

Cruise Report 2006 and Research Plan 2007
Monitoring the FORTUNA REEFER Restoration and Researching Coral Disease
and Coral Reef Ecology at Mona Island, Desecheo Island and La Parguera

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Summary

Research efforts in 2007 will continue with their focus on Mona Island, Desecheo Island, La Parguera and reefs off the west coast of Puerto Rico, Activities will include restoration monitoring, coral disease surveys, targeted *Acropora palmata* monitoring and mapping, coral disease sampling, characterization of reef fish assemblages, and testing of low-tech ecological restoration approaches. At Mona Island work will focus on: 1) 10 year reevaluation of the Fortuna Reefer restoration site, with emphasis on the patterns of survival of *Acropora palmata* fragments, restoration of community structure, and extent of ecological recovery of the site over time with comparisons of coral reef community structure in representative *Acropora* habitats outside of the grounding site; 2) coral disease and predation surveys within permanent sites at Carmelitas, Sardinera, Mujeres, Carabinero, and Pajaros, including reevaluation of tagged corals; 3) random AGGRA surveys throughout Mona Island reefs to characterize patterns of recovery and community changes in response to the 2005 bleaching event; 4) expansion of pilot studies to reduce rates of decline of *Acropora palmata* colonies from white-band disease and snail predation and to enhance recovery of this coral; 5) continued GPS mapping and characterization of *Acropora palmata* colonies; 6) characterization of the extent and condition of *Acropora cervicornis* thickets in deeper water off Sardinera, including the role of these communities as fish habitat; and 7) sampling of corals with disease for histopathological studies. At Desecheo Island we will resurvey permanent sites, including characterization of coral condition, reexamination of tagged colonies, and assessment of fish community structure. In La Parguera, we will 1) reexamine permanent sites at Mario Reef, Pinnacles and shelf edge (Old Buoy); 2) continue *Acropora palmata* mapping and characterization work, focusing on Media Luna, Laurel, and San Cr stobal. Monitoring activities off the west coast will target *Acropora* habitats. If time allows, we will also reexamine the fates of restored corals at the Magara grounding site.

Activities completed in FY06:

Two research missions were completed in FY-06.

I. December 5-13, 2005.

1. A broad scale survey of the extent of bleaching and initial patterns of recovery was undertaken in December 2005. Bruckner (coral) and Hill (fish) completed 34 dives.

Sites examined included:

- Desecheo Island: Candyland, Puerto de Botes, Candlesticks; 4 dives;
- Mayaguez: Tourmaline, El Negro, Cayo Ron; 4 dives;
- Bajo Gallardo (off Boqueron): 3 dives in deeper habitat, snorkel surveys of *Acropora palmata*

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- Mona Island: Random survey sites (Carmelitas, Sardinera, Mujeres, Carabinero, Uvero, Coco Beach, Pajaros; 14 dives
- La Parguera: Old buoy, Laurel, El Palo, Mario, Turrumote, San Cristóbal, 7 dives; and
- The shipgrounding off Guayanilla; 2 dives.

All surveys were random, and involved using a modified AGGRA approach to characterize coral size, condition, cover and extent of bleaching. Patterns of colony bleaching were described and differentiated into five primary categories, ranging from complete bleaching (colony is entirely white) to pale (near full recovery). Reefs examined included several locations being monitored through the DNER coral monitoring project undertaken by Dr. Reni Garcia. Initial results of these surveys were compiled and presented at a bleaching workshop in St. Croix in January 2006 and data were submitted to the Coral Watch program at NOAA/NESDIS for inclusion in a Caribbean wide assessment of the extent of bleaching and relationships with thermal anomalies and degree heating weeks. A copy of the report provided to NESDIS, an excel sheet with the data summaries, as well as the draft manuscript under development by NESDIS (Dr. Mark Eakin) are available upon request.

2. Two sets of samples of bleached *Montastraea annularis* and *M. faveolata* colonies were collected for examination of zooxanthellae clades in collaboration with Dr. Andrew Baker (University of Miami). The goal of this effort is to determine if corals can acclimate to elevated sea water temperature through shifts in the dominant clade of zooxanthellae. One set was collected from Mona Island (a patch reef off Sardinera at 45 feet deep) and the second was from Mario Reef, off La Parguera at depths of 0-3 m. A total of 45 samples were removed from colonies exhibiting varying degrees of bleaching, including fully bleached, pale yellow, light brown, and normal green/brown pigmentation with multiple samples removed from selected colonies in different locations to capture differences in coloration within colonies (e.g., some corals were pale yellow with light brown blotches). Each sample was approximately 1 cm diameter X 0.5 cm thick.

II. August 13-21 2006. Bruckner (coral) and Hill (fish) completed a total of 30 dives, as well as 14 hours of snorkel surveys. Sites examined included:

- Bajo Gallardo; 4 dives
- Mona Island (Carmelita, Sardinera, Mujeres, Pajaros, Carabinero, Fortuna Reefer); 15 dives
- Desecheo (Candlesticks, Candyland and Puerto de Botes); 4 dives
- Parguera (Pinnacles, Mario and Old Buoy); 5 dives
- Guayanilla (Margara grounding) 2 dives (Bruckner with NOAA Restoration)

1. Surveys included AGGRA assessments of coral condition and recovery/mortality associated with 2005 bleaching event; reexamination of tagged colonies; and mapping and characterization of *Acropora* populations. Transect surveys of reef fish assemblages were paired with each coral/benthos survey.

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2. Bruckner conducted extensive surveys, mapping and characterizing colonies, in acroporid habitats at Bajo Gallardo, Mona (Carmelita back reef and fore reef, Sardinera, Pajaros fore reef) and Parguera (Pinnacles, Mario, Turrumote and Media Luna). Methods are those developed by SEFSC (Williams, Miller, and Kramer) in order to develop consistent data on distribution, health, and changes in *Acropora palmata* populations throughout its range.

3. Two sets of *Acropora cervicornis* samples were collected for histopathology to characterize coral disease assessment. This includes 20 branch fragments at Mona Island (offshore *A. cervicornis* patch near Sardinera/Carmelita) and 15 fragments from the Magara sampling site. All samples were fixed in z-fix and provided to NOAA's Oxford Laboratory (International Registry of Coral Pathology) as a Coral Disease and Health Consortium contribution to this effort. In addition, small fragments of *A. cervicornis* were collected for coral culturing efforts (under Tom Moore; DNER permit) with samples provided to Dr. Alina Szmant; Dr. Debbie Santavy and Dr. Tom Capo. Because these were taken just before implementation of the TSA restrictions on carrying liquid on board airlines, samples for Dr. Santavy were mailed by Federal Express, and they did not survive due to excessive heating of the package during shipping. Dr. Szmant's samples were provided to her at the University of Puerto Rico DMS laboratory in Parguera, and Dr. Capo's samples were hand carried to Miami.

Work Plan for 2007

In 2007, we propose to continue or expand research into the status and health of coral reef ecosystems of coastal areas of the south and west coasts of Puerto Rico and the remote islands of western Puerto Rico, including Mona, Monito, and Desecheo. The project components include monitoring ecosystem structure (benthic organisms and fish), assessing restoration techniques and success, documenting population structure, quantifying coral disease and success of mitigation techniques, and correlation of reef fish assemblages to environmental conditions, for example restoration success or disease occurrence. As in the past, work will be coordinated with University of Puerto Rico researchers/students and DNER participation is welcome. We will also have assistance from a coral researcher from the University of Houston (Eric Borneman, PhD candidate) on the ecological restoration efforts.

Explanations of individual project components follow.

1. Monitoring the success of the Fortuna Reefer restoration:

In 2007 we will reassess the remaining live restored *A. palmata* fragments and record the same parameters as in previous years:

- **size** (the maximum length and width),
- **orientation** (up, down, sideways),
- **location of attachment** (reef or skeleton),
- **signs of new growth** (number and length of protobranches; fusion; growth over the wire; growth onto the substrate and resheeting over exposed skeleton)

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- **condition** (amount of partial tissue mortality on upper branch surfaces) and
- **causes of mortality** (wire abrasion, disease, predation by parrotfish, gastropods or fireworms, competition with algae, overgrowth by the brown boring sponge, *Cliona* spp., or other encrusting invertebrates and damselfish algal lawns).

Concurrent underwater visual census methods will document the reef fish assemblages, using a) fish abundances and densities, b) population size structure, and c) fish assemblage composition (diversity and trophic status) to assess the effectiveness of the restoration of reef fish habitat.

2. Monitoring *Acropora palmata* stands:

We will assess the condition of surrounding *A. palmata* colonies outside of the grounding site near Pajaros and two populations near Sardinera and Carmelita to evaluate the impact of the white-band disease (WBD) outbreak observed between 2003 and 2006 and to characterize the prevalence of other biotic agents responsible for coral mortality (e.g., snails, *Stegastes planifrons* (threespot damselfish), clionid sponges, and other diseases). This will involve running transects through *Acropora* areas and assessing each colony. Information will include size (height and width), percent live, amount of recent mortality, and causes of mortality. Concurrent fish surveys will document reef fish assemblages and changes in habitat use. Concurrently, GPS coordinates of all *A. palmata* colonies will be recorded with data contributed to the NOAA *Acropora* database to assist in the implementation of the Endangered Species Act threatened status for *Acropora palmata*, identification of critical habitat and development of a recovery plan. Andrew Bruckner is one of the official members of the NOAA *Acropora* Recovery Team responsible for the development of a recovery plan as mandated by the ESA.

3. Evaluation of pilot snail removal experiments:

Data collected at Mona Island over the last 8 years have demonstrated the high prevalence of the coral eating snail *Coralliophila abbreviata*, and the extensive tissue loss caused by these snails. Given their high prevalence and significant (and increasing) impacts to remaining restored *Acropora palmata* fragments and standing colonies, we removed several hundred snails (every snail we observed) within a 200 X 100 m area of *Acropora* habitat off Pajaros. During 2007, we will reexamine all living colonies in this area to determine the extent of reoccupation by new snails and degree of regrowth of coral tissue in affected ('treated') colonies. Based on the feasibility of the pilot study and potential contribution to recovery of acroporids in the area, we will expand this effort to include removal of snails from all *A. palmata* colonies identified through the ongoing GPS mapping effort.

4. Restoration approach for *Acropora palmata* to mitigate impacts of WBD:

Surveys conducted off Pajaros in 2006 indicated the continued persistence of white band disease on the remaining colonies. Over the 4 years of this outbreak, WBD has been the most significant source of mortality to remaining colonies. Large areas of *Acropora* habitat that previously contained extensive thickets of living, old growth colonies are now nearly devoid of living coral and 50-80% of the remaining live colonies showed signs of active WBD in August 2006. In Feb 2005, I conducted a pilot experiment to

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determine whether a portion of affected colonies can be salvaged and reestablished. This involved removal of apparently healthy branch tips from diseased colonies, and re-securing these to the reef substrate or dead standing colonies. A total of 25 fragments were secured either upside down or right side up to dead *A. palmata* colonies using cable ties. We attempted to secure additional fragments to hard substrate in a location free of macroalgae using underwater putty, but had difficulties in getting the fragments to attach to the reef due to the high wave surge conditions. We reexamined the fragments in December 2005 and again in August 2006. A total of 24 of the 25 fragments were still alive in 2006. Approximately 90% were securely fused to the substrate and fragments exhibited initial signs of growth (new protobranches), although growth has been slower than that recorded in early studies (linear extension rates of standing colonies). This may be due to the small size of the fragments (all were 15-30 cm in length), stress associated with the 2005 bleaching event, and/or a reallocation of energy towards reattachment. Despite the slower than expected growth, the fact that no branches have succumbed to WBD and all donor colonies are now 100% dead (unmanipulated branches were left on these colonies as controls) is a positive sign that this may be a feasible low-tech method to salvage colonies. We had intended to expand this study in 2006 (as indicated in our 2006 progress report), but were unable to accomplish this due to investment of time in snail removal experiments and GPS mapping efforts. In 2007, we propose to expand this study to include a larger sample size, fragments of different sizes, and two reattachment approaches - to the reef substrate and to dead colonies. In addition, we propose to attempt "treatment" of affected corals involving application of an underwater putty "bandage" over affected tissue to determine whether we can smother the pathogenic microorganisms associated with the WBD lesion. This highly successful approach was undertaken on a small scale at Mona Island in 2000 for large *Montastraea faveolata* colonies with YBD, and in the mid 1990s as a mechanism to treat massive corals affected by black band disease. The total number of corals we propose to treat is unknown at this time, as it is dependent on the extent of WBD observed in acroporid habitats. We envision an experiment involving reattachment of a minimum of 50 fragments (maximum of 200) and 25 additional WBD-affected branches treated with underwater putty.

In addition to the ecological restoration approaches, I will collect small pieces of diseased *Acropora palmata* tissue from 10 colonies for histological examination. This involves the removal of a small piece of a branch (5 X 5 cm) at the interface between denuded skeleton and live, diseased tissue, fixation in Z-fix for 12 hours, and subsequent processing at the NOAA Oxford Laboratory. All sampled colonies will be outside of the Fortuna Reefer grounding site.

5. Coral Disease (and benthic community structure) surveys:

1995-2006 Surveys. Paired radial sites (n=10; each 314 m² in area), were established in 1995 on five reefs around Mona Island (Carmelita North, Carmelita South, Mujeres West, Mujeres East and Carabinero; with additional sites selected near Pajaros in 2004), on two reefs off Desecheo, and on three reefs off La Parguera (Pinnacles, Mario and old Buoy) to characterize the prevalence and impact of coral diseases. All corals within each site were counted, recorded to species, and assessed for the presence of disease in 1995 and 1996. In 1999, sites were reassessed using a modified Atlantic and Gulf Rapid Reef

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Assessment (AGRRA) protocol. All corals within each radial site were recorded to species, measured, and their condition assessed for the following characteristics: percent live tissue, percent recent mortality and cause of mortality. Representative colonies affected by yellow band disease, black band disease and white band disease (primarily *Montastraea faveolata*, *M. annularis* and *M. franksi*) on each reef were marked in 1998-2000 with numbered tags; and one to five nails were placed in the exposed skeleton immediately behind the disease interface to measure rates of tissue loss. Each site was reexamined at least once per year between 2000 and 2006. Additional colonies were tagged in 2006 due to a reemergence of yellow band disease and an increase in other diseases and extent of tissue mortality, which may be linked to the mass bleaching event recorded in 2005. In July 2004 new paired sites were established on the east coast (Pajaros Reef, 15-18 m depth) in an area of high live coral cover and a low prevalence of disease. During the February 2005 surveys, we reassessed all corals within each radial site to characterize changes in coral community structure that have occurred since 1999. In December 2006, we conducted random AGGRA surveys throughout permanent sites as well as other random locations to characterize the extent of bleaching and initial impacts. We reevaluated these sites in August 2006 to characterize patterns of recovery and changes to living coral cover. In all of our sites we observed significant declines in living coral cover (losses of 20-60%), with *M. faveolata* and *M. annularis* sustaining the largest losses. In addition, we observed an increase in prevalence of diseases, including a reemergence of YBD on colonies in remission and numerous new infections on previously unimpacted colonies including the spread of this disease to Pajaros.

2007 surveys. In 2007 we will reexamine all permanent sites to determine the impacts of the 2005 bleaching event and subsequent disease outbreak. Efforts will focus on characterizing the coral composition and size structure, with emphasis on the extent of recruitment of reef building corals and changes to *Montastraea annularis* complex. In representative colonies with actively progressing disease, additional nails will be placed in the exposed skeleton immediately behind the diseased tissue. These will be reexamined two times during 2007 to determine spreading rates over this period.

Coral Sampling. If a disease outbreak is identified within permanent sites, samples will be collected of diseased tissue. Using a leather punch, small circular pieces of tissue, 1.5 cm diameter will be removed from selected colonies at the interface between recently exposed skeleton and live (diseased) tissue. These will be fixed in Z-fix, decalcified, embedded, sectioned and stained in the laboratory.

6. Reef fish Assemblage Surveys:

At each of the long-term survey sites as well as within and adjacent to the grounding site, belt transects (30 m x 2 m) and point count surveys (100 m² area) will be performed to census the diversity, abundance and size-classes of reef fishes. In the transects, all species of the following families are recorded: grouper, snapper, grunt, parrotfish, surgeonfish, triggerfish, angelfish, and butterflyfish; counts of yellowtail damselfish (*Microspathodon chrysurus*), hogfish (*Lacholaimus maximus*), Spanish hogfish (*Bodianus rufus*), barracuda (*Sphyræna barracuda*) and bar jack (*Caranx ruber*) will also be made. Point count surveys will record all fish species within the cylinder

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surveyed (Bohnsack-Bannerot method). The size of fish will be estimated to the nearest centimeter using a 1 m T-bar or ruled slate edge for scale. Fish census data will be analyzed in correlation with environmental conditions documented in benthic surveys.

Fish sampling: Past surveys have identified an unknown condition mainly manifested as black spots on the face afflicting some reef fish species, primarily French grunts (*Haemulon flaveolatum*). Prior samples (1996) were inconclusive as to the nature of the “infection.” During 2006 this work was not accomplished due to other priorities (i.e., the unexpectedly severe bleaching event) but we will again plan to explore this in 2007. We will sample by spear, up to 5 fish from sites at Mujeres, Carmelita, and Pajaros to conduct laboratory analysis to identify the infecting organism. The possibility that this persistent condition is environmentally caused, makes analysis of great interest.

7. Environmental monitoring:

Since coral bleaching and possibly spread of disease have been linked to elevated water temperatures, remote temperature monitors were placed in four locations around Mona Island and one location off Desecheo. These will be retrieved, data downloaded and redeployed at the various sampling sites. Additional environmental monitoring will be considered as warranted.