GUANA ISLAND MARINE SCIENCE MONTH REPORT & PROPOSAL

There were three projects that I worked on in 2010, and propose to continue in 2011

1) Long term monitoring of reef communities

This is a continuation of the monitoring study initiated in 1992. Its aim is to provide a long-term analysis of patterns in the abundance of reef fishes, corals and sponges and how they relate to characteristics of the reef habitat. Censuses were done in 2010 at the same 8 sites that have been monitored annually since 1992. During the surveys, we make counts of the fish species present, and estimate the abundance of corals, sponges, sea fans, and most other members of the reef community

In 2010, we also continued a more specific project on the effects of changes in coral communities on fish populations (Holbrook et al. 2000). In has been argued that the recently documented general declines in Caribbean fishes (Paddack et al. 2009) are a time-lagged response to the general decline in Caribbean corals (Gardner et al. 2003). This project focuses on the 3-spot damselfish, *Stegastes planifrons*, a common and ecologically important species on Caribbean reefs. Like many species, 3-spot damselfish associate with specific habitats, which for this fish seem to be certain species of live coral. We are testing the hypothesis that *Stegastes planifrons* will use several species of coral as habitat, but has a preference which allows the corals to be ranked from most- to least-preferred (Precht et al. 2010). The corals used as habitat by the fish have all declined to varying degrees on the Guana monitoring sites. We are testing the hypothesis that declines in fish populations can be explained as the cumulative effect of losing different usable habitat types. We argue 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 disappear the fish populations will crash.

In 2011 we propose to continue the long-term monitoring, and also to continue the more focused analysis of the habitats used by 3-spot damselfish and whether that can predict their change in population size over time.

2) Population assessment of Caribbean whelks

In 2010, we also continued monitoring the long-term population dynamic studies of Caribbean whelks (also called the West Indian Topshell), *Cittarium pica*. Small-scale fisheries constitute a major source of food and economic activity in the Caribbean and throughout the coastal tropics. These fisheries are challenging to manage, because they often comprise a mix of full-time commercial fishers as well as subsistence fishers whose activities supplement household incomes. Adding to this complexity, there are also typically many species being harvested from several habitats using multiple fishing methods.

C. pica appear to be an important component of small-scale fisheries throughout the Caribbean, but has received little attention from scientists. *C. pica* can grow in excess of 130 mm in diameter, and is a nocturnal grazer of algae in the intertidal and shallow subtidal zones of rocky shores. *C. pica* appear to have limited home ranges as adults, but are broadcast spawners whose larvae are planktonic for 3-5 days (Debrot 1990, Bell 1992). They are collected from the shore by people for food, as an ingredient for cosmetics, and their shells are used in jewelry. Their other predators include carnivorous snails, octopi, fish, and seabirds (Robertson 2003).

Fig. 1. (left) A large C. pica being measured and (right) two local harvesters collecting C. pica in Brewer's Bay, Tortola

C. pica is reported to be harvested widely and intensively for sale and for personal consumption (Randall 1964, Debrot 1990, Bell 1992, Jimenez 2006, Osorno Arango et al 2009) but the nature and amount of harvesting has been little-studied. The status of *C. pica* populations across the Caribbean and how they are affected by fishing is also not well documented. There are published surveys of *C. pica* abundance and size-distributions from the Bahamas (Debrot 1990), USVI (Randall 1964), Costa Rica (Schmidt 2002), and Colombia (Osorno Arango 2006, Rosique 2008), plus unpublished surveys from USVI (Toller 2004), Puerto Rico (Jimenez 2006), and BVI (Forrester unpubl.). The rarity or absence of larger individuals from many areas has long been interpreted as the effect of over-harvesting (Clench and Abbott 1943; Randall 1964; Robertson 2003; Rosique et al 2008; Osorno Arango 2006, Rosique 2008), as is the complete disappearance of *C. pica* from Bermuda and Florida (Walker 1994, Robertson 2003; Rhyne et al. 2009). Putative unharvested populations used as "benchmarks" for this interpretation come from surveys of *C. pica* in a remote, little-populated, area in the Bahamas (Debrot 1990), and from surveys inside a Costa Rican reserve (Schmidt et al. 2002). It is, however, important to note that neither study provided direct evidence that "benchmark" sites were unfished and, more generally, there is little direct evidence linking actual harvesting rates to the status of *C. pica* populations. Direct evidence is critical to separate effects of fishing from natural disturbances and other anthropogenic impacts on the shoreline, such as coastal development and pollution (Strand et al. 2009).

Despite the lack of definitive evidence for overharvesting, the widespread perception that *C. pica* populations are depleted has led to the establishment of various regulations to regulate harvesting of *C. pica* around the Caribbean. For example, in Puerto Rico, there is a minimum size limit (63.5 mm) (Jimenez 2006) and some reserves that incorporate shoreline habitat provide implicit protection (Aguilar-Perera 2006). In the USVI, no license is required to harvest *C. pica* but there is a size limit (62 mm) and closed season (April 1-Sept 30: stated to coincide with the reproductive season), and within the USVI National Park collecting is further limited to 1 gallon/day. By contrast, in the BVI, a license is required for both recreational and commercial harvesting, but the closed season is very different (Aug 15-Oct 31). The BVI does, however use the same size limit as the USVI (62 mm). The Cayman Islands has a closed season (01 May-31 Oct) and a catch limit (2.5 gallons/day). *C. pica* is completely protected in Bermuda and the Dominican Republic, but in other countries, such as Dominica, Colombia, Trinidad and Tobago, and USA (Florida), *C. pica* is recognized as "vulnerable" but there are no restrictions on harvesting. Clearly, it would be valuable to evaluate the relative effectiveness of these different management actions.

The effectiveness of size-limits, closed seasons and catch limits depends partly on accurate knowledge of *C. pica* demography. Inspections of gonad development in USVI, the Bahamas and Colombia suggest that *C. pica* can mature beginning at roughly 32 mm. Based on limited mark-recapture data, *C. pica* grows ≈1-2.5 mm/month and so 32 mm *C. pica* are between 18-40 months old (Randall 1964; Debrot 1990). These mark-recapture analyses can be improved by further consideration of bias due to tag loss, tag visibility to predators, and resighting error. In the Bahamas, Colombia and St John, the abundance of juveniles on the shore peaked in January, but individuals held in the lab in the Bahamas from June-October spawned regularly, so the seasonality of reproduction is also uncertain (Randall 1964; Bell 1992; Rosique 2008). It will be valuable to obtain more accurate information on growth and mortality rates, size at maturity, size-specific fecundity, and reproductive seasonality. It is also crucial to assess whether these parameters vary among locations and, in particular whether they are altered in response to the past level of harvesting, because fishing itself can have strong impacts on these life-history parameters (Conover & Munch 2002).

We have been monitoring whelk populations around Guana, and occasionally on Tortola, since 2000. Three, 10 m transects are placed along the shore at the waterline during low tide and whelks counted in a 0.5 m strip on either side of the line. All whelks counted are measured using calipers and replaced. We sampled 6 sites on Guana in 2000. We have resampled these sites annually from 2004-2010 (data from 2006 are shown in Fig. 2). We hypothesize that sites on Guana may be less accessible to collectors than most sites on Tortola and so will have both a higher densities of whelks, and a greater proportion of larger sized individuals. We propose to continue monitoring of whelk populations in 2010, and also explore new methods to estimate the actual amount of collecting on different shores.

We also tested methods for placing individual tags on whelks in 2004. These preliminary trials showed that small plastic numbered tags may be usable to recognize individual whelks without side-effects. We propose to commence a preliminary mark-recapture study in August 2011, by tagging 100 whelks at each of two sites on Guana (Bigelow Beach and Crab Cove). We propose to resample these populations in October 2011 to test for tag loss and resighting error, and establish whether recapture rates are high enough to warrant a more extensive mark-recapture study. If recaptures rates are high enough, we would be able to begin assessing the growth, survival, and reproductive rates of whelk populations in order to assess the effectiveness of the various regulations used to manage whelk harvesting in the BVI and other parts of the Caribbean.

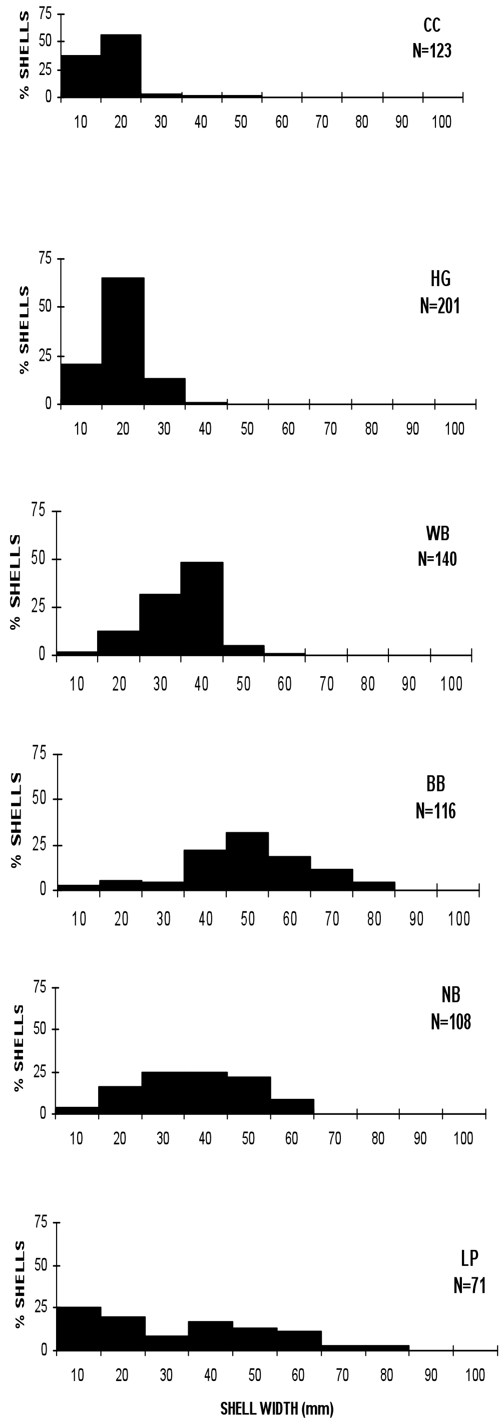

Fig. 2. Size distribution of whelks at 6 sites on Guana Island in 2006. BVI size limit = 62 mm.

3) Reef restoration by transplanting elkhorn corals

Since 2005, we have tested various methods for reef restoration by transplanting small pieces of elkhorn corals from different source sites to the dead reefs in White Bay.

In 2010 we completed two new experimental studies as part of this restoration effort.

1) *We tested whether the success of transplanted corals depends on genetic differences among source populations or on effects of environmental conditions.* **These results were presented at a national conference (the Benthic Ecology meeting, in Mobile AL) in March 2011. A manuscript describing these results was submitted to the "Journal of Marine Biology" and is attached.**

2) *We evaluated the extent and causes of stress induced by the process of transplanting corals.* The success of our approach to restoration depends on the level of stress induced by collecting and transporting of coral fragments to the restoration site, and on the possible cost of acclimation to conditions at the restoration site. We tested for transplanting stress by comparing the level of tissue loss and bleaching in newly transplanted corals in White Bay to corals that had been present at the site for over a year. We also documented the causes of tissue loss in order to test whether agents of mortality differ between new transplants and well-established corals. Storm-generated fragments of *Acropora palmata* from two source populations (Harris Ghut and Little Camanoe) were transplanted to the White Bay restoration site. In the following two weeks, new transplants displayed greater tissue loss (% of tissue recently dead) and bleaching (% tissue bleached) than established corals. New transplants were affected by disease (white syndrome) more frequently than established corals. Over the subsequent 2 months, the fate of new transplants (measured as % change in live surface area) did not differ from that of established corals, but the lack of longer-term effects may be due to a hurricane 3 weeks after transplanting that appeared to cause substantial mortality and overwhelmed effects of transplant stress. Newly transplanted *A. palmata* thus appear to experience modest short-term transplant stress, which makes them more susceptible to bleaching and disease, but the longer-term impacts are uncertain. **These results were presented at a national conference (the Benthic Ecology meeting, in Mobile AL) in March 2011 and a manuscript for publication is nearing completion.**

For 2001 we propose two activities:

1) *A careful and systematic survey of all corals transplanted from 2005-2010 and of the reef community.* Each year, we have performed different, self-contained, experiments to evaluate different aspects of our approach to reef restoration. However, most of the corals are transplanted to White Bay and so a major product of the ongoing effort is practical and conservation-related: we hope to restore the White Bay reef community. Each year we necessarily focus our attention on the new experiment, and although we try to monitor corals from past years time constraints often prevent a systematic survey of all corals.

For 2011, we propose to map all surviving transplanted corals from preceding years. We will make a detailed map of the site and locate all corals on the map. Each coral will be measured and photographed, and if necessary have its ID tag replaced. In this way, we will be able to make a careful overall assessment of the growth and survival of the transplanted population. We also propose to make an assessment of whether any of the transplanted corals have become reproductively active. Spawning for *A. palmata* happens just once a year, at night, and in 2011 is predicted to occur on the evening of August 15 or 16.

In 2005, before the restoration project began, we also made a general survey of the common organisms living on the White Bay reefs using methods similar to those employed for the long-term reef monitoring begun in 1992. In 2001, we propose to repeat that survey in order to assess whether 5 years of restoration has made a detectable difference to the overall composition of the reef community.

2) *An experimental test of the optimum size of coral fragments to be used for restoration*. All of our restoration projects use coral fragments formed by branches breaking off in storms or by human activity. Fragments vary greatly in size, and scientists have asked whether the survival and growth rate of corals depends on fragment size. Some of these studies conclude that large fragments have a higher survival rate (Bowden-Kerby 2001; Bruno 1998; Soong and Chen 2003). A few of these studies have also looked at growth rate and concluded that large fragments have a faster growth rate (Forsman et al 2006; Okubo et al 2009; Soong and Chen 2003). In contrast, Rogers et al (1982) determined that small fragments were healthier than large fragments after a hurricane, and had a higher survival rate. Others studies found that small fragments have a faster growth rate than large fragments (Yap et al 1992; 1998).

There is thus no consistent effect of size on the growth and survival of fragments. For restoration, answering this question is of practical importance because, given a fragment of a certain size, it is important to know whether it is better to transplant it intact, or subdivide it into smaller pieces? We propose to answer this question experimentally by locating pairs of fragments of similar initial size. One member of each pair will be split into two pieces, whereas the other will remain intact. All fragments will be transplanted and we will monitor their growth and survival. If subdividing fragments is beneficial, the overall growth and probability of survival for the two subdivided pieces will be greater than that of the undivided fragment.