

Majuro Atoll Monitoring update FY 2011 Coral Reef Monitoring Final Report

Grant Title: Monitoring the effects of human and natural disturbances at Majuro Atoll

Grantee: College of the Marshall Islands

Award Period: October 1, 2010 - Sept. 30, 2011

Period covered by this report: October 1, 2010 – September 30, 2011

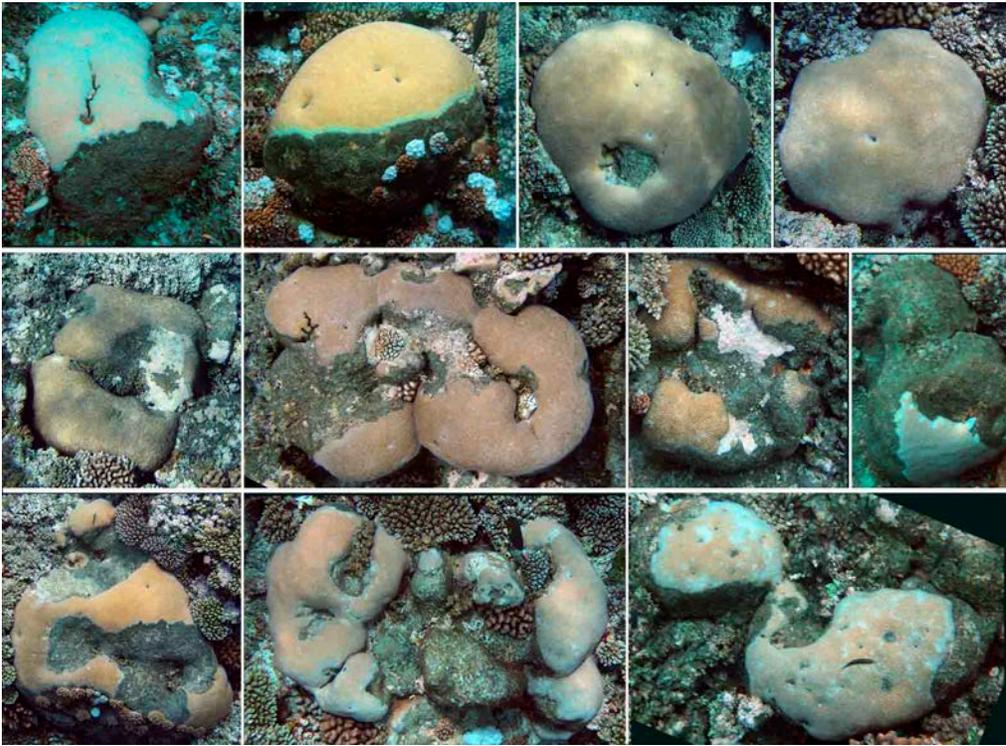
Summary of Progress

1. Work Accomplished

Three recent developments in the almost ten year span of my Majuro atoll reef monitoring efforts emerged in 2011. The first involves disease of massive corals. Recent efforts sought to characterize disease signs and determine the geographical extent of each disease syndrome, with a view to finding environmental correlates (such as human population density). Earlier work focused on Ajeltake and eastern Woja, with the highest disease incidence found. The western-most site, in Laura, was subjected in 2011 to time series analysis, a necessary tool since disease signs tend to be transient, displaying brief episodes of active spreading followed by periods of inactivity (during which the disease lesion is often overgrown and obscured by encrusting algae).

Massive Coral Disease

Now that enough time-series are in hand, it is clear that the Laura population of massive corals such as *Hydnophora* and *Platygyra* are nearly free of signs of active disease, although they suffer considerably from the pernicious algal over-growth that is widespread in southern Majuro. However, late in the year, two instances of active disease were documented, perhaps indicating the inception of a more widespread disease outbreak. Given the much lower density of human settlement along the adjacent shoreline in Laura compared to the Ajeltake, sites, this strengthens the case that localized sources of human waste are a contributing factor.



2011 Laura South massive corals (mostly *Hydnophora*). Compare these signs with those of Ajeltake (below), which in most cases clearly display infectious lesions not entirely covered by encrusting algae.

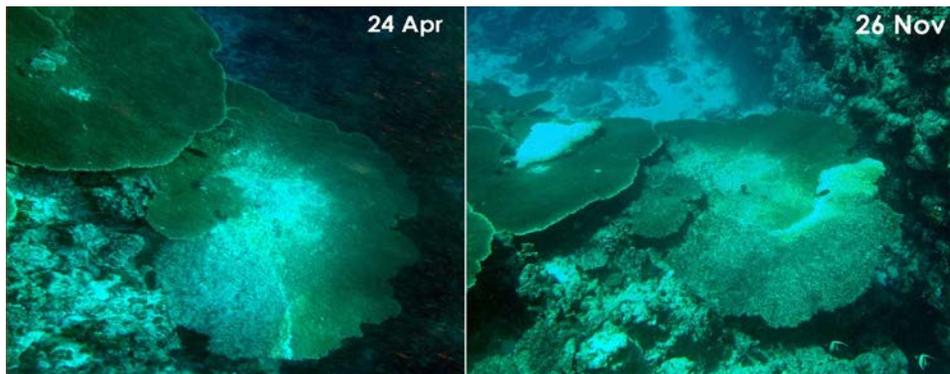


Rapid assessments of massive coral health at the Airport further support this hypothesis, as the colonies appear healthier than in Ajeltake. (This site is normally inaccessible due to powerful surf)

The trajectory of this disease lags behind those that infect tabulate *Acropora* colonies (first observed in 2001 in Laura) and foliose *Turbinaria* colonies (first seen in 2006 after an estimated 3 years of disease progression had already occurred).

To summarize what is known so far, the following microbial coral disease syndromes are found on Majuro:

A. White syndrome affecting *Acropora* spp oceanside (especially *A. cytherea*, from Rita to Laura), disease is usually peripheral and appears as a white band spreading like the hands of a clock, 2 cm/day. (2003 to present) 70% of table coral population has been killed since 2003, but disease incidence has declined considerably despite a still abundant population. Brown band ciliates were often seen within the white band in 2004. Mortality was almost always complete.



2011 white syndrome progression on *Acropora cytherea* at Laura South

B. White syndrome affecting *Acropora* cf. *paniculata* inside Uliga dock (2009-2010), disease lesion beginning in center and spreading rapidly outward (2 cm/day). Mortality complete, except for purple-hued colonies, which lose 40-75% of tissue.

C. "Slow" syndrome on numerous massives (especially *Hydnophora microconos* and *Platygyra sinensis*, but also *Scapophyllia*, *Favia* spp., and *Pavona duerdeni*. First noted in 2003, Rairok, and later detected in 2006, Ajeltake. Infections often start at worm or shrimp burrows. Leading edge often but not always marked by green algal discoloration. The active leading edge often has a bleached band inside of a darkened brownish band. Mortality was always complete.

D. A common infection of *Isopora* have a similar slow spreading rate, moving upward through colony. Disease has recently killed over half of the once dominant population in Ajeltake and Woja (the high mortality in Laura is due to COTS, however). Mortality complete.

E. The slowest tissue loss syndrome involves *Symphyllia recta*, very few colonies are unaffected from Rairok to Laura. No algal discoloration along the leading edge. However, once still finds some unblemished large colonies in Rairok.

F. *Turbinaria* colonies in Laura also have slow spreading rates, incidence has risen dramatically in recent years (from only two colonies in 2006 to at least 50% of all colonies in 2011). In some cases coral growth can outpace tissue loss. In two weeks, the lesion below advanced a mere millimeter or so, roughly equal with the coral's growth rate.



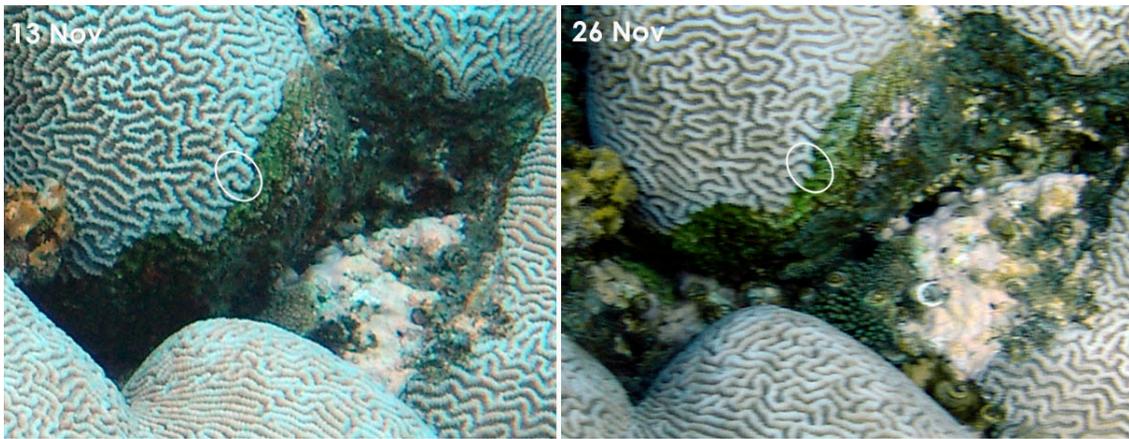
G. Massive *Porites* sp. (ocean reefs) show very high mortality on much of the southern shore, usually as a slow tissue loss syndrome similar to *Symphyllia*, but also as sudden episodes of blotchy bleaching and tissue loss. Re-sheeting can occur on some lesions, unlike any other disease-like syndrome.

Additional algal overgrowth syndromes are a dominant cause of tissue loss.

H. Branching *Porites cylindrica*, Arrak lagoon, near shore: A nearly black encrusting algae grows from the base upward, destroying large colonies (large outbreak in 2005). This coral further east in Ajeltake appears unaffected.

I. Dark brownish-green or dark grey encrusting algae (resembling *Peyssonnelia*) overgrowing all species massive and foliose corals in Ajeltake to Laura, with very high incidence, affecting the same species as in C (along with *Porites*, *Montipora*, *Echinopora* and others), usually colonizing disease lesions or growing upward from base.

New green lesion on Laura Platygyra.



Growth anomalies

Aberrant growths are commonly seen on tabulate *Acropora*, but not on other coral.

Of these nine syndromes, only A (white syndrome) has been found on Arno. An additional syndrome, resembling red-band disease, was found on a single *Platygyra* colony in northern Arno in 2004.

Disease signs can be divided into two classes: single lesions that spread throughout the colony, and colonies with multiple lesions, additional lesions appearing more than a year after the infection first appeared.

Single lesion: A, B, D

Multiple lesions: C, F, E

Crown of thorns Resurgence

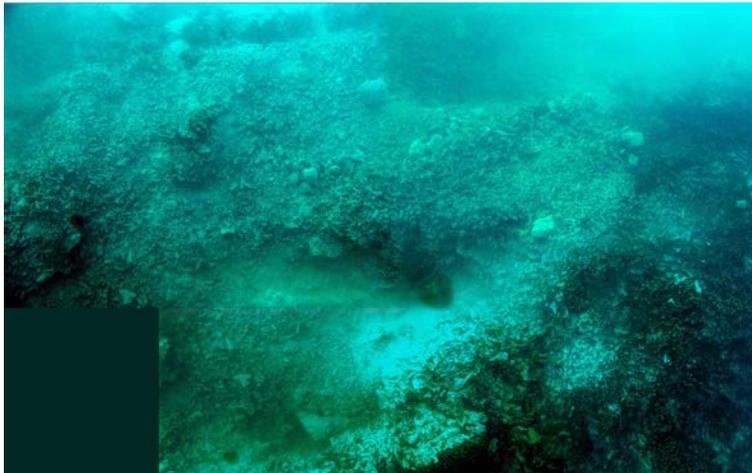
A small number of COTS signs (fresh feeding scars) were seen last year in Rairok. These signs increased in 2011, and were also found at a number of other sites (see map). Four animals collected at Laura in November shows the presence of at least 3 year classes, including very young individuals. (Indeed, the feeding scars mostly involved small coral colonies).



An attempt was made in November to check on the Arno Arno outbreak, which began several years ago, but the boat malfunctioned.

Lagoon reefs impinged by Airport construction projects

The story of my characterization of the reef at the western end of the runway, and my intervention on behalf of this reef, was told in the previous report. Since then, I surveyed the reef that had been suction dredged by the contractor in 2008 for the ARFF project (rescue and fire station facility). Due to the abundant fine sediments leftover from the mining, this site is usually very turbid. I took advantage of an unusually calm period, maximizing water clarity. By assembling “fisheye” view mosaics, I was able to show the massive extent of the devastation.



2008 view before the conclusion of suction dredging

Devastation of a coral reef caused by suction dredging in 2008 by PII for the FAA Airport Fire Station Project





In the three years following mining, very little coral recruitment has occurred. Coral restoration should be a required mitigation, and this is especially warranted due to the former dominance of *Porites rus*. Transplanting a variety of coral, including fast growing branching species such as *Acropora muricata* would “reset” the reef to one more attractive to fish. Rebar can be hammered into soft sediment pockets, while hard substrate can be planted using Tygon tubing adaptors, the tubing to be nailed onto rock.

Fish Populations

Informal assessments have been made of certain food or commercially valuable fish, including flame angelfish, reef sharks, napoleon wrasse, Pacific steephead and longnose parrotfish, and rabbitfish.

For the past few years very few flame angelfish have been seen, a dramatic decline. On outer islands these are common even above 10 meters, but unregulated overfishing has apparently exhausted this population. Aquarium fish collectors now range far north (to Maleolap) and south (to Mili) in search of fish.

Napoleon wrasse (*Cheilinus undulata*) is a critically overfished species, and local incentives to hunt this magnificent fish are high; the owner of a Chinese restaurant in Uliga is known to pay \$100 for a single fish. Delap point was know for the largest population (three or more adult super males) but a recent November visit revealed only one male. Numerous sites between Delap and Uliga previously hosted other super-males, but in 2011 none were found; only smaller females or juveniles were found.

Delap Point was found to be a spectacular aggregation site for Black snapper, bigeye travelly, blue fin trevally and rudderfish. Numerous schools, each numbering in the hundreds, were found over a coral-rich segment of shelf. Just north of the point, where coral relief abruptly became much lower (due to strong wave action), fish abundance dropped just as abruptly. A video of the big eye school, along with a turtle is found on YouTube: "Delap point2011".



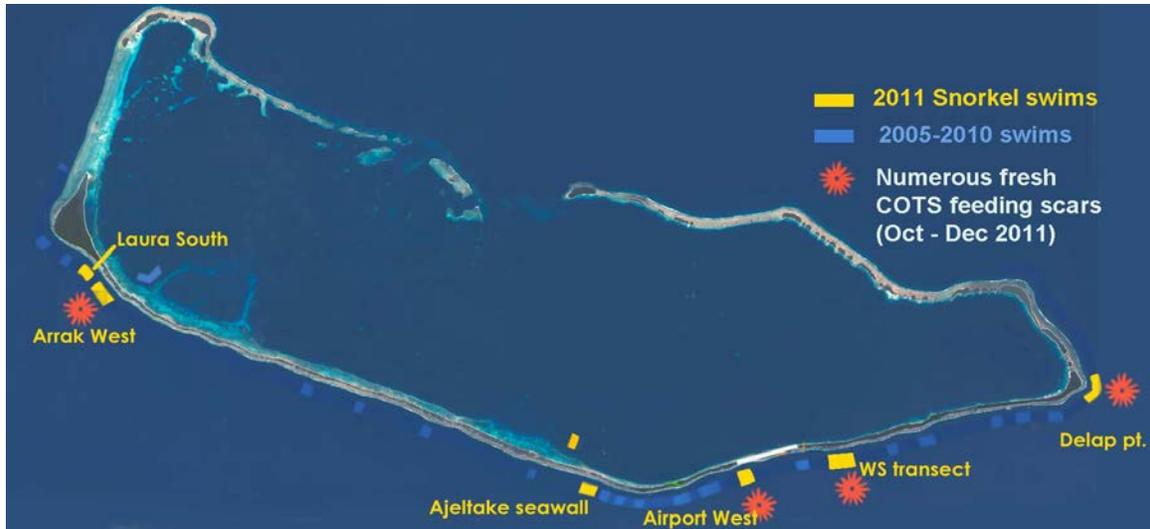
Kyphosid school south of Delap Point, up-current of the largest fish aggregation site.



Four steephead parrotfish (filled arrow) with a threadfin parrot (open arrow)

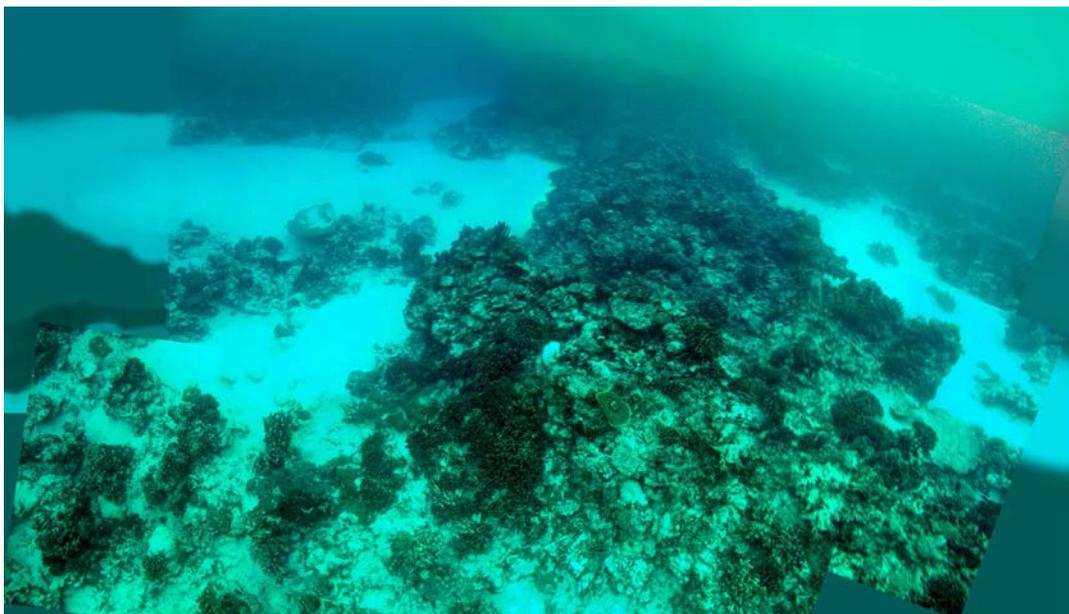
Much larger schools of steepheads (i.e. over 15 on Likiep) and other large species are typical of outer islands.

New sites:



The reef between Arrak CMI campus and the southern Laura site, “Arrak West” was snorkel, a swim stretching over 500 meters.

Several dozen fresh COTS feeding scars (mostly on *Isopora*) were seen, the highest feeding intensity currently known on Majuro. Coral cover was exceptionally low, and many dead or nearly dead massive *Porites* were seen. The shallow spur substrate, which in Laura has nearly 100% coral cover, was nearly barren. A large sediment-filled basin system over 50 meters offshore was associated with a “plastered” or “white-washed” region within the spur and groove system. This carbonate veneer prevented any coral recruitment.



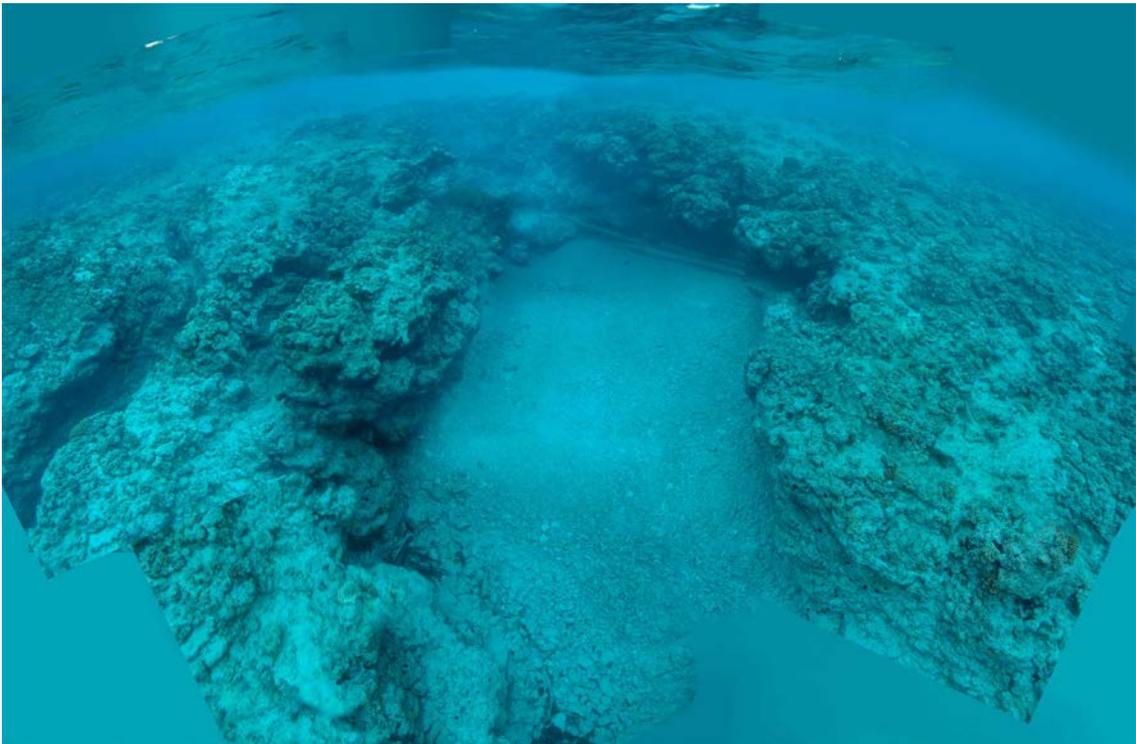


“plastered” substrate; arrows shows Chevron butterfly fish on its isolated “island” table.

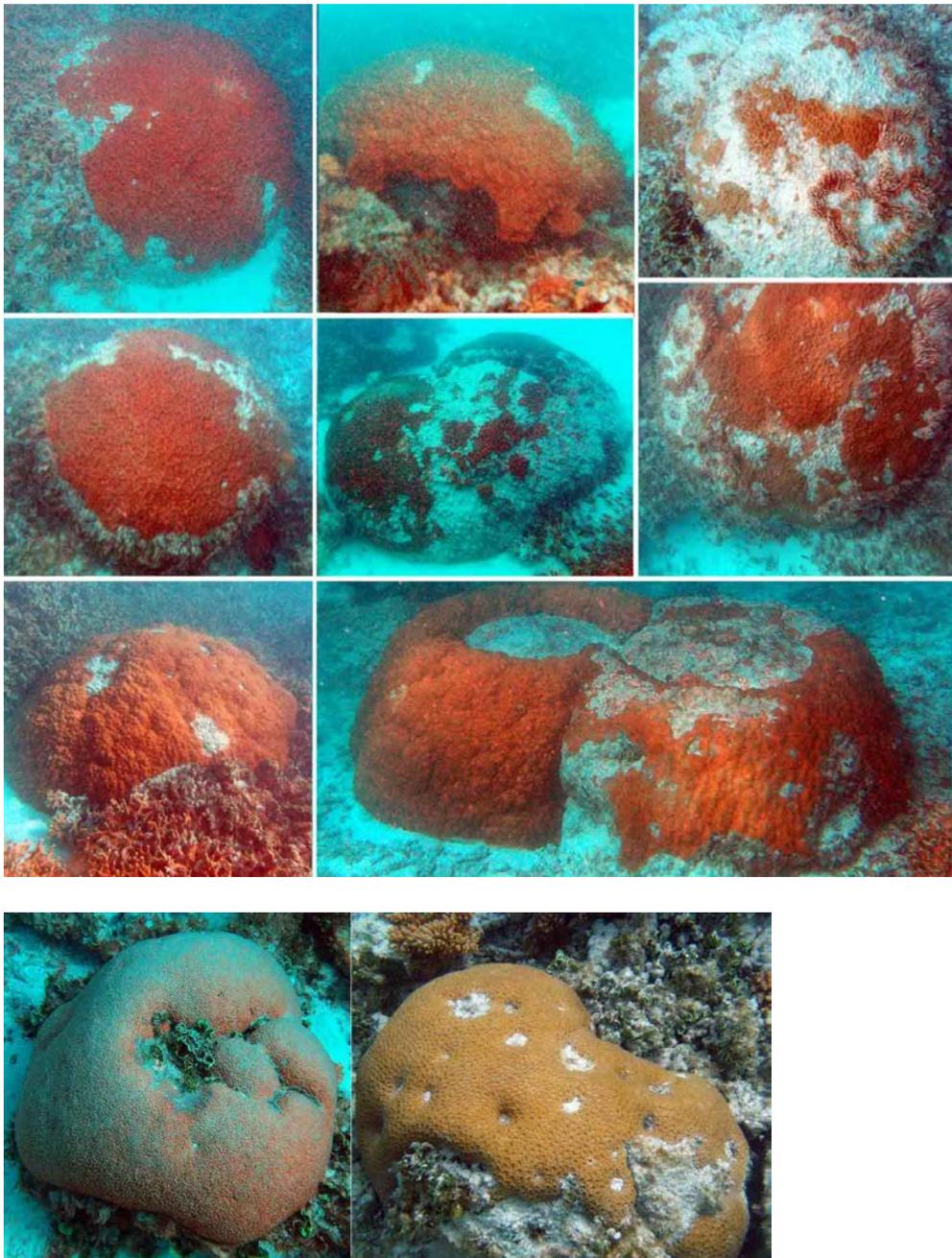


Fish abundance was very low. I found only two pyramid butterfly fish (a species typically found in schools of 50 or more). Black surgeons (*Ctenochaetus striatus*) were spawning in very small groups, strung out along the shore. Normally this species forms aggregations of over 100 fish before engaging in coordinated group spawning. This is the only time I have seen such “scattered” spawning in this species; perhaps the population is too low to trigger an aggregation.

To the west of the coral-rich Laura South site, the shallow reef is extremely barren, as shown by this fish-eye panoramic mosaic. Apparently the coral-rich shallow band opposite the radio tower is a small remnant, surrounded by degraded reef.



A new site in the lagoon in Ajeltake was visited revealing much less COTS damage (during the 2004-2006 peak of the outbreak) than reefs further to the west, in Woja. Small COTS-killed tabulate *Acropora* hosted only sparse coral (chiefly *Pocillopora damicornis*). At the shelf a living, intact reef of large tabulate *Acropora* grew as multi-tiered structures. Three rare massive colonies (*Favia*, *Astreopora*, and *Scapophyllia*) were healthy, free of disease or large dead areas. However, over half of the massive *Porites* colonies inside of the shelf edge showed considerable tissue loss in a pattern that matches those in the far eastern lagoon that suffered bleaching mortality as a result of the 2009 hot water episode. As shown, tissue loss ranged from >10 to 90%. Macroalgal growth was abundant on dead coral, the typical *Halimeda* and *Asparagopsis* blankets.



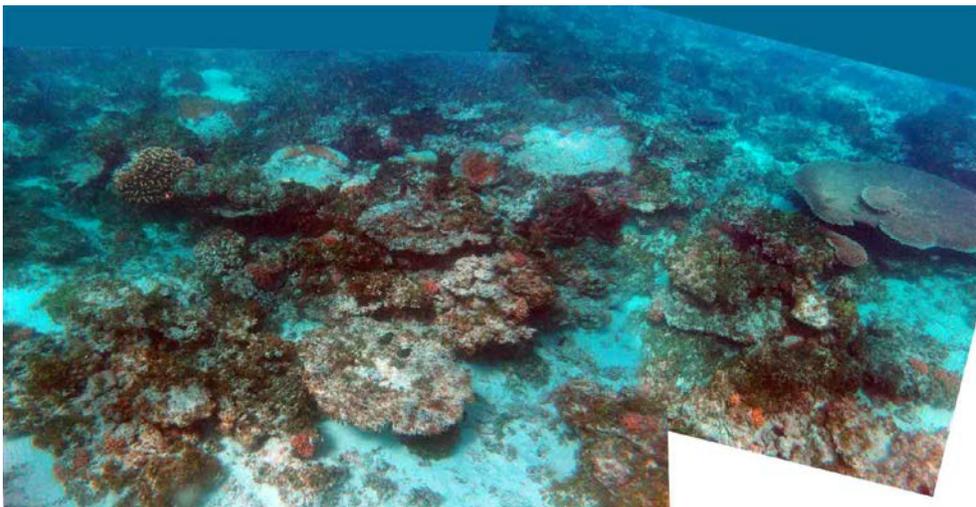
Healthy *Astreopora* (left) and *Favia*, two lagoon forms very uncommon on Majuro



Impressive multi-tiered *Acropora cytherea* colonies at the outer edge of the reef.



Branching *Porites* dominates near shore, joined by *Heliopora*.



Tabulate colonies killed by COTS in 2005 or so, showing very little coral recruitment.

The Airport West site was visited for the first time in several years to determine the geographical leading edge of the “black slime” algae, an encrusting rhodophyte. This is a high-energy reef; the waves limit coral development in the shallows. No black slime was found, even though it had spread to the eastern edge of the airport in 2008. Given its 1-2 km/year spreading rate, it should have appeared at the west end of the airport. The fact that it did not may indicate that with out elevated nutrients, like those found in the populated area of Rairok, it is unable to become established. The airport may be acting as a “fire break” preventing its further spread. This airport reef had large schools of rabbitfish (also seen in Ajeltake, but missing from a number of sites) as well as snappers and rudderfish, suggesting that this would be a valuable protected area.

In conclusion, as more sites are visited, one is left with an impression of increasingly degraded reefs on Majuro. This is a slow-motion crisis. The reefs are dying! The ongoing mining of near-shore reefs by contactors, funded by US FAA, is in this context alarming. Local food security is being put at ever increasing risk, as the ecological functioning of reefs, as both food and shelter for fish, is further reduced. It is time to stop this destruction and begin a process of reef restoration, at the very least as mitigation (a promised by as yet unrealized component of each FAA project, whose budgets have totaled tens of millions of dollars) for past reef destruction.

II. Data Analysis Workshop

Introduction

Despite having common goals of protecting their resources for future generations, jurisdictions across Micronesia differ in their approach used to monitor coral reefs, and thus, in the information that is available for conservation and management. In 2009, a positive collaboration between the Pacific Marine Resources Institute (PMRI), Dr. Peter Houk, and RMI coral monitoring and management programs was initiated under the framework of the Micronesian Challenge. Through this effort, existing datasets were examined, and new tools and software were provided to RMI’s programs to enhance the scientific rigor of coral-reef monitoring. Subsequently, a recent award from the University of Guam, Western Pacific Coral Reef Institute, provided for extensive, collaborative monitoring on Majuro and Rongelap atolls. Standardized protocols were used to collect coral, fish, macroinvertebrate, and benthic substrate data across 10 sites on each atoll. A final report summarizing the findings is nearly completed, and a manuscript in preparation that will highlight the ecological gradients founds, and hopefully provide an improved framework for management and conservation. This project built upon these efforts by bringing Dr. Peter Houk to Majuro for a week long data analysis and interpretation workshop. During this workshop, many datasets across Micronesia, as well as the specific datasets in the RMI, were examined. Additionally, a step-by-step guidebook that was previously developed by PMRI was provided to the local programs for continued use into the future. This book provides a “hands on” vector for individuals to evaluate their data, and learn how to efficiently visualize and, when appropriate, test for significance. The guidebook represents a framework for this process. The guidebook was produced using four major software platforms: Microsoft

Excel, Access, PRIMER-E, and Sigma Plot. These software were procured by the College of the Marshall Islands (CMI) to provide licenses for all of the relevant local programs.

Agenda:

Monday (9/12, 9AM – 4 PM). Working group introduction, personal introductions, load necessary software platforms on laptops. Licensed copies of the PRIMER and PERMANOVA+ software will be available as well updated versions of MS Excel 2010. Trial versions, and potentially licensed copies, of Sigmaplot will be available. Introduce guidebook and begin conducting exercises and associated short presentations. Work on Excel data manipulations, database building, and interpretive graphing. All datasets we will use are from coral monitoring programs across Micronesia, including the RMI.

Tuesday (9/13, 9AM – 4 PM). Initial presentation describing varying approaches toward conceptualizing large datasets and extracting information to meet our driving questions effectively and efficiently. Continue guidebook exercises and associated short presentations/discussions. Work continues on Excel-data manipulations, begin working with Sigmaplot for graphing and univariate statistics.

Wednesday (9/14, 9AM – 4 PM). Initial presentation deals with Sigmaplot and R software packages as tools for handling, analyzing, and graphing univariate datasets of interest. Continue guidebook exercises and associated short presentations/discussions. Work continues on Excel data manipulations, advanced uses of Sigmaplot for graphing and univariate statistics, as well as using R for conducting power analysis.

Thursday (9/15, 9AM). Initial presentation describing varying approaches toward handling and processing multivariate datasets, and how the PRIMER platform can assist us. Continue guidebook exercises and associated short presentations/discussions. Work continues on Excel data manipulations, but will focus on data importation to PRIMER. Thursday afternoon each monitoring program will get together and collectively work on processing/formatting some aspect of their dataset. This could be building a sound database or conducting higher level analyses that were learned. Each program will present out to the group on Friday.

Friday (9/16, 9AM – 4 PM) Complete guidebook exercises pertaining to multivariate analyses. Programs will report to group on their data management or analyses efforts they have been working on. Discuss presentations with the group.
Friday PM – Presentation on the findings of recent work completed by PMRI and MICS in Rongelap and Majuro. These datasets will also be used throughout the week whenever possible, and will be handed over to all RMI monitoring programs.

Summary of Accomplishments:

During the week of 12 - 16 September 2011 the Pacific Marine Resources Institute (PMRI) conducted an informative and timely data management and analysis workshop for RMI ecological monitoring programs. Through the workshop there was a direct transfer of skills and reference materials to enable improved data processing, handling, visualization, and statistical examination. These products are all necessary to improve RMI's ability to evaluate the **quality** and **meaning** of coral

reef monitoring program datasets. The step-by-step guidebook provided to participants at this workshop will continue to be available online through PMRI's website (www.pacmares.com). Also, electronic copies of the guidebook were provided along with all powerpoints and other reference materials used on an accompanying CD-ROM.

Project Activities:

During the workshop, powerpoint presentation were first made for each of the numerous topics covered by the guidebook by Dr. Peter Houk. Pending some discussion and generalized group calculations to ensure that analytical concepts were initially transferred, collaborative work on the exercise guidebook followed. While participants explored the various datasets from the RMI and Micronesia's coral monitoring programs while completing the exercises, Dr. Houk provided further individual guidance to participants as necessary on a continuous basis. This proved to be a very successful approach for peer learning and also enhanced collaboration, as many of the participants teamed up to process datasets that were collected together.

Summarized list of activities:

- Activities conducted at the workshop included:
 - Transfer of enhanced data analysis skills through the week-long workshop;
 - Powerpoints to describe initial concepts for each software platform, including subsequent discussions from the group;
 - Analyzing many existing datasets together, and providing one-on-one technical guidance for participants while conducting the exercises;
 - Discussing each exercise for technical as well as conceptual insight;
 - Work with newly collected datasets from Rongelap and Majuro and assess statistical power and trends;
 - Jurisdictions present one example of their own data analysis back to the group to facilitate peer-to-peer learning and discussion;
 - Introduction and basic usage of three desirable software platforms for analyzing ecological datasets (advanced Microsoft Excel, Sigmaplot, and PRIMER/PERMANOVA+.

Project Outcomes

Through completing this workshop we collectively took logical steps towards improving RMI's monitoring programs. Capacity building is a sincere requirement for improving coral monitoring programs, and continuous collaboration with regional partners, and scientific expertise when needed, are key to positive change. While much data exists in the RMI, questions regarding their quality and ability to

answer pressing management concerns exist. Through this workshop: 1) programs have an improved ability to assess the quality of existing datasets, and 2) if data quality is acceptable, programs have an improved ability to translate these data for management. It is not suggested that the insight gained represents the total capacity needed for monitoring program to flourish through time. Rather, this represents a logical step in the right direction. Through continued meetings and trainings, peer-to-peer learning and technical skills will continue to develop. More than just evaluating local management issues, improved data collection and interpretation facilitates an improved understanding of major regional efforts such as the Micronesian Challenge.