Comprehensive Long-term Coral Reef Monitoring at Permanent Sites on Guam: Final Report for NA10NOS4260046 December 2012 Status Report

Prepared by Dave Burdick, Monitoring Program Coordinator

Program overview

The *Comprehensive Long-term Monitoring at Permanent Sites in Guam* project involves the collection of data for a suite of coral reef ecosystem health parameters at several high priority reef sites around the island. Data are collected annually by a team of highly-trained field biologists from the Guam Coastal Management Program, the NOAA Pacific Islands Regional Office, the University of Guam Marine Lab, and with occasional assistance by staff from other agencies. The monitoring team collects data for a number of important parameters related to ecosystem health; these parameters are grouped into three categories: water quality, benthic habitat, and associated biological communities. Many of these parameters are indicators of stressors, and significant changes in these parameters will likely raise concern and possibly trigger management actions. Data collected for these indicators will also provide important information about the resilience of high priority reef areas around Guam. Monitoring these parameters will also allow resource managers to evaluate the effectiveness of specific management strategies, and inform the development of new management actions.

2012 accomplishments at a glance:

- Essential services, equipment, and supplies procured
- Staff participated in NOAA/DOI Motorboat Operator Certification Course
- Piti Bay monitoring site was established
- Collection of benthic habitat and macroinvertebrate data completed at Piti Bay, Tumon Bay, and East Agana Bay sites
- Reef fish community surveys completed at 14 stations in Piti Bay and 4 in Tumon Bay
- A total of 215 team member dives carried out over 24 field days
- Support provided Humatak Project with installation of sediment traps and CTDs in Fouha Bay
- Site exploration carried out in Fouha Bay
- Training received in calibration of datasonde sensors
- Significant progress made in development of monitoring database and web-based data entry application

Summary of 2012 program activity

Preparation for 2012 field season

Upon completion of data collection for the 2011 field season, the results of the preliminary analysis of benthic cover and reef fish community data collected to-date were presented in a report entitled *Comprehensive Long-term Monitoring at Permanent Sites in Guam: Report of program status and presentation of preliminary baseline data and power*

analyses results for Tumon Bay, East Agana Bay, and Western Shoals sites. The report also presented a thorough summary of the program's brief history, which can be referred to if more background information is desired.

Soon after the submission of the report, preparations for the 2012 field season began with the procurement of scuba cylinder rental services, a boat charter service, a replacement point and shoot camera/housing, an additional set of dive gear, and consumables. Field season preparations also included providing assistance to Valerie Brown, Coral Reef Ecologist with NOAA's Pacific Islands Regional Office, in the cleaning and maintenance of the newly-acquired 18' Achilles inflatable, engine, and trailer. The Achilles will allow access to relatively sheltered sites and those sites in relatively close proximity to a marina, such as Western Shoals, East Agana Bay, and sites located along the southwestern coast. The Achilles will also provide a cost-effective means of installing, maintaining, and retrieving datasondes, temperature/conductivity loggers, and other water quality instrumentation. The larger and more stable platform provided by the boat charter service will continue to be used for Tumon Bay, Piti Bay, and sites located on the southeast coast.

In order to prepare for the eventual use of the Achilles for monitoring program activities, several monitoring program staff received training and certification as NOAA small boat operators. The monitoring coordinator and Ms. Brown participated in a three-day NOAA/Department of Interior Motorboat Operator Certification Course (MOCC) and a two-day Open Water Module (OWM) in Hawai'i from March 26-30. The 2012 NOAA Technical Support Specialist and recently selected 2013 NOAA Coral Fellow, Roxanna Miller, as well as staff from partnering agencies, participated in the same courses when brought to Guam in September 2012. The monitoring coordinator, Ms. Brown, Ms. Miller, along with other federal and Government of Guam staff, also participated in a NOAA Component Course and an Operational Risk Management Workshop held on Guam on May 1-2; these courses are required in addition to the MOCC/OWM prior to operating a NOAA vessel. During this time the 18' Achilles inflatable boat, engine, and trailer acquired by the NOAA PIRO Guam Field Office from the National Park Service was also inspected by NOAA PIRFSC staff. The Monitoring Coordinator, Ms. Brown, and Mrs. Miller, and several other staff from partnering agencies will be able to operate the Achilles once a boat policy is approved.

Prior to the commencement of data collection efforts, monitoring program staff participated in several training/survey calibration dives. Time was also spent delineating the initial site boundaries for the Piti Bay monitoring site. Images taken during a series of exploratory dives along the length of the outer reef slope in Piti Bay in November 2011 were georeferenced using the software application GPS-Photo Link, and were then added to a Geographic Information System. The georeferenced images were critical in the accurate delineation of the site's eastern boundary, where a more topographically complex reef structure typical of the western and central portion of the bay's outer reef slope transitions into a reef structure with relatively low rugosity. LIDAR bathymetry data were used to constrain the site boundaries to a depth range of between 7 and 15 meters.

Data collection

Data collection for the 2012 field season began at the newly established Piti Bay monitoring site in July 2012. A total of eight field days between July 23 and August 31 and a total of 90 team member dives were required to complete all benthic and macroinvertebrate surveys and the majority of fish surveys at the site's 20 sampling stations. Fish surveys were not conducted at four of the Piti Bay sampling stations due to the unavailability of Ms. Brown during those field days.

Upon completion of data collection within the Piti site, data collection efforts began in the Tumon Bay site. As described in the 2011 report, the results of a preliminary analysis of data collected in the Tumon Bay site in 2010 indicated that the eastern and western halves of the site possess distinctly different benthic communities, and suggested that the site boundaries may need to be re-drawn in order to minimize variance in key ecosystem health parameters and increase the ability to detect relatively small changes with a relatively small sample size. In order to collect data to inform the re-delineation of the Tumon site, a series of three exploratory dives was carried out on Sept. 7 along approximately 2.4 km of the outer reef slope of the southern half of Tumon Bay; the dives began at the far southwestern extent of the original monitoring site boundary and ended approximately 0.75 km beyond the northeastern boundary. Photos taken during the exploratory dives were georeferenced and used in a GIS to delineate new site boundaries that enclose a more homogeneous benthic community. The new (and still tentative) Tumon site boundary includes about half of the original site and extends northwestward.

Between Sept. 5 and Nov. 9, the monitoring team completed photo transect, coral quadrat, macroinvertebrate, and rugosity surveys at a total of 21 sampling stations within the new Tumon Bay site, including three permanent stations originally surveyed in 2010, nine new permanent stations, and nine non-permanent stations. The data collection effort in Tumon Bay required a total of 76 team member dives carried out over nine field days. Fish surveys were carried out at a total of four sampling stations, but could not be completed at the remaining stations due the limited availability of Ms. Brown.

Following the completion of surveys in the Tumon site, data collection began in East Agana Bay. The monitoring team carried out photo transect, coral quadrat, macroinvertebrate, and rugosity surveys at 10 permanent sampling stations. A total of 35 team member dives over four field days between Nov. 16 and Nov. 28 were required to complete surveys at the permanent stations. A new set of non-permanent stations was not surveyed due to the lack of remaining boat time through the charter service and the unavailability of the Achilles.

A list of all sampling stations surveyed to-date is presented in Appendix A.

Data analysis

A limited amount of analysis for other datasets has occurred since the submission of the December 2011 report, including a preliminary analysis of coral colony size data from sites surveyed in 2010 and 2011 and macroinvertebrate data from all sites/sampling periods except the recent sampling effort of East Agana Bay. The analysis of macroinvertebrate data was recently requested by the Department of Agriculture's Division of Aquatic and Wildlife Resources and focused primarily on data pertaining to holothurians. The results of the preliminary analysis of coral colony size data, which was carried out by the 2012 NOAA Technical Support Specialist, is presented in Appendix B. The results of further analyses will be provided in a comprehensive technical report to be released in 2013. Once data collection efforts for the 2012 field season were completed, work began on the substantial amount of effort required to analyze the hundreds of photo transect images using CPCe.

Database

A database server and associated applications for data entry, quality control, management, analysis and reporting are currently in development through collaboration with NOAA PIFSC Coral Reef Ecosystem Division. The database hardware and software have been procured and are currently housed at the Government of Guam's Department of Administration. NOAA CRED staff, through regular consultation

with the Monitoring Coordinator, designed data models and migrated several datasets to a temporary database server that will be used for the testing of the web-based applications. Data migration has occurred for the coral colony, macroinvertebrate, and fish data; development and testing of a web-based application is currently on-going. The data entry application will likely be launched in early 2013, with the integration of the benthic cover and water quality data occurring later in the year. Future web application development will likely provide for the automatic generation of descriptive statistics and summary reports, as well as additional functionality for the display and query of spatial data. The Bureau of Statistics and Plans also hired a contractor to assist the Monitoring Coordinator and the NOAA Technical Support Specialist in compiling coral reef monitoring/assessment datasets and associated metadata from various organizations. The information gathered through the effort, which was completed in December, will allow for the eventual integration of data from a handful of Guam coral reef monitoring projects, possibly including the NOAA PIRO-supported Community-based Coral Reef Monitoring Program, DAWR's Marine Preserve Monitoring Program, and Guam EPA's E-MAP and Status and Trends programs. At a later date, metadata for these and a number of other Guam coral reef assessment/monitoring efforts may be made searchable through a web application.

Reporting

While the results of the preliminary analysis of select datasets were not broadly distributed, general information about the monitoring program was presented to the public via an informational pamphlet, several blog articles written by the NOAA Technical Support Specialist and the Monitoring Coordinator, and presentations to students of various ages.

Other Monitoring Program activities

Between October 31st and November 1st, the Monitoring Coordinator and the NOAA Technical Support Specialist assisted Austin Shelton, Coordinator of the Humatak Project and a Ph.D. student at the University of Hawai'i at Manoa, with the installation of ten sediment trap devices and three CTDs within Fouha Bay. The Monitoring Coordinator and the NOAA Technical Support Specialist retrieved the sediment traps and CTDs in late November. The primary purpose of the sediment traps and CTDs is to provide data to support Mr. Shelton's thesis work and to evaluate the effectiveness of watershed restoration efforts and other work carried out for the Humatak Project, but the data will also aid in the interpretation of biological data collected through the long-term monitoring program; the long-term monitoring program data will, in turn, contribute to Austin's thesis research and to the Humatak Project. The Monitoring Coordinator and NOAA Technical Support Specialist also utilized the visit to Fouha Bay to collect numerous georeferenced images of the reef to aid in the delineation of the monitoring site/strata boundaries as well as began efforts to document the diversity of coral species within the bay.

2012 NOAA Technical Support Specialist

In FY2012, a NOAA-funded technical support specialist was hired to assist with various aspects of the long-term coral reef monitoring program and related monitoring and assessment activities, such as carrying out different types of field surveys, assisting with the development of the program's water quality monitoring component, helping to coordinate the activities of the monitoring assistants, assisting

with data management and analysis, and developing outreach materials and participating in outreach events. The position has proved critical in the continued development of the long-term monitoring program, significantly improving the capacity of the program, which had previously been dependent on a single full-time staff (the coordinator) and several part-time monitoring assistants who sometimes required a considerable amount of training and whose course schedules sometimes presented challenges to completing the required field work in a timely manner. The success of the one-year position led to consensus that the position should be continued, and for FY2013 the responsibilities currently carried out by the Technical Support Specialist will be funded through the NOAA Coral Reef Fellowship Program. Funding was also requested to support the continuance of the Fellow/Technical Support Position through FY2014 and FY2015.

Program challenges

While the monitoring team carried out a total of 215 team member dives over the course of 24 field days, established a new monitoring site in Piti Bay, collected a second set of data for the Tumon and East Agana Bay sites, and assisted with the installation and retrieval of water quality instrumentation in Fouha Bay, several challenges limited the collection of reef fish community data and prevented the completion of data collection at the non-permanent stations in East Agana Bay. A late start as a result of procurement challenges extended the field season into the time of the year when tropical disturbances are more common, and, indeed, dangerous water conditions limited the number of available field days.

Data collection at sampling stations required more time than in previous years, primarily due to the time required to train and calibrate a new monitoring assistant with the Stationary Point Count (SPC) method used by Valerie Brown to census reef fish communities. During the training/calibration period, which is still on-going and is necessarily intensive due to the high potential for inter-observer bias when surveying reef fish communities, Ms. Brown had to complete two SPCs during a single dive instead of two divers each simultaneously completing one, causing the total dive time to be nearly double that of the previous two years. As a result, only two sampling stations (and sometimes only) could be completed during a field day. The limited availability of Ms. Brown in the latter half of the field season also contributed to the limited amount of reef fish community data collected in 2013. The class schedules of the monitoring assistants also presented challenges once the semester began in mid-August, with the monitoring team having to return earlier than usual to attend class.

The reduced the number of sampling stations that could be surveyed in a given day, in turn, reduced the total number of sampling stations that could be surveyed utilizing the limited number of boat days available through the boat charter service. Unfortunately, the Achilles was not available to finish surveys in East Agana Bay; in any case, the commencement of the trade winds would have greatly limited the use of the Achilles.

The deployment of datasondes, temperature/conductivity loggers, and temperature loggers did not occur during the 2012 field season as was originally scheduled, primarily as a result of the lack of staff training in the proper deployment of the instrumentation and the discovery that several calibration standards for the multiparameter datasondes had expired. However, hands-on training was recently provided by Guam EPA staff to the Monitoring Coordinator and the NOAA Technical Support Specialist in the calibration of the various datasonde sensors and training in the use of the datasondes in the field is scheduled to occur in early 2013.

Program plans for 2013

The benthic cover data derived from photo transect images collected at the Piti Bay and Tumon Bay sites will be explored in multivariate space using PRIMER/PERMANOVA and power analyses will be carried out for coral cover and other parameters in order to determine if the sampling designs for the Piti Bay site and the new boundaries for the Tumon Bay site are adequate for achieving the desired level of statistical power. Further analysis of coral colony size/condition and macroinvertebrate data collected in 2010, 2011, and 2012, and the generation of descriptive statistics for these datasets, will also be carried out in early 2013. Assistance by Dr. Peter Houk will also be sought in the further analysis of the baseline data from Piti, for the comparison of data collected at sites across time, as well as between-site comparisons. Once further analysis is carried out with the 2010 and 2011 datasets and the analysis of the 2012 data is completed, a second technical report will be produced and an accompanying summary for policy makers and outreach products (e.g., one-pagers, brochure, blogs, and articles) will be developed for consumption by a broader audience.

Preparations for the 2013 field season are currently underway, with staff engaged in an early start to the often lengthy procurement process to secure a boat charter service and additional equipment and supplies. It is hoped that the purchase order for the boat charter service will be finalized prior to April in order to begin field work as soon as the trade winds subside and water conditions improve.

As described above, the limited availability of Ms. Brown and the lack of a second reef fish survey specialist calibrated with Ms. Brown significantly hindered the collection of reef fish community data, and also reduced the total number of sampling stations surveyed in 2012. It is anticipated that one of the UOGML monitoring assistants who carried out numerous training dives with Ms. Brown throughout the 2012 field season will be cleared to conduct official reef fish surveys in 2013. The ability for the team to carry out two SPCs simultaneously and to carry out fish surveys even when Ms. Brown isn't available will significantly increase the number of sampling stations and sites that can be surveyed during the 2013 field season. In an effort to increase the pool of available reef fish community survey specialist and improve program efficiency and redundancy in the longer-term, the Monitoring Coordinator, the NOAA Coral Fellow, and at least two other Government of Guam biologists will receive training in the SPC survey protocol used by Ms. Brown.

Baseline data collection at the Fouha Bay site will likely occur in February or March if the Achilles is operational and a boat policy is approved. The reduced rainfall and the resulting improvement in water clarity make this time of the year ideal for conducting visual censuses in areas of southern Guam influenced by riverine discharge; this is particularly important for reef fish community surveys, which require a minimum of 8-10 m visibility. Once the boat charter service is available (likely late April/early May), the field season will re-commence with surveys in new sites to be established in the Achang Reef Flat Marine Preserve and an adjacent non-preserve reef area. These sites are of interest because of their preserve/non-preserve status and their occurrence within the Mannel-Geus watershed unit, which has recently been designated as a high priority watershed management area and has been the site of upland restoration efforts. Once surveys at the southern sites is complete, work at Western Shoals will commence. If data collection at Western Shoals can be completed, and if charter service boat trips remain, the team will return to Tumon and East Agana Bays.

After considerable delay, water quality sampling is planned for the 2013 field season. Water column profiles will be performed at each sampling station using an electronic multiparameter water quality monitoring system/datasonde equipped for conductivity/salinity, depth, dissolved oxygen, pH, temperature and turbidity. Temperature loggers will be deployed at all sites. At least one, possibly two datasondes equipped for conductivity/salinity, depth, dissolved oxygen, pH, temperature and turbidity

will be deployed at select sites for long term in situ monitoring. Additionally, an array of conductivity/temperature loggers will be deployed along the Tumon Bay and East Agana Bay sites in order to improve our understanding of the impacts of submarine discharge on reef communities at those sites. Just prior to the submission of this report, the Monitoring Coordinator and the NOAA Technical Support Specialist (and soon-to-be 2013 NOAA Coral Fellow) participated in hands-on training provided by Guam EPA staff in the calibration of the YSI multiparameter datasonde sensors. Training in the use of the datasonde in the field will occur prior to the start of the 2013 field season.

Reef Flat Monitoring Program – 2012 Activities

At present, seven reef flats along Guam's western coast are being monitored for coral health impacts and nutrient levels. Sites were chosen to represent a gradient of water quality impacts, starting with the relatively pristine reference point to the north, Haputo, and ending with Luminao reef flat, seaward of Apra Harbor. Each of the sites is currently monitored bimonthly, along three 20 m x 2 m belt transects established on the reef flat at 1-2 m depth. The data generated through the reef flat monitoring program provides a strong complement to the data collected at the outer reef slope sites targeted with the long-term monitoring program, particularly at locations, such as Tumon Bay and Piti Bay, where both the reef flat and outer reef slope communities with these bays are concurrently addressed through these two monitoring programs. The reef flat monitoring program provides information to managers for a critical, dynamic, yet vulnerable reef zone, and is an essential component of a comprehensive coral reef monitoring strategy.

Dr. Laurie Raymundo, along with a part-time assistant and with occasional support by one or more monitoring assistants, carried out line-intercept transects and coral health surveys at all six reef flat sites in June and retrieved all temperature data loggers. Surveys in September were incomplete due to several weeks of bad weather; West Agana, Haputo and Tanguisson were inaccessible. The reef flat monitoring team is currently planning to survey these remaining sites in December. Data are currently being compiled, reformatted for consistency and descriptive statistics being calculated by a UOGML graduate student. A manuscript presenting the results of an analysis of four years of reef flat monitoring data is planned for early 2013; the manuscript will provide information about changes in live coral cover, coral community structure, and disease impacts at the reef flat sites.

Appendix A. Data collection activities to-date.

Site Name	Site Location (lat/long)		Date			
			2009	2010	2011	2012
TUM-01-10	13.511539	144.790475	-	8/26	-	-
TUM-02-10	13.510719	144.786276	-	8/27	-	-

TUM-03-10	13.511342	144.792448	-	9/2	-	-
TUM-04-10	13.509778	144.786392	-	8/27	-	-
TUM-05-09	13.510616	144.793549	8/29	-	-	-
TUM-05-10	13.511426	144.793549	-	9/2	-	-
TUM-06-10	13.510956	144.789757	-	9/3	-	9/5
TUM-08-10	13.512194	144.792858	-	9/3	-	-
TUM-11-10	13.509338	144.785796	-	8/13	-	-
TUM-12-10	13.510893	144.792047	-	8/20	-	-
TUM-13-10	13.510006	144.788443	-	8/25	-	
TUM-14-10	13.510839	144.787866	-	8/18	-	-
TUM-15-09	13.510616	144.788699	6/16	-	-	-
TUM-15-10	13.510616	144.788699	-	8/6	-	
TUM-16-10	13.510793	144.787011	6/15	8/4	-	-
TUM-17-09	13.511281	144.791729	6/16	-	-	-
TUM-17-10	13.511281	144.791729	-	8/6	-	
TUM-18-10	13.511218	144.793065	6/15	8/4	-	-
TUM-19-09	13.510979	144.790277	9/11	-		-
TUM-19-10	13.510979	144.790277	-	8/11	-	-
TUM-20-10	13.509976	144.787922	-	8/18	-	-
TUM-33-09	13.512267	144.794727	9/11	-	-	-
TUM-33-10	13.512267	144.794727	-	8/11	-	-
TUM-35-10	13.51278	144.794671	-	8/13	-	-
TUM-36-10	13.511712	144.794557	-	8/20	-	9/24
TUM-41-12	13.51181	144.790238	-	-	-	9/26
TUM-42-12	13.511524	144.790772	-	-	-	11/5
TUM-43-12	13.51225	144.794832	-	-	-	10/29
TUM-46-12	13.514726	144.797149	-	-	-	10/24

TUM-47-12	13.513951	144.796491	-	-	-	11/5
TUM-48-12	13.515403	144.796954	-	-	-	11/7
TUM-49-12	13.512988	144.796032	-	-	-	10/10
TUM-50-12	13.512554	144.795473	-	-	-	11/7
TUM-51-12	13.510924	144.789946	-	-	-	9/26
TUM-52-12	13.51161	144.793053	-	-	-	10/29
TUM-53-12	13.511842	144.792828	-	-	-	9/24
TUM-54-12	13.512007	144.794258	-	-	-	11/5
TUM-56-12	13.513327	144.796267	-	-	-	10/24
TUM-57-12	13.513747	144.796278	-	-	-	11/7
TUM-58-12	13.511978	144.794777	-	-	-	10/29
TUM-60-12	13.51677795	144.79726894	-	-	-	11/13
TUM-61-12	13.51162868	144.79131339	-	-	-	11/9
TUM-63-12	13.51504522	144.79665729	-	-	-	11/9
EAB-01-10	13.48466	144.758266	-	9/7	-	-
EAB-02-10	13.488348	144.764662	-	10/15	-	11/16
EAB-03-10	13.487438	144.763627	-	9/7	-	-
EAB-04-10	13.484903	144.760463	-	10/15	-	11/28
EAB-05-10	13.483918	144.758468	-	9/9	-	-
EAB-06-10	13.484863	144.759294	-	10/15	-	11/26
EAB-07-10	13.487987	144.764383	-	9/9	-	-
EAB-08-10	13.485134	144.76153	-	10/21	-	11/28

Appendix A. Data collection activities to-date.

Site Name	Site Location (lat/long)		Date			
			2009	2010	2011	2012
EAB-09-10	13.489031	144.764979	-	9/9	-	-
EAB-10-10	13.48678	144.763303	-	11/26	-	11/26

EAB-11-10	13.48548	144.761173	-	9/13	-	-
EAB-12-10	13.490523	144.765836	-	10/21	-	11/16
EAB-13-10	13.484827	144.758741	-	9/13	-	-
EAB-14-10	13.486008	144.761456	-	11/19	-	11/19
EAB-15-10	13.48609	144.762667	-	9/13	-	-
EAB-16-10	13.487492	144.764295	-	11/19	-	11/26
EAB-17-10	13.491285	144.765902	-	10/14	-	-
EAB-18-10	13.489676	144.765319	-	11/19	-	11/16
EAB-19-10	13.486051	144.763042	-	10/14	-	-
EAB-20-10	13.486219	144.765319	-	11/26	-	-
EAB-22-10	13.490937	144.765607	-	-	-	11/28
WS-01-11	13.449859	144.654263	-	-	7/11	-
WS-02-11	13.453136	144.653894	-	-	7/19	-
WS-03-11	13.452543	144.653686	-	-	7/11	-
WS-04-11	13.453796	144.654659	-	-	8/19	-
WS-05-11	13.452178	144.654397	-	-	7/15	-
WS-6-11	13.453547	144.65416	-	-	7/19	-
WS-7-11	13.45169	144.654395	-	-	7/11	-
WS-8-11	13.451273	144.654545	-	-	8/12	-
WS-9-11	13.452662	144.654055	-	-	7/19	-
WS-10-11	13.452947	144.654145	-	-	7/22	-
WS-11-11	13.452422	144.654577	-	-	7/22	-
WS-12-11	13.453135	144.654576	-	-	8/15	-
WS-13-11	13.451909	144.654678	-	-	8/12	-
WS-14-11	13.449894	144.654862	-	-	8/15	-
WS-15-11	13.450771	144.654561	-	-	8/12	-
WS-16-11	13.453344	144.654896	-	-	8/15	-

WS-18-11	13.450373	144.655295	-	-	8/19	-
WS-19-11	13.452567	144.655947	-	-	8/19	-
WS-20-11	13.451098	144.655814	-	-	7/22	-
WS-22-11	13.451071	144.654526	-	-	8/12	-
WS-23-11	13.449823	144.655298	-	-	8/1	-
WS-25-11	13.449997	144.653873	-	-	8/1	-
WS-29-11	13.453782	144.655629	-	-	8/1	-
PIT-01-12	13.46962	144.686791	-	-	-	7/23
PIT-02-12	13.46846	144.684132	-	-	-	7/27
PIT-03-12	13.469279	144.686032	-	-	-	7/23
PIT-04-12	13.470043	144.688288	-	-	-	8/10
PIT-05-12	13.470095	144.688996	-	-	-	8/8
PIT-06-12	13.469011	144.685059	-	-	-	8/8
PIT-07-12	13.469727	144.687814	-	-	-	7/27
PIT-08-12	13.470193	144.689606	-	-	-	8/15
PIT-09-12	13.475202	144.696334	-	-	-	8/22
PIT-10-12	13.471938	144.69198	-	-	-	8/17
PIT-11-12	13.475133	144.696808	-	-	-	8/22
PIT-12-12	13.475628	144.696983	-	-	-	8/31
PIT-13-12	13.472565	144.692736	-	-	-	8/10
PIT-14-12	13.474848	144.695302	-	-	-	8/29
PIT-15-12	13.472722	144.693384	-	-	-	8/31

Appendix A. Data collection activities to-date.

Site Name	Site Location (lat/long)		Date			
			2009	2010	2011	2012
PIT-16-12	13.473073	144.692943	-	-	-	8/17
PIT-17-12	13.470881	144.69216	-	-	-	8/15

PIT-18-12	13.474127	144.69436	-	-	-	8/29
PIT-19-12	13.473711	144.693623	-	-	-	8/17
PIT-20-12	13.472984	144.693776	-	-	-	8/31

Appendix B. Preliminary analysis of coral colony size data from the Tumon Bay (2010), East Agana Bay (2010), and Western Shoals (2011) monitoring sites. Prepared by Roxanna Miller, 2012 NOAA Technical Support Specialist.

Introduction and Methods

Coral size frequency distributions provide valuable information about ecological processes and their effects on coral populations. While most studies address population dynamics in terms of means and variances of coral size datasets, information on the shape of distributions, which can provide key insights into the health of the coral reef ecosystem in question, is often overlooked. In order to determine how the size structure of coral populations may vary in space and time, and to aid in understanding how they respond to natural and anthropogenic stressors, we assessed coral size structure using parameters that describe size frequency distribution, such as standard deviation, skewness, and kurtosis. Coral size frequency distributions were generated and described for three sites and their substrata (outlined in Burdick & Brown 2011). Size frequency distributions were also compared between stations within a site using the two-sample Kolmogorov-Smirnov test.

Results and Discussion

Size frequency distributions at each site were not normally distributed (significantly different from a normal sample, $p < 0.05$) and highly skewed to the right (Figure 1 and Table A). When comparing size frequency distributions within a site, distributions in East Agana Bay varied significantly only between a few stations. Size frequency distributions at stations 9, 12, and 3 of East Agana Bay were significantly different from 95%, 89%, and 74% (respectively) of the other stations at that site (Table B). Size frequency distributions in Tumon, however, varied significantly between stations, largely according to the strata outlined in the benthic cover analysis (Burdick & Brown 2011, Table C). Of the 102 comparisons between stations of different strata, 76% were significantly different from each other. Of the remaining 88 comparisons that were between stations within the same strata, only 7% were significantly different from each other. Unlike those at Tumon, size frequency distributions in Western Shoals did not vary according to strata (Table D). Coral sizes across all stations were relatively small, with the majority (82%) at East Agana and Tumon being 10 cm or less. At Western Shoals, corals were also generally small (60% 10 cm or less), but the percentage of corals above 50 cm was approximately 3% -- three times the amount present in East Agana or Tumon. While analysis is incomplete and more information will be gained through further analysis, this preliminary analysis of coral size structure provides a baseline to which future datasets can be compared. Information obtained through the

analysis of coral size frequency data will eventually be examined with regard to other biological as well as environmental data, providing insight into how environmental changes affect the size distribution of corals and to overall health and resilience of the reef systems at several high priority sites on Guam.

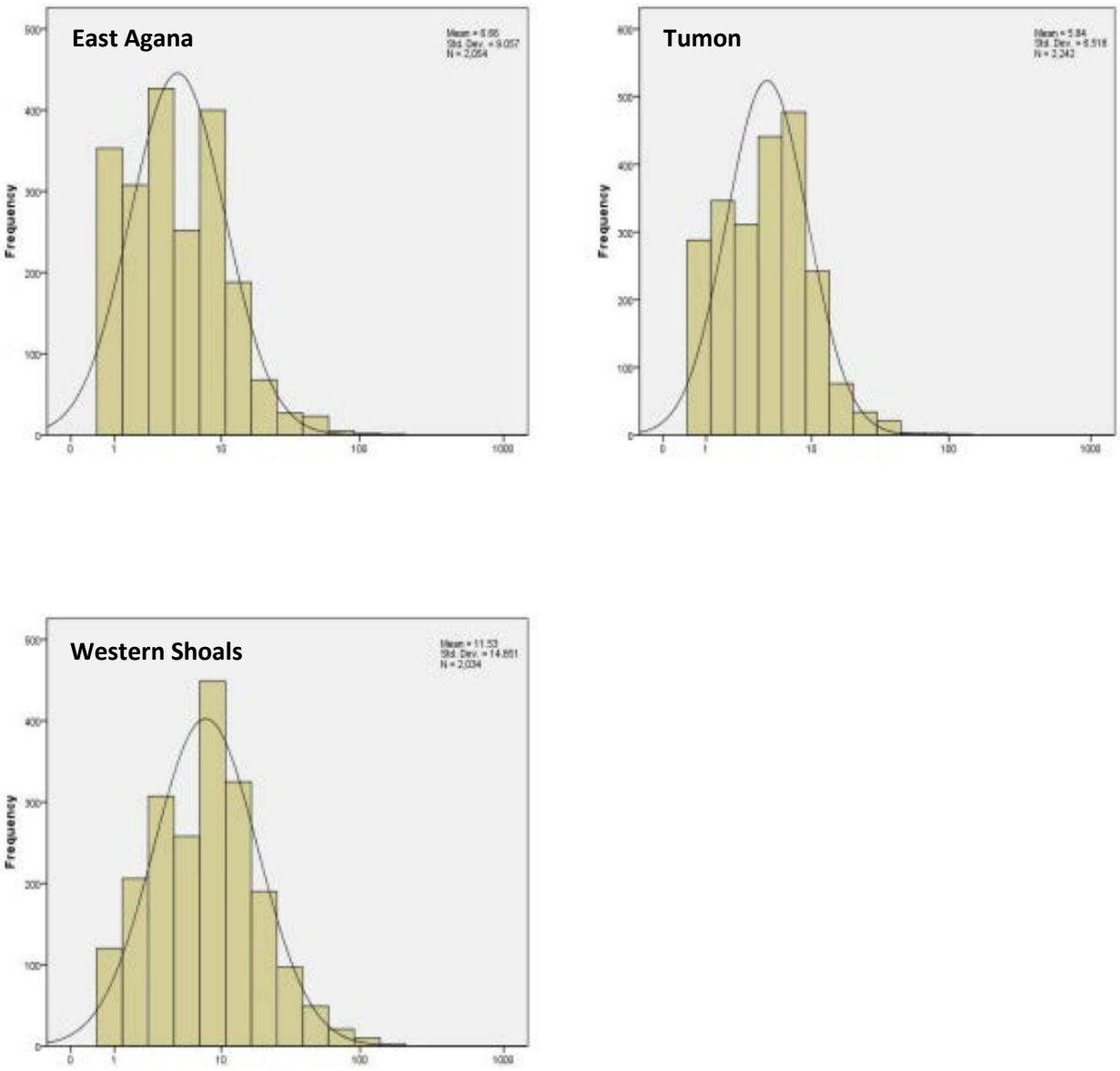


Figure 1. Size frequency distributions of all corals with overlaid normal distributions at three sites. Note the different scales on the y-axis.

Table A. Distribution parameters of size data at the East Agana Bay (EAB), Tumon Bay (TUM), and Western Shoals (WS) sites. P-values in bold are those distributions which are not significantly different from a normal distribution. [g1 = skewness, g2 = kurtosis, SD = standard deviation, and p_{norm} (Kolmogorov-Smirnov Test using Lilliefors adjusted probability = the probability that data are from a normal distribution].

Site	Mean	g1	g2	SD	p_{norm}	n
EAB	6.660	6.111	61.021	9.057	0.000	2054
TUM	5.840	5.605	60.122	6.518	0.000	2242
WS	11.530	4.839	36.582	14.851	0.000	2034

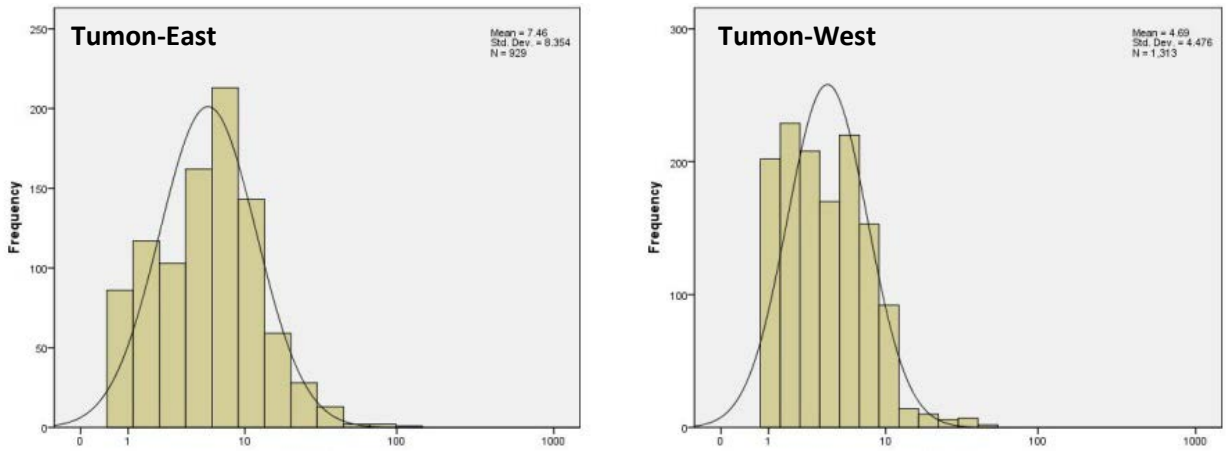
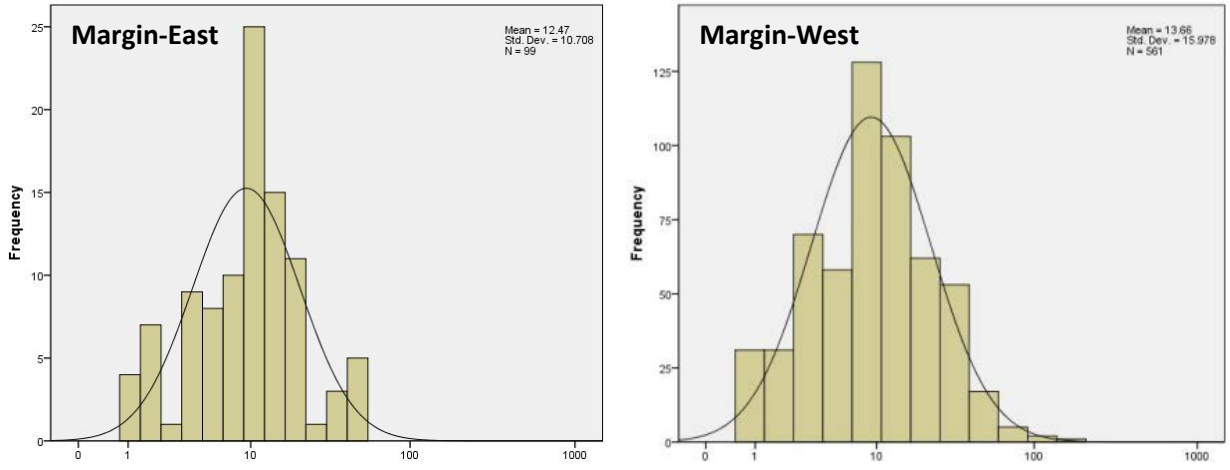


Figure 2. Size frequency distributions with normal distributions for Tumon-East and Tumon-West.



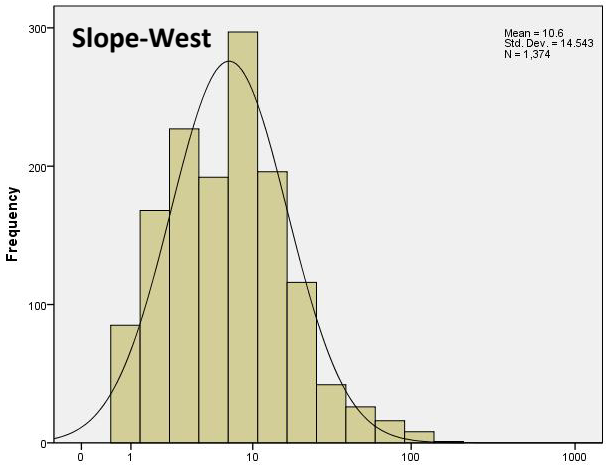


Figure 3. Size frequency distributions with normal distributions for Western Shoals strata: Margin-East, Margin-West, and Slope-West.

Table B. Size frequency distribution comparisons between East Agana sampling stations. Numbers along the top and left sides indicate Station number. Values within the table are p-values resulting from the 2-sample Kolmogorov-Smirnov test. Those p-values in bold indicate significant difference.

East Agana Bay

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	----																
2	0.9098	----															
3	**0.0051**	**0.0050**	----														
4	0.1786	0.1645	0.3036	----													
5	0.5079	0.7649	**0.0086**	0.4940	----												
6	0.9224	0.3018	**0.0003**	0.0849	0.1486	----											
7	0.5334	0.9684	0.0581	0.6640	0.2019	0.1101	----										
8	0.8486	0.9972	**0.0016**	0.0590	0.7953	0.3187	0.7755	----									
9	**0.0001**	**0.0001**	0.2069	**0.0164**	**0.0015**	**0.0000**	**0.0010**	**0.0002**	----								
10	0.6432	0.9430	**0.0119**	0.3511	0.7295	0.2084	0.9584	0.8906	**0.0003**	----							
11	0.8161	0.9658	**0.0091**	0.3447	0.7229	0.3953	0.3877	0.8300	**0.0005**	0.9646	----						
12	0.0653	0.0833	**0.0000**	**0.0007**	**0.0028**	0.0869	**0.4119**	0.1103	**0.0000**	**0.0460**	**0.0053**	----					
13	0.5460	0.1216	**0.0219**	0.9014	0.4102	0.0687	0.2938	**0.0416**	**0.0009**	0.2756	0.2651	**0.0003**	----				
14	0.1142	0.3445	0.5724	0.8155	0.2034	**0.0174**	0.4732	0.3285	0.0524	0.3301	0.1299	**0.0008**	0.2927	----			
15	**0.0224**	0.1209	0.6726	0.7638	0.2053	**0.0077**	0.1937	0.0515	**0.0240**	0.0862	**0.0421**	**0.0000**	0.3211	0.9946	----		
16	0.9385	0.7638	**0.0223**	0.6155	0.7053	0.5441	0.8801	0.3855	**0.0011**	0.9821	0.9863	**0.0242**	0.9341	0.1525	0.0860	----	
17	0.5016	0.8117	**0.0048**	0.2714	0.7804	0.4447	0.8583	0.9930	**0.0005**	0.9990	0.5941	0.0889	0.2162	0.2829	0.1114	0.8975	----
18	0.8617	0.5918	0.4710	0.8004	0.7737	0.4261	0.7712	0.3126	**0.0208**	0.8428	0.7125	**0.0426**	0.7639	0.8998	0.7644	0.9694	0.7119
19	**0.0388**	0.1008	**0.0000**	**0.0056**	0.0931	**0.0494**	**0.0294**	0.2325	**0.0000**	0.0718	**0.0070**	0.8481	**0.0029**	**0.0084**	**0.0006**	0.0539	0.3340
20	0.3334	0.5782	**0.0014**	0.0508	0.3630	0.3839	0.2885	0.8377	**0.0001**	0.5410	0.1447	0.4233	**0.0392**	0.0997	**0.0257**	0.2656	0.7949

Table C. Size frequency distribution comparisons between Tumon sampling stations. Numbers along the top and left side indicate Station number. Red lettering indicates those stations within the Tumon-West stratum, and those in blue lettering indicate those stations within the Tumon-East stratum. Values within the table are p-values resulting from the 2-sample Kolmogorov-Smirnov test. Those p-values in bold indicate significant difference.

Tumon Bay

	1	2	3	4	5	6	8	11	12	13	14	15	16	17	18	19	20	33
1	----																	
2	0.1355	----																
3	**0.0000**	**0.0001**	----															
4	0.3656	**0.0349**	**0.0000**	----														
5	**0.0285**	0.2749	0.0109	**0.0013**	----													
6	0.1978	0.6445	**0.0006**	0.1206	0.5313	----												
8	**0.0084**	0.1881	0.1675	**0.0008**	0.6823	0.2842	----											
11	0.8587	0.1882	**0.0000**	0.1990	0.1080	0.8213	**0.0138**	----										
12	**0.0000**	**0.0004**	0.3902	**0.0000**	**0.0368**	**0.0047**	0.3917	**0.0002**	----									
13	0.0818	0.9847	**0.0067**	**0.0035**	0.8033	0.8248	0.6264	0.1166	**0.0071**	----								
14	0.8866	0.9301	**0.0003**	0.0996	0.1134	0.5049	0.0894	0.8555	**0.0001**	0.6096	----							
15	0.9413	0.5232	**0.0001**	0.1283	0.2789	0.9074	0.0654	0.9170	**0.0007**	0.3605	0.9984	----						
16	0.9413	0.3169	**0.0000**	0.8004	**0.0128**	0.2678	**0.0042**	0.8275	**0.0000**	0.0602	0.4550	0.6356	----					
17	**0.0004**	**0.0119**	0.4821	**0.0000**	0.2153	**0.0099**	0.7290	**0.0042**	0.9335	0.0979	**0.0038**	**0.0071**	**0.0001**	----				
18	**0.0004**	**0.0085**	0.3101	**0.0000**	0.1114	**0.0176**	0.6434	**0.0075**	0.7942	0.0563	**0.0029**	**0.0102**	**0.0003**	0.9164	----			
19	0.5044	0.5984	**0.0000**	0.1468	0.0726	0.7280	**0.0300**	0.5955	**0.0000**	0.2970	0.6704	0.9385	0.6698	**0.0007**	**0.0098**	----		
20	0.7287	0.1925	**0.0000**	0.9975	**0.0137**	0.2415	**0.0049**	0.5197	**0.0000**	**0.0429**	0.2415	0.4668	1.0000	**0.0001**	**0.0002**	0.4971	----	
33	**0.0000**	**0.0014**	0.4184	**0.0000**	0.0334	**0.0028**	0.2744	**0.0002**	0.2375	**0.0135**	**0.0005**	**0.0010**	**0.0000**	0.5758	0.8509	**0.0001**	**0.0000**	----
35	**0.0139**	0.2124	**0.0046**	**0.0022**	0.8985	0.3426	0.9553	**0.0234**	**0.0211**	0.6684	0.1005	0.1133	**0.0473**	0.1109	0.2519	0.2285	**0.0341**	**0.0380**
36	**0.0002**	**0.0084**	0.1673	**0.0001**	0.3598	0.0872	0.8262	**0.0026**	0.6658	0.0861	**0.0026**	0.0145	**0.0001**	0.5759	0.5281	**0.0020**	**0.0002**	**0.0354**

Table D. Size frequency distribution comparisons between Western Shoals sampling stations. Numbers along the top and left side indicate Station number. Red lettering indicates those stations within the Slope-West stratum, green lettering indicates those stations within the Margin-West stratum, and purple lettering indicates those stations within the Margin-East stratum. Values within the table are p-values resulting from the 2-sample Kolmogorov-Smirnov test. Those p-values in bold indicate significant difference.

Western Shoals

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19
1	----																	
2	0.9936	----																
3	0.9869	0.8445	----															
4	0.0749	**0.0475**	**0.0305**	----														
5	0.4388	0.2992	0.4592	0.6937	----													
6	**0.0132**	**0.0331**	**0.0058**	0.6584	0.4586	----												
7	0.9185	0.9663	0.8937	**0.0007**	0.0973	**0.0019**	----											
8	0.0790	**0.0066**	0.1725	0.6666	0.9692	0.5767	**0.0104**	----										
9	**0.0262**	**0.0103**	**0.0220**	0.2460	0.7899	0.5665	**0.0051**	0.9240	----									
10	0.4506	0.2083	0.2570	0.1487	0.6334	0.1350	0.1180	0.4473	0.1824	----								
11	0.9514	0.8406	1.0000	0.2491	0.6428	**0.0436**	0.7577	0.0959	0.0928	0.8297	----							
12	**0.0003**	**0.0000**	**0.0003**	**0.0084**	0.2559	0.1688	**0.0000**	0.2990	0.6710	**0.0005**	**0.0007**	----						
13	**0.0039**	**0.0027**	**0.0048**	**0.0037**	0.1229	**0.0305**	**0.0001**	0.0751	0.1155	**0.0057**	**0.0162**	0.2219	----					
14	**0.0007**	**0.0017**	**0.0027**	0.0873	0.4202	0.2731	**0.0000**	0.6125	0.5480	0.0986	**0.0235**	0.8425	0.4184	----				
15	**0.0127**	**0.0058**	**0.0580**	0.2775	0.9743	0.3482	**0.0012**	0.9541	0.5060	**0.0001**	**0.0974**	0.1432	0.2264	0.2610	----			
16	**0.0000**	**0.0000**	**0.0001**	**0.0036**	0.1002	0.1089	**0.0000**	0.1273	0.5314	**0.0023**	**0.0003**	0.9817	0.3280	0.5360	**0.0340**	----		
18	**0.0003**	**0.0001**	**0.0019**	**0.0331**	0.2023	0.2472	**0.0000**	0.3324	0.8627	**0.0205**	**0.0010**	0.9639	0.1234	0.6941	0.2201	0.8710	----	
19	**0.0033**	**0.0062**	**0.0108**	0.1169	0.2323	0.9119	**0.0009**	0.3441	0.8283	**0.0205**	**0.0468**	0.5926	**0.0364**	0.4025	0.4319	0.4814	0.9214	----
22	**0.0385**	**0.0227**	0.0922	0.5171	0.9941	0.4102	**0.0058**	0.9813	0.7002	0.2504	**0.1114**	0.5298	0.1621	0.9529	0.9477	0.1073	0.5642	0.5851
23	**0.0044**	**0.0098**	**0.0235**	0.3507	0.8454	0.5021	**0.0003**	0.9907	0.8042	**0.0344**	0.1470	0.1754	0.1511	0.7137	0.9194	0.1007	0.2066	0.5683
25	0.1465	**0.0433**	0.1769	0.9993	0.4939	0.4710	**0.0256**	0.4563	0.1616	0.6822	0.3367	**0.0214**	**0.0019**	**0.0438**	0.1740	**0.0084**	0.0808	0.1966
29	0.8690	0.6094	0.9875	**0.0026**	0.2300	**0.0012**	0.8226	**0.0363**	**0.0064**	0.0895	0.9722	**0.0000**	**0.0009**	**0.0002**	**0.0194**	**0.0000**	**0.0001**	**0.0098**