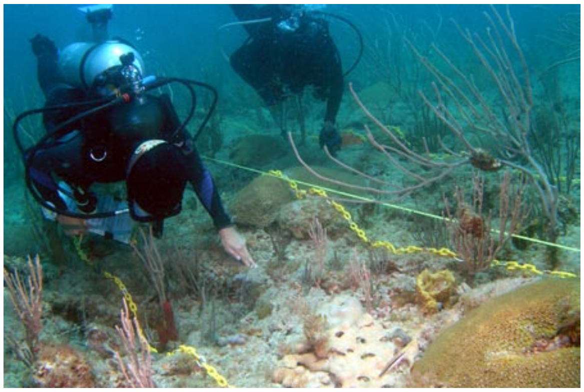
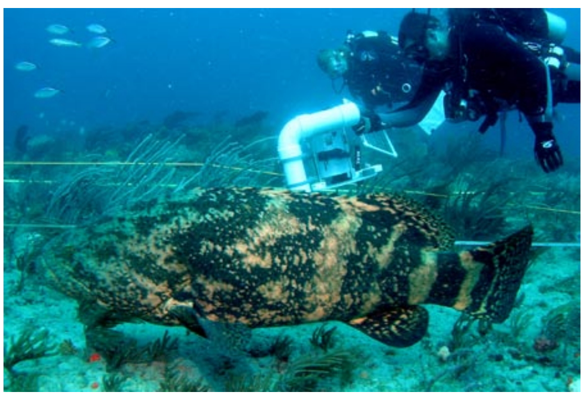
Southeast Florida Coral Reef Evaluation and Monitoring Project





Land-Based Sources of Pollution
Southeast Florida Coral Reef Initiative
Local Action Strategy Project 12

Southeast
Florida
Coral Reef
Initiative

Acting above to protect what's below.

Southeast Florida Coral Reef Evaluation and Monitoring Project

2009 Year 7 Draft Final Report

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INTRODUCTION

The coral reef ecosystem in Florida extends approximately 577 km from the Dry Tortugas in the south to the St. Lucie Inlet in the north. However, until 2003, the primary focus for coral reef research and long-term monitoring was limited to the Florida Keys and Dry Tortugas in Monroe County, with only limited attention directed towards the reefs off Miami-Dade, Broward, Palm Beach and Martin Counties. Coral reef monitoring efforts in the Keys grew with the establishment of the Florida Keys National Marine Sanctuary (FKNMS) in 1990. Since 1996, the Coral Reef Evaluation and Monitoring Project (CREMP) has documented changes in reef resources in the Florida Reef Tract, from Key West to Carysfort (Callahan et al. 2007). In 1999, the project was expanded to include three sites in the Dry Tortugas.

In 2003, CREMP was further expanded to include 10 sites offshore southeast Florida in Miami-Dade, Broward, and Palm Beach counties. The project was expanded again in 2006 with the establishment of three sites in Martin County. This CREMP expansion, named the Southeast Florida Coral Reef Evaluation and Monitoring Project (SECREMP), is filling gaps in coverage of knowledge and monitoring of coral reef ecosystems in Florida and nationwide. SECREMP also complements the goals of the National Monitoring Network to monitor a minimum suite of parameters at sites in the network. These efforts will assist the National Monitoring Network in building its capacity to archive biotic attributes of coral reef ecosystems nationwide. To date, seven years (2003-2009) of SECREMP sampling have been completed.

The southeast Florida reef system extends north of the Florida Keys reef system, approximately 170 km from Miami-Dade into Martin County. From Cape Florida (Miami-Dade County), north to central Palm Beach County, in particular offshore Broward County, the southeast Florida reef system is described as a series of linear reef complexes (referred to as reefs, reef tracts or reef terraces) running parallel to shore (Moyer et al. 2003; Banks et al. 2007; Walker et al. 2008) (Figure 1). The Inner Reef (also referred to as the “First Reef”) crests in 3 to 7 m depths. The Middle Reef (“Second Reef”) crests in 6 to 8 m. A large sand area separates the Outer and Middle Reef complexes. The Outer Reef (“Third Reef”) crests in 15 to 21 m depths. The Outer Reef is the most continuous reef complex, extending from Cape Florida to northern Palm Beach County. Inshore of these reef complexes, there are extensive nearshore ridges and colonized pavement areas. From Palm Beach County to Martin County, the reef system is comprised of limestone ridges and terraces, and worm reef (*Phragmatapoma* spp.) substrata colonized by reef biota (Cooke and Mossom 1992; Herren 2004).

Most previous and current monitoring efforts (Dodge et al. 1995; Gilliam et al. 2008) along the mainland southeast coast originated as impact and mitigation studies from adverse environmental impacts to specific sites (dredge impacts, ship groundings, pipeline and cable deployments, and beach renourishment). The temporal duration of monitoring efforts associated with marine construction activities were limited, defined by the activity permit, and focused on monitoring for project effects to the specific reference areas.

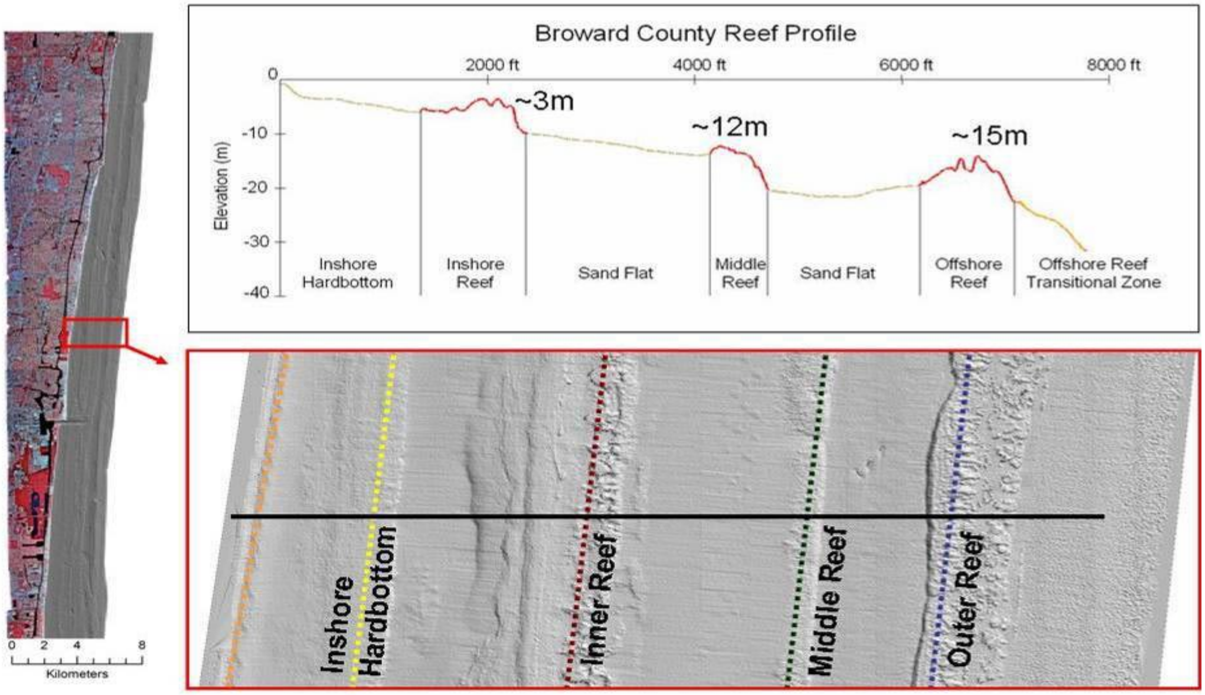

Figure 1. Panel A (at left): View of the southeast Florida coastline of Broward County, showing the land area in red and offshore reefs in gray. Panel B (bottom right): The sea floor shown is bathymetry from LIDAR data. The red square is enlarged in Panel B, showing the LIDAR bathymetry in greater detail. The black line shows the location of a bathymetric profile illustrated in Panel C (top right).

Beginning in 1997, in response to beach renourishment efforts in Broward County, annual collection of environmental data (sedimentation quantities and rates and limited temperature measurements), and coral, sponge, and fish abundance/cover data has been conducted at 18 sites. In 2000, Nova Southeastern University (NSU) assumed this monitoring responsibility from the County. During that year, five new sites were added. In 2003, two additional sites were added. Monitoring of these 25 sites has been conducted annually from 1997 to 2009 (Gilliam et al. 2008) and is scheduled to continue in 2010.

Previous monitoring of reef habitats off Miami-Dade and Palm Beach Counties has been short term, localized, and of little use in evaluating the overall health and condition of the northern extension of the Florida Reef Tract. Estimates of functional group (stony coral, octocoral, sponge, macroalgae, etc.) cover are available from some local areas such as those in Broward County, but to a large extent, cover throughout the southeast Florida reefs has been poorly defined. Because the area has few long-term data sets on abundance and/or cover for benthic components, it has been difficult to provide scientifically valid information on status and trends for this reef system.

In 2003, the Florida Department of Environmental Protection (FDEP) proposed and was awarded funding for the inception of coral reef monitoring along the southeast Florida coast. To ensure that this monitoring is of the highest scientific quality, and consistent with CREMP monitoring in the Dry Tortugas and the FKNMS, and National Monitoring Network protocols, the FDEP contracted this work to the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWC-FWRI).

The southeast Florida reef system exists within 3 km of the mainland Atlantic coast, offshore a highly urbanized area influenced by numerous impacts from commercial and recreational fishing and diving, major shipping ports, sewer outfalls, canal discharges, ship groundings, and marine construction activities. These reefs are important economic assets with an annual input for southeast Florida at over 5.7 billion dollars (Johns et al. 2003, 2004). The uniqueness, proximity and value of southeast Florida's reefs to the community demand sustained monitoring and increased investigations into limiting environmental/ecological processes. The goal of SECREMP is to provide local, state, and federal resource managers an annual report on the status/condition of the southeast Florida (Miami-Dade, Broward, Palm Beach, and Martin Counties) reef system. These annual reports also provide these same managers with information on temporal changes in resource condition. SECREMP is also important for resource managers because, unlike previous southeast Florida monitoring efforts, the reef status and trend information is independent of marine construction activities and is not tied to the geographic or temporal constraints of those activities.

Project Planning

Planning for Year 1 fieldwork began in early 2003. Year 1 fieldwork included locating, installing, and monitoring ten sites in Miami-Dade, Broward, and Palm Beach Counties. Principal investigators from FWRI supplied to, and discussed with, researchers from the National Coral Reef Institute (NCRI) at Nova Southeastern University, the CREMP Standard Operating Procedures for site selection, installation and monitoring. Representatives from Miami-Dade County Department of Environmental Resource Management (DERM), Broward County Environmental Protection and Growth Management Department (EPGMD), and Palm Beach County Environmental Resource Management (ERM) were kept informed on the progress of the project and were invited to participate in site selection and sampling. On 16 June 2003, a workshop was held at Nova Southeastern University Oceanographic Center to discuss the purpose, background, and methods of CREMP and SECREMP. Participants included personnel from NCRI, FWRI (St. Petersburg and Tequesta), EPGMD, DERM, and ERM.

During Year 1 (2003) of the project, NCRI worked closely with FWRI on site selection, methods training, and site sampling. NCRI was responsible for managing and completing the sampling efforts for Years 2 (2004) through 7 (2009) in consultation with FWRI and FDEP. Planning for all years began in January. Prior to sampling, FWRI and FDEP were notified of the proposed sampling dates and invited to participate.

In 2004, expansion of SECREMP north into Martin County, within the St. Lucie Inlet Preserve State Park (SLIPSP) (http://www.floridastateparks.org/stlucieinlet/default.cfm) was initiated. In addition to expanding upon the overall SECREMP goal of providing reef monitoring data for the southeast Florida reef system, expanding SECREMP to include sites offshore SLIPSP is providing coral community monitoring data in this area as St.

Lucie River water discharge changes occur, associated with Everglades restoration efforts. Researchers and managers from NCRI, FWC-FWRI, FWC, FDEP, and the State Park were involved in all Martin County planning discussions.

In 2009, additional funds were awarded to FDEP to install an additional four sites to the project. Researchers and managers from NCRI, FWC-FWRI, FWC, and FDEP's Office of Coastal and Aquatic Managed Areas (CAMA) had several meetings to discuss the location of these four new sites. The final decision on the general locations for these new sites was made in spring 2009. The National Oceanic and Atmospheric Administration (NOAA) was informed and approved of the site selection process and the location of the new sites.

Monitoring Site Selection and Sampling

Initial 10 Sites

Initially (2003), three sites were proposed to be installed and sampled in each of three southeast Florida counties (Miami-Dade, Broward, and Palm Beach). For Miami-Dade and Broward Counties one site was to be selected on each of three reef habitats from nearshore to offshore. Because Palm Beach does not have three separate reef habitats, one site was selected on a nearshore patch reef and two sites were selected on the outer reef. Additionally, because of the unique *Acropora cervicornis* patches located off Ft. Lauderdale, a fourth site was added to the project in Broward County to monitor one of these patches. These initial ten sites (Figures 2a and b) each include four standard CREMP stations. In 2003, during the initial SECREMP site selection process, personnel from NCRI, FWC-FWRI, and each of the Counties were present. Each county assisted by providing vessel support. Industrial Divers Corporation (IDC) of Fort Lauderdale, FL was subcontracted to install the reference stakes.

New Martin County Sites

In 2005, site selection efforts began in Martin County. Researchers and managers from NCRI, FWC-FWRI, FWC, FDEP-CAMA, and SLIPSP met several times in 2005 with the purpose of selecting sites, but each time, conditions (rough seas or very poor water visibly) did not permit fieldwork. Martin County site selection was completed in February 2006. Three sites (sites MC1, MC2, and MC3) were selected within the offshore boundaries of the SLIPSP (Figure 2a). Researchers and managers from NCRI, FWC-FWRI, FWC, FDEP, and the Park were present during site selection. With the addition of the three Martin County sites, the total number of SECREMP sites was increased to 13.

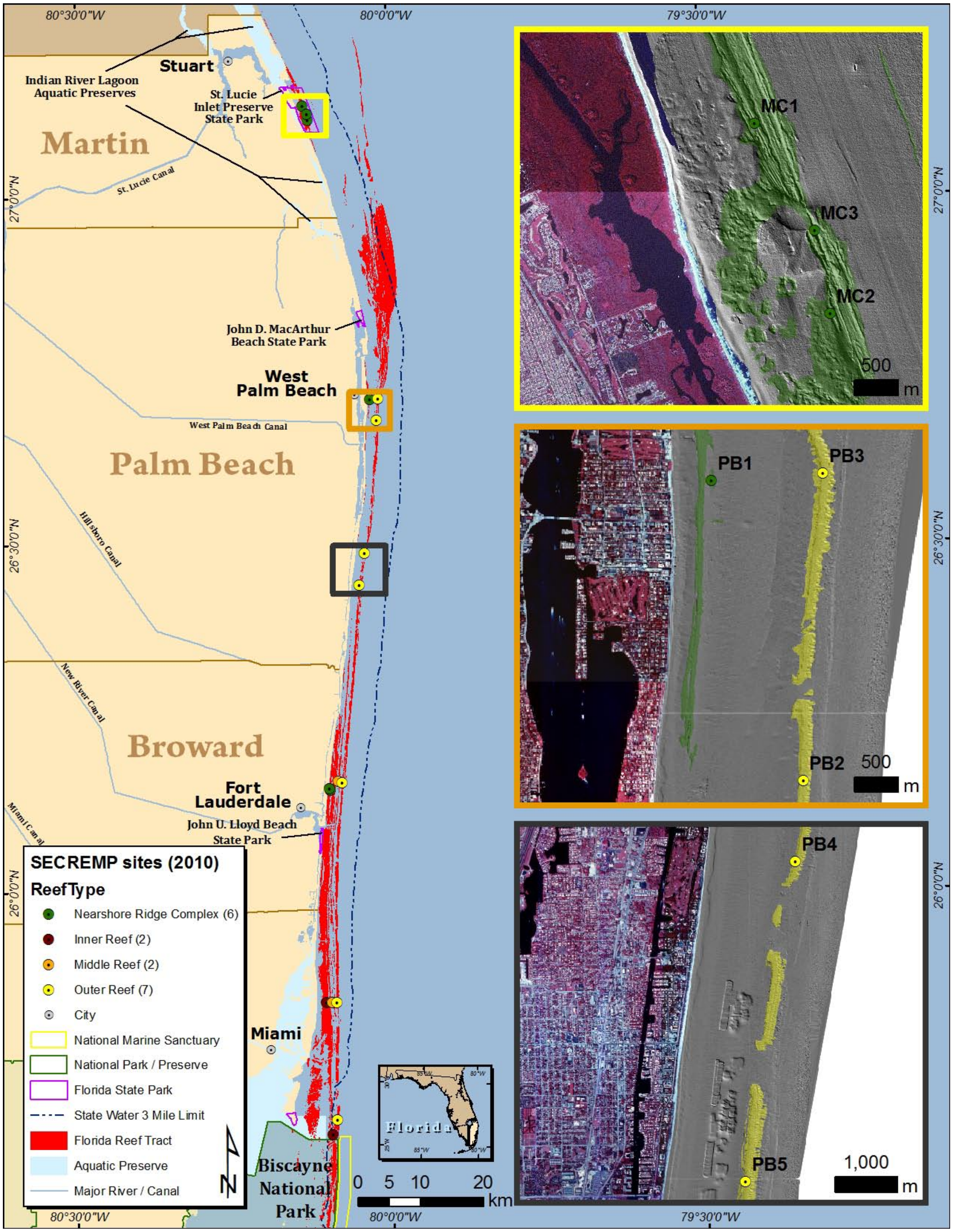

Figure 2a. Map of the seventeen SECREMP sites illustrating their locations offshore southeast Florida and insert boxes showing the locations of the Palm Beach and Martin Counties sites (note the new sites PB4 and PB5).

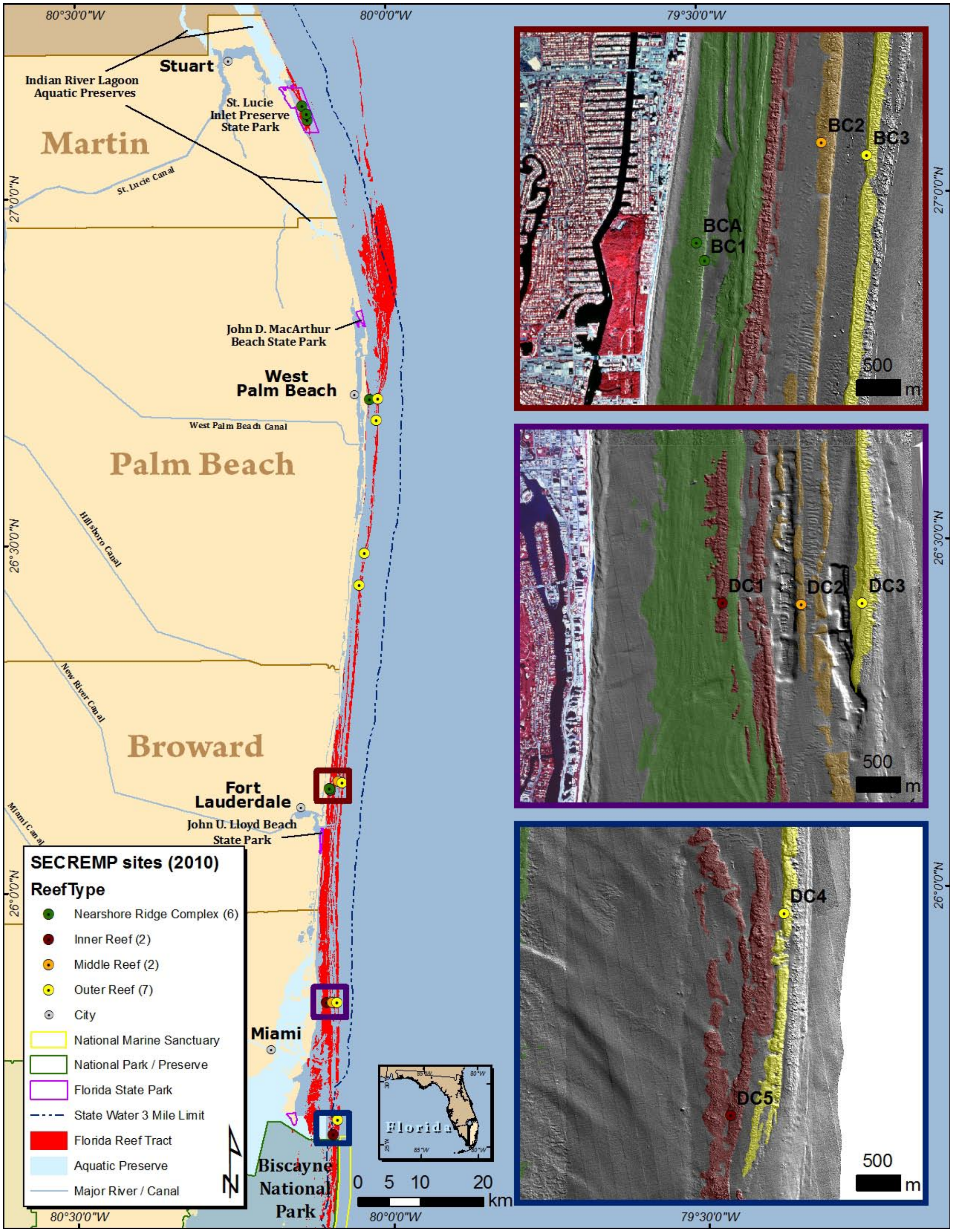

Figure 2b. Map of the seventeen SECREMP sites illustrating their locations offshore southeast Florida and insert boxes showing the locations of the Miami-Dade and Broward sites (note the new sites DC4 and DC5).

New Palm Beach and Miami-Dade Sites

Researchers and resource managers from NCRI, FWC-FWRI, FWC, FDEP-CAMA met and decided that two new sites (to be named PB4 and PB5) would be established on the Outer Reef in Palm Beach County south of the existing Palm Beach sites (PB2 and PB3), and two new sites (to be named DC4 and DC5) would be established offshore Key Biscayne in Miami-Dade County. One new Miami-Dade site would be established on the Outer reef and one on the Inner reef. These four new sites serve the SECREMP goal of providing resource managers with reef monitoring data by increasing spatial coverage and providing much needed information on large, important reef features throughout the southeast Florida reef system.

Discussion also involved possible approaches for selection of the actual sites. Two general site selection approaches were considered: 1) a resource management / professional experience driven approach. Sites could be chosen based on locations where resource managers would like more information. These locations would have some type of local and project defined importance (e.g. near sewer outfalls or near sand source borrow areas), and 2) a stratified random approach, where some *a priori* decisions on site choice are made (e.g. general geographic location, reef habitat), but the specific location for the sites are randomly chosen within appropriate areas.

Although there is a need for additional information at specific sites, a stratified random approach was chosen. SECREMP has been designed to be a long-term effort, and choosing sites that have only locally specific and project management importance may actually inhibit the strength of SECREMP by limiting the more regional effort. This may be especially true if sites chosen for local and project management importance lose their importance in the future. A stratified random approach provides information that is not potentially time limited.

Five locations (GPS points) were randomly selected within the Palm Beach Outer reef areas, Key Biscayne Outer reef area, and Key Biscayne Inner reef area. Final site selection among each group of five random locations was based on in-water assessments by resource managers and project scientists. If the first randomly chosen location was appropriate for a SECREMP site then it was used. If, however, the first site was not appropriate then the second site would have been visited. This would have continued until an appropriate site was determined. The appropriateness of a site was based on the physical nature of the site (reef substrate not dominated by rubble or sand and not dominated by ledges, crevices or other features which reduce the effectiveness of video transects) and the biological community (presence of stony corals, octocorals and reef sponges). Although this determination is qualitative, agreement from the site selection resource managers and project scientists was required during final site choice.

Site selection dives were completed on 16 June 2009 for the Palm Beach sites and on 15 September 2009 for Miami-Dade sites. The Palm Beach sites were installed on 4 May (PB5) and 5 May (PB4) 2010, and both Miami-Dade sites were installed on 6 May 2010. Data collection at all four new sites will follow the standard SECREMP sampling protocols. These sites are scheduled to be sampled starting in the Year 8, 2010, effort.

Project sampling is scheduled between May and August. Table 1 provides depths and locations of each of the SECREMP sites, and Table 2 provides the date sampling was completed at each site for each year.

METHODS

Sixteen of the seventeen SECREMP monitoring sites consist of four monitoring stations delineated by permanent stainless steel markers (the seventeenth site, MC3, is described separately below) (note that the four new 2009 sites were installed during the Year 7 effort but will not be sampled until the Year 8, 2010, effort). Stations are approximately 2 x 22 meters. The SECREMP stations have a north-south orientation, which is generally parallel to the reef tracts of southeast Florida. Within each station, field sampling consists of a station species inventory (SSI), three video transects (100, 300, and 500), and a bio-eroding sponge survey (Figure 3). The SECREMP sampling protocols generally follow standard CREMP sampling protocols.

Table 1. Location and depth for the seventeen SECREMP monitoring sites (BC = Broward County; DC = Miami-Dade County; PB = Palm Beach County; MC = Martin County) (the four new 2009 sites are in bold).

Site Code	Depth (ft)	Latitude (N)	Longitude (W)
BCA	25	26° 08.985’	80° 05.810’
BC1	25	26° 08.872’	80° 05.758’
BC2	40	26° 09.597’	80° 04.950’
BC3	55	26° 09.518’	80° 04.641’
DC1	25	25° 50.530’	80° 06.242’
DC2	45	25° 50.520’	80° 05.704’
DC3	55	25° 50.526’	80° 05.286’
DC4	41	25° 40.357’	80° 05.301’
DC5	24	25° 39.112’	80° 05.676’
PB1	25	26° 42.583’	80° 01.714’
PB2	55	26° 40.710’	80° 01.095’
PB3	55	26° 42.626’	80° 00.949’
PB4	55	26° 29.268’	80° 02.345’
PB5	55	26° 26.504’	80° 02.854’
MC1	15	27° 07.900’	80° 08.042’
MC2	15	27° 06.722’	80° 07.525’
MC3	15	27° 07.236’	80° 07.633’

Table 2. Site selection and sample dates (BC = Broward County; DC = Miami-Dade County; PB = Palm Beach County; MC = Martin County) (note DC4, DC5, PB4, and PB5 not scheduled to be sampled until year 8).

Site Code	Date Selected	2003 Yr 1	2004 Yr 2	2005 Yr 3	2006 Yr 4	2007 Yr 5	2008 Yr 6	2009 Yr 7
BCA	5-06-03	6-19-03	6-11-04	6-08-05 6-30-05	6-16-06	6-14-07	6-10-08	6-19-09
BC1	5-06-03	6-17-03	6-14-04	5-27-05	6-16-06	6-04-07 6-13-07	5-23-08 6-20-08	7-6-09
BC2	5-12-03	6-18-03	6-03-04	6-30-05	6-18-06	6-04-07	5-23-08	7-6-09
BC3	5-06-03	6-18-03	6-09-04	6-08-05	6-27-06	6-13-07	6-20-08	7-14-09
DC1	5-16-03	6-24-03	6-15-04	7-15-05 8-10-05	7-07-06 8-04-06	6-05-07 8-14-07	7-25-08	6-08-09 6-09-09
DC2	5-16-03	6-24-03	6-15-04	7-15-05	8-04-06	6-05-07	7-25-08	6-09-09
DC3	4-30-03	6-23-03	6-04-04	8-10-05	7-07-06	8-14-07	7-15-08	6-08-09
DC4	9-15-09	NA	NA	NA	NA	NA	NA	NA
DC5	9-15-09	NA	NA	NA	NA	NA	NA	NA
PB1	5-05-03	8-20-03	7-21-04	7-29-05	6-21-06	7-19-07	8-07-08	8-05-09
PB2	5-05-03	8-18-03	7-21-04	7-28-05	6-21-06	7-18-07	8-05-08	8-04-09
PB3	5-05-03	8-19-03	7-22-04	7-27-05	6-22-06	7-17-07	8-06-08	9-22-09
PB4	6-16-09	NA	NA	NA	NA	NA	NA	NA
PB5	6-16-09	NA	NA	NA	NA	NA	NA	NA
MC1	2-22-06	NA	NA	NA	5-31-06	7-30-07	5-20-08	6-03-09
MC2	2-22-06	NA	NA	NA	5-31-06	7-30-07	5-21-08	6-03-09
MC3	2-23-06	NA	NA	NA	9-28-06	7-31-07	5-21-08	6-04-09

Video Transects

Video was selected as the method for benthic cover evaluation because it is a rapid and efficient means of field data collection that provides a permanent data record. Percent cover of live stony coral, sessile benthic biota, and selected substrates are determined annually from video transects filmed at each station. The videographer films a clapperboard prior to filming each transect. This provides a complete record of date and location of each segment recorded. Three video transects are filmed at a constant distance (40cm) above the substrate at each station.

Two lasers converge 40 cm from the camera lens and guide the researcher in maintaining the camera at a uniform distance above the reef surface. Filming is conducted perpendicular to the substrate at a constant swim speed of about 4 meters per minute. All transects are filmed with a SONY TRV 900 digital video camcorder. The minimum number of digital images necessary to represent each station are framegrabbed and then written to, and archived on, CD-ROM.

Analysis of benthic cover images is predicated on selecting video frames that abut, with minimal overlap between images. At a filming distance of 40 cm above the reef surface,

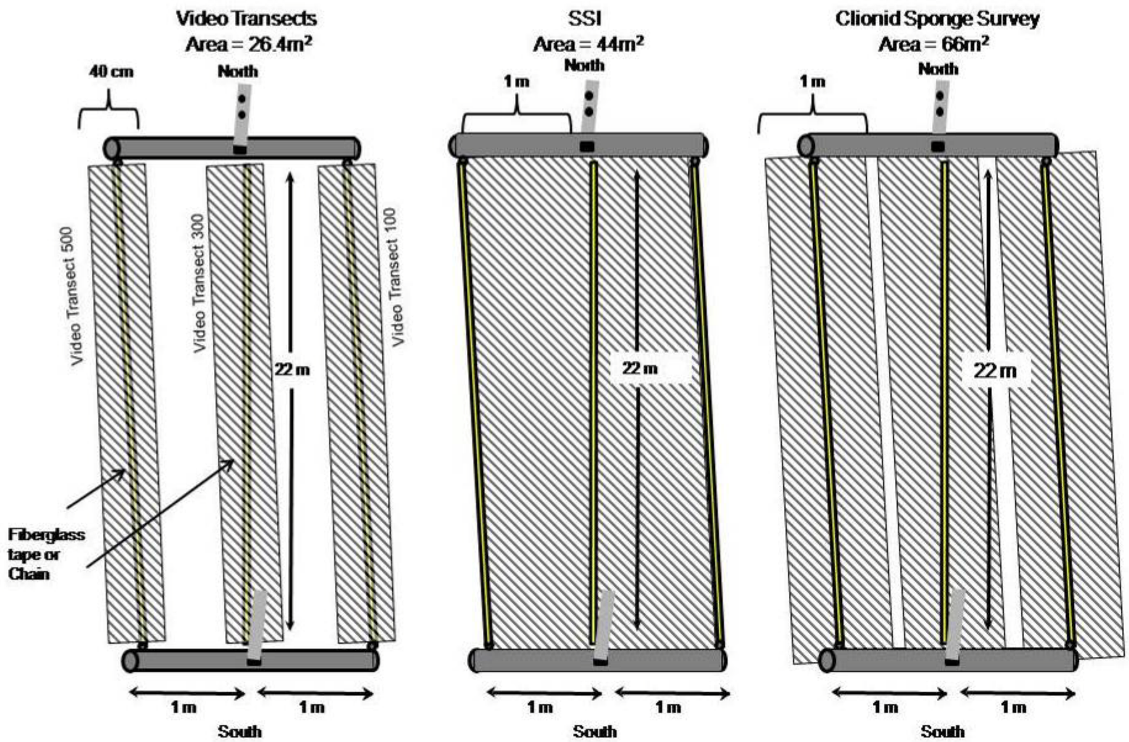

Figure 3. Typical layout of each SECREMP station showing the areas (hatch areas) within which the video, station species inventory (SSI), and bioerosion (clionid sponge) data are collected.

the field of view is approximately 40 cm wide. A set of abutting images that best covers the station is grabbed directly from the video tape.

The image analyses are conducted using a custom software application, PointCount '99, for coral reefs. The software places fifteen random points on each image. Under each point, selected benthic taxa (stony coral species, octocoral, zoanthid, sponge, seagrass, and macroalgae) and substrate are identified. The software has a "point and click" feature that feeds the identification data into a backend spreadsheet. After all images are analyzed, the data are converted to an ASCII file for Quality Assurance and entry into a master ACCESS data set.

Standard video protocol is modified slightly for site BCA (Broward County nearshore *A. cervicornis* patch), and all five Palm Beach County sites. Standard protocol calls for a plastic chain to be laid across the substrate to delineate the transect, and act as a guide for the videographer. At site BCA, extensions are added to the transect end stakes in order to raise transect lines above the coral. Fiberglass tapes are used to delineate the transects and guide the videographer instead of chains. All transect videos are taken on the east side of the transect tapes. These modifications reduce the potential for damage to the *A. cervicornis* colonies during sampling.

Off Palm Beach County, there is generally a strong north-flowing current present at the offshore sites (PB2, PB3, PB4, and PB5). This current adds a safety risk and greatly increases the effort required to complete the sampling. In order to reduce this risk, fiberglass tapes are used in lieu of chains to mark transects and guide the videographer. Transect videos at all Palm Beach County sites are taken on the east side of the transect tapes. Additionally, all transects are videotaped with the videographer swimming into the current to slow his or her speed (all stations in Miami-Dade and Broward Counties are sampled north-south).

Percent Cover Statistical Analysis

To test for single year differences (2007 vs. 2008 and 2008 vs. 2009) in stony coral, macroalgae, octocoral, and sponge percent cover between sites and years, a two way general linear mixed model was used with year and site as fixed factors and stations nested within sites as random factors. The point count data pooled for each station was transformed using a square root transformation. Significant differences in the mean overall (combined for all sites) cover of coral, macroalgae, octocoral, and sponges between years were identified from F-tests. Degrees of freedom used in the F-test were estimated using the Kenward-Rogers method. Post-hoc paired T tests with a Tukey's correction (to control for repeated testing) were used to compare differences in the mean cover of stony corals, macroalgae, octocorals, and sponges within sites between years. All data was analyzed using SAS/STAT® software using PROC GLIMMIX.

Station Species Inventory (SSI)

Stony coral species (Milleporina and Scleractinia) presence is recorded at each station. Two observers conduct simultaneous, timed (20 minute) inventories within the SSI area and enter the data on underwater data sheets. Each observer records all stony coral taxa and records the number of long-spined urchins (*Diadema antillarum*) within the station boundaries. During the species inventory, any species within a station that exhibits specific signs of either bleaching or disease is documented on the data sheet. Diseases are sorted into three categories: black band, white complex (including white plague, white band, white pox), and other (dark spot, yellow band, and idiopathic diseases). After conducting the survey, the observers compare data (5 minutes) underwater and each confirms the species recorded by each observer. Data sheets are verified aboard the vessel and entered into the database. All data and data sheets are then forwarded to the Fish & Wildlife Research Institute for quality assurance checks. This method facilitates robust data collection with broad spatial coverage at optimal expenditure of time and labor.

Bio-eroding Sponge Survey

Three clionid sponge species (*Cliona delitrix, C. lampa,* and *C. caribbaea*) recorded by CREMP/SECREMP are known to be aggressive coral bio-eroders and over-growers. Three 1-meter wide belt transects provide the maximum spatial coverage within each station. A 22-meter survey tape marks the center of reference for each transect. A diver delineates the survey area by swimming directly above the tape holding a meter stick perpendicular to the tape and parallel to the reef surface. The location, species, and size of each clionid sponge colony and species of stony coral affected by the clionid colony is recorded. Area is measured by means of a 40 cm^2 quadrat frame subdivided into 5 cm squares. The area occupied by the clionid colony is recorded to the nearest quarter square.

Site MC3 Stony Coral Colony Condition

Limited appropriate reef area within the Martin County sampling area did not permit the establishment of three standard SECREMP sites. Stony coral cover and density is low in this area which limits the ability of the standard SECREMP sampling protocol to track changes in the stony coral assemblage. After discussions with project colleagues from FDEP and FWRI, it was decided that a third site (MC3) would be established; but this site will be used to fate track a representative sample of stony coral colonies. Five stakes were deployed in a reef area between sites MC1 and MC2. These stakes mark the center point from which stony coral colonies were identified and recorded. The distance and bearing from these center stakes to the colonies was recorded. These measurements permit the same colony to be located and sampled each year. During the first monitoring year (2006), colonies approximately within 10 m of the stake were targeted. As colonies mapped and tagged in 2006 die or become missing, new colonies are added to the project by mapping and tagging colonies greater than 10 m from the stake or by adding colonies within 10 m of the stake that were not included in 2006.

Total colony size (length and width) and colony condition (presence of bleaching, disease, etc.) were recorded *in situ*. In addition to the *in situ* measurements, a digital image was taken of each colony. The images were taken with a digital camera attached to a PVC framer ($0.38m^2$). Date and colony tag numbers were included within each image. The framer allows all images from each monitoring event to be a consistent planar view of the colony. These consistent planar view images permit changes in tissue area between monitoring events to be measured. NCRI developed software (Coral Point Count with Excel Extensions, CPCe, http://www.nova.edu/ocean/cpce/index.html) (Kohler and Gill, 2006) is used to trace the tissue area (cm^2) in each colony planar image. The software automatically calculates the area (cm^2) encompassed by the traced portion of the image (Figure 4). If dead areas are present within the living area of a colony, these dead areas are also traced. The dead area(s) are subtracted from the previously traced living tissue area thus providing a more accurate measure of the living tissue area.

Monitoring Site Temperature Record

In 2007, the deployment of StowAway TidbiT™ (www.onsetcomp.com) temperature loggers was added to the SECREMP sampling protocol. Two recorders are deployed at each site and are replaced during each annual sampling event. The loggers are programmed to record data at a sampling interval of two hours. Because the loggers remain on site for a year, two loggers are deployed at each site in order to provide backup data in case one logger fails or is lost. The two loggers are attached approximately 10 cm off the substrate to the ‘northern’ stake identifying stations 1 and 2. Data from both loggers are downloaded. If data from both loggers are successfully downloaded, the data from the logger attached to station 1 is reported.

Figure 4. Example of a site MC3 mapped colony, *Diploria clivosa*, Tag # 24, with the live tissue area traced and area (721 cm^2) determined using NCRI CPCe.

YEAR 7 (2009) RESULTS

Stony Coral Species Richness

Stony coral species richness was summarized from SSI data. In 2009, a total of 27 stony coral species were identified within the twelve standard SECREMP sites (Table 3). The mean number of species identified per site was eleven. Six species were identified in all four counties (*Millepora alcicornis*, *Montastraea cavernosa*, *Porites astreoides*, *Siderastrea siderea*, *Solenastrea bournoni*, and *Phyllangia americana*), and eleven species were identified in Miami-Dade, Broward, and Palm Beach counties. Common species included: *Siderastrea siderea* which was identified in the most site stations (44 total stations) followed by *Millepora alcicornis* (42 stations), *Montastraea cavernosa* (36 stations), and *Porites astreoides* (37 stations). Miami-Dade County (21) contained the most species identified followed by Broward County (20), Palm Beach County (19), and then Martin County (9). Figure 5 shows the number of species identified for each site 2003-2009. One species identified in 2008 was not identified in 2009, *Mycetophyllia ferox*, which was only seen in 2008. One new species was identified in 2009, *Cladocora arbuscula* in site PB1.

Table 3. Stony coral species presence/absence for the twelve standard SECREMP sites in Broward, Miami-Dade, Palm Beach, and Martin Counties for 2009. Key: A, 1, 2, 3 = sites with species present; 0 = species absent.

Species List	**Broward**	**Miami-Dade**	**Palm Beach**	**Martin**
Acropora cervicornis	A	1	0	0
Agaricia agaricites	1,2	1	3	0
Agaricia fragilis	1,2	2	0	0
Agaricia lamarcki	2	2	0	0
Cladocora arbuscula	0	0	1	0
Colpophyllia natans	1	0	0	0
Dichocoenia stokesii	1,2,3	1,2,3	2,3	0
Diploria clivosa	A, 3	0	1	1,2
Diploria labyrinthiformis	1	1	0	0
Diploria strigosa	0	2	2, 3	0
Eusmilia fastigiata	0	2	2	0
Madracis decactis	1,2,3	2,3	2,3	0
Isophyllia sinuosa	0	0	0	1, 2
Madracis mirabilis	0	0	2	0
Meandrina meandrites	2,3	1,2,3	2,3	0
Millepora alcicornis	1,2,3	1,2,3	1,2,3	1,2
Montastraea annularis complex	1,2	1,2	0	0
Montastraea cavernosa	A,1,2,3	1,2,3	1,2,3	1
Mycetophyllia aliciae	0	3	2	0
Mycetophyllia ferox	0	0	0	0
Oculina diffusa	1	0	1	1,2
Phyllangia americana	2, 3	2	1	1,2
Porites astreoides	A,1,2,3	1,2,3	2,3	1
Porites porites	A, 2	1,2	0	0
Scolymia cubensis	0	2	2	0
Siderastrea radians	0	0	0	1
Siderastrea siderea	A,1,2,3	1,2,3	1,2,3	1,2
Solenastrea bournoni	A,1,2,3	1,2,3	1	2
Stephanocoenia intersepta	1,2,3	1,2,3	2,3	0

Miami-Dade County had a mean 10.5 stony coral species per station (n=12 stations), Broward County had 7.9 species per station (n=14 stations), Palm Beach had 7.2 species per station (n=12 stations), and Martin County had 5.8 species per station (n=8 stations). Counts at Broward County sites were slightly skewed by site BCA, which is dominated by *A. cervicornis*. Without site BCA, Broward County had a greater mean number (9.0) of species per station. Counts at Palm Beach sites were slightly skewed by site PB1, which was partially buried by sand between the 2004 and 2005 samples. Without site PB1, Palm Beach County had a greater mean number (9.1) of species per station.

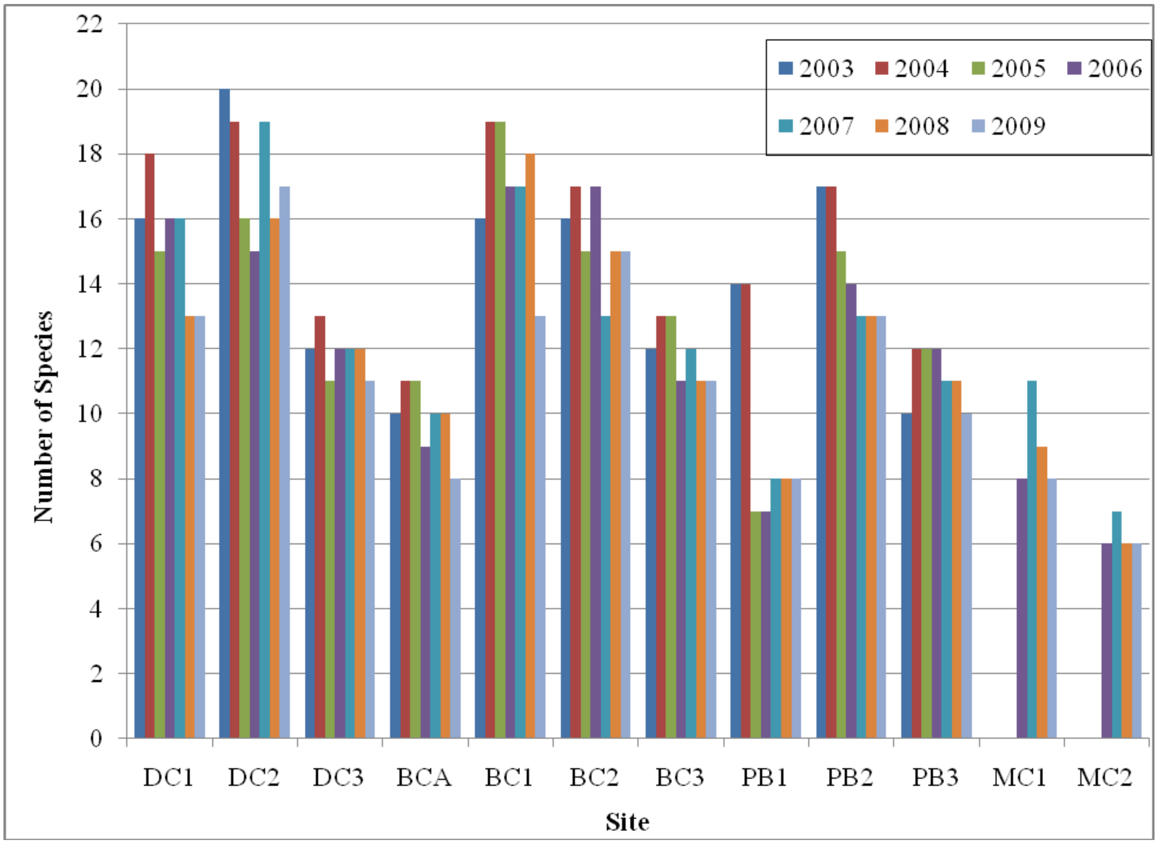

Figure 5. Stony coral species richness for Broward (BC), Miami-Dade (DC), Palm Beach (PB), and Martin (MC) County sites 2003-2009 (n= 3 sites, 12 stations, for Miami-Dade and Palm Beach Counties; n= 4 sites, 16 stations, for Broward County; n = 2 sites, 8 stations for Martin County).

Stony Coral Condition

In addition to recording stony coral species presence, the SSI protocol includes an assessment of stony coral condition – defined as the presence or absence of bleaching and diseases. Disease categories include black band, white complex (white plague, white band, white pox), and "other" (dark spot). Starting in 2004, images were taken of most diseased colonies in order to track the fate of these colonies the following year.

Table 4 lists the stony coral species which have shown the presence of disease and/or partial bleaching at each of the sites, 2003-2009. In 2009, partially bleached colonies were identified in only six sites (MC2, PB3, PB2, BC2, DC2, and DC1) and included only three species (*M. cavernosa*, *S. siderea*, and *S. bournoni*). No completely bleached colonies were observed (Table 4).

In 2009, diseased colonies were identified at seven sites (DC1, DC3, BCA, BC1, BC2, BC3, and PB2). "Other" diseases were seen at six sites (BC1, BC2, BC3, DC1, DC3, and PB2), and most cases were 'Dark Spots' on *S. siderea* colonies. "White Complex" diseases were identified at four sites (BC1, BC2, BC3, and DC1) (Tables 4 and 5). Diseased *A. cervicornis* colonies were seen at site BCA but were not seen at site DC1.

Site BCA is within an *A. cervicornis* "thicket" and the number of affected colonies within a station was not quantified.

Table 4. Stony coral species within each site compared with the presence of disease or partial bleaching (A = absence of bleaching or disease; H = bleaching, O = other disease, W = white complex disease, B = Black band) (Note: Martin County sites were not sampled prior to 2006).

Site	Species Affected	03	04	05	06	07	08	09
DC1	*A. cervicornis*	A	A	A	W or O	W or O	W or O	A
DC1	*A. agaricites*	A	A	A	H	A	H	A
DC1	*D. stokesii*	A	W	A	A	W	A	A
DC1	*M. meandrites*	A	A	H	H	A	A	A
DC1	*M. annularis*	A	O	A	A	A	A	A
DC1	*M. cavernosa*	A	A	W	A	A	B	H
DC1	*P. astreoides*	H	H	H	H	A	H	A
DC1	*P. porites*	A	A	H	H	A	A	A
DC1	*S. siderea*	O	H, O	H, O, W	H, O	O	H,O	H,W,O
DC1	*S. bournoni*	A	A	A	W	A	A	A
DC2	*A. agaricites*	A	A	A	H	A	A	A
DC2	*E. fastigiata*	A	A	A	H	A	A	A
DC2	*M. annularis*	O	A	A	A	A	A	A
DC2	*M. cavernosa*	A	A	H	A	A	H	H
DC2	*P. astreoides*	A	A	A	H	A	A	A
DC2	*S. bournoni*	A	H	H	O, W	A	H	A
DC2	*S. intersepta*	A	A	H	H, W	A	H	A
DC2	*S. siderea*	A	A	H	H, O, W	W	H	A
DC3	*M. annularis*	A	H	A	A	A	A	A
DC3	*S. bournoni*	A	A	H	H	A	A	A
DC3	*S. siderea*	A	A	A	A	A	H	O
DC3	*St. intersepta*	A	H	H	A	A	A	A
BC1	*D. stokesii*	A	A	H	H, W	A	H	W
BC1	*M. annularis*	A	A	A	H	A	H	W
BC1	*M. cavernosa*	O	H	A	H, W	H,B	H	A
BC1	*P. astreoides*	H	A	A	A	A	A	A
BC1	*O. diffusa*	A	A	A	A	A	H	A
BC1	*S. siderea*	H	H,O	O, W	H	O	H,O	W,O
BC1	*S. bournoni*	A	A	A	A	A	A	W
BC1	*S. intersepta*	A	A	A	H	A	O	A
BC2	*D. stokesii*	A	H	A	H	A	A	A
BC2	*M. meandrites*	A	H	A	A	A	A	A
BC2	*M. cavernosa*	A	H	A	A	A	A	A
BC2	*P. astreoides*	A	H	H	A	H	A	A
BC2	*S. radians*	A	A	A	H, W	A	A	A
BC2	*S. siderea*	H	H, O	H, W	H, O, W	O	W,O	W
BC2	*S. bournoni*	W	A	A	A	A	A	H
BC2	*S. intersepta*	A	H	A	A	H	A	W,O

Table 4. Continued.

Site	Species Affected	03	04	05	06	07	08	09
BC3	*A. fragilis*	A	A	H	A	A	H	A
BC3	*D. stokesii*	H	A	A	A	A	A	A
BC3	*M. meandrites*	A	H	A	H	A	H	A
BC3	*M. cavernosa*	A	A	H	A	H,W	H	A
BC3	*S. siderea*	H	H	H, O, W	H, O, W	W,O	H,O	W
BC3	*S. intersepta*	A	A	A	H	A	A	W,O
BCA	*A. cervicornis*	NA	NA	W	W or O	W or O	W or O	W or O
PB1	*D. clivosa*	A	H	A	A	A	A	A
PB1	*M. meandrites*	H	A	A	A	A	A	A
PB1	*O. diffusa*	H	A	A	A	A	A	A
PB1	*S. bournoni*	H, O, W	H	A	A	A	A	A
PB1	*S. radians*	H	H	H	A	A	A	A
PB1	*S. siderea*	A	O	A	A	A	H	A
PB2	*D. strigosa*	A	A	O	A	A	A	A
PB2	*M. meandrites*	A	H	A	H	A	A	A
PB2	*M. cavernosa*	A	H	H	H	H	O	H,O
PB2	*P. astreoides*	A	H	H	A	W	A	A
PB2	*S. intersepta*	A	H	A	A	W	H	A
PB2	*S. radians*	A	H	A	A	A	A	A
PB2	*S. siderea*	A	H	H, W	A	H	H,W	H
PB2	*M. decactis*	A	A	A	A	W	A	A
PB3	*D. stokesii*	A	H	A	A	A	A	A
PB3	*M. cavernosa*	A	A	H	A	H	H	H
PB3	*S. siderea*	A	A	A	A	A	H	A
PB3	*M. aliciae*	A	A	A	A	W	A	A
MC1	*D. clivosa*	NA	NA	NA	H	H	H	A
MC1	*M. cavernosa*	NA	NA	NA	H	A	A	A
MC1	*P. astreoides*	NA	NA	NA	A	H	A	A
MC1	*S. siderea*	NA	NA	NA	H	H,O	H	A
MC2	*D. clivosa*	NA	NA	NA	H	H	H	A
MC2	*O. diffusa*	NA	NA	NA	H	A	A	A
MC2	*S. siderea*	NA	NA	NA	H	H,O	H	H

Table 5 lists the number of colonies of each species that displayed symptoms of disease at each site and station 2004-2009. Beginning in 2004, diseased colonies were mapped at each station and images were taken of most diseased colonies. The condition of these colonies is tracked over consecutive years. During each sampling event, mapped colonies from the previous year were located, and if the colonies remained diseased, new images were taken. In 2009, the colonies mapped in 2008 were re-assessed for disease, and new colonies identified with disease were mapped. Table 6 summarizes the condition of the diseased colonies identified in 2008 and 2009. Of the twenty-one diseased colonies identified in 2008, eight were still identified with disease in 2009. All of these colonies were *S. siderea* colonies. Three of the twenty-one colonies were found dead (Table 6).

Table 5. Sites and stations with diseased stony corals (species codes include the first initial of the genus and first three letters of the species) (# = number of colonies; C = condition [O = other disease, W = white complex disease, B = Black band; only presence, P, is noted for site BCA and DC1]) (Note: No diseased colonies have been identified in sites PB3, MC1, or MC2).

			2004		**2005**		**2006**		**2007**		**2008**		**2009**	
Site	**Station**	**Species**	**#**	**C**	**#**	**C**	**#**	**C**	**#**	**C**	**#**	**C**	**#**	**C**
DC1	1	*S. sid*	3	O	0	---	1	O	5	O	1	O	2	O
DC1	1	*S. sid*	0	---	0	---	0	---	0	---	0	---	1	W
DC1	1	*M. cav*	0	---	1	O	0	---	0	---	0	---	0	---
DC1	2	*M. cav*	0	---	0	---	0	---	0	---	1	B	0	---
DC1	2	*S. sid*	1	O	2	O	0	---	1	O	2	O	1	O
DC1	2	*S. sid*	0	---	0	---	0	---	0	---	0	---	1	W
DC1	3	*S. sid*	1	O	0	---	0	---	1	W	1	O	1	W
DC1	3	*M. ann*	1	O	0	---	0	---	0	---	0	---	0	---
DC1	3	*A. cer*	0	---	0	---	P	W	P	W/O	P	W/O	0	---
DC1	3	*D. sto*	0	---	0	---	0	---	1	W	0	---	0	---
DC1	4	*A. cer*	0	---	P	O	0	---	0	---	0	---	0	---
DC1	4	*S. sid*	2	O	1	O	0	---	2	O	1	O	3	W
DC1	4	*S. sid*	0	---	0	---	0	---	0	---	0	---	1	O
DC1	4	*S. bou*	0	---	0	---	1	W	1	W	0	---	0	---
DC1	4	*D. sto*	1	W	0	---	0	---	1	W	0	---	0	---
DC2	1	None	0	---	0	---	0	---	0	---	0	---	---	0
DC2	2	*S. int*	0	---	0	---	1	W	0	---	0	---	---	0
DC2	3	*S. sid*	0	---	0	---	1	W	1	W	0	---	---	0
DC2	3	*S. bou*	0	---	0	---	1	W	0	---	0	---	---	0
DC2	4	None	0	---	0	---	0	---	0	---	0	---	---	0
DC3	1	*S. sid*	0	---	0	---	1	O	0	---	0	---	0	---
DC3	2	None	0	---	0	---	0	---	0	---	0	---	0	---
DC3	3	*S. sid*	0	---	0	---	0	---	0	---	0	---	1	O
DC3	4	*S. sid*	0	---	0	---	1	O	0	---	0	---	0	---
BCA	1,2,3,4	*A. cer*	NA	NA	P	W/O	P	W/O	P	W/O	P	W/O	P	W/O
BC1	1	*S. sid*	1	O	2	O	0	---	2	O	1	O	1	W
BC1	1	*M.ann*	0	---	0	---	0	---	0	---	0	---	1	O
BC1	1	*S. bou*	0	---	0	---	0	---	0	---	0	---	1	W
BC1	2	*S. sid*	1	O	2	O	0	---	5	O	1	O	1	W
BC1	2	*M. cav*	0	---	0	---	0	---	1	O	0	---	0	---
BC1	2	*M.ann*	0	---	0	---	0	---	0	---	0	---	1	O
BC1	2	*D. sto*	0	---	0	---	0	---	0	---	0	---	1	W
BC1	3	*S. sid*	1	O	1	O	0	---	1	O	0	O	1	W
BC1	3	*S. sid*	0	---	0	---	0	---	2	W	0	---	1	O
BC1	3	*S. int*	0	---	0	---	0	---	0	---	1	0	0	---
BC1	4	*S. sid*	0	---	0	---	0	---	0	---	2	O	0	---

Table 5. Continued

Site	Station	Species	2004 #	2004 C	2005 #	2005 C	2006 #	2006 C	2007 #	2007 C	2008 #	2008 C	2009 #	2009 C
BC2	1	*S. sid*	0	---	1	W	1	O	3	O	2	O	1	O
BC2	1	*S. sid*	0	---	0	---	0	---	0	---	0	---	1	W
BC2	2	*S. sid*	0	---	0	---	1	W	1	O	1	O	1	O
BC2	2	*S. sid*	0	---	0	---	0	---	2	W	1	W	1	W
BC2	3	*S. sid*	1	O	2	W	2	O	3	O	2	O	1	W
BC2	3	*S. sid*	0	---	0	---	1	W	1	W	0	---	1	0
BC2	4	*S. sid*	0	---	0	---	2	O	1	O	0	---	0	---
BC2	4	*S. sid*	0	---	2	W	2	W	3	W	0		0	---
BC3	1	*S. sid*	0	---	0	---	1	O	1	O	1	O	0	---
BC3	2	*S. sid*	0	---	1	O	0	---	1	O	1	W	2	W
BC3	3	*M. cav*	0	---	0	---	0	---	1	O	0	---	0	---
BC3	3	*S. int*	0	---	0	---	0	---	0	---	0	---	1	W
BC3	4	*S. sid*	0	---	0	---	2	O	2	W	0	---	1	O
PB1	1	*S. sid*	1	O	0	---	0	---	0	---	0	---	0	---
PB1	1	*S. bou*	1	W	0	---	0	---	0	---	0	---	0	---
PB1	2	None	0	---	0	---	0	---	0	---	0	---	0	---
PB1	3	*S. sid*	1	O	0	---	0	---	0	---	0	---	0	---
PB1	4	*D. cli*	1	O	0	---	0	---	0	---	0	---	0	---
PB2	1	*S. sid*	0	---	1	W	0	---	0	---	1	W	0	---
PB2	1	*P. ast*	0	---	0	---	0	---	1	W	0	---	0	---
PB2	1	*M. cav*	0	---	0	---	0	---	0	---	1	O	2	O
PB2	1	*M. dec*	0	---	0	---	0	---	1	W	0	---	0	---
PB2	1	*D. stri*	0	---	1	O	0	---	0	---	0	---	0	---
PB2	2	None	0	---	0	---	0	---	0	---	0	---	0	---
PB2	3	None	0	---	0	---	0	---	0	---	0	---	0	---
PB2	4	*S. int*	0	---	0	---	0	---	1	W	0	---	0	---

Three colonies exhibiting disease in 2008 were no longer diseased in 2009, and seven colonies were not found.

In 2009, thirty-one diseased colonies were mapped and images were taken (Table 7). Twenty-three of these colonies were not categorized as diseased in 2008. In 2009, seven sites had identified diseased colonies, and these were the same sites as identified in 2008 with the addition of DC3. Similar to 2008, most of the diseased colonies were *S. siderea* (23 of the 31 colonies). Nine of these *S. siderea* diseased colonies were categorized with "other" disease (Dark Spot). Fourteen of the 23 *S. siderea* colonies were categorized with "white complex" disease.

Table 6. List of all mapped diseased stony corals in 2008 and the condition of these colonies in 2009 (ND = not diseased, O = other disease, W = white complex disease; B = Black band, D = dead, NF = not found).

Site	Station	Species	2008	2009
BC1	2	*S. siderea*	O	W
BC1	2	*S. siderea*	O	NF
BC1	4	*S. siderea*	O	D
BC1	4	*S. siderea*	O	NF
BC1	3	*S. intersepta*	O	D
BC2	2	*S. siderea*	W	ND
BC2	1	*S. siderea*	O	O
BC2	1	*S. siderea*	O	W
BC2	2	*S. siderea*	O	W
BC2	3	*S. siderea*	O	W
BC2	3	*S. siderea*	O	NF
BC3	1	*S. siderea*	O	ND
BC3	2	*S. siderea*	W	W
DC1	2	*S. siderea*	O	O
DC1	4	*S. siderea*	O	NF
DC1	1	*S. siderea*	O	O
DC1	2	*M. cavernosa*	B	ND
DC1	2	*S. siderea*	O	D
DC1	3	*S. siderea*	O	NF
PB2	1	*S. siderea*	W	NF
PB2	1	*S. intersepta*	O	NF

Sea Urchin (*Diadema antillarum)* Abundance

Diadema antillarum sea urchin abundance was recorded for each station during the SSI sampling. No *Diadema* were seen at any of the ten sites in 2003. In 2009, a total of 46 *Diadema* were identified within nine sites (Table 8). This was the highest number of urchins recorded to date in the project and 2009 had the most sites with urchins. *Diadema* continue to be more abundant in the Martin County sites (24 of the 46 urchins) than the sites in the other three counties.

Stony Coral Cover

Table 9 lists, and Figures 6 and 7 illustrate, the mean (+SD) percent stony coral coverage for each of the twelve standard SECREMP sites, 2003-2009. Two sites, PB1 (Figure 6) and BCA (Figure 7), have shown obvious variable stony coral cover since the start of this monitoring effort in 2003.

Table 7. All mapped diseased stony corals in 2009 identified in 2009) (O = other, W = white complex; B = Black Band).

Site	Station	Species	2009 Condition
BC1	2	*S. siderea*	W
BC1	3	*S. siderea*	O
BC1	3	*S. siderea*	W
BC1	2	*D. stokesii*	W
BC1	2	*M. annularis*	O
BC1	1	*M. annularis*	O
BC1	1	*S. siderea*	W
BC1	1	*S. bournoni*	W
BC2	1	*S. siderea*	O
BC2	1	*S. siderea*	W
BC2	2	*S. siderea*	W
BC2	3	*S. siderea*	W
BC2	2	*S. siderea*	O
BC2	3	*S. intersepta*	O
BC3	2	*S. siderea*	W
BC3	2	*S. siderea*	W
BC3	4	*S. intersepta*	W
BC3	4	*S. siderea*	O
DC1	2	*S. siderea*	O
DC1	1	*S. siderea*	O
DC1	1	*S. siderea*	W
DC1	3	*S. siderea*	W
DC1	4	*S. siderea*	W
DC1	4	*S. siderea*	W
DC1	4	*S. siderea*	W
DC1	4	*S. siderea*	O
DC1	1	*S. siderea*	O
DC1	2	*S. siderea*	W
DC3	3	*S. siderea*	O
PB2	1	*M. cavernosa*	O
PB2	1	*M. cavernosa*	O

The loss of stony coral cover within site PB1 is attributable to the movement of sand between the 2004 and 2005 sampling events which covered stations 2 and 4. These two stations remained covered in sand in 2006, but in 2007 both stations had started to become uncovered, re-exposing substrate. In 2008 and 2009, stations 2 and 4 continued the process of becoming uncovered.

Site BCA in 2009 was the only site with significantly ($p<0.0001$, F-test) reduced cover from 2008 dropping from 31% to 26%. BCA cover is dominated by *A. cervicornis*, contributing over 95% of stony coral cover at this site.

Table 8. *Diadema antillarum* sea urchin abundance at each of the twelve standard SECREMP sites in 2003-2009.

Site	2003	2004	2005	2006	2007	2008	2009
BCA	0	0	0	4	0	0	1
BC1	0	2	6	0	4	3	1
BC2	0	1	2	3	0	0	1
BC3	0	2	0	0	1	1	1
DC1	0	0	3	4	3	10	13
DC2	0	1	2	1	0	0	0
DC3	0	0	1	2	1	0	1
PB1	0	0	1	0	0	0	4
PB2	0	0	0	1	0	0	0
PB3	0	0	0	0	0	0	0
MC1	NA	NA	NA	7	13	17	18
MC2	NA	NA	NA	2	5	11	6
Total (n= 10)	0	6	15	15	9	14	22
Total (All sites)	0	6	15	24	27	42	46

Table 10 lists the five species for each site which contributed most to stony coral cover 2003-2009. The mean cover for each species over this six year span was used to determine this list. The two most prevalent species in the SECREMP sites were *S. siderea* and *M. cavernosa*. *S. siderea* was one of the top five species contributing most to stony coral cover in all nine sites while *M. cavernosa* contributed in 10 of the sites.

Table 9. Mean (+SD) percent stony coral cover for each site from 2003-2009 (n = 4 stations). Martin County sites were not sampled prior to 2006.

Year		BC1	BC2	BC3	BCA	DC1	DC2	DC3	PB1	PB2	PB3	MC1	MC2
2003	**Mean**	12.2	0.4	0.3	31.7	2.4	0.6	0.2	1.0	1.8	1.0	NA	NA
	SD	3.7	0.2	0.1	4.9	0.9	0.4	0.1	0.7	1.1	0.4	NA	NA
2004	**Mean**	11.8	0.4	0.4	39.6	2.6	0.5	0.2	0.9	1.8	1.0	NA	NA
	SD	3.9	0.2	0.1	3.6	1.3	0.2	0.0	0.7	1.4	0.2	NA	NA
2005	**Mean**	12.6	0.5	0.3	39.9	2.8	0.5	0.3	0.1	1.6	1.0	NA	NA
	SD	3.8	0.4	0.1	2.3	1.4	0.0	0.2	0.3	1.1	0.3	NA	NA
2006	**Mean**	13.1	0.4	0.5	25.4	3.0	0.8	0.2	0.4	1.8	1.0	1.6	1.0
	SD	3.7	0.2	0.2	2.8	1.3	0.1	0.3	0.8	0.7	0.2	1.1	0.5
2007	**Mean**	12.5	0.3	0.3	31.0	2.5	0.7	0.3	0.2	1.8	1.3	2.2	0.9
	SD	3.2	0.3	0.2	3.0	0.9	0.2	0.3	0.2	1.2	0.8	1.5	0.3
2008	**Mean**	11.8	0.3	0.3	30.8	2.5	0.7	0.1	0.1	1.9	1.2	2.1	0.8
	SD	4.2	0.2	0.2	2.3	1.8	0.2	0.1	0.2	1.3	0.6	1.2	0.3
2009	**Mean**	12.5	0.3	0.3	26.0	2.8	0.7	0.3	0.2	1.8	1.2	2.2	1.0
	SD	3.6	0.3	0.1	1.4	0.9	0.6	0.2	0.3	1.2	0.4	1.8	0.4

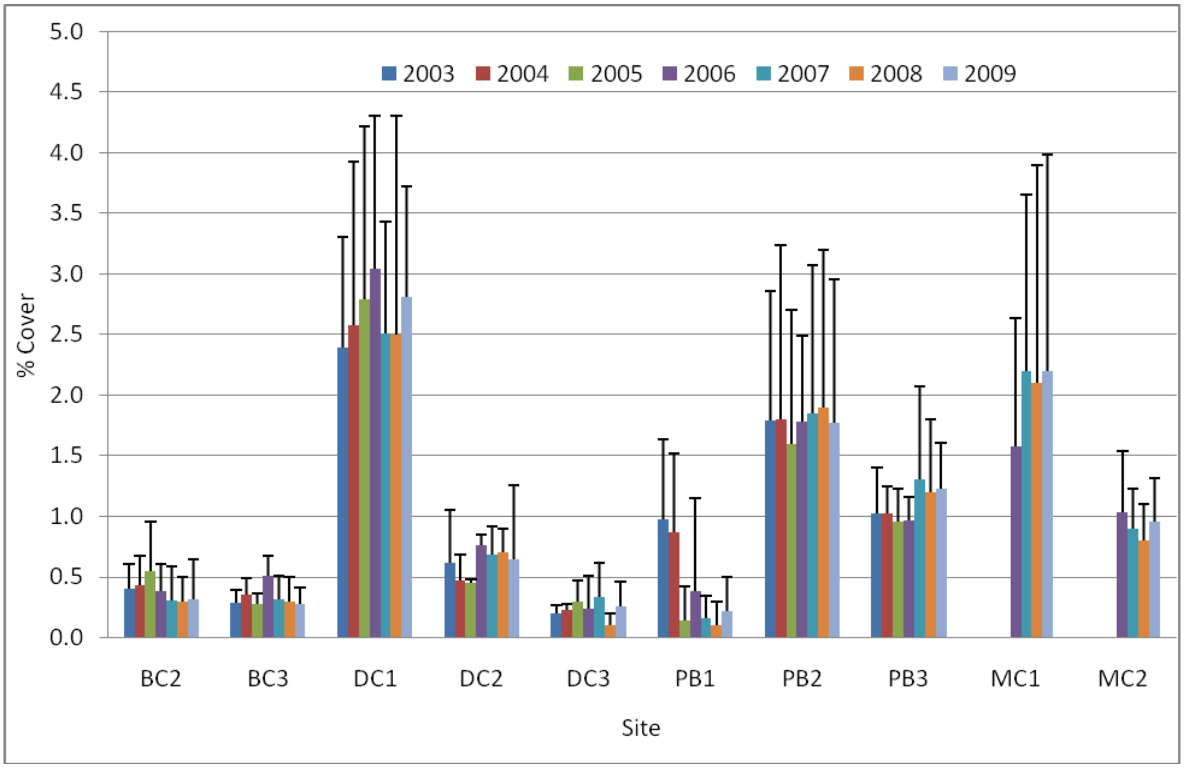

Figure 6. Mean (±SD) percent stony coral cover at the SECREMP sites from 2003-2009. Martin County sites were not sampled prior to 2006.

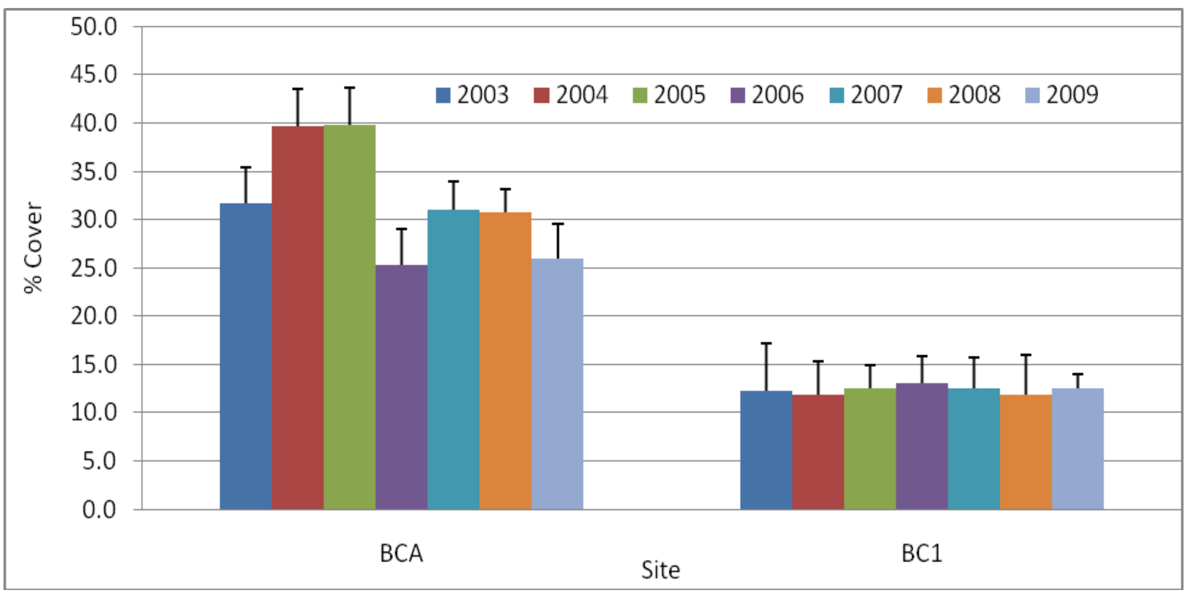

Figure 7. Mean (±SD) percent stony coral cover at BCA and BC1 sites from 2003-2009. Site BCA was the only site with significantly reduced stony coral cover in 2009.

Table 10. The five species which contributed most to total stony coral cover for each site from 2003-2009 (n = 7 years). The species order for each site is in decreasing cover.

BC1	BC2	BC3	BCA
M. cavernosa	*S. siderea*	*M. cavernosa*	*A. cervicornis*
M. annularis complex	*M. meandrites*	*P. astreoides*	*M. cavernosa*
S. siderea	*M. alcicornis*	*S. siderea*	*D. clivosa*
S. bournoni	*M. cavernosa*	*M. alcicornis*	*P. astreoides*
C. natans	*P. astreoides*	*M. meandrites*	*D. strigosa*
DC1	**DC2**	**DC3**	**PB1**
M. cavernosa	*M. meandrites*	*M. cavernosa*	*D. clivosa*
P. astreoides	*M. alcicornis*	*M. alcicornis*	*M. cavernosa*
S. siderea	*M. cavernosa*	*P. astreoides*	*D. strigosa*
M. annularis complex	*P. astreoides*	*S. bournoni*	*M. alcicornis*
A. cervicornis	*S. siderea*	*S. siderea*	*M. meandrites*
PB2	**PB3**	**MC1**	**MC2**
M. cavernosa	*M. cavernosa*	*D. clivosa*	*D. clivosa*
M. alcicornis	*M. meandrites*	*M. alcicornis*	*M. alcicornis*
M. meandrites	*M. alcicornis*	*D. strigosa*	*O. diffusa*
S. siderea	*P. astreoides*	*O. diffusa*	*D. strigosa*
P. astreoides	*D. stokesii*	*S. siderea*	*S. siderea*

Functional Group Benthic Cover

Tables 11, 12, 13 and 14 list the mean functional group cover for each site. Functional groups included substrate (rock, rubble, and sediments), stony corals, octocorals, zoanthids, sponges, macroalgae, and 'other biota' (since 2003 this category has included other biota such as: hydroids, cyanobacteria [*Lyngbya* spp.] and polychaete worms). As found with all previous years, substrate dominated benthic cover at all sites (>50%), ranging from 96% at site PB1 (Table 13) to 51% at site MC2 (Table 14). As seen in previous monitoring years, macroalgae and octocorals were the biota functional groups which contributed most to benthic cover.

The statistical comparisons between 2008 and 2009 determined significant changes in cover for some groups at several sites. Octocoral cover was significantly greater in site BC3 (p=0.0028, F-test) but significantly reduced in sites DC2 (p=0.0403, F-test) and PB3 (p=0.0214, F-test). Sponge cover was significantly greater (p<0.0001, F-test) in site DC3. Macroalgae cover was significantly reduced in sites DC1 (p<0.0093, F-test) and DC2 (p<0.0004, F-test) and significantly greater in site DC3 (p<0.0100, F-test).

In 2008, site DC3 was largely covered with the cyanobacteria *Lyngbya* spp. Cover for *Lyngbya* is listed as part of 'other biota' in Tables 11-14. DC3 other biota cover was 12% in 2008. In 2009 the other cover (still dominated by cyanobacteria) in site DC3 dropped to 3.31%. DC3 octocoral cover in 2008 and in 2009 were the lowest determined during the seven years of the project (Table 12). All three Miami-Dade sites had reduced other biota (cyanobacteria) cover in 2009 versus 2008 (Table 12). In contrast, three Broward sites (BC1, BC2, and BC3) had higher other biota cover (cyanobacteria) in 2009 versus 2008 (Table 11).

Bio-eroding Sponge

In 2009, *Cliona delitrix* was seen in all four counties (Table 15). Only site BCA did not have bio-eroding sponge present. As in previous years, sites MC1 and BC1 had the greatest bio-eroding sponge cover. In total, the area of bio-eroding sponge in 2009 (50.2 cm^2/m^2) was very similar to the area in 2008 (49.0 cm^2/m^2). Four sites decreased in area in 2009 and five sites increased. Table 16 lists the coral species eroded by *C. delitrix* in 2003-2009 (Martin County sites are not included in this table because these sites were not part of the project prior to 2006). *M. cavernosa* colonies continue to have the greatest area impacted by *C. delitrix*. In 2007, in Martin County (sites MC1 and MC2), all *C. delitrix* colonies were identified growing on substrate. In 2008, in addition to substrate, at site MC1, *C. delitrix* was identified on one *D. clivosa* and one *D. strigosa* colony, and in 2009 *C. delitrix* was identified on two *D. clivosa* colonies.

Table 11. Functional group mean percent coverage for the Broward County sites (Sub = substrate, SC = stony coral, Oct = octocoral, MA = macroalgae, Por = porifera, Zoa = zoanthid, and Oth = other biota).

Site	Year	Sub	SC	Oct	MA	Por	Zoa	Oth
BCA	2003	64.96	31.7	2.34	0.03	0.27	0.68	0.00
	2004	55.85	39.6	2.03	0.96	0.47	0.84	0.23
	2005	55.60	39.9	1.54	1.78	0.42	0.78	0.01
	2006	64.95	25.4	1.35	6.75	1.10	0.50	0.00
	2007	62.53	31.0	2.30	2.51	0.96	0.54	0.13
	2008	63.82	30.8	1.40	2.54	0.65	0.68	0.00
	2009	70.20	26.0	2.00	0.77	0.60	0.46	0.00
BC1	2003	77.37	12.2	6.46	0.43	1.84	1.68	0.00
	2004	73.21	11.8	6.41	4.04	1.99	1.40	1.00
	2005	63.97	12.6	6.76	11.89	3.10	1.38	0.33
	2006	66.72	13.1	6.70	8.07	3.62	1.71	0.09
	2007	68.59	12.5	7.48	6.77	3.25	1.31	0.07
	2008	64.30	11.8	6.33	12.57	3.64	1.20	0.30
	2009	65.03	12.5	6.41	10.27	3.89	1.31	0.60
BC2	2003	86.58	0.4	6.63	3.70	2.67	0.00	0.01
	2004	87.09	0.4	6.89	1.92	3.27	0.14	0.25
	2005	80.39	0.5	9.43	5.41	4.08	0.08	0.06
	2006	76.03	0.4	6.37	12.13	5.05	0.03	0.00
	2007	85.96	0.3	6.92	2.56	4.12	0.05	0.08
	2008	85.42	0.3	6.14	2.66	5.12	0.02	0.30
	2009	78.74	0.3	5.82	7.04	5.05	0.08	2.95
BC3	2003	79.76	0.3	13.54	3.62	2.79	0.00	0.01
	2004	78.20	0.4	15.99	1.74	3.64	0.03	0.05
	2005	70.52	0.3	17.90	7.01	4.18	0.00	0.09
	2006	46.46	0.5	14.06	34.64	4.30	0.00	0.02
	2007	76.42	0.3	13.89	3.73	5.48	0.00	0.16
	2008	70.05	0.3	10.08	15.24	4.30	0.00	0.05
	2009	75.21	0.3	13.86	5.50	4.02	0.00	1.13

Table 12. Functional group mean percent coverage for the Miami-Dade County sites (Sub = substrate, SC = stony coral, Oct = octocoral, MA = macroalgae, Por = porifera, Zoa = zoanthid, and Oth = other biota).

Site	Year	Sub	SC	Oct	MA	Por	Zoa	Oth
DC1	2003	72.21	2.4	5.86	13.32	0.85	5.36	0.00
	2004	53.04	2.6	7.31	31.44	1.08	4.57	0.00
	2005	69.10	2.8	7.96	12.80	1.54	5.77	0.04
	2006	71.02	3.0	7.67	10.25	2.09	5.89	0.05
	2007	57.58	2.5	10.35	20.32	3.42	5.57	0.26
	2008	57.67	2.5	7.30	23.19	2.84	5.73	0.74
	2009	72.56	2.8	8.26	8.08	2.24	5.98	0.07
DC2	2003	69.56	0.6	14.67	9.97	5.14	0.03	0.03
	2004	79.50	0.5	11.54	3.26	4.02	0.05	1.16
	2005	78.46	0.5	15.90	1.12	4.03	0.01	0.01
	2006	61.69	0.8	12.15	20.50	4.81	0.01	0.07
	2007	77.82	0.7	12.41	3.60	5.35	0.01	0.12
	2008	67.38	0.7	12.83	12.23	5.31	0.03	1.55
	2009	83.34	0.7	10.40	0.50	5.03	0.02	0.06
DC3	2003	78.48	0.2	15.48	2.25	3.50	0.00	0.09
	2004	78.20	0.2	12.25	3.92	2.74	0.00	2.66
	2005	76.72	0.3	15.04	3.20	3.08	0.01	1.66
	2006	70.01	0.2	10.38	16.41	2.57	0.01	0.37
	2007	79.46	0.3	8.96	5.06	2.99	0.00	3.19
	2008	71.02	0.1	5.92	9.18	1.91	0.00	11.83
	2009	68.71	0.3	5.70	17.14	4.88	0.00	3.31

Table 13. Functional group mean percent coverage for the Martin County sites (Sub = substrate, SC = stony coral, Oct = octocoral, MA = macroalgae, Por = porifera, Zoa = zoanthid, and Oth = other biota).

Site	Year	Sub	SC	Oct	MA	Por	Zoa	Oth
MC1	2003	NA	NA	NA	NA	NA	NA	NA
	2004	NA	NA	NA	NA	NA	NA	NA
	2005	NA	NA	NA	NA	NA	NA	NA
	2006	61.89	1.6	0.01	34.54	1.06	0.66	0.00
	2007	52.72	2.2	0.01	42.33	1.38	1.00	0.31
	2008	58.58	2.1	0.01	37.10	1.05	1.05	0.07
	2009	62.58	2.2	0.01	33.10	1.09	0.82	0.12
MC2	2003	NA	NA	NA	NA	NA	NA	NA
	2004	NA	NA	NA	NA	NA	NA	NA
	2005	NA	NA	NA	NA	NA	NA	NA
	2006	53.20	1.0	0.01	41.99	2.63	1.08	0.00
	2007	38.20	0.9	0.00	56.86	2.89	0.95	0.19
	2008	50.58	0.8	0.02	44.85	2.47	1.05	0.08
	2009	50.82	1.0	0.03	43.82	3.05	1.06	0.22

Table 14. Functional group mean percent coverage for the Palm Beach County sites (Sub = substrate, SC = stony coral, Oct = octocoral, MA = macroalgae, Por = porifera, Zoa = zoanthid, and Oth = other biota).

Site	Year	Sub	SC	Oct	MA	Por	Zoa	Oth
PB1	2003	83.54	1.0	2.70	0.10	10.29	0.55	1.84
	2004	82.55	0.9	2.88	1.39	9.82	0.78	1.71
	2005	98.09	0.1	0.03	0.84	0.17	0.02	0.71
	2006	95.44	0.4	0.00	3.85	0.14	0.00	0.00
	2007	97.87	0.2	0.05	0.03	0.23	0.00	1.63
	2008	95.87	0.1	0.03	0.83	0.55	0.00	2.63
	2009	96.17	0.2	0.09	0.97	0.72	0.00	1.83
PB2	2003	67.23	1.8	27.32	0.00	3.53	0.09	0.05
	2004	61.92	1.8	31.20	0.26	4.15	0.05	0.63
	2005	67.13	1.6	27.49	0.72	2.89	0.08	0.09
	2006	57.28	1.8	23.40	12.39	4.90	0.24	0.00
	2007	64.30	1.8	25.44	1.80	6.46	0.11	0.05
	2008	65.76	1.9	23.00	3.12	5.51	0.09	0.67
	2009	67.50	1.8	22.26	0.39	7.02	0.19	0.86
PB3	2003	55.37	1.0	30.34	0.27	10.46	1.36	1.17
	2004	55.69	1.0	29.84	2.54	8.87	1.20	0.83
	2005	61.12	1.0	24.98	1.45	9.51	1.02	0.96
	2006	61.18	1.0	19.61	7.55	9.32	1.20	0.17
	2007	59.23	1.3	21.30	0.75	14.41	1.46	1.55
	2008	57.23	1.2	20.97	4.69	12.42	1.25	2.22
	2009	58.96	1.2	17.72	1.73	13.14	1.50	5.72

Table 15. *Cliona delitrix*, total colony area (cm^2/m^2) (total sponge area/total site area) for each site in 2003-2008. Note: Site BCA had no *C. deletrix* present all years. The total area for years 2006 - 2009 does not include sites MC1 and MC2.

Site	2003	2004	2005	2006	2007	2008	2009
BC1	24.7	24.6	11.7	32.1	30.3	24.8	27.1
BC2	0.5	0.6	0.7	1.5	1.8	0.6	0.7
BC3	1.6	1.2	1.3	1.5	2.2	0.6	2.9
DC1	1.1	1.4	1.1	2.1	3.9	4.7	4.0
DC2	3.8	2.9	3.6	3.4	3.8	4.2	2.9
DC3	0.3	0.1	0.4	0.4	0.7	0.3	0.3
PB1	6.8	8.9	1.7	1.3	3.2	5.9	8.0
PB2	4.5	1.6	3.6	2.9	3.6	3.8	2.8
PB3	0.9	0.4	1.1	0.7	2.4	3.9	1.4
MC1	NA	NA	NA	26.0	32.1	16.4	19.2
MC2	NA	NA	NA	4.2	4.5	3.1	2.3
Total	44.1	41.7	25.2	45.8	52.0	49.0	50.2

Table 16. *Cliona delitrix*, total colony area (cm^2/m^2) (total sponge area/total site area) for each sponge-eroded coral species within nine of the sites shown in Table 15. NA refers to sponge growing on unidentified coral or on substrate. Martin County sites are not included because these sites were not part of the project prior to 2006.

Coral Species	2003	2004	2005	2006	2007	2008	2009
M. cavernosa	1.03	1.01	1.03	2.87	2.96	2.54	2.30
M. annularis	0.00	0.00	0.00	0.00	0.00	0.01	0.06
M. meandrites	0.13	0.12	0.09	0.07	0.06	0.08	0.02
D. clivosa	0.03	0.13	0.00	0.05	0.36	0.06	0.02
P. astreoides	0.03	0.02	0.00	0.00	0.00	0.00	0.00
C. natans	0.02	0.04	0.08	0.13	0.42	0.05	0.00
S. intersepta	0.02	0.00	0.00	0.04	0.06	0.00	0.10
S. siderea	0.02	0.02	0.04	0.41	0.09	0.11	0.01
A. agaricites	0.01	0.00	0.01	0.00	0.00	0.01	0.00
D. stokesii	0.00	0.00	0.00	0.00	0.00	0.00	0.02
NA	3.62	3.30	1.36	1.42	1.83	2.57	1.67

Site MC3 Stony Coral Colony Condition

In 2006, within the five staked locations at MC3, 49 colonies were mapped within 10m of the center stake and data (including images) collected (Table 17). Although ten stony coral species were recorded within sites MC1 and MC2 in 2006, only six species were included in this effort (colonies of *D. stokesii* and *I. sinuosa* were not present within this site area and colonies of *P. americana* and *M. alcicornis* were not targeted for imaging). Images were taken of all 49 mapped colonies, four colonies did not have images of appropriate quality to permit image analysis to be completed (blurry images or colony edges obstructed).

In 2007, all 49 colonies mapped in 2006 were re-visited. Images were taken of 35 colonies and 14 colonies were not found and presumed dead and/or missing (Table 17). Eight new colonies were mapped and assessed and added to the monitoring effort.

In 2008, two new colonies were added to the effort (Tag numbers 109 and 415). The total number of monitored colonies assessed was 45 (35 colonies found living in 2007 plus eight new colonies mapped in 2007 and two new colonies mapped in 2008).

In 2009, four new colonies were added to the effort (Tag numbers 110, 214, 215, and 313). An attempt was made to locate all 63 colonies that have been mapped (49 in 2006 plus eight new mapped in 2007, two new mapped in 2008, and four new mapped in 2009).

Table 17 summarizes the status (2006-2009) of the 49 colonies mapped in 2006 and the new colonies mapped in 2007, 2008, and 2009. Table 18 includes the colony tissue area measured in 2006-2009 and the change in tissue area. Table 19 summarizes for each species the number of colonies that increased and decreased in tissue area and the number of colonies not found.

Of the original 49 colonies mapped in 2006, 27 were found alive in 2009, three were found dead, and 19 were not found. Of the eight new colonies mapped in 2007, seven were found alive and one was not found. Twenty colonies were assessed for tissue area change (images taken and used in 2006-2009). Five had reduced tissue area and 15 had increased tissue area. The remaining seven colonies mapped in 2006 and alive in 2009 either had images in 2006 and/or 2009 that were not adequate for image analysis.

No diseased colonies were identified in 2006-2009. Fishing line was noted entangling seven of the 15 *O. diffusa* colonies mapped in 2006. In 2007, three of those seven *O. diffusa* colonies were not found, two had measurable reduced tissue area, and the remaining two had images, which although were not adequate for quantitative tissue area analysis, showed reduced tissue area (Table 18). In 2008, only seven *O. diffusa* colonies remain alive and of these seven, three have fishing line and only one had a measurable increase in tissue area. In 2009, only four remain alive, two of those had fishing line and only two had a measurable increase in tissue area.

Monitoring Site Temperature Record

Temperature loggers have been present in all three Miami-Dade, all four Broward and all three Martin County sites since February 2007 (ten sites). Loggers have been present at the Palm Beach County sites since August 2007. Loggers are collected and replaced during each sampling event. During the 2009 sampling event, temperature data was successfully downloaded from all thirteen sites.

The year 7 sample dates shown in Table 2 are the same dates that temperature loggers were redeployed or deployed at each of the thirteen SECREMP sites. Table 20 presents the dates and maximum and minimum temperatures (°C) for each site from late winter 2007 to summer 2009. Figure 8 shows the mean monthly temperatures for all thirteen sites from winter 2007 to summer 2009. This figure illustrates the general warming trend (as expected) at all sites from February to August/September. Figure 8 also shows that the three Martin County sites tend to have lower winter temperatures. Figures 9-12 show the mean daily temperatures for each of the sites by county. For all sites the maximum temperature recorded was over 30°C. These warm temperatures were generally recorded during the later summer months of 2007 and 2008 (August-September). The low temperatures ranged from 16.4°C (site MC1) to 20.2°C (site BC3). The cooler temperatures were recorded during the winter months of 2008 and 2009 (January-March). Figures 8-12 all show that in general the summer period in 2008 was cooler than the summer period in 2007, and the winter period in 2009 was cooler than the winter period in 2008.

Table. 17. Site MC3 monitored colony data. Initial colony size (maximum diameter) and the condition of each colony during each sample date are presented. (* = new colonies added to the effort in 2007; ** added in 2008, *** added in 2009; A = alive; D = dead; FL = fishing line present on colony; PB = partially bleached colony; NF = colony not found)

Tag	Species	Colony Size Dia (cm)	2006 Condition Notes	2007 Condition Notes	2008 Condition Notes	2009 Condition Notes
101	*O. diffusa*	20	A, FL	A, FL	A, FL	A, FL
102	*S. siderea*	8	A	A	NF	NF
103	*O. diffusa*	30	A, FL	A, FL	A	D, FL
104	*D. clivosa*	18	A	A	NF	NF
105	*S. bournoni*	14	A, PB	A	A	A, PB
106	*S. siderea*	5	A	NF	NF	NF
107	*S. siderea*	9	A	A	A	A
*108	*M. cavernosa*	14	NA	A	A	A
**109	*S. siderea*	5	NA	A	A	NF
***110	*O. diffusa*	NA	NA	NA	NA	A
201	*D. clivosa*	28	A	NF	NF	NF
202	*S. siderea*	6	A	A	A	A
203	*D. clivosa*	35	A	A	NF	NF
204	*D. clivosa*	35	A	NF	NF	NF
205	*D. clivosa*	22	A	A	A	A
206	*S. siderea*	6	A	A	A	NF
207	*D. clivosa*	35	A	A	A	A
208	*D. clivosa*	20	A	NF	A	NF
209	*O. diffusa*	20	A, FL	A, FL	A	NF
210	*M. cavernosa*	15	A	A	A	A
211	*O. diffusa*	16	A, FL	NF	NF	NF
212A	*S. siderea*	4	A	A	A	A
212B	*S. siderea*	6	A	A	A	A
212C	*S. siderea*	5	A	A	A	A
213	*M. cavernosa*	12	A	A	A	A, FL
***214	*O. diffusa*	NA	NA	NA	NA	A
***215	*M. cavernosa*	NA	NA	NA	NA	A
301	*S. siderea*	7	A	A	A	A
302	*O. diffusa*	20	A, PB	NF	D	D
303	*O. diffusa*	10	A	NF	NF	NF
304	*M. cavernosa*	15	A	A	A	A
305	*O. diffusa*	25	A, PB	NF	NF	NF
306	*D. clivosa*	20	A	NF	NF	NF
307	*M. cavernosa*	18	A	A	A	A
308	*S. siderea*	6	A	A	A	A
309	*M. cavernosa*	10	A	A	A	A
310	*M. cavernosa*	43	A	A	A	A
311	*O. diffusa*	19	A, FL, PB	A	A	A
312	*M. cavernosa*	80	A	A	A	A
***313	*O. diffusa*	NA	NA	NA	NA	A

Table 17. Continued

Tag #	Species	Colony Size Dia (cm)	2006 Condition Notes	2007 Condition Notes	2008 Condition Notes	2009 Condition Notes
401	*D. clivosa*	60	A	A	A	A
402	*O. diffusa*	28	A	NF	NF	NF
403	*O. diffusa*	13	A	A	A	A, PB
404	*S. siderea*	9	A	A	NF	NF
405	*D. clivosa*	55	A	A	A	A
406	*O. diffusa*	19	A, PB	A	A, FL	NF
407	*O. diffusa*	13	A, PB	A, FL	A, FL	A
408	*P. astreoides*	14	A	NF	NF	NF
409	*O. diffusa*	35	A, FL	NF	NF	NF
410	*M. cavernosa*	25	A	A	A	A
*411	*O. diffusa*	14	NA	A	NF	NF
*412	*S. siderea*	33	NA	A	A	A
*413	*S. siderea*	32	NA	A	A	A
*414	*D. clivosa*	30	NA	A	A	A
**415	*S. siderea*	13	NA	NA	A	A
501	*M. cavernosa*	35	A	A	A	A
502	*O. diffusa*	22	A, FL, PB	NF	NF	NF
503	*O. diffusa*	15	A	NF	NF	D
504	*M. cavernosa*	55	A	A	A	A
505	*S. siderea*	40	A, NT, PB	A	A	A
*506A	*S. siderea*	18	NA	A	A	A
*506B	*S. siderea*	9	NA	A	A	A
*507	*S. siderea*	11	NA	A	A	A

Table. 18. Site MC3 monitored colony data. The 2006 - 2009 colony area (cm^2) measurements were determined by image analysis. (* = new colonies added to the effort since 2006; NA = colony not part of project that year, NI = colony alive but no image adequate for image analysis, NT = no image taken because colony dead or not found)

Tag	Species	2006 Area (cm^2)	2007 Area (cm^2)	2008 Area (cm^2)	2009 Area (cm^2)	Area (cm^2) Change 2009-Inital
101	*O. diffusa*	113.1	16.5	27.5	65.5	-47.6
102	*S. siderea*	25.6	29.1	NT	NT	---
103	*O. diffusa*	248.3	NI	NI	NT	---
104	*D. clivosa*	176.1	169.5	NT	NT	---
105	*S. bournoni*	115.7	130.2	NI	176.3	60.6
106	*S. siderea*	12.6	NT	NT	NT	---
107	*S. siderea*	15.0	10.3	8.4	10.4	-4.6
*108	*M. cavernosa*	NA	50.9	53.1	62.2	11.4
*109	*S. siderea*	NA	NA	4.5	NT	---
*110	*O. diffusa*	NA	NA	NA	45.9	---
201	*D. clivosa*	412.9	NT	NT	NT	---
202	*S. siderea*	8.2	8.7	8.7	12.3	4.1
203	*D. clivosa*	352.9	270.2	NT	NT	---
204	*D. clivosa*	618.5	NT	NT	NT	---
205	*D. clivosa*	172.8	169.2	184.6	211.1	38.4
206	*S. siderea*	13.0	8.1	4.6	NT	---
207	*D. clivosa*	437.8	288.8	320.3	NI	---
208	*D. clivosa*	242.6	NI	NI	NT	---
209	*O. diffusa*	56.6	19.1	NI	NT	---
210	*M. cavernosa*	129.0	116.1	136.2	147.1	18.4
211	*O. diffusa*	49.2	NT	NT	NT	---
212A	*S. siderea*	2.0	1.9	1.4	2.3	0.3
212B	*S. siderea*	5.0	5.1	3.4	2.3	-2.7
212C	*S. siderea*	4.7	3.3	2.5	1.8	-2.9
213	*M. cavernosa*	56.7	59.2	66.8	72.3	15.6
*214	*O. diffusa*	NA	NA	NA	39.7	---
*215	*M. cavernosa*	NA	NA	NA	76.6	---
301	*S. siderea*	33.1	31.5	38.6	48.9	16.1
302	*O. diffusa*	127.8	NT	NT	NT	---
303	*O. diffusa*	43.8	NT	NT	NT	---
304	*M. cavernosa*	112.7	85.3	69.9	124.6	12.0
305	*O. diffusa*	166.7	NT	NT	NT	---
306	*D. clivosa*	369.1	NT	NT	NT	---
307	*M. cavernosa*	NI	190.4	221.4	234.2	---
308	*S. siderea*	12.4	11.8	13.6	13.1	2.6
309	*M. cavernosa*	62.4	42.3	45.5	73.6	11.2

Table 18. Continued

Tag #	**Species**	**2006 Area (cm2)**	**2007 Area (cm2)**	**2008 Area (cm2)**	**2009 Area (cm2)**	**Area (cm2) Change 2009-2006**
310	*M. cavernosa*	266.9	325.5	216.4	373.1	106.1
311	*O. diffusa*	159.5	NI	NI	284.5	124.9
312	*M. cavernosa*	657.1	NI	NI	NI	---
*313	*O. diffusa*	NA	NA	NA	101.9	101.9
401	*D. clivosa*	974.8	1700.2	NI	NI	---
402	*O. diffusa*	380.1	NT	NT	NT	---
403	*O. diffusa*	83.5	116.3	155.8	152.8	69.3
404	*S. siderea*	42.3	15.6	NT	NT	---
405	*D. clivosa*	NA	730.5	524.0	NI	---
406	*O. diffusa*	118.4	96.2	22.0	76.5	---
407	*O. diffusa*	71.6	74.2	26.8	8.6	-63.0
408	*P. astreoides*	NI	NT	NT	NT	---
409	*O. diffusa*	819.5	NT	NT	NT	---
410	*M. cavernosa*	270.2	263.6	255.6	310.7	40.5
*411	*O. diffusa*	NA	43.1	NI	NT	---
*412	*S. siderea*	NA	373.5	666.3	NI	---
*413	*S. siderea*	NA	166.0	182.3	190.8	8.6
*414	*D. clivosa*	NA	421.2	472.9	547.5	74.6
*415	*S. siderea*	NA	NA	55.7	NI	---
501	*M. cavernosa*	224.8	210.2	267.0	244.6	19.7
502	*O. diffusa*	338.4	NT	NT	NT	---
503	*O. diffusa*	94.4	NT	NT	NT	---
504	*M. cavernosa*	928.2	921.6	NI	NI	---
505	*S. siderea*	NI	310.5	150.7	219.4	187.8
*506A	*S. siderea*	NA	79.3	81.8	86.3	4.5
*506B	*S. siderea*	NA	20.4	21.7	25.8	4.1
*507	*S. siderea*	NA	35.8	31.6	NI	---

Table 19. Summary data for colonies mapped in 2006 and assessed in 2007, 2008 and 2009, the number of colonies not traced (NT) in 2006 and/or 2009, the number of colonies alive (A), dead (D), and not found (NF) in 2008, and the number of colonies with an increase in tissue area in 2008 and a decrease in tissue area in 2008.

	2006	2006	2009	2009 Status				
Species	**# Col**	**NT**	**NT**	**A**	**D**	**NF**	**Increase**	**Decrease**
O. diffusa	15	0	0	4	3	8	2	2
S. siderea	12	1	0	8	0	4	4	3
D. clivosa	10	1	2	4	0	6	1	0
M. cavernosa	9	1	3	9	0	0	7	0
S. bournoni	1	0	0	1	0	0	1	0
P. astreoides	1	1	1	0	0	1	0	0

Table 20. Maximum and minimum temperatures (°C) and dates for the thirteen sites winter 2007 to summer 2009.

	Max		Min	
Site	**Temp**	**Date**	**Temp**	**Date**
BCA	30.9	8 Aug 07	19.0	6 Feb 09
BC1	30.6	14 Sep 07	19.6	6 Feb 09
BC2	30.2	21 Aug 07	20.7	5 Feb 09
BC3	30.4	19 Aug 07	20.9	5 Feb 09
DC1	30.7	16 Sep 07	19.7	6 Feb 09
DC2	30.4	19 Aug 07	20.3	6 Feb 09
DC3	30.5	19 Aug 07	20.8	6 Feb 09
PB1	30.3	25 Aug 07	20.2	5 Feb 09
PB2	30.2	20 Aug 07	19.8	8 Mar 08
PB3	30.1	21 Aug 07	19.8	8 Mar 08
MC1	30.5	11 Aug 07	16.4	6 Feb 09
MC2	30.3	13 Aug 07	16.6	5 Feb 09
MC3	30.3	11 Aug 07	16.4	5 Feb 09

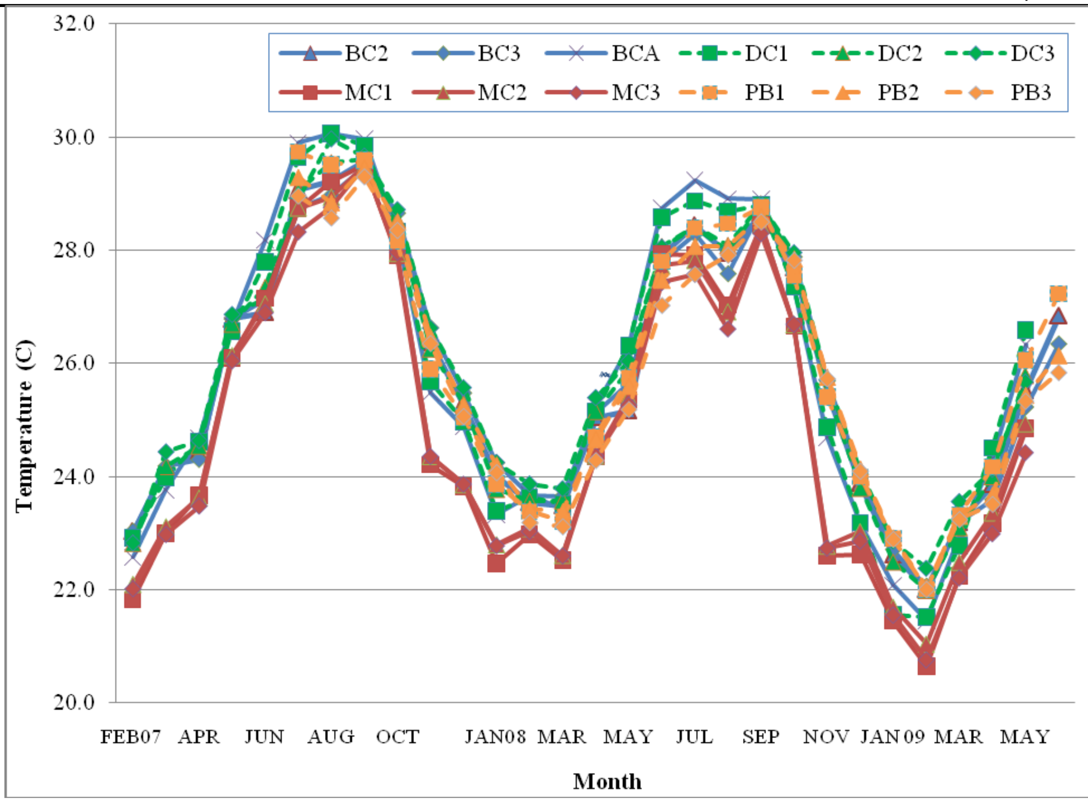

Figure 8. Mean monthly temperatures (°C) for all sites, February 2007 – May August 2009.

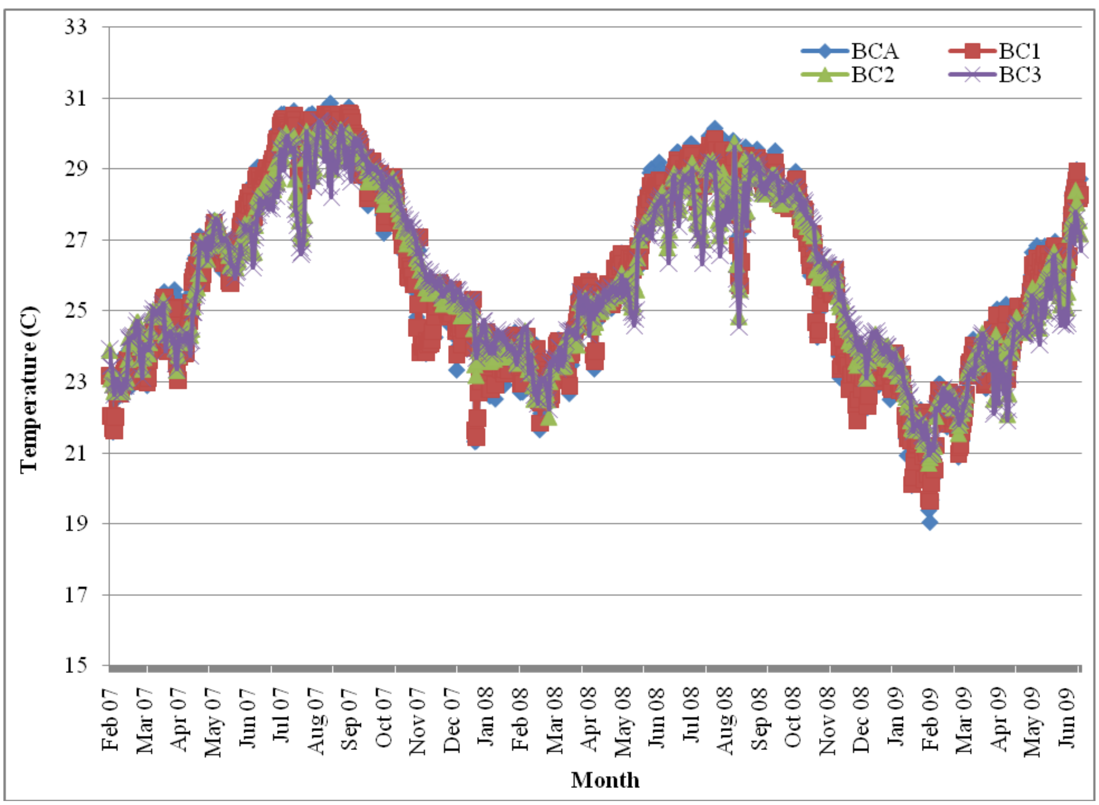

Figure 9. Mean daily temperatures (°C) for the four Broward County sites.

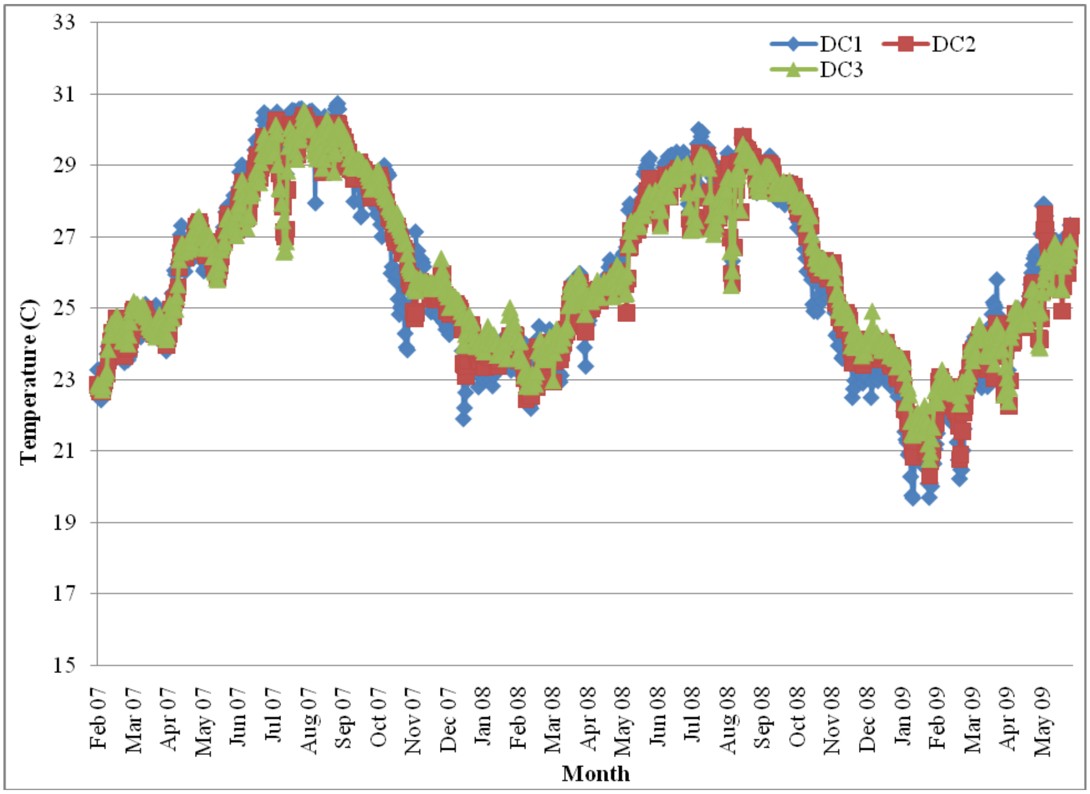

Figure 10. Mean daily temperatures (°C) for the three Miami-Dade sites.

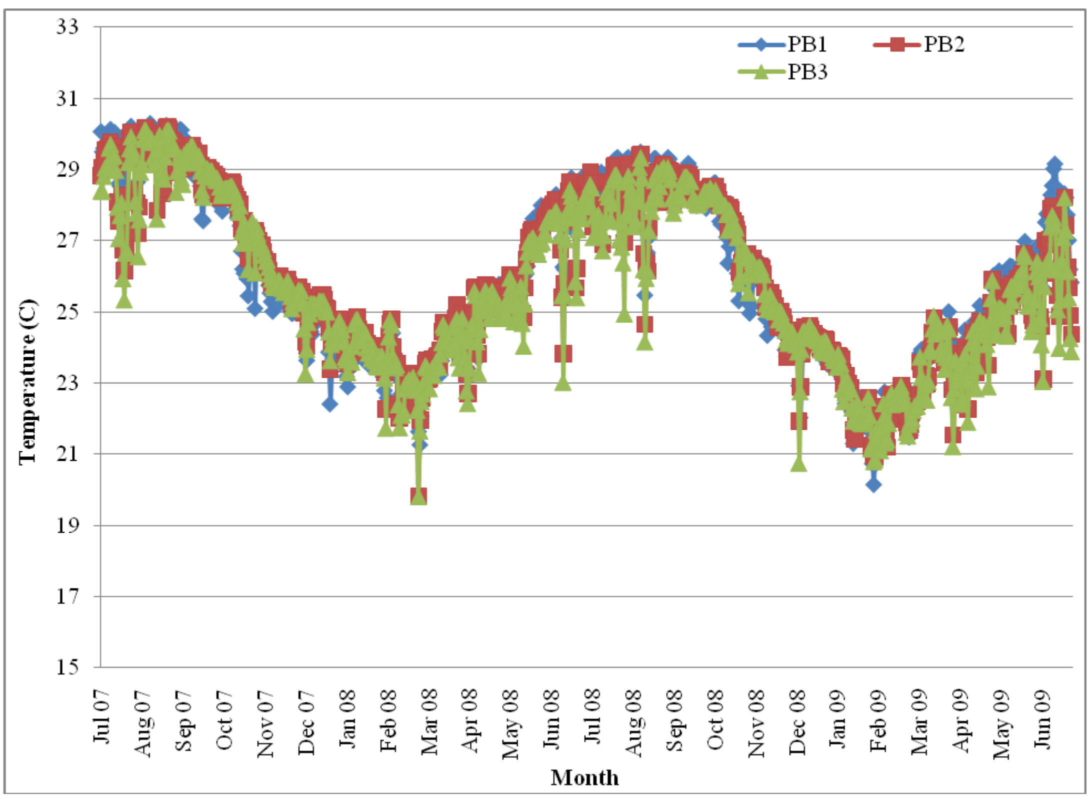

Figure 11. Mean daily temperatures (°C) for the three Palm Beach sites.

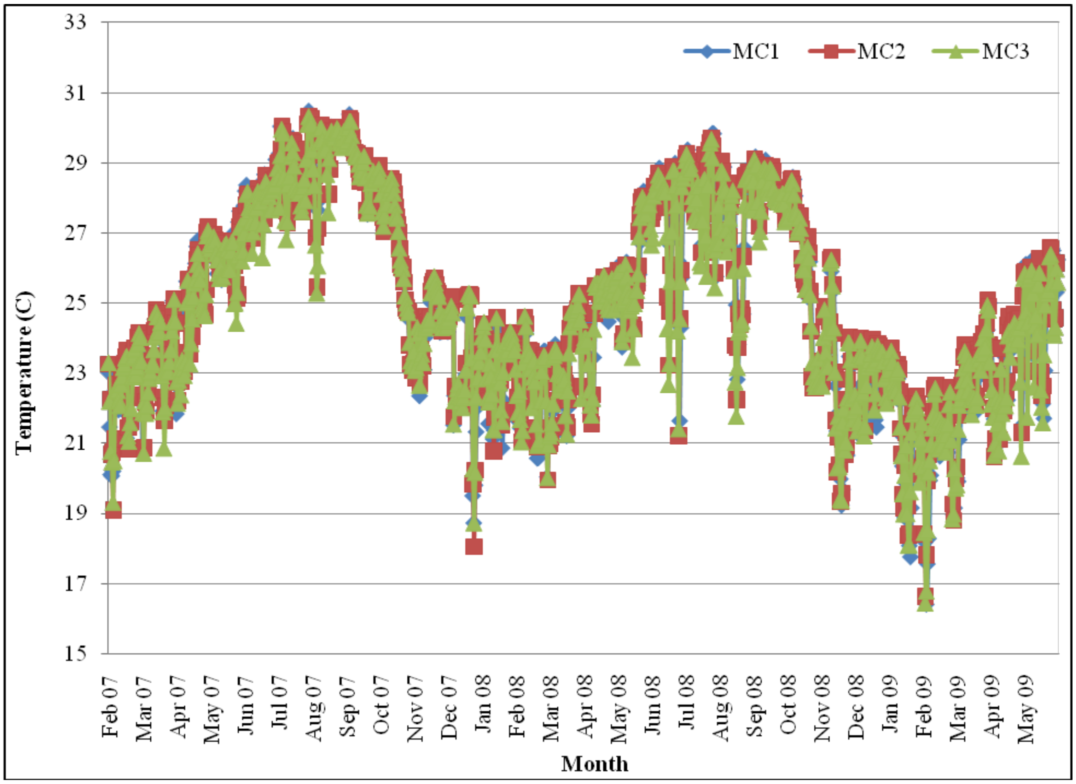

Figure 12. Mean daily temperatures (°C) for the three Martin County sites.

DISCUSSION

The coral reef ecosystem off southeast Florida is the northern extension of the Florida Reef Tract and as such is a high-latitude system near the environmental threshold for significant reef growth. Southeast Florida reefs generally have similar stony coral species richness but reduced stony coral cover compared to the southern portions of the Florida Reef Tract in the Dry Tortugas and Florida Keys (Callahan et al. 2007). Benthic cover by octocorals is similar throughout the Florida Reef Tract, while macroalgae appears to contribute less cover and sponges appear to contribute more cover off southeast Florida (Callahan et al. 2007).

With seven years of data, in general, the status of the southeast Florida reef system has changed little from 2003 to 2009 (except for site PB1 and in some respects, site BCA). Stony coral species richness (Table 3; Figure 5) and cover are very similar between years (Table 8; Figures 6 and 7). The incidence of disease in 2009 (31 colonies) (Tables 5 and 6) was more than that identified in 2008 (21 colonies), but less than the 46 colonies identified in 2007. Of these 31 colonies, eight were still diseased from 2008 and 23 were newly diseased colonies. Although determining colony density has not been part of this project, examining all thirteen sites within this project, diseases do not appear to be a major factor affecting stony coral condition or cover in the SECREMP sites, especially since the presence of 'disease' within the sites is primarily in *S. siderea* colonies (23 of the 31 colonies in 2009). For a majority of the functional groups measured at most of the sites there do not appear to be any consistent regional trends in temporal changes in functional group cover between 2003 and 2009 (Tables 11-14). Macroalgae and octocorals remain the two (non-substrate) benthic functional groups with the highest cover for the region. The sites with changes in functional group cover are discussed below.

In 2005, site PB1 was greatly affected by sand movement. Stations 2 and 4 were completely covered with sand more than several centimeters in depth. Stations 1 and 3 were also impacted but to a lesser degree than stations 2 and 4. In 2006, stations 2 and 4 remained buried in sand. From 2007 to 2009, stations 2 and 4 have started to become uncovered. From 2006 to 2009, no stony corals were observed in these stations. The cause of this sand movement is unknown although past beach nourishment activities and the 2004 hurricanes, Jeanne and Frances, may have contributed to this significant sand movement. The variable sand cover at this site greatly influenced summary data for site PB1, and therefore, the year comparisons. The loss of reef habitat at these two stations reduced the number of coral species identified in Palm Beach, the percent stony coral cover, reduced functional group coverage data (see Table 14 and note the reduction in porifera cover), and reduced the total bio-eroding sponge coverage area.

Site BCA was added to the project as the fourth site in Broward County for the purpose of monitoring one of the unique southeast Florida *A. cervicornis* patches. With the recent listing of *A. cervicornis* as a threatened species under the U.S. Endangered Species Act (http://www.nmfs.noaa.gov/pr/pdfs/fr/fr71-26852.pdf), it is important to make special note of site BCA. *Acropora cervicornis* cover decreased from a high of 39% in 2004 and 2005 to a low of 25% in 2006 (Table 8). *Acropora cervicornis* cover increased to 31% in 2007 (Table 8) and remained essentially at this level in 2008. The cover decreased again in 2009 to 26%. The reason(s) for the decline in 2006 and 2009, measured within the permanent transects, is unknown. Sampling of the site has been conducted at the same time each year. (June in 2004-2009, Table 2). The passing of Hurricane Wilma over the area in October 2005 may have contributed to some of the decline in 2006. The cyanobacteria, *Lyngbya* spp., bloom seen in previous years (2004) appeared to be in decline between 2005 and 2009 (D. Gilliam, personal observation). Data collected by a separate monitoring effort, which includes the site BCA *A. cervicornis* patch and a second *A. cervicornis* patch north, has suggested that disease and predation by the fireworm, *Hermodice carunculata*, may be the primary causes of tissue loss (Gilliam unpublished data). SECREMP is an annual monitoring project designed with the use of permanent transects. This annual permanent transect design may not provide all the data appropriate for monitoring and/or determining the changes in condition of a large *A. cervicornis* patch. Since asexual reproduction is an important mechanism structuring *A. cervicornis* populations, these larger patches may be in a dynamic state with changing boundaries and relative cover within the patch (as evident from the increase in cover in 2007, stability in 2008 an a reduction again in 2009).

The cyanobacteria, *Lyngbya* spp., were covering much of site DC3 in 2008. Cyanobacteria are part of the Other Biota function group for the image analysis cover estimates. In 2008, the *Lyngbya* spp. cover was over 11%, compared to 3% or less in previous years (Table 12). In 2009 this cover dropped back to 3%. *Lyngbya* was covering many octocorals and sponges in 2008, and likely contributed to the decline in octocoral and sponge cover determined in 2008. In 2009, the octocoral cover was again reduced

(Table 12). The sponge cover, however, increased from 2008. Octocoral cover in site DC2 was also reduced in 2009. These two sites consistently have greater percent cover of Other Biota than the other sites. For both sites, the Other Biota group is dominated by cyanobacteria. The continued high cover of cyanobacteria is likely a contributing factor to the decline in octocoral cover at both sites DC2 and DC3.

Temperature loggers were deployed at ten sites in February 2007 and the three Palm Beach sites in July 2007. With more than 2 years of temperature data recorded, some trends in water temperatures are becoming evident. All sites (Figures 8-12) show the expected pattern of cooler water temperatures in the winter months (December – March) and warmer temperature in the summer months (June – September). For all sites, August and September are the warmest months. It is also becoming clear that there is inter-annual variability in seasonal water temperatures. For all sites the summer 2008 temperatures were generally cooler than in 2007 while the winter 2009 temperatures were generally cooler than the 2008 temperatures (Figures 8-12). Temperatures greater than 30.5°C, which is a temperature above which bleaching has been recorded in the Florida Keys (Manzello et al. 2007), were recorded for five sites (BCA, BC1, DC1, DC3, and MC1) during the summer (July-September, mostly late August) of 2007. Three of these sites (BCA, BC1, DC1, and MC1) are shallow (less than 7 meters), nearshore sites. No sites recorded temperatures above 30.5°C in 2008. In addition, all sites in 2007 had at least 5 days with temperatures above 30°C, and three nearshore, shallow sites (BCA, BC1, and DC1) had over 50 days of temperatures above 30°C. In 2008, only site BCA (3 days) and site DC1 (1 day) had temperatures above 30°C recorded. The SECREMP sampling period is generally conducted between late May and early August (Table 2), prior to the warmest recorded temperatures and to the time of year warm water bleaching is observed. The effect of these high temperatures on the stony coral communities at the SECREMP sites is not entirely known, but with (except for site BCA) stony coral cover not significantly changing at the sites, a measurable negative effect associated with high water temperatures appears to be unlikely.

The coral reefs of southeast Florida represent a significant economic resource to the region. Between June 2000 and May 2001, visitors spent 28 million person-days enjoying artificial and natural reefs in southeast Florida. During the same period, reef-related expenditures and income amounted to over 5.7 billion dollars and supported over 61,300 jobs in Miami-Dade, Broward, Palm Beach and Martin Counties (Johns et al. 2003, 2004). Notably, Johns et al. (2003) indicate southeast Florida reefs generate six times the sales, income and jobs compared to reefs in the Florida Keys.

These important economic and recreational benefits are threatened because the coral reef environments of southeast Florida are under varied and chronic stressors. This area is highly urbanized along the coast. Dredging for beach renourishment, inlet and port channel deepening, and maintenance can have significant direct impacts on reef substrate, as well as impacts on water quality. Chronic turbidity and deposition of silt can smother sessile invertebrates and result in barren areas. Nearshore reef areas are at risk from the diversion of millions of gallons of fresh water and treated wastewater into the ocean, and the resultant reduction in salinity. Additional risks include the introduction of agricultural and industrial chemical contamination, and excess nutrients.

Impacts from boating and fishing activities are a significant threat to reef areas as damage from fishing gear and anchoring can be severe. A possible example of this can be seen in the site MC3 colony fate tracking effort with nearly half of the mapped *O. diffusa* colonies showing effect from entanglement from fishing line (Table 17). Adverse impacts from SCUBA divers can also occur. Traffic from large ports (Miami, Port Everglades, and Palm Beach) including cruise and container ships, military vessels, and oil tankers, can conflict with reef resources. Ships occasionally run aground and anchor on reefs causing extensive and often long-lasting damage. Other recent impacts include those of the installation of fiber optic cables deployed across the reefs, which may cause abrasion and detachment of corals and sponges (Jaap 2000).

The chronic nature of disturbances to, and the significant economic value of, the southeast Florida reefs requires comprehensive, long-term monitoring to be conducted to define change and help identify threats to the ecosystem. The region-wide information generated during the annual SECREMP site visits provide scientifically valid status and trends data designed to help local resource managers understand the implications of actions occurring in terrestrial and adjacent marine habitats. However, SECREMP was established to be a monitoring project independent of coastal development projects and un-permitted incidents (e.g. ship groundings), and as such most localized impacts from these activities are not captured by SECREMP. There is a need for more comprehensive, longer-term, and site-specific project/incident monitoring. Both continual region-wide monitoring (SECREMP) and improved site-specific monitoring are necessary if resource managers are to develop sound management plans for coral reefs that permit continued use, and realization of the economic value, of these fragile marine ecosystems.

The expansion of the Coral Reef Evaluation and Monitoring Project to include sites in Broward, Miami-Dade, Palm Beach, and Martin Counties has insured that this minimum suite of parameters is being monitored for the full extent of the Florida coral reef ecosystem. One of the goals of the NOAA Coral Ecosystem Monitoring Program is monitoring with an explicit link to assessing the efficacy of "coastal" management strategies. While a true effects study designed to assist resource managers in gauging potential effects from past or future impacts (e.g., beach renourishment, pipelines, etc.) is not possible with our limited sample size, local resource managers (County) were directly involved in choosing the sample sites and were present during the site selection field work. Site BCA (Broward County *Acropora cervicornis* patch) is an example of a site specifically chosen by State and County resource managers in order to monitor potential changes to this unique area.

The partnership with Nova Southeastern University Oceanographic Center and its constituent National Coral Reef Institute has worked to expand local capacity for maintaining long-term monitoring sites, complementing those being sampled as part of the National Coral Reef Monitoring Network. As a monitoring project under the Coral Reef Conservation Grant Program for the Florida east coast, the SECREMP will continue characterization of baseline ecosystem condition, inventory/mapping of biotic resources, and data base development, providing resource managers with the critical information required to manage this valuable natural resource.

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