. Each year this conservation work is combined with experimentation to determine

the factors that lend success to coral restoration efforts. The results are regularly reported in the scientific literature. Forrester et al. 2010, published in Restoration Ecology, for example, reports that the successful establishment of coral fragments is not affected by the attachment method used, whether by cable ties, underwater epoxy, or hydraulic cement. This result has led the team to use only cable ties, which is by far the most inexpensive option. The paper also reports the finding the survival of loose coral fragments, which regularly break off of larger parent colonies, is vastly improved by human intervention to physically attach the fragments to hard substrate. Thus, we continue our efforts to "plant" more corals every year.

The team's most recent experimental results have been submitted to the Journal of Marine Biology. In this paper, Dr. Forrester and his team show that corals grow faster if "planted" in their home environment, e.g. Crab Cove, Guana Head, or Harris Ghut, than if they are moved to a new location, e.g. White Bay Finger Reefs. They also show that coral fragments from different source populations have inherently different, genetically-determined, growth rates, no matter where they are planted.

Further experiments have been implemented to determine the optimal fragment size for replanting, and a map of the planted corals is being generated to better track Guana's new coral garden in White Bay.

C. Elkhorn Coral Population Monitoring

Erinn Muller, PhD candidate, Florida Institute of Technology

Jessica Gulbranson, student assistant MSM 2009

Erinn Muller annually monitors the important natural populations of Elkhorn coral, *Acropora palmata*, in Muskmelon Bay and White Bay. She has found that the populations are currently stable in both areas, and she reports a death rate of 8% per year and an equal rate of new colony formation. Her results show that large coral heads (> 50cm across) are less susceptible to whole-colony death than are smaller coral heads.

Photo left shows Elkhorn coral suffering from the loss of its symbiotic algae, a condition known as "bleaching" that is caused by extraordinarily warm sea surface temperature.

Ms. Muller has also determined that the potential stressors to coral colonies have changed over time. Since 2004 in Muskmelon Bay, there has been a massive increase in predation by coral-eating snails and infection by ciliates, with a concurrent reduction in predation by fireworms and fish. In White

Bay, a combination of stressors has become increasingly severe, including snail, fireworm and fish predation, ciliate infections and physical damage.

This work complements the coral-replanting studies of Graham Forrester's team, as it allows us to understand and compare the dynamics of naturally-recruited Elkhorn populations to those that have been planted. Thus far, we have found no perceptible differences, though we conclude from Erinn's studies and similar studies elsewhere in the Caribbean that the endangered Elkhorn coral populations are under severe environmental stress and may never recover to their pre-1990's abundance. The Elkhorn coral planting efforts on the White Bay finger reefs (see previous summary) are designed to counteract the decline of these key reef-building corals.

D. Parasites of Reef Fish

Paul Sikkel, Arkansas State University

Ann Marie Coile, Arkansas State University

Elizabeth Brill, Arkansas State University

Amber McCammon, Arkansas State University

Paul Sikkel's student assistants 09-10

Will Jenkins *Whitney Spears*
Adam Parr *Richard Walecki*

Gnathia marleyi, an ectoparasite of reef fish. Photo by Ann Marie Coile,

Paul Sikkel and his team of graduate students from Arkansas State University and the University of the Virgin Islands investigate the relationship between reef fish and their parasites on Guana's White Bay reef. Their studies focus on parasitic gnathid isopods, which are small tick-like crustaceans. The parasites attach themselves between the scales of sleeping fish at night, drink blood for a few hours and then drop off before sunrise. Hundreds of these parasites can attach to a single fish each night, thereby substantially weakening their host. It is the work of Paul Sikkel's research team to find out what factors make fish more or less susceptible to gnathid isopod infestation, including differences in habitat, fish species, and condition of the fish.

The Sikkel team works mainly at night. Each evening they catch several reef fish and set them out in cages in White Bay. Before sunrise, the biologists pick up the cages, allow the fish to sit in aerated buckets until the parasites drop off, and then release the fish. The rest of the day they spend counting the parasites that fell off each fish.

Reporting their findings in recently published papers, the Sikkel team has shown: that the gnathid isopod parasites shift their feeding time (middle of the night versus early morning) according to their stage of development and gender (Sikkel et al. 2009 in Coral Reefs); and that the same parasites rely mainly on their sense of smell rather than sight to locate their fish hosts (Sikkel et al. 2011 in Marine Biology).

E. Population Assessment of Caribbean Whelks

Dr. Graham Forrester, U. of Rhode Island
Linda Forrester, U.R.I.
Elizabeth Mclean, U.R.I.
Katherine & Fiona Forrester

Whelks (a.k.a. West Indian Topshell or *Cittarium pica*) are large (up to 130mm diameter) intertidal snails that are locally considered a delicacy to eat. People collect them from the shoreline for food. The price of whelk meat in the BVI has transcended the price of better-known seafoods such as lobster, conch and fish. Imported whelk meat has recently been observed in the local grocery stores (Alfred Dorsette, personal communication), which suggests that local demand exceeds the current natural supply of whelk meat in the BVI.

The Forrester research team monitors whelk populations at six sites around Guana by counting and measuring all whelks within 30m x 2m shoreline transects during low tides. The resulting data is used to determine the size distribution of Guana's whelk population and to estimate the effect of harvesting on this size distribution.

Published studies report that whelks begin to reproduce once they reach a size of 32mm in diameter, which corresponds with approximately 1 ½ to 3 years in age. The Forrester team has shown that whelks in the most accessible, harvested areas around Guana (e.g. Crab Cove and Harris Ghut) are nearly all less than this minimum reproductive size. This alarming result suggests that the whelk population may have limited potential for replenishing itself.

Guana's whelk monitoring study may contribute important information of use to the BVI government in planning for conservation of the BVI's valuable whelk fishery.

F. Vermetid Worm Snail Diversity

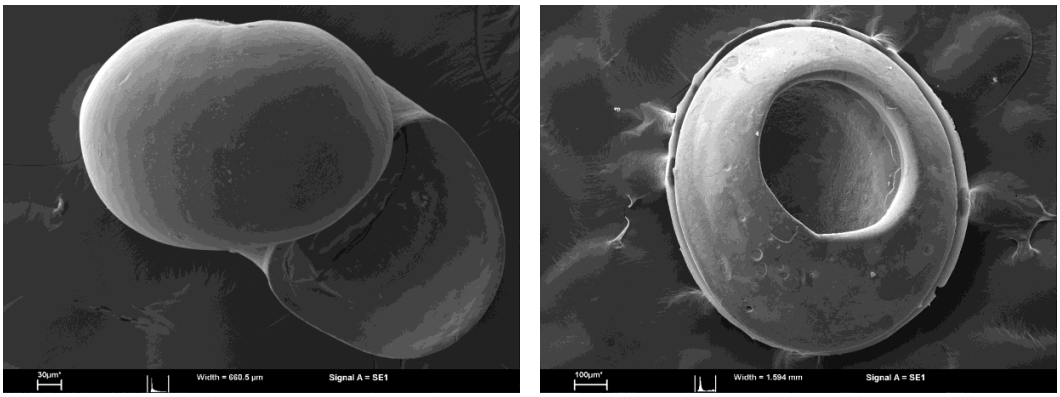
Tim Collins, National Science Foundation and Florida International University

Rudiger Bieler, Field Museum of Natural History, Chicago

Above: Tiny (ca. 3 mm) *Dendropoma meroclista* occurs in two morphs, dark brown (left) and orange (right). The Collins/Bieler team is investigating whether these might in fact be two different species. (Photos Collins/Bieler)

This team of systematists (a branch of Biology that studies biodiversity and evolutionary relationships) joined us during MSM 2010 to investigate the occurrence of worm snails in the family Vermetidae. Worm snails are snails that permanently attach themselves to hard objects in the water, such as oyster clusters, seafans and other objects that stand above the ocean floor. Their shells grow in an extended spiral, looking more like a hard worm than a typical snail, hence the name "worm-snail".

Before Tim and Rudiger visited Guana, there were no official records of any worm-snail occurring there, though one widely-distributed species was expected to occur. Instead of one species, they found five different worm-snail species around Guana. One of these species they found in two colors (see figure above). Further study of these and other specimens using advanced tools of electron microscopy (see figure below) and molecular biology may reveal one or more new species to science.



Above: Electron microscopy and molecular markers are used to identify worm snails. Scanning electron micrographs above shows the larval shell of *"Dendropoma meroclista"* (left) and its operculum (right). These are micrographs of specimens collected on Guana. (Photos Collins/Bieler)

G. Anemone-shrimp relationships

Amber McCammon, Univeristy of the Virgin Islands

Tobias Ortega, University of the Virgin Islands

Amber McCammon joined Guana's MSM program a few years ago to investigate the relations between parasites and reef fish as part of Paul Sikkel's team. She is now a member of the faculty at the University of the Virgin Islands in St. Thomas, and she has launched a new investigation into the relationships between anemones and their symbionts (the creatures that live with and inside the anemones). She and her student assistant, Tobias Ortega, laid the groundwork for her new study on Guana in 2011 by surveying the anemone populations in White Bay and Crab Cove.

They found that the Giant Red-tipped sea anemone is common in White Bay but not in Crab Cove, while the Sun Anemone shows the opposite distribution. Both species are host to a variety of symbionts (animals that live in association with the sea anemone). The team also found up to seven different crustaceans living within the tentacles of a single Giant Red-tipped sea anemone. Some of these crustaceans are cleaner shrimp, which eat parasites off of fish that visit special "cleaner stations" near the anemone.

Despite their ecological importance and a high demand in the aquarium industry, very little is known about the life-history and population dynamics of large Caribbean reef anemones. With her survey data and annual monitoring, Amber McCammon will learn much about the lives of Guana's sea anemones. She then intends to design experimental studies to elucidate the anemones' role in the lives of cleaner shrimp. Her future studies will complement the parasite-load studies by Dr. Sikkel's group, as they may help us to understand the natural balance of parasites and cleaner organisms in the lives of reef fish.

H. Seagrass Community Assessment and Mapping

Rick Ware, Coasta Resources Mangement Inc., California

Stephen Whitaker, Channel Islands National Park

Seagrass requires calm water, but Guana is exposed to the rough waters of the Atlantic. Thus there are only two seagrass areas near Guana, and these were mapped previously by Rick Ware in 1998 and 2001. By surveying these same areas again in 2009, this team was able to make temporal comparisons to tell us how our seagrass habitats are faring over time.

They found that the small (1,749 m^2) shallow seagrass bed near the shore of North Beach supports a greater diversity of macroalgae and invertebrate life than the deeper seagrass bed in the "Guana channel" between Monkey Point and Tom Point on Tortola. As many regular visitors to Guana know, Spotted Eagle Rays and small sharks are often seen hunting over this vibrant seagrass community near the shore of North Beach.

Mr. Whitaker and Mr. Ware found that the North Beach seagrass bed shrunk by 25% between 2001 and 2009, presumably due to wave scouring during storms. Mr. Ware notes that this shallow area often experiences high daytime temperatures, at or near the maximum temperatures tolerated by seagrass. Given enough calm weather, the seagrass bed is expected to expand once again, though its ability to move into deeper, cooler areas is limited by rough water outside of the shallow reef at North Bay.

The Guana Channel seagrass bed is deeper and larger, covering a tenth of a square kilometer. It extends all the way from Guana to Tortola across the bottom of the channel. The seagrass meadow here is supported by the calm and clear water, protected by the islands and cleaned by the currents that flush through the channel. Sea turtles are a common sight here, especially Green Turtles that feed over these rich underwater meadows.

III. EDUCATION AND OUTREACH

Lianna Jarecki, Marine Science Month Program Director, and H. L.S. Community College

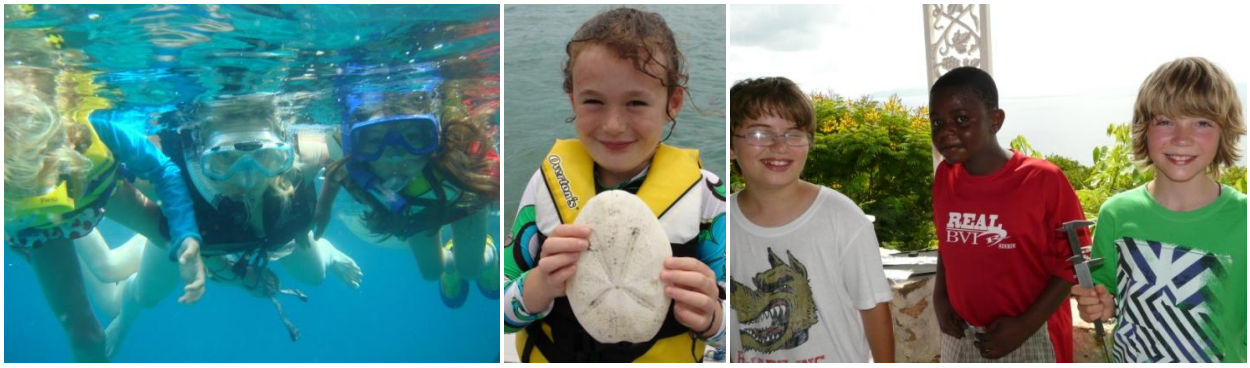
Graham Forrester, University of Rhode Island

Linda Forrester, University of Rhode Island

Stacy Lettsome, Youth Empowerment Program, BVI

Guana's marine scientists are committed to sharing their research where it counts the most—within the local community.

A. Science Week



"Science Week" is a program that has been run annually since about 2004 by Skip Lazell's group of terrestrial scientists who conduct research on Guana every October. In 2010, Science Week joined Marine Science Month for the first time. It was designed and implemented by Lianna Jarecki and Linda Forrester, with contributions from other scientists and parents. Jarecki family children aged 5 to 12 and three promising youths from Tortola studied Guana's fascinating marine environment and conducted scientific research with Guana's marine biologists from July 27th – 31st, 2010.

The busy five-day week was full of field work, exploration and fun. The children gained confidence in the water, confidence in handling animals, and confidence in "doing" science. The

children were consistently enthusiastic, focused and cooperative. This was a week of intensive learning in action, which will positively influence the children's future development of scientific reasoning.

A full report of the Science Week activities is available from drjarecki@gmail.com.

B. Community Workshop

Drs. Graham Forrester and Lianna Jarecki designed and implemented a community workshop to train local residents in the Elkhorn coral restoration techniques that have been used and perfected on Guana. With this training and ongoing consultation, local groups would have the capacity and inspiration to replant Elkhorn corals on other suffering reefs in the BVI.

Reef restoration workshop participants

The reef restoration workshop was organised in partnership with the BVI's Association of Reef Keepers and the BVI chapter of Reef Check International. It combined a public lecture on Tortola with a full day hands-on training session on Guana.

The public lecture was presented by Dr. Graham Forrester at the Royal BVI Yacht Club, Road Town, Tortola, on the evening of August 13th, with about 50 people in attendance. This was followed by a hands-on training workshop on Guana to demonstrate and allow practice in coral restoration techniques. Seventeen people participated in the workshop, including local dive operators, marine enthusiasts, and members of the local Rotaract club. Of these 17, eight were BVIslanders and the rest were resident dive operators and Reef Check volunteers.

Both the lecture and the field training were very well-received. Freeman Rogers, of the BVI Beacon, ran a newspaper article on the workshop and Guana's reef restoration project, and Jim Kelly posted a full video record of the lecture and field work, including underwater footage, on his Online BVI website (www.onlinebvi.tv).

C. Visiting Youth Groups

Each year we host youth groups from Tortola's Youth Empowerment Program and the BVI's Environmental Camp. The young people are given presentations of the work of the scientists and the natural history of Guana Island. Afterwards, they are taken on a walking tour of the salt pond, the sugar mill ruins, North Beach and White Bay. Each participant is given a worksheet/guide and encouraged to make notes in order to reinforce learning objectives. The participants bring lunch, and Guana's hotel provides cold drinks. After lunch, the participants spend an hour enjoying the beach before Guana's boats return them to Tortola.

In 2010, we were also visited by the Sail Caribbean teenage sailing camp because the program director had read about our research into coral restoration. Dr. Graham Forrester gave a special evening presentation on reef restoration to this group, while the group's boats were anchored at Monkey Point. The students were invited to snorkel over the "coral gardening" project the next morning.

IV. 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 the authors cited. These publications have not been cited in previous MSM reports. A complete list of publications arising from MSM research is available by request from drjarecki@gmail.com.

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