Southeast Florida Coral Reef Evaluation and Monitoring Project

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2018 Year 16 Final Report

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LIST OF ACRONYMS

CRCP ……………………………..………. (FDEP) Coral Reef Conservation Program
CREMP ……………………………..…. Coral Reef Evaluation and Monitoring Program
FDEP ……………………………..…… Florida Department of Environmental Protection
FKNMS ……………………………………….. Florida Keys National Marine Sanctuary
FWC ……………………………… Florida Fish and Wildlife Conservation Commission
FWRI ……………………………………………...Fish and Wildlife Research Institute
SECREMP ……………………. Southeast Coral Reef Evaluation and Monitoring Project

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Executive Summary

The southeast Florida coral reef ecosystem is offshore a highly urbanized mainland (population > 6 million) influenced by numerous human activity-related local and global stressors. To document changes potentially related to increasing stressors, the Florida Department of Environmental Protection (FDEP) working with Florida Fish and Wildlife Conservation Commission (FWC) and Nova Southeastern University (NSU) initiated a long-term annual coral reef monitoring program in 2003 along the southeast Florida coast. In order to provide continuity in monitoring efforts along the entire Florida Reef Tract (FRT), the Southeast Florida Coral Reef Evaluation and Monitoring Project (SECREMP) was established as an expansion of the FWC managed Coral Reef Evaluation and Monitoring Project (CREMP) in the Florida Keys. SECREMP provides local, state, and federal resource managers annual reports on the status and condition of the southeast Florida (Miami-Dade, Broward, Palm Beach, and Martin counties) coral reef system as well as information on temporal changes in resource condition. Survey methods include photographic transects to quantify percent cover of major benthic taxa (stony corals, sponges, octocorals, macroalgae, etc.) and demographic surveys to quantify abundance, size distribution, and overall condition of stony corals, octocorals, and the giant barrel sponge. SECREMP is also a partnership between FDEP, FWC, and NSU that facilitates collaboration and knowledge sharing benefiting coral reef ecosystems nationwide.

Prior to the 2018 sampling year, the Southeast Florida Coral Reef Ecosystem Conservation Area experienced significant stony coral community declines largely due to an unprecedented stony coral disease event. In 2018, further significant losses were recorded in stony coral cover and live tissue area (LTA), a metric used to estimate amount of coral tissue. Region-wide LTA was significantly lower starting in 2016 with no significant recovery through 2018; there was a significant 40% loss in LTA from 2015 to 2018. During the same time period, the region suffered a 57% loss in stony coral cover. This disease event was very likely the greatest contributing factor to the significant loss of stony coral colonies and LTA identified within the SECREMP sites. Conditions appear to be improving with a decrease in disease prevalence in 2018 and the recording of many juvenile stony corals of the species affected by disease in the SECREMP sites. Additionally, it is positive to note that neither the octocoral nor barrel sponge, *Xestospongia muta*, communities appear to have been impacted by the disease event.

The chronic nature of disturbances to and the significant economic value of the coral reefs within the Southeast Florida Coral Reef Ecosystem Conservation Area requires comprehensive, long-term monitoring to define and quantify change and to help identify threats to the ecosystem. Both continual region-wide monitoring (SECREMP) and improved incident-specific monitoring are necessary if resource managers are to develop sound management plans for coral reefs that allow continued use and realization of the economic value of these fragile marine ecosystems. The value for a long-term region-wide monitoring program is highlighted by the information, albeit concerning, presented in this report.

Introduction

The coral reef ecosystem in Florida is an important aesthetic and economic resource that extends approximately 577 km from the Dry Tortugas in the south to the St. Lucie Inlet in the north. The southeast Florida reef system exists within 3 km off the mainland Atlantic coast of Florida and extends approximately 170 km from Miami-Dade County in the south to Martin County in the north. These reefs support diverse benthic organisms and fish communities. Additionally, the southeast Florida reef habitats are an important economic asset for the region. The reef system has been estimated to protect nearly 6,000 people, over $500 million in infrastructure and $300 million in economic activity from storm-related flooding (Storlazzi et al. 2019). These reefs have also been estimated to generate more than $3 billion in sales and income and support more than 35,000 jobs (Johns et al. 2001, 2004). While the southeast Florida reefs are clearly an important resource their location offshore a highly urbanized area (population > 6 million) drives ever-increasing human activity-related stress on the reefs. In recognition of the reef system's ecological and economic value and vulnerability to human population-related stress, the State of Florida designated state waters offshore Martin (south of St Lucie Inlet), Palm Beach, Broward, and Miami-Dade (north of Biscayne National Park) Counties as the Southeast Florida Coral Reef Ecosystem Conservation Area (Coral ECA) in July 2018.

Prior to 2003, most coral reef monitoring efforts (e.g. Gilliam et al. 2015) along the mainland southeast coast were associated with impact and mitigation studies (dredge impacts, ship groundings, pipeline and cable deployments, and beach renourishment). The temporal duration and spatial extent of these monitoring efforts were limited, being defined by an activity permit and focused on monitoring for effects specific to a given impact. In 2003, the Florida Department of Environmental Protection (FDEP) was awarded funding for the inception of a long-term coral reef monitoring program along the southeast Florida coast. Prior to this the primary focus for long-term coral reef monitoring was limited to the Florida Keys and Dry Tortugas in Monroe County. 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 along the Keys portion of the Florida Reef Tract (FRT) from Key West to Carysfort Reef (Ruzicka et al 2010; Ruzicka et al. 2013). In 1999 the project was expanded to include sites in the Dry Tortugas. In order to provide continuity in monitoring efforts along the FRT from the Keys through southeast Florida, FDEP established the Southeast Florida Coral Reef Evaluation and Monitoring Project (SECREMP) as an expansion of CREMP. The goal of SECREMP has been to provide local, state, and federal resource managers an annual report on the status and condition of the southeast Florida (Miami-Dade, Broward, Palm Beach, and Martin counties) reef system as well as information on temporal changes in resource condition.

Survey Sites

Off the mainland coast of southeast Florida from Miami-Dade County north to central Palm Beach County, in particular offshore Broward County, the Coral ECA 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 12 to 14 m depths. 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 Miami-Dade County 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 colonized by reef biota (Walker and Gilliam 2013). Since the inception of SECREMP sites have been spread across these four habitats.

SECREMP began monitoring in 2003 at 10 sites, three each in Palm Beach and Miami-Dade counties and four in Broward County, including a nearshore monotypic stand of *Acropora cervicornis*. In 2006, two sites were added in Martin County extending efforts to the northernmost area of the FRT. Four additional sites were added in 2010, two each in Palm Beach County and Miami-Dade County. Finally, in 2013 six sites were added, three each in Broward and Miami-Dade counties. Currently SECREMP monitors 22 sites from Miami-Dade County to Martin County distributed across all four described habitats. Figures 2 and 3 show the location of the 22 current sites along the southeast Florida coast. Project sampling occurs annually between May and August. Table 1 provides reef type, depths, locations, and the 2018 sample date of each of the SECREMP sites.

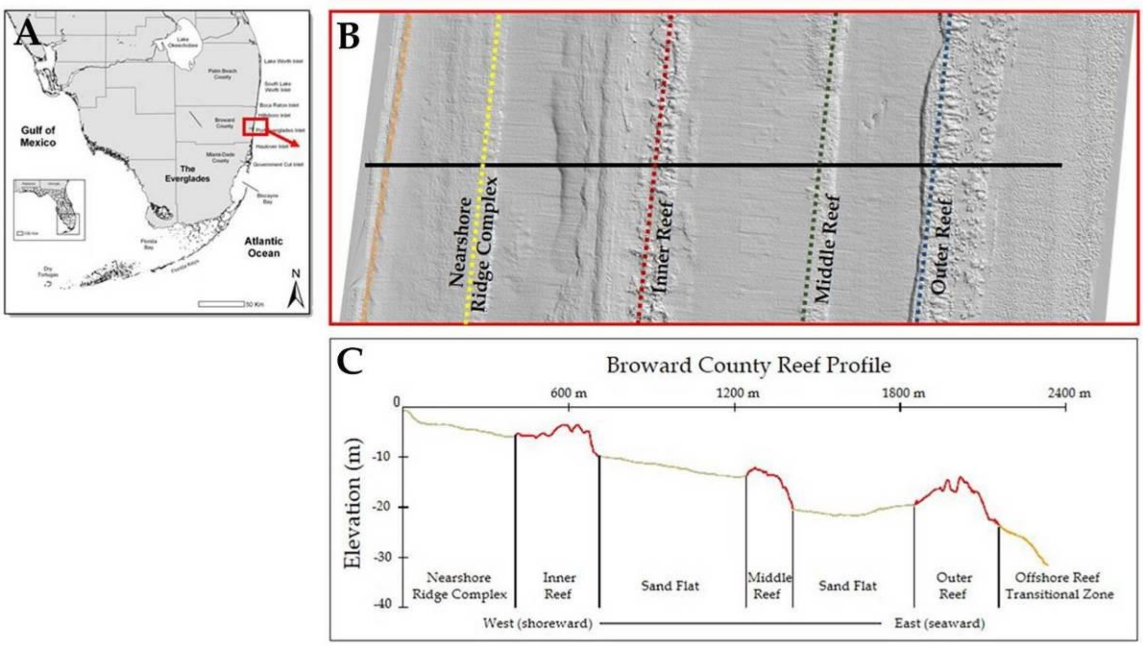

Figure 1. View of the southeast Florida coastline. Panel A is a view of southern Florida showing an area off Broward County in red that corresponds to Panel B which is sea floor bathymetry from LIDAR (Light Detection and Ranging) data. The black line in Panel B shows the location of a bathymetric profile illustrated in Panel C.

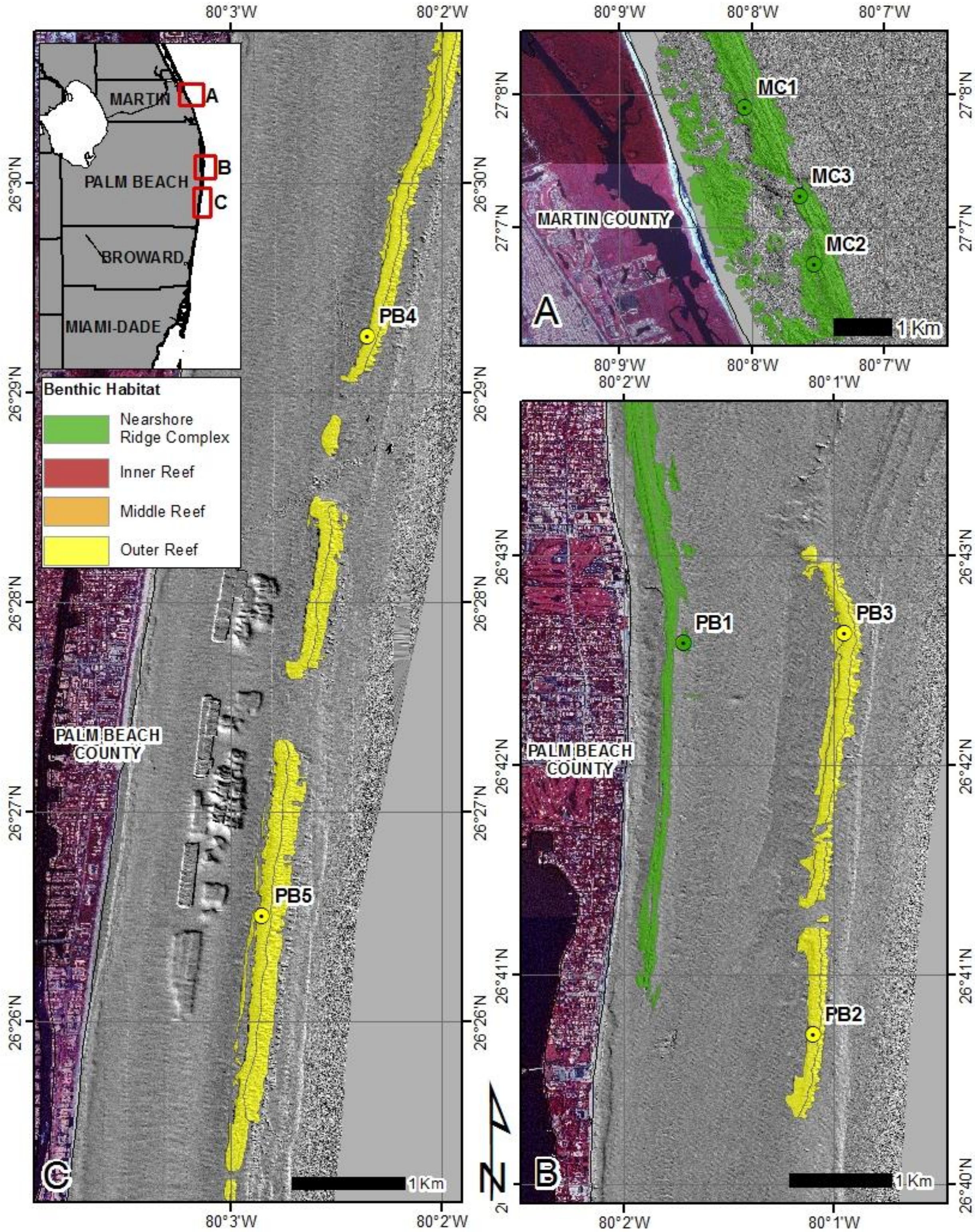

Figure 2. Site location and habitat map of Martin (Panel A) and Palm Beach (Panels B and C) counties.

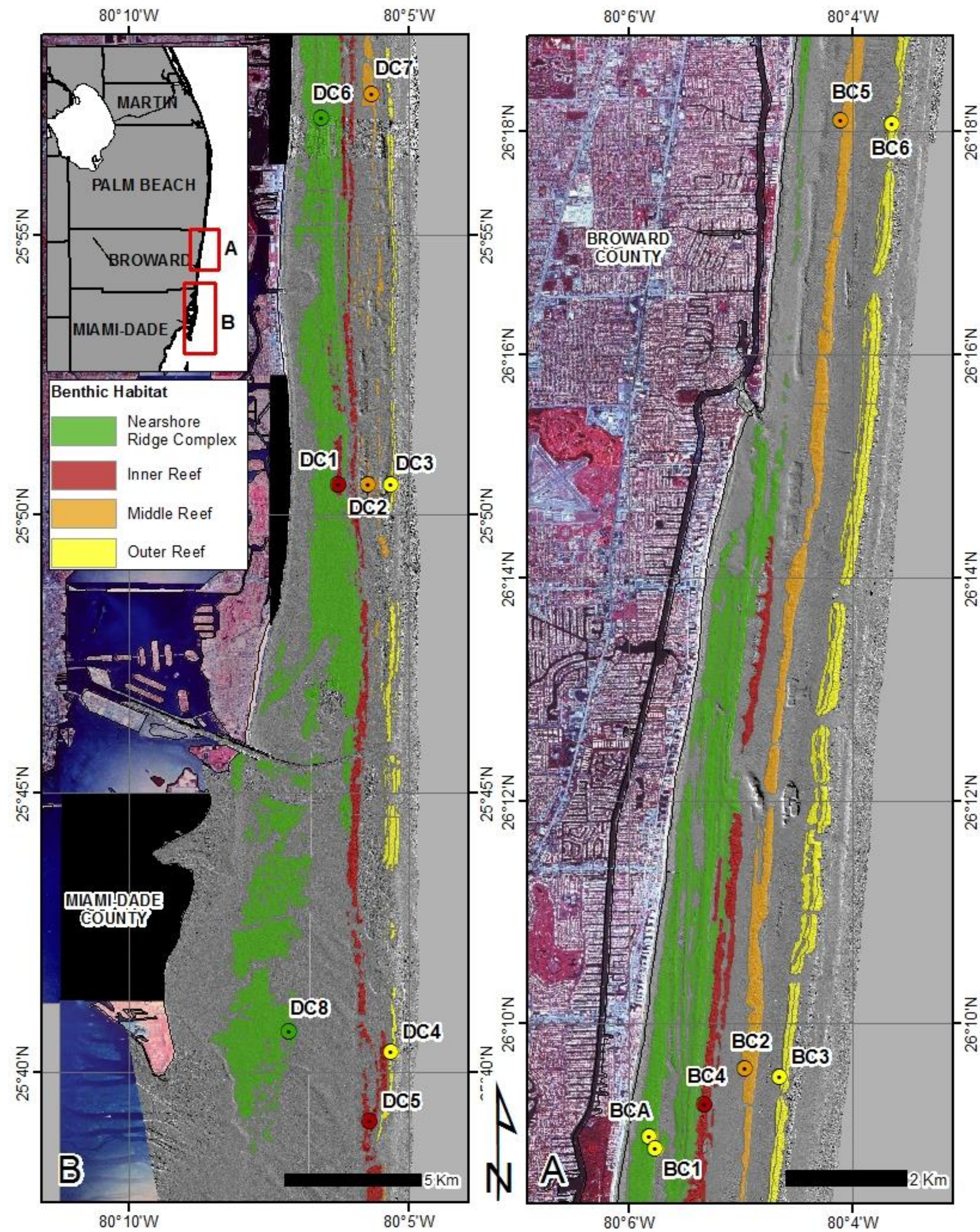

Figure 3. Site location and habitat map of Miami-Dade (Panel B) and Broward (Panel A) counties.

Table 1. Monitoring site reef types, depth (ft), location, and 2018 sample date (DC = Miami-Dade County; BC = Broward County; PB = Palm Beach County; MC = Martin County) (NRC = Nearshore Ridge Complex).

Site Code	Reef Type	Depth	Latitude (N)	Longitude (W)	Sample Date
DC1	Inner	25	25° 50.530’	80° 06.242’	3-July
DC2	Middle	45	25° 50.520’	80° 05.704’	12-July
DC3	Outer	55	25° 50.526’	80° 05.286’	3-July
DC4	Outer	41	25° 40.357’	80° 05.301’	5-July
DC5	Inner	24	25° 39.112’	80° 05.676’	28-June
DC6	NRC	15	25° 57.099’	80° 06.534’	22-Aug
DC7	Middle	55	25° 57.530’	80° 05.639’	22-Aug
DC8	NRC	15	25° 40.707’	80° 07.111’	12-Aug
BCA	NRC	25	26° 08.985’	80° 05.810’	7-June
BC1	NRC	25	26° 08.872’	80° 05.758’	2-July
BC2	Middle	40	26° 09.597’	80° 04.950’	2-July
BC3	Outer	55	26° 09.518’	80° 04.641’	9-July
BC4	Inner	30	26° 08.963’	80° 05.364’	20-June
BC5	Middle	45	26° 18.100’	80° 04.095’	15-Aug
BC6	Outer	55	26° 18.067’	80° 03.634’	15-Aug
PB1	NRC	25	26° 42.583’	80° 01.714’	17-July
PB2	Outer	55	26° 40.710’	80° 01.095’	17-July
PB3	Outer	55	26° 42.626’	80° 00.949’	18-July
PB4	Outer	55	26° 29.268’	80° 02.345’	19-July
PB5	Outer	55	26° 26.504’	80° 02.854’	16-July
MC1	NRC	15	27° 07.900’	80° 08.042’	12-June
MC2	NRC	15	27° 06.722’	80° 07.525’	12-June

Methods

Each site consists of four monitoring stations demarcated by stainless steel stakes that are permanently placed in the substrate. Each station is 22 meters in length and has a north-south orientation, which is generally parallel to the reef tracts of southeast Florida. Survey transects are delineated by a fiber glass tape stretched between the stainless steel stakes at either end of a station. In situ sampling included photo transects at all site stations sampled each year (2003-2018). Starting 2013, a stony coral population survey, an octocoral population survey, and a *Xestospongia muta* population survey, were conducted along the same transect covering a similar area of the substrate (Figure 4).

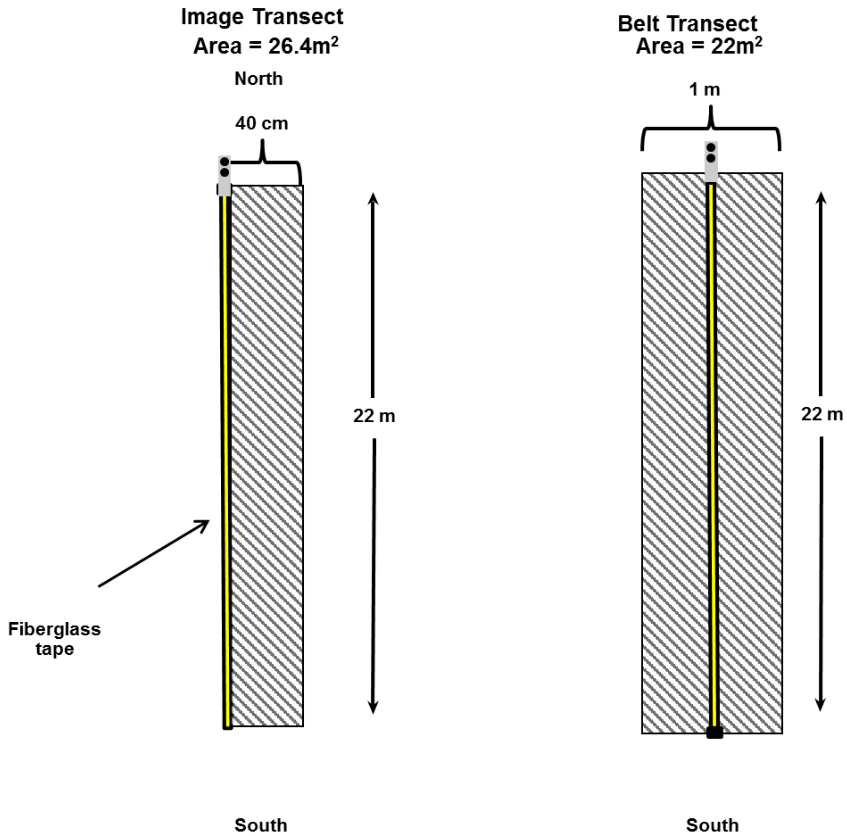

Figure 4. Layout of each SECREMP station showing the areas (hatched) within which the image and belt transect data were collected (note the gorgonian belt area is 1 m x 10 m).

Image Transects

Transect images were taken at all stations at all sites sampled each year (2003-2018). All transect images were taken to the east of the fiberglass tape delineating a transect. In 2018, the images were taken using a Olympus TG-4 tough digital camera. Each image was captured at a distance of ~40 cm above the reef substrate to yield images approximately 40 cm wide by 30 cm in height. A constant distance above the substrate was maintained using an aluminum bar affixed to the bottom of the camera housing. Benthic features seen in the top border of the camera viewfinder and the fiberglass tape were used as visual reference points to take abutting images with minimal overlap. This results in a transect consisting of about 60 images and covering an area of approximately 0.4 m x 22 m.

In the lab, images were formatted for PointCount '99 image analysis software. Fifteen random points were overlaid on each image. Underneath each point, select benthic taxa were identified to species (e.g. stony corals, *Gorgonia ventalina*, *Xestospongia muta*), genus (e.g. *Dictyota* spp., *Halimeda* spp., and *Lobophora* spp), or higher taxonomic levels (e.g. encrusting or branching octocoral, crustose coralline algae, zoanthid, sponge, and macroalgae). Uncolonized substrate was identified as sand or substrate (consolidated pavement or rubble). After all images were analyzed, the data were checked for quality assurance and entered into the Microsoft Access database managed by FWC.

Stony Coral Demographic Survey

Stony coral population surveys were performed at all site stations starting in 2013. Divers conducted a 1 m x 22 m belt transect from north to south along the transect tape identifying every stony coral colony to species (Figure 4). From 2013-2017, all colonies ≥ 4 cm in diameter were identified to species and the maximum diameter and the maximum height, perpendicular to the plane of growth, were measured. Each colony was then visually assessed for the presence of diseases, bleaching and other conditions (i.e. predation, damselfish, Clionaids etc.). Where these conditions resulted in partial mortality the percentage was visually estimated. Diseases include those with conditions that resulted in tissue mortality (i.e. Stony Coral Tissue Loss Disease or blackband disease) as well as conditions that may not visually result in tissue mortality (i.e. dark spot syndrome and tissue growth anomalies). Mortality was considered ''recent'' if the corallite structure was clearly distinguishable and there was minimal overgrowth by algae or other fouling organisms. Otherwise, mortality was classified as ''old''. In 2018, the minimum colony size for demographic data was reduced to ≥ 2 cm in diameter. Also starting in 2018, colonies < 2 cm were identified to lowest taxonomic level possible and tallied at each station. However, for this report, only colonies ≥ 4 cm in diameter were included in the demographic data analysis. All corals < 4 cm in diameter were presented as tallied data only. For *Millepora alcicornis* (fire coral) only colony presence or absence was recorded. Prior to 2014 SECREMP grouped *Orbicella* (formerly known as *Montastraea*) *annularis*, *Orbicella faveolata*, and *Orbicella franskii* as the *Montastrea annularis* complex, and they are, therefore, grouped for this report.

Octocoral Demographic Survey

Octocoral population surveys starting in 2013, were also conducted at all stations but covered a reduced survey area. Divers conducted a 1 m x 10 m belt transect starting at the northernmost stake for each station. Octocoral surveys were completed in two parts. First, all octocoral colonies within the belt transect were counted, regardless of species, to provide a measurement of overall octocoral density. Second, for three target species, *Antillogorgia americana* (formerly *Pseudopterogorgia americana*), *Eunicea flexuosa* (formerly *Plexaura flexuosa*), and *Gorgonia ventalina*, all colonies within the belt transect were recorded, the maximum height was measured and the colony was visually assessed for the presence of disease, bleaching and/or various other conditions (e.g., predation, overgrowths, etc.). These species were selected because they are generally more confidently distinguishable in the field and are relatively abundant in their preferred reef habitat along the Florida Reef Tract. While colony conditions were assessed the condition data are not presented in this report.

Barrel Sponge Demographic Survey

A barrel sponge (*Xestospongia muta*) population survey, starting in 2013, was also conducted at each station. *Xestospongia muta* density was determined by counting all sponges within the 1 m x 22 m belt centered under the transect tape (Figure 4). For each sponge the maximum diameter, maximum base diameter, and maximum height were measured, and the sponge was visually assessed for the presence of disease, bleaching and other conditions (i.e. damage/injury, predation). The percent of the sponge affected by injury, disease, and/or bleaching was also recorded. Similar to octocorals, sponge conditions are not presented in this report.

Monitoring Site Temperature Record

The deployment of Onset (www.onsetcomp.com) temperature loggers has been part of the SECREMP sampling protocol since 2007. Temperature loggers were deployed at all existing sites annually and at new sites as they were established. Throughout the course of the project three models of temperature loggers have been deployed: StowAway TidbiT™, Hobo Pendant Temperature Data Logger, and Hobo Water Temp Pro v2. Two temperature recorders were deployed at each site and were replaced during each annual sampling event. Two loggers were deployed at each site in order to provide redundancy in case one logger failed or was lost. The loggers were programmed to record data at a sampling interval of two hours. The two loggers were attached approximately 10 cm off the substrate to the 'northern' stakes identifying Stations 1 and 2 at each site. Data from both loggers were downloaded. If data from both loggers were successfully downloaded, the data from the logger attached to Station 1 was reported.

Analyses

To provide an additional metric to evaluate changes to the stony coral community (only colonies ≥ 4 cm diameter because colonies 2-4 cm were only first included in 2018), stony colony width, height and percent mortality (sum of old and recent) were used to calculate total live tissue area (LTA) for each site for 2013-2018. Region-wide LTAs were also calculated for select stony coral species for 2013-2018. The LTA for each colony was calculated using the following equation:

$$SA = 2\pi\left(\frac{a^p\left(\frac{1}{2}b\right)^p + a^p\left(\frac{1}{2}b\right)^p + \left(\frac{1}{2}b\right)^p\left(\frac{1}{2}b\right)^p}{3}\right)^{\frac{1}{p}}$$

This equation was modified from Knud Thomsen's formula for the estimated surface area (SA) of an ellipsoid. The original SA equation was multiplied by ½ to estimate the surface area of a coral as the equivalent of the top half of an ellipsoid. In this modified version a = maximum height of the colony, b = the maximum diameter of the colony, and p ≈ 1.6075, a constant yielding a relative error of at most 1.061%. Following calculation of the SA, the value was converted to LTA via the following formula:

$$LTA = SA\left(1 - \left(\frac{\%\ Old\ Mortality + \%\ Recent\ Mortality}{100}\right)\right)$$

Mortality was divided by 100 to convert to a proportion. Additionally, LTA was calculated in cm^2 and then converted to m^2.

Region-wide stony coral (colonies ≥ 4 cm diameter) density and LTA, octocoral density, and barrel sponge density were tested for differences between years 2013 – 2016. Additionally, select stony coral species (*M. cavernosa*, *M. meandrites*, *D. stokesii*, *P. astreoides*, *S. bournoni*, *Montastrea (Orbicella) annularis* complex, and *S. siderea*) were examined for changes in LTA between years. Similar to stony corals, the three octocoral target species were tested for differences in density and mean height between years. For metrics meeting the assumptions of a repeated measures analysis of variance (ANOVA), the ANOVA was performed using the linear mixed-effects model (lme) and anova functions in the nlme (Pinheiro et al. 2017) and base R packages, respectively, in R (version 3.3.3 (2017-03-06)) (R Core Team 2017). The lme equation was "metric" ~ year with site as the repeated measure within Year. Following the lme function, the anova function was used to perform the ANOVA on the lme model. Significant differences between years for all metrics were identified by $p \leq 0.05$. For metrics analyzed via the lme and anova test and identified as significant, a general linear hypothesis (glht) and multiple comparisons "post-hoc" were performed to determine which years were significantly different. The "post-hoc" was performed using the glht function in the multcomp package (Hothorn et al. 2008) in R. Significant differences between years were identified by multiple comparison adjusted (Tukey single-step method) p-values ($p \leq 0.05$).

Region-wide stony coral disease prevalence was calculated for the 2013 – 2018 (colonies ≥ 4 cm diameter). Regional prevalence was calculated by taking the total number of diseased stony coral colonies for the region and dividing it by the total number of all stony coral colonies and multiplying by 100% to get prevalence as a percent. Site level prevalence values were calculated by dividing the total number of diseased colonies within a site it by the total number of colonies and multiplying by 100% to get prevalence as a percent.

Differences in stony coral, macroalgae, octocoral, and sponge percent cover between 2017 and 2018 at each site were tested using a two-way mixed model ANOVA, with year and site (stations nested within site) as fixed effects. Station data were pooled and square-root transformed. Significant differences within sites between years were identified using a Bonferroni adjusted ($p \leq 0.002$) post-hoc Tukey-Kramer test. All analyses were completed using a generalized linear mixed model (GLIMMIX) with SAS/STAT® v 9.2 software. In order to provide a comprehensive review of percent cover data including all survey sites and all survey years multiple analyses were conducted. Each group of survey sites was analyzed separately with the groups delineated based on their initial survey years. Group A consists of nine original survey sites (DC1, DC2, DC3, BC1, BC2, BC3, PB1, PB2 and PB3). The tenth original site, BCA, was analyzed on its own due to the special nature of the *Acropora cervicornis* patch at this location. Group B consists of the two Martin County sites first surveyed in 2006 (MC1 and MC2). Group C consists of the four sites added in 2010 (PB4, PB5, DC4 and DC 5) and Group D consists of the six sites added in 2013 (BC4, BC5, BC6, DC6, DC7 and DC8).

For all assessments annual survey data were blocked into different time intervals that generally reflect when additional sites were added to the survey (interval I, 2003-2005; interval II, 2006-2009; interval III, 2010-2012; interval IV, 2013-2015; interval V, 2016-2018). Whereas long-term trend analysis can provide information on whether a taxa is increasing or decreasing in percent cover over the entire 16 year period of monitoring shorter term or more recent changes in percent cover can often be overlooked. Many taxa groups may both increase and decrease over a 16 year period which potentially makes fitting a linear trend less informative than blocking the data as done herein and fitting binomial or polynomial trends can be more difficult. Pooling annual survey data in this manner allows for shorter term changes and more recent changes to be examined in a historical context while at the same time limiting the effects of both observer variability and temporary ephemeral events.

All analyses were conducted in SAS Enterprise Guide® v7.1. Percent cover data for the four major taxa groups (stony corals, octocorals, macroalgae [including cyanobacteria], and sponges) were analyzed using generalized linear mixed models (PROC GLIMMIX) with site and time intervals designated as fixed effects. A 'random' statement was added to all analyses to account for the effects of repeated measures on the residual error structure. Each group of sites (defined above) were analyzed separately. Data were square-root transformed prior to analysis except in two cases where a log-transformation was found to better meet the assumptions of a homogeneity of variance and a normally distributed variance (Site group C for macroalgae and site BCA for sponges). Several of the tests had somewhat heteroscedastic variance structures. Where these occurred either a first order sandwich estimator was used to adjust standard errors accordingly or 1 – 2 outliers were removed from the data. While these outliers were removed in order to have the statistical text more appropriately meet variance structure assumptions the overall results of each test did not change when these points were included. A list of the outliers removed is provided in Table 2. To identify significant differences between time intervals Tukey-Kramer post-hoc comparisons were used in each analysis. The adjusted P-values based upon the multiple comparisons in the Tukey-Kramer analyses were used to determine significance at $\alpha = 0.05$.

Table 2. List of outliers removed from long-term analyses.

Site Group A	Octocorals	PB2 station 1 - 2007 PB2 station 1 - 2010
Site Group A	Macroalgae	PB1 station 1 - 2005 PB2 station 2 - 2005
Site Group C	Stony Corals	PB4 station 1 – 2017 DC5 station 3 – 2014
Site Group C	Octocorals	PB4 station 1 – 2017 PB4 station 3 – 2018
Site Group C	Sponges	PB4 station 1 – 2017

Year 16 (2018) Results

Stony Coral

Year to year analysis of regional (all sites combined) stony coral cover showed a significant decrease from 2017 to 2018 (two-way mixed model ANOVA: $p < 0.05$, see Appendix 1for region wide and site mean values and Appendix 2 for statistical p-values). At the site level, three sites (BC4, MC1 and MC2) had a significant decrease from 2017 to 2018, for all other sites no significant difference was identified (two-way mixed model ANOVA: $p < 0.05$, see Appendix 1 for region wide and site mean values and Appendix 2 for statistical p-values).

Stony coral cover generally increased through time interval IV (2013-2015) but then significantly decreased by the final time interval (V: 2016-2018) across nearly all site groups. For site group A, stony coral cover steadily increased from time interval I through time interval III, though not significantly (Figure 5). Time interval IV (2.63% ± 0.73 [SE]) had the highest stony coral cover and was significantly greater than time intervals I, II, and III ($p < 0.0001$, $p < 0.0001$ and $p = 0.0479$, respectively); however, the final time interval, V (2016-2018), had significantly lower coral cover than all previous intervals (1.35 ± 0.37, for each comparison $p < 0.0001$). For site group B (Figure 5), the Martin County sites, there were no significant changes in stony coral cover across all time intervals though the year to year comparisons indicate a sharp decrease in 2018. Site group C (Figure 5) coral cover increased slightly from time interval III (1.56 ± 0.11) to time interval IV (1.77 ± 0.14) with time interval V being significantly less than both previous intervals (0.77 ± 0.09; $p < 0.0001$ for both comparisons). Site group D (Figure 5) coral cover significantly decreased from time interval IV (1.82 ± 0.32) to time interval V (1.19 ± 0.27; $p < 0.0001$). Site BCA (Figure 6), the *Acropora cervicornis* site, stony coral cover significantly decreased through all time periods with the highest value, 37.07 ± 2.68, in time interval I and the lowest in time interval V, 3.58 ± 0.77 ($p < 0.0001$ for all comparisons but one, for interval III to interval IV $P = 0.0012$).

There was no significant difference in region-wide colony live tissue area (LTA), all species combined, between 2013, 2014, and 2015; however, LTA was determined to be significantly lower in 2016, 2017 and 2018, which did not significantly differ (Figure 7, linear mixed-effects model ANOVA: $p < 0.05$; see Appendix 4 for region-wide and site mean values and Appendix 5 for regional statistical p-values). For the period from 2013-2018, 17 of 22 sites, representing all four counties, had the lowest LTA calculated either in 2017 or 2018. Previously 2016 was the lowest LTA calculated for 16 of the 22 sites, and there was an average LTA loss from 2015 to 2017 of 46% (2015: 6.48 ± 2.36 m^2, 2016: 3.3 ± 1.09 m^2). Four sites had LTA losses from 2015 to 2018 greater than 70%: MC1 (2015: 1.52 ± 0.27 m^2, 2018: 0.63 ± 0.20 m^2), MC2 (2015: 0.53 ± 0.12 m^2, 2018: 0.06 ± 0.05 m^2), PB4 (2015: 1.27 ± 0.15 m^2, 2018: 0.35 ± 0.08 m^2), and BC5 (2015: 0.91 ± 0.26 m^2, 2018: 0.21 ± 0.05 m^2).

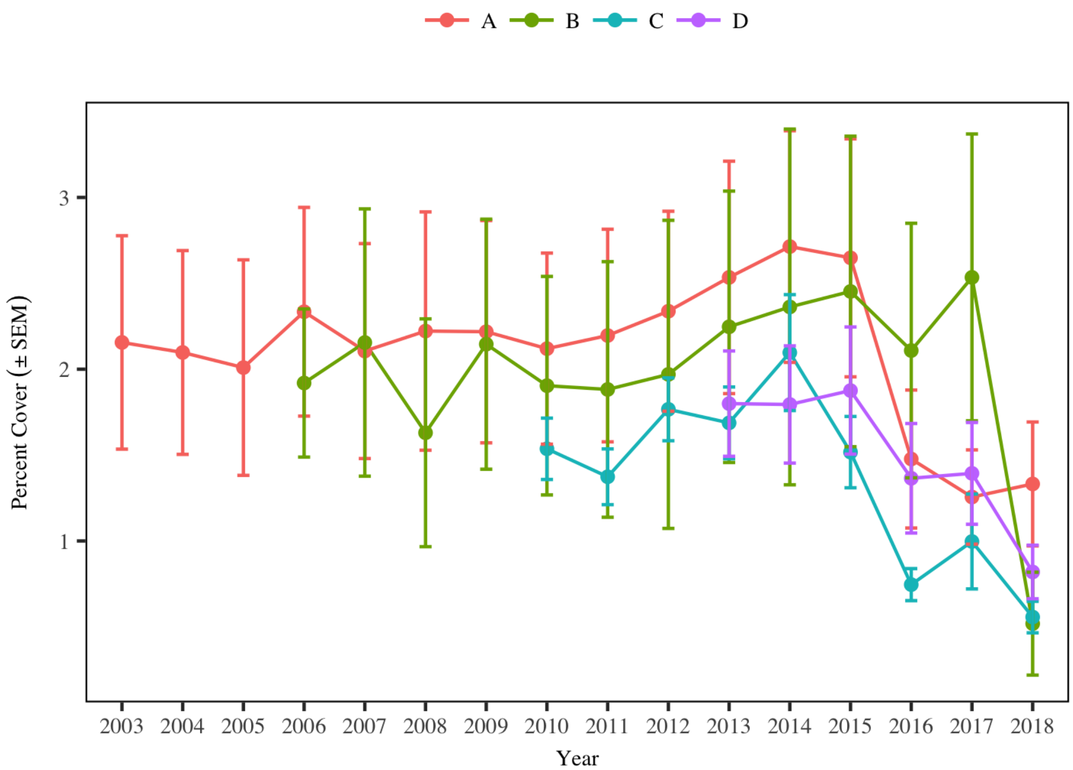

Figure 5. Mean stony coral percent cover (±SEM) for Groups A, B, C and D.

Figure 6. Mean stony coral percent cover (±SEM) for Group BCA.

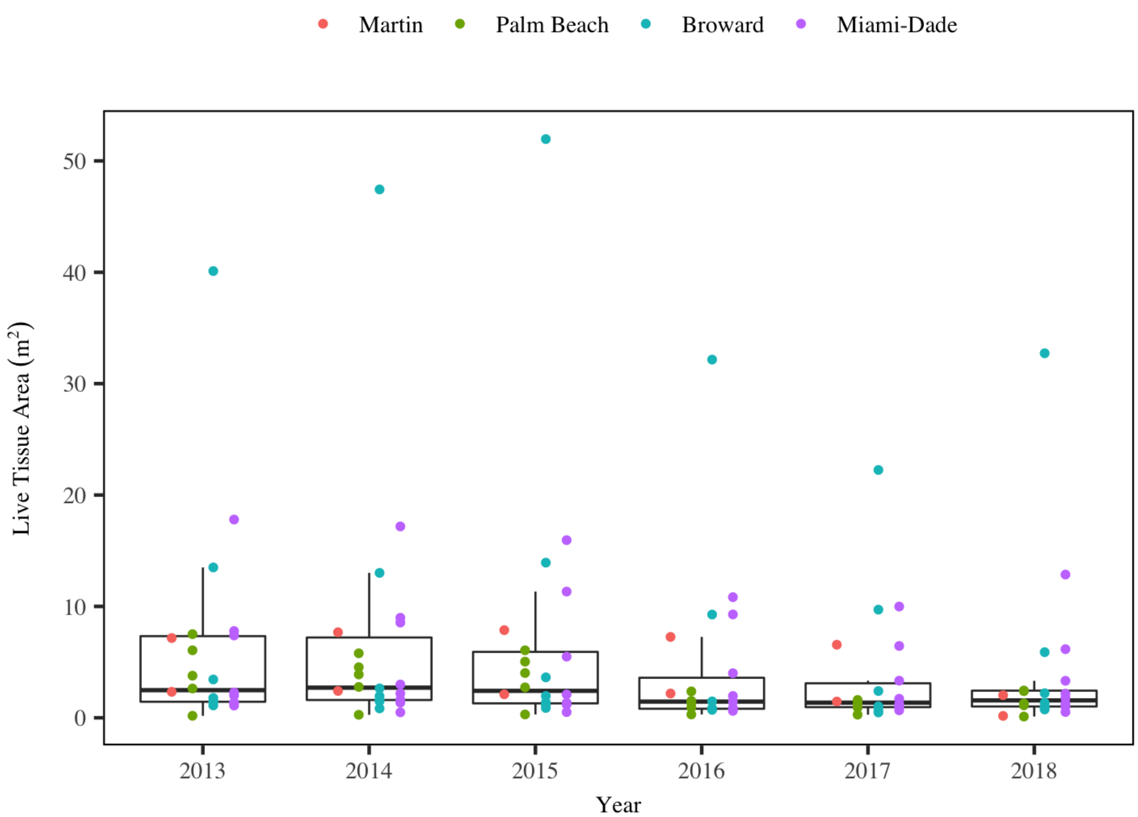

Figure 7. Distribution of live tissue area (LTA) for all stony corals summed by site from 2013 – 2018. Each point is the LTA at a site colored by county. The middle bar in the boxplot is the median LTA for the region, the areas above and below the median, hinges, represent the 1st and 3rd quartiles, respectively. The whiskers, upper and lower, extend from the hinge to the largest value no greater than 1.5*IQR, where IQR is the inter-quartile range (distance between 1st and 3rd quartiles). Points lying beyond the whiskers are considered outliers. There was a significant LTA decrease in 2016, 2017 and 2018, however the years were not significantly different from each other (Tukey post-hoc: $p < 0.05$: $p < 0.05$; see Appendix 4 for region-wide and site mean values and Appendix 6 for regional statistical p-values).

There was significant region-wide loss of *M. cavernosa*, *M. meandrites*, *Montastraea (Orbicella) annularis* complex, *S. bournoni* and *D. stokesii* LTA between the years 2013-2018 (linear mixed-effects model ANOVA: $p < 0.05$; see Appendix 5 for region-wide mean values and Appendix 6 for regional statistical p-values). From 2015 to 2018 *Montastraea (Orbicella) annularis* complex, *M. meandrites*, and *D. stokesii* each lost (region-wide) over 70% of all LTA, 73% (2015: 0.67 ± 0.29 m^2, 2018: 0.18 ± 0.07 m^2), 99% (2015: 0.26 ± 0.09 m^2, 2018: 0.002 ± 0.001 m^2) and 92% (2015: 0.04 ± 0.02 m^2, 2018: 0.003 ± 0.001 m^2) LTA, respectively (Figure 8, Figure 9, Figure 10). Other significant losses include *M. cavernosa* 38% (2015: 3.28 ± 1.98 m^2, 2018 2.03 ± 1.34 m^2) and *S. bournoni* 50% (2015: 0.14 ± 0.06 m^2, 2018: 0.07 ± 0.03 m^2) (Figure 11, Figure 12). Two species, *P. astreoides* and *S. siderea* saw significant increases in LTA in 2018 (Figure 13, Figure 14, linear mixed-effects model ANOVA: $p < 0.05$; see Appendix 5 for region-wide mean values and Appendix 6 for regional statistical p-values).

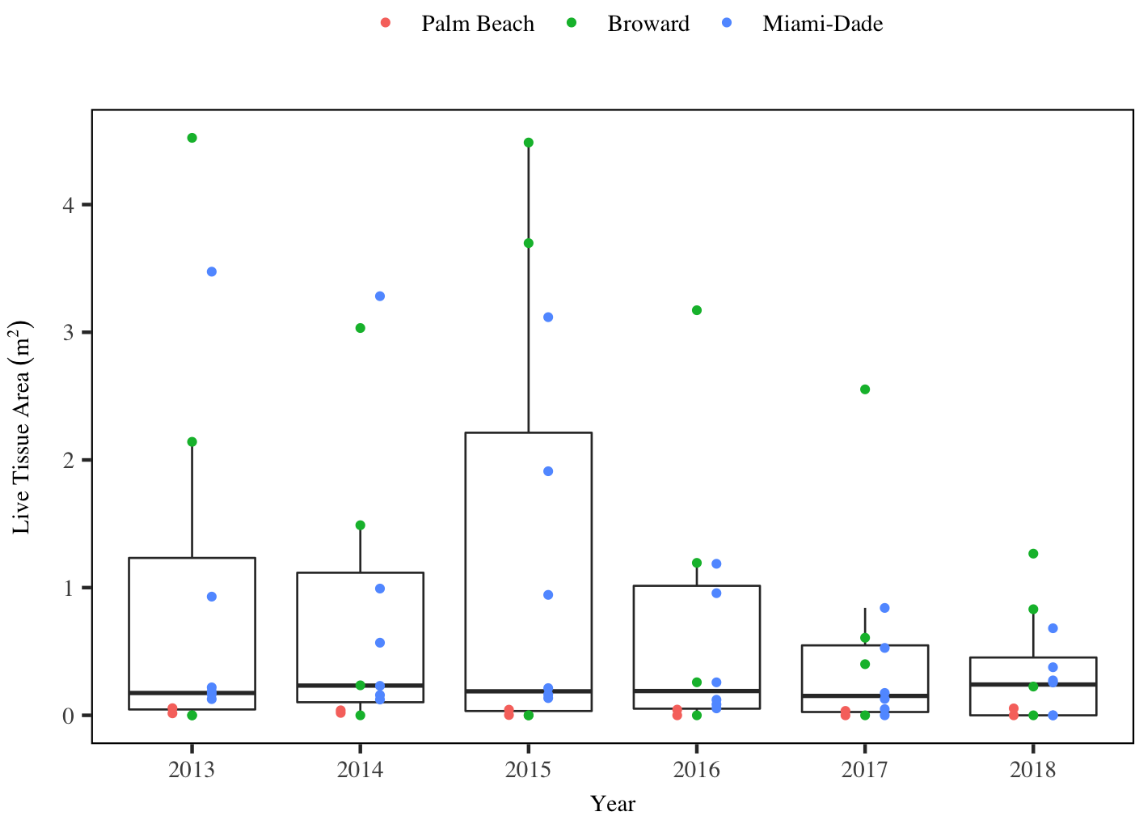

Figure 8. *Montastraea (Orbicella) annularis* complex regional LTA from 2013 to 2018. Each point is the sum of the LTA at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Only sites that have had the species were included. LTA in 2018 was significantly lower than in 2015 (Tukey post-hoc: $p < 0.05$; see Appendix 5 for species mean LTA values and Appendix 6 for statistical values).

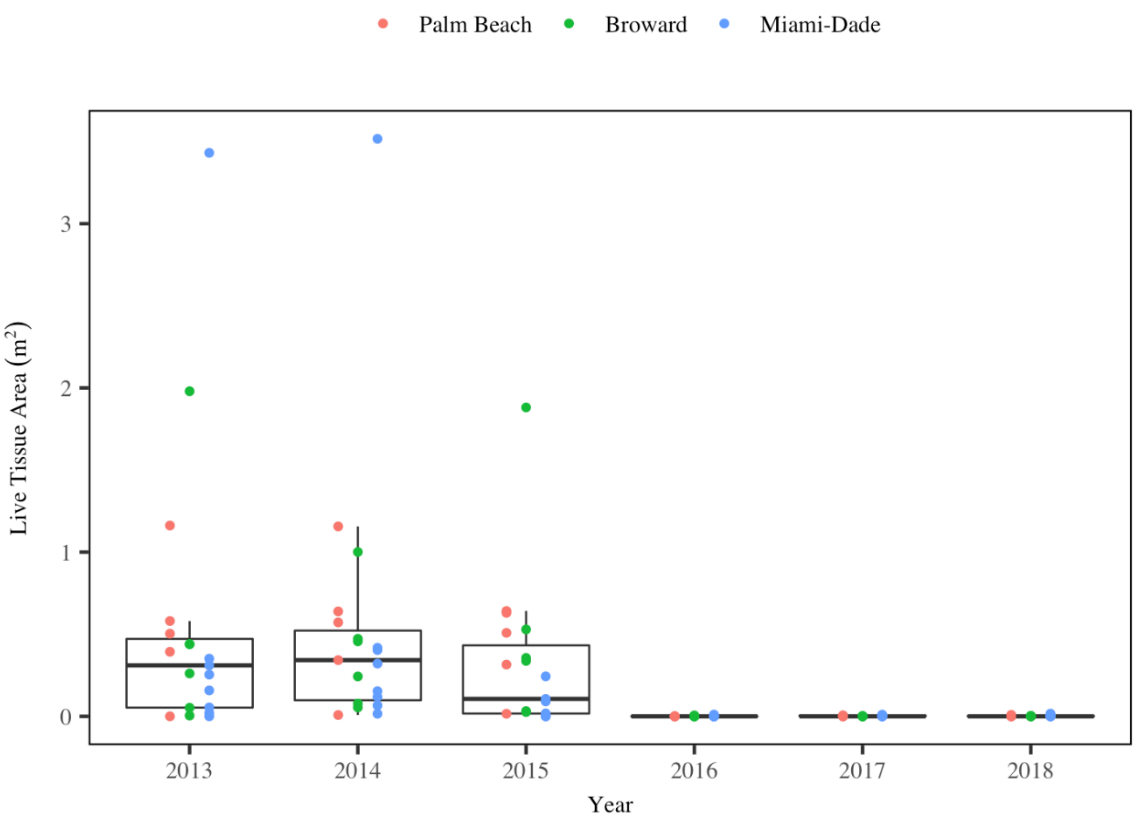

Figure 9. *Meandrina meandrites* regional live tissue area from 2013 to 2018. Each point is the sum of the LTA at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Only sites that have had the species were included. LTA in 2018 was significantly lower than in 2015 (Tukey post-hoc: $p < 0.05$; see Appendix 5 for species mean LTA values and Appendix 6 for statistical values).

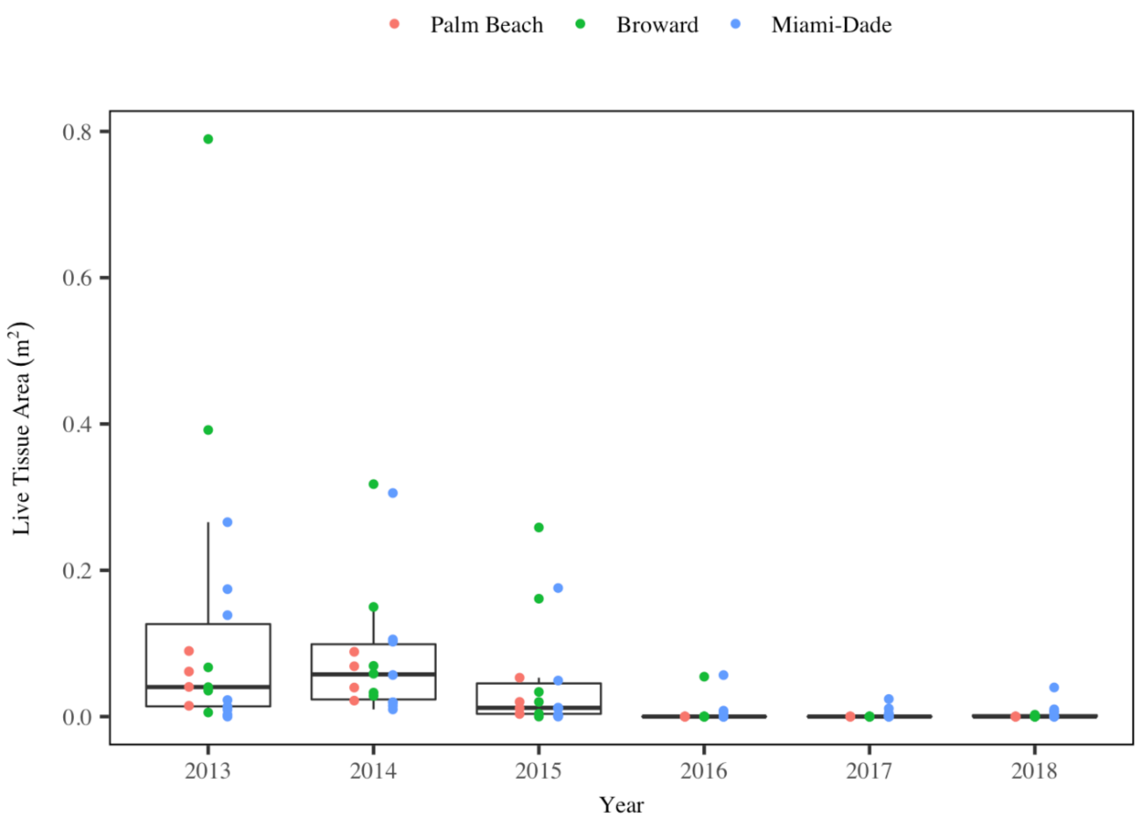

Figure 10. *Dichocoenia stokesii* regional LTA from 2013 to 2018. Each point is the sum of the LTA at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Only sites that have had the species were included. LTA in 2018 was significantly lower than in 2015 (Tukey post-hoc: $p < 0.05$; see Appendix 5 for species mean LTA values and Appendix 6 for statistical values).

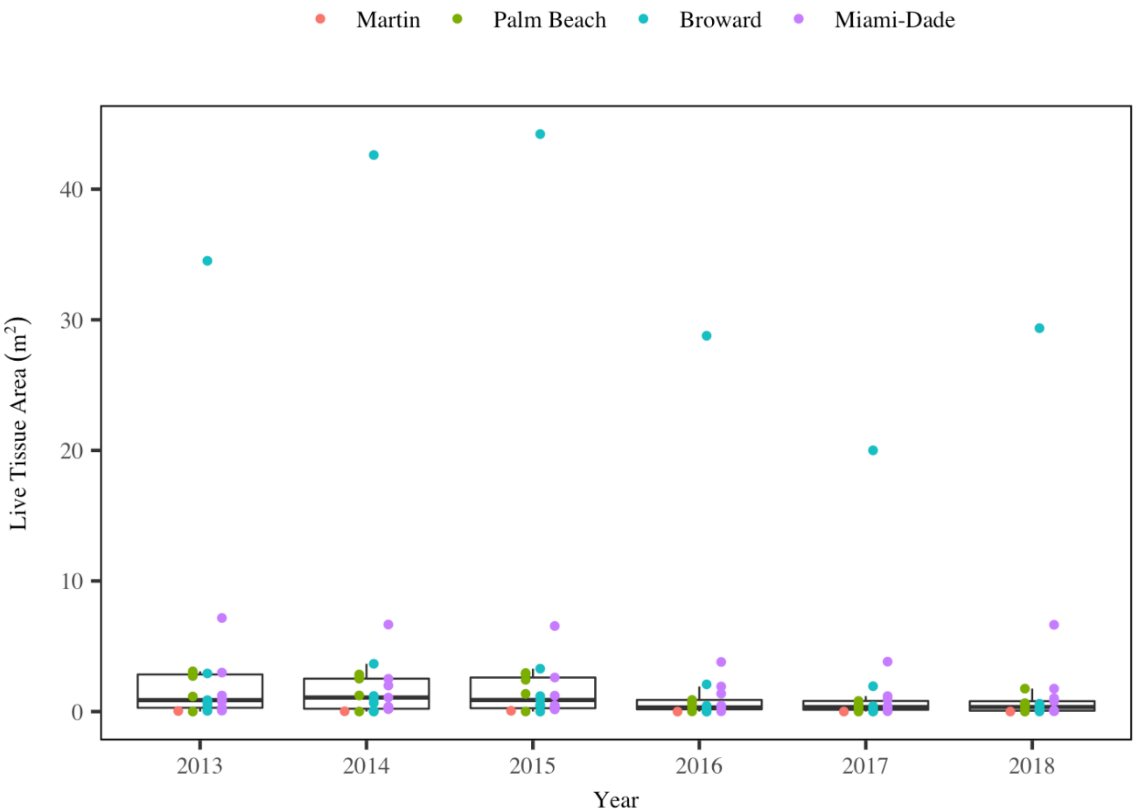

Figure 11. *Montastraea cavernosa* regional live tissue area from 2013 to 2018. Each point is the sum of the LTA at a site colored by county. Each point is the sum of the LTA at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Only sites that have had the species were included. LTA in 2018 was significantly lower than in 2015 (Tukey post-hoc: $p < 0.05$; see Appendix 5 for species mean LTA values and Appendix 6 for statistical values).

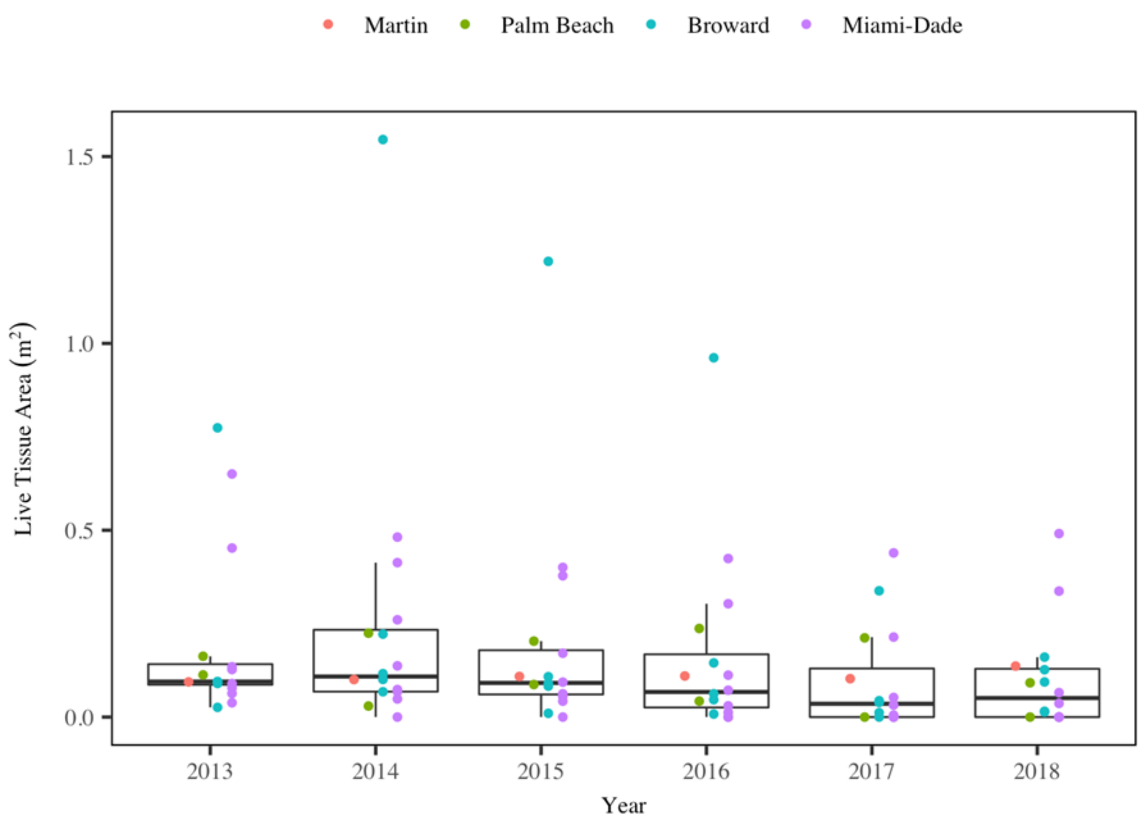

Figure 12. *Solenastrea bournoni* regional LTA from 2013 to 2018. Each point is the sum of the LTA at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Only sites that have had the species were included. LTA in 2018 was significantly lower than in 2015 (Tukey post-hoc: $p < 0.05$; see Appendix 5 for species mean LTA values and Appendix 6 for statistical values).

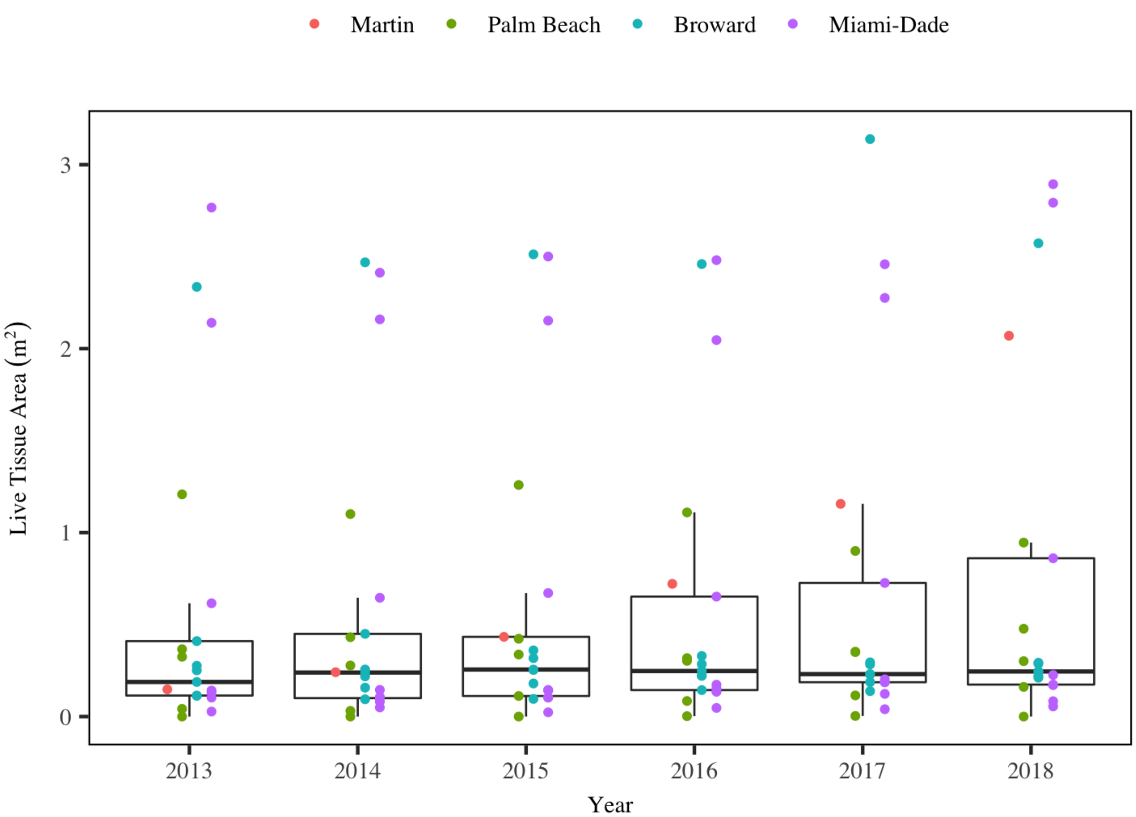

Figure 13. *Porites astreoides* regional LTA from 2013 to 2018. Each point is the sum of the LTA at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Only sites that have had the species were included. LTA in 2018 was significantly lower than in 2015 (Tukey post-hoc: $p < 0.05$; see Appendix 5 for species mean LTA values and Appendix 6 for statistical values).

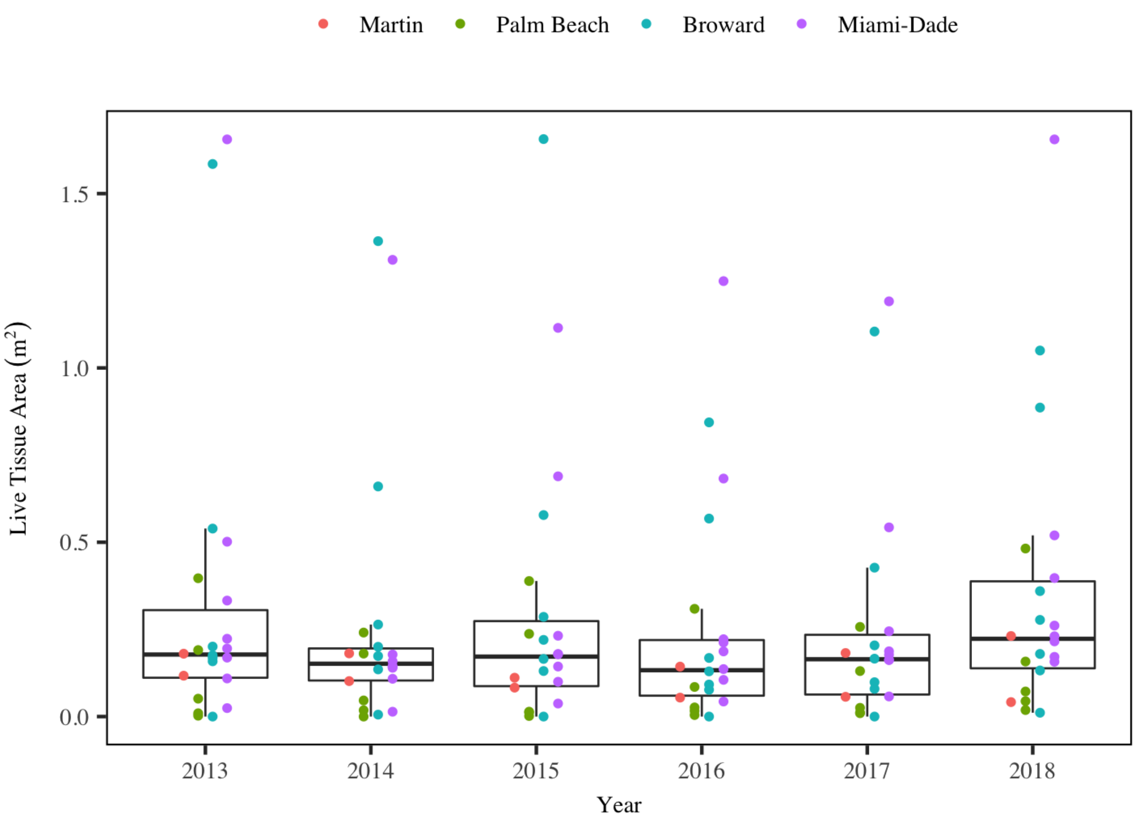

Figure 14. *Siderastrea siderea* regional live tissue area from 2013 to 2018. Each point is the sum of the LTA at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Only sites that have had the species were included. LTA in 2018 was significantly lower than in 2015 (Tukey post-hoc: $p < 0.05$; see Appendix 5 for species mean LTA values and Appendix 6 for statistical values).

Figure 15 illustrates the site distribution of colony densities across the region for 2013-2018 (22 sites). The 2018 regional mean (±SEM) stony colony density was 1.43 ± 0.25 colonies/m², which although not significant, was the highest recorded density across study years (repeated measure ANOVA: $p < 0.5$; see Appendix 7 for region and sites mean density values and Appendix 8 for statistical values). Density in 2018 ranged from a high of 4.30 ± 1.37 colonies/m² at site BCA to a low of 0.15 ± 0.03 colonies/m² at site MC2 (see Appendix 7). Eight sites, representing three counties, had their lowest colony densities in 2016, three sites had their lowest colony densities in 2017 while three additional sites had the lowest density occurring in 2018 (Appendix 7).

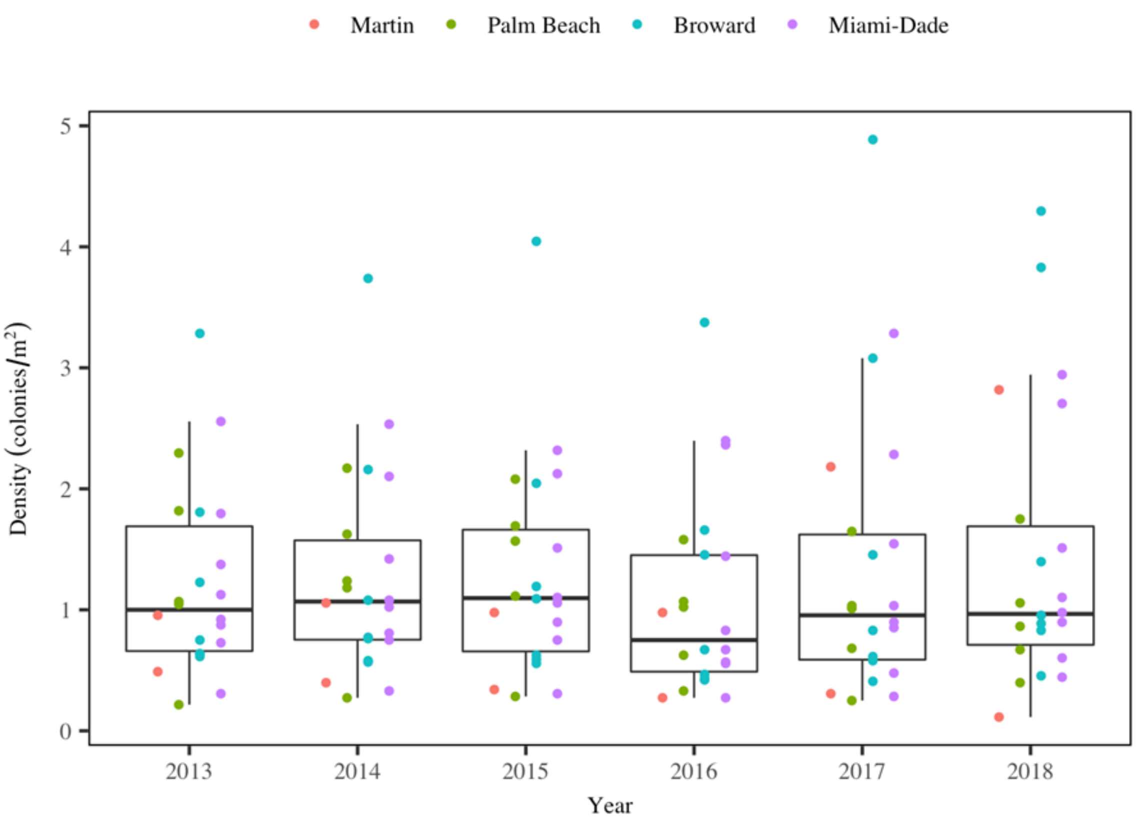

Figure 15. Distribution of region-wide stony coral density (colonies ≥ 4 cm) summed by site from 2013 – 2018. Each point is the density at a site colored by county. See the caption for Figure 7 for explanation of the box and whisker components. Density did not change significantly across study years (Linear mixed-effects model: $p > 0.05$; see Appendix 7 for region and sites mean density values and Appendix 8 for statistical values).

Region-wide disease prevalence increased every year from 2013 to 2016 (Table 3). The greatest prevalence increase occurred from 2015 (1.8%) to 2016 (4.4%). Prevalence dropped to 1.1% in 2017 and again to 0.8% in 2018. At the site level, 12 sites had their highest recorded prevalence in 2016, while four sites had their highest in 2015. In 2016, three sites had disease prevalence > 10%, with only one site having prevalence >10% in 2017 and none in 2018(Table 3). Throughout the four years of surveys collecting disease data, BC6 was the only site to never have a diseased colony identified at the time of the survey. In 2013, dark spot syndrome, mostly on *S. siderea* colonies, was the primary contributor to disease prevalence. In contrast, in 2015 and 2016 stony coral tissue loss disease (SCTLD) (https://floridadep.gov/rcp/coral/documents/coral-disease-outbreak-faq-v52) was the main contributor to disease prevalence and was the primary driver of the disease event. The greater disease prevalence at BC1 in 2018 (6.5%) was primarily driven by SCTLD infection on *M. cavernosa*.

Table 3. Stony coral disease prevalence (%). Values are the percent of total colonies identified with disease in each site and for the region values are the total number of diseased colonies for all sites combined divided by the total number of coral colonies for all sites.

Site	2013 (%)	2014 (%)	2015 (%)	2016 (%)	2017 (%)	2018 (%)
DC1	0.0	1.1	4.3	9.6	3.0	1.7
DC2	0.0	0.0	1.1	12.3	0.0	0.0
DC3	0.0	0.0	0.0	4.2	0.0	0.0
DC4	0.0	4.5	6.1	0.0	0.0	0.0
DC5	0.0	2.7	3.4	1.9	0.0	0.8
DC6	0.0	3.2	0.8	5.5	1.5	0.8
DC7	0.0	0.0	0.0	1.7	1.3	0.0
DC8	1.2	0.0	11.4	0.0	0.0	0.0
BCA	2.5	1.1	0.6	13.7	0.0	0.3
BC1	0.0	0.0	0.0	0.0	10.2	6.5
BC2	3.0	3.0	0.0	2.7	0.0	2.4
BC3	3.5	1.8	0.8	1.7	0.0	0.0
BC4	1.9	4.2	0.0	0.0	0.5	0.6
BC5	0.0	16.0	0.0	13.2	0.0	0.0
BC6	0.0	0.0	0.0	0.0	0.0	0.0
PB1	0.0	0.0	0.0	6.9	0.0	0.0
PB2	0.0	0.0	0.0	1.1	0.0	0.0
PB3	0.0	0.0	1.0	1.8	1.7	0.0
PB4	0.0	0.0	0.7	3.3	0.0	0.0
PB5	0.0	0.5	0.0	7.9	2.1	0.0
MC1	0.0	0.0	9.3	0.0	0.0	0.0
MC2	9.3	0.0	3.3	0.0	0.0	0.0
Region	1.0	1.6	1.8	4.4	1.1	0.8

A total of 2,007 stony coral colonies < 4 cm in maximum diameter were recorded across the 22 sites (Table 4) in 2018. *Siderastrea siderea* was the most abundant of species < 4 cm with 1,164 colonies regionally and *Porites astreoides* was the second most abundant with 309 colonies regionally. *Acropora cervicornis*, *Agaricia lamarki*, *Diploria labyrinthiformis*, *Isophyllia sinuosa*, *Montastrea (Orbicella) annularis* complex, *Oculina diffusa*, and *O. robusta* were the species identified with colonies ≥ 4 cm within the region that did not have any colonies < 4 cm identified at any site (Table 4). All sites (22) had colonies < 4 cm present within the sample area. Martin County 1 had the largest number of colonies < 4 cm (492) followed by PB1 (208) and BC4 (197).

Table 4. Count of 2018 stony coral colonies < 4 cm by site. The coral colonies are totaled by species and by site. Four letter species codes are the first letter of the genus followed by the first three letters of the species (BC = Broward County, DC = Dade County, MC = Martin County, PB = Palm Beach County).

	BC1	BC2	BC3	BC4	BC5	BC6	BCA	DC1	DC2	DC3	DC4	DC5	DC6	DC7	DC8	MC1	MC2	PB1	PB2	PB3	PB4	PB5	Total
AAGA	2	0	0	4	0	0	54	6	1	0	0	24	1	0	0	0	0	0	0	0	0	0	92
ACER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AFRA	2	0	0	1	0	0	8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12
ALAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CNAT	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
DCLI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DLAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSTO	0	3	3	4	3	3	0	2	3	0	0	4	2	0	2	0	0	0	0	0	0	4	33
DSTR	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2
EFAS	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	3
ISIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MCAV	2	17	11	16	17	3	3	1	11	3	11	13	3	5	2	0	0	0	7	4	17	12	158
MDEC	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	4	7
MMEA	0	4	1	0	0	1	0	0	1	2	1	0	0	1	0	0	0	0	1	0	1	1	14
MMIR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	16
MYLA	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
ODIF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OROB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAME	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	8	2	0	0	0	0	12
PAST	2	2	3	67	4	1	7	20	0	0	6	18	38	2	3	107	0	0	5	4	3	17	309
PPOR	0	1	0	20	10	0	2	8	0	0	2	3	6	0	0	0	0	0	0	0	0	0	52
SBOU	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SCUB	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SMIC	4	10	15	16	4	3	0	0	21	2	4	7	0	15	1	0	0	0	3	1	3	13	122
SRAD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	0	1	0	0	0	0	6
SSID	20	26	24	69	17	9	2	111	43	6	23	54	34	15	53	381	30	205	12	7	10	13	1164
Total	32	64	59	197	55	21	77	149	84	13	49	124	85	39	61	492	38	208	44	16	36	64	2007

Octocoral

Regionally, year to year analysis of octocoral cover showed a significant decrease from 2017 to 2018 (two-way mixed model ANOVA: $p < 0.05$, see Appendix 1 for region wide and site mean values and Appendix 2 for statistical p-values). Seven sites (DC2, DC5, DC6, BC4, PB2, PB3 and PB4) had a significant decrease in cover from 2017 to 2018, for all other sites no significant change was identified (two-way mixed model ANOVA: $p < 0.05$, see Appendix 1 for region wide and site mean values and Appendix 2 for statistical p-values).

Octocoral cover generally decreased through time (Figure 16). For site group A, time interval I had the highest octocoral cover which was significantly higher than all following time intervals (13.12 ± 1.71; $p < 0.0001$ for all comparisons) (Figure 16). Time interval II (10.60 ± 1.17) was not significantly different from the two following time intervals, but was significantly greater than the final time interval (9.16 ± 0.91, $p = 0.0444$). Time interval III (11.04 ± 1.30) was significantly greater than both time intervals IV (9.33 ± 0.95, $p = 0.0026$) and V (9.16 ± 0.91, $p = 0.0008$). There was no significant difference between the final two time intervals. No test was performed for site group B, the Martin county sites, because octocoral cover was near zero for all time periods. Site group C significantly decreased from time interval III (19.46 ± 1.04) to time interval IV (16.12 ± 1.02, $p < 0.0001$) and again from time interval IV to time interval V (13.61 ± 0.71, $P = 0.0033$), and Site group D significantly decreased from time interval IV (9.77 ± 1.00) to time interval V (8.13 ± 0.89, $p < 0.0001$). For site BCA, the first two time intervals (1.97 ± 0.23 for interval I and 1.79 ± 0.23 for interval II) were not significantly different from any other time interval. However, cover had slightly increased by time intervals III (2.31 ± 0.15) and IV (2.32 ± 0.26), and both had significantly greater cover than time interval V (1.31 ± 0.13; $p = 0.0008$ and $p = 0.0007$, respectively).

The 2018 regional mean (±SEM) octocoral colony density was 10.41 ± 1.50 colonies/m^2 (Figure 17). Density in 2018 ranged from a high of 23.30 ± 2.11 colonies/m^2 at site PB5 to a low of 0 colonies/m^2 at site MC1 and MC2. Regional octocorals colony density increased every year from 2013 to 2017, peaking in 2017 at 12.58 ± 1.58 colonies/m^2, with the first regional decrease in density recorded in 2018 where density was 10.14 ± 1.50 colonies/m^2. A region-wide significant change in octocoral colony density was identified between years (Linear mixed-effects model: $p > 0.05$; see Appendix 7 for region and sites mean density values and Appendix 8 for statistical values). Following the linear mixed-effects model ANOVA, pairwise comparisons indicated 2015 (11.51 ± 1.77 colonies/m^2), 2016 (11.85 ± 1.83 colonies/m^2) and 2017 (12.58 ± 1.85 colonies/m^2) had significantly lower densities than 2013 (8.68 ± 1.34 colonies/m^2) and 2014 (9.97 ± 1.55 colonies/m^2). Additionally, 2018 (10.41 ± 1.50 colonies/m^2) had a significantly lower density than 2013 but a significantly lower density than 2016 and 2017 (glht Tukey post-hoc: $p < 0.05$; see Appendix 8 for statistical p-values).

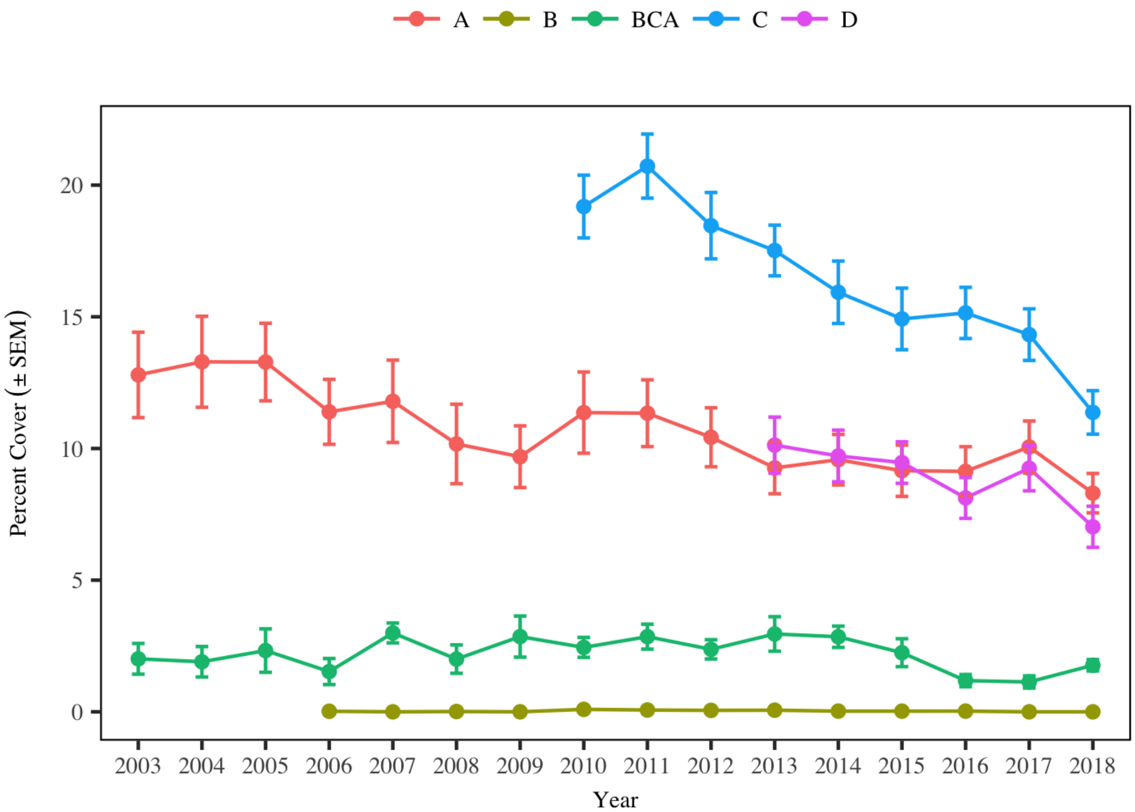

Figure 16. Mean octocoral percent cover (±SEM) for Group A, B, BCA, C and D.

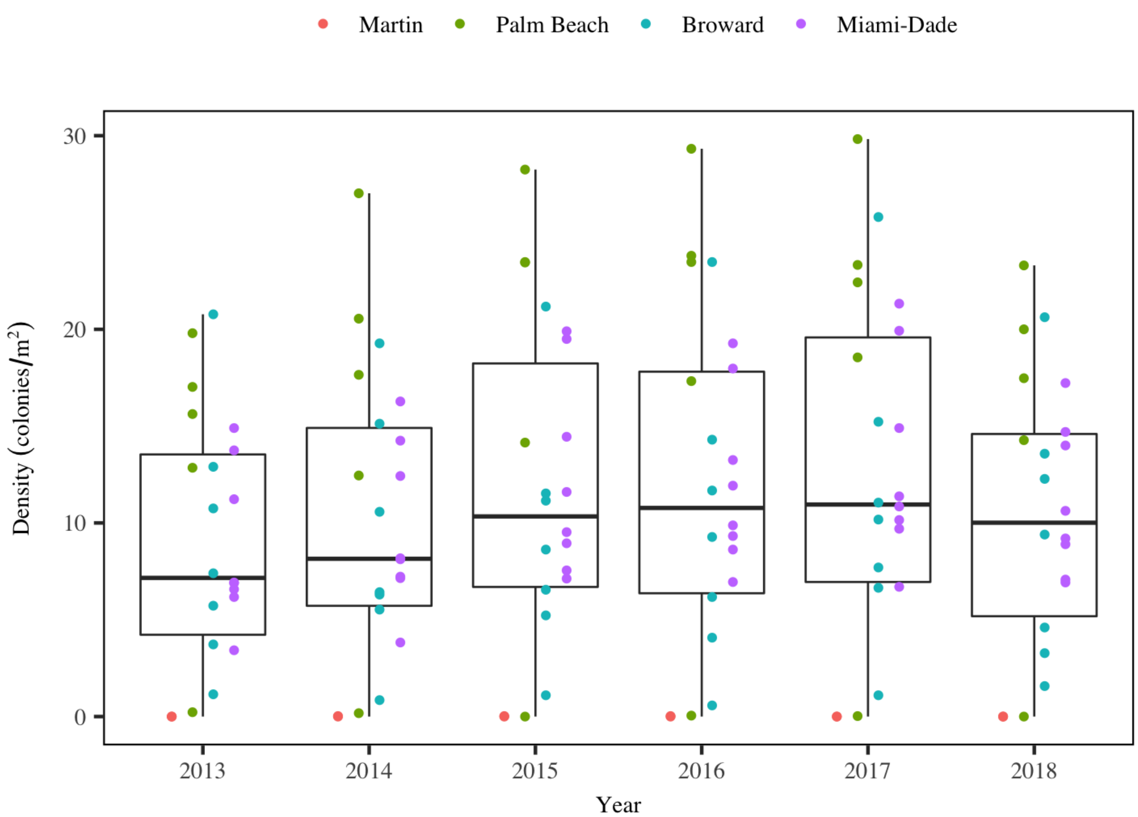

Figure 17. Region wide octocoral density (colonies/m²) distribution from 2013 to 2018. Each point is the density at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Density in 2015, 2016 and 2017 was significantly higher than in 2013 and 2014; density was also higher in 2018 than in 2013. Density was significantly lower in 2018 compared to 2016 and 2017 (Tukey post-hoc: $p < 0.05$; see Appendix 8 for statistical p-values).

None of the three octocoral target species (*A. americana*, *E. flexuosa*, and *G. ventalina*) were identified at site PB1 or either of the Martin County sites (MC1 and MC2). In 2018, regional *Antillogorgia americana* density (1.97 ± 0.31 colonies/m^2) was the greatest of the three species followed by *E. flexuosa* (0.69 ± 0.21 colonies/m^2) and *G. ventalina* (0.34 ± 0.07 colonies/m^2) (Appendix 9. Octocoral target species mean density.). *Eunicea flexuosa* (Figure 18) density peaked in 2015 and 2016; however, no years were found to be significantly different from each other (linear mixed-effects model ANOVA & glht Tukey post-hoc: $p < 0.05$; see Appendix 9 for octocoral mean density values and Appendix 10 statistical p-values).). *Gorgonia ventalina* (Figure 19) had significantly higher colony density in 2017 (0.38 ± 0.08 colonies/m^2) than in 2013 (0.34 ± 0.07 colonies/m^2), which was not significantly different from 2014 (0.30 ± 0.06 colonies/m^2), 2015 (0.37 ± 0.09 colonies/m^2), 2016 (0.34 ± 0.07 colonies/m^2) and 2018 (0.34 ± 0.07 colonies/m^2) (linear mixed-effects model ANOVA & glht Tukey post-hoc: $p < 0.05$; see Appendix 9 for octocoral mean density values and Appendix 10 statistical p-values). *Antillogorgia americana* (Figure 20) had significantly higher colony densities in 2016 (2.07 ± 0.31 colonies/m^2) and 2017 (2.08 ± 0.32 colonies/m^2) than in 2013 (1.57 ± 0.24 colonies/m^2) and 2014 (1.61 ± 0.27 colonies/m^2) (linear mixed-effects model ANOVA: $p < 0.05$, glht Tukey post-hoc: $p < 0.05$, see Appendix 9 for octocoral mean density values and Appendix 10 statistical p-values).

No significant differences in average colony height was identified between years for *G. ventalina* (Figure 21; linear mixed-effects model ANOVA: $p < 0.05$; see Appendix 11 for target species mean heights and Appendix 12 for statistical p-values). Mean *E. flexuosa* colony height was significantly lower in 2015 (21.5 ± 0.6 cm) compared to 2013 (24.9 ± 0.6 cm), and 2014 (24.4 ± 0.7 cm) (Figure 21; linear mixed-effects model ANOVA & glht Tukey post-hoc: $p < 0.05$; see Appendix 11 for target species mean heights and Appendix 12 for statistical p-values). *Antillogorgia americana* mean colony height was significantly higher in 2013 (27.1 ± 0.5 cm) compared to all other years (2014 [25.1 ± 0.5 cm], 2015 [23.2 ± 0.5 cm], 2016 [23.8 ± 0.4 cm], 2017 [23.3 ± 0.4 cm] and 2018 [21.9 ± 0.5 cm]. Mean density in 2014 was also significantly higher than 2018 (Figure 21; linear mixed-effects model ANOVA; see Appendix 11 for target species mean heights and Appendix 12 for statistical p-values).

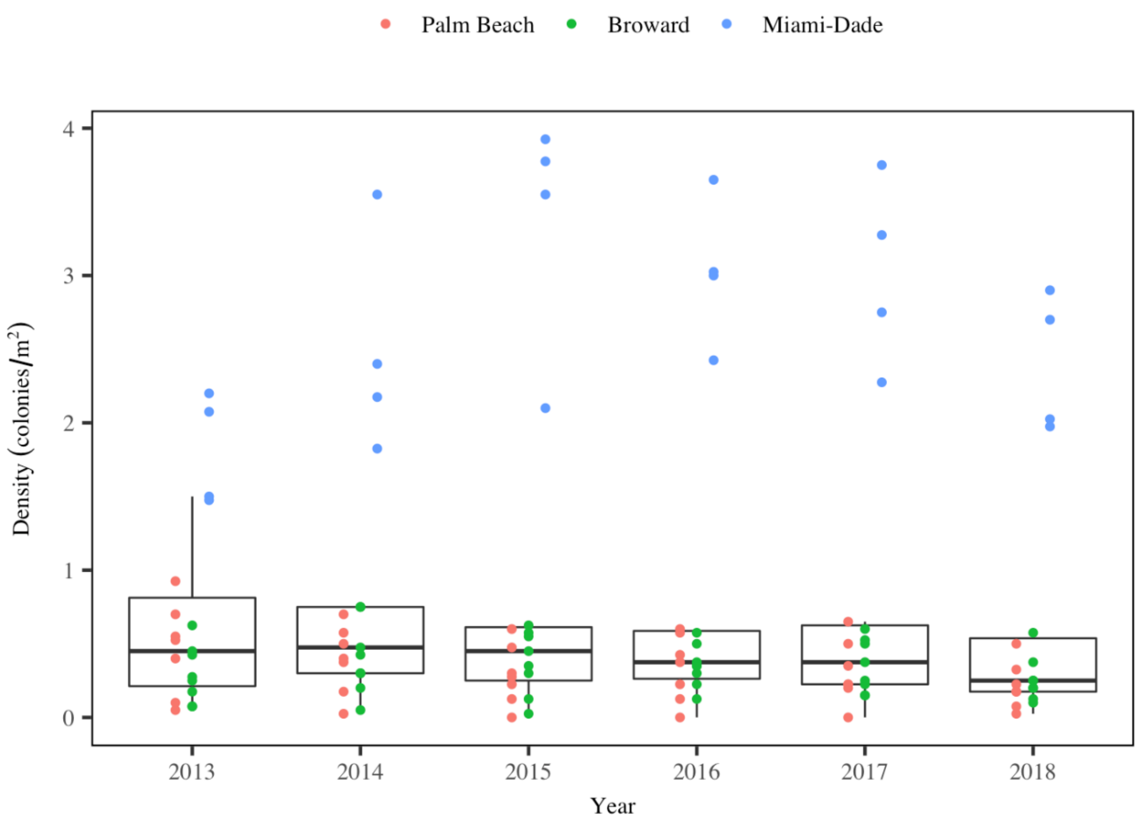

Figure 18. *Eunicea flexuosa* regional density (colonies/m2) distribution from 2013 to 2018. Each point is the density at a site colored by county. For an explanation of the box and whisker components see the caption for Figure 7. Only sites that have had the species were included. An overall significant difference in density was identified, however there was no significant difference between years (Tukey post-hoc: $p < 0.05$; see Appendix 10 for statistical p-values).

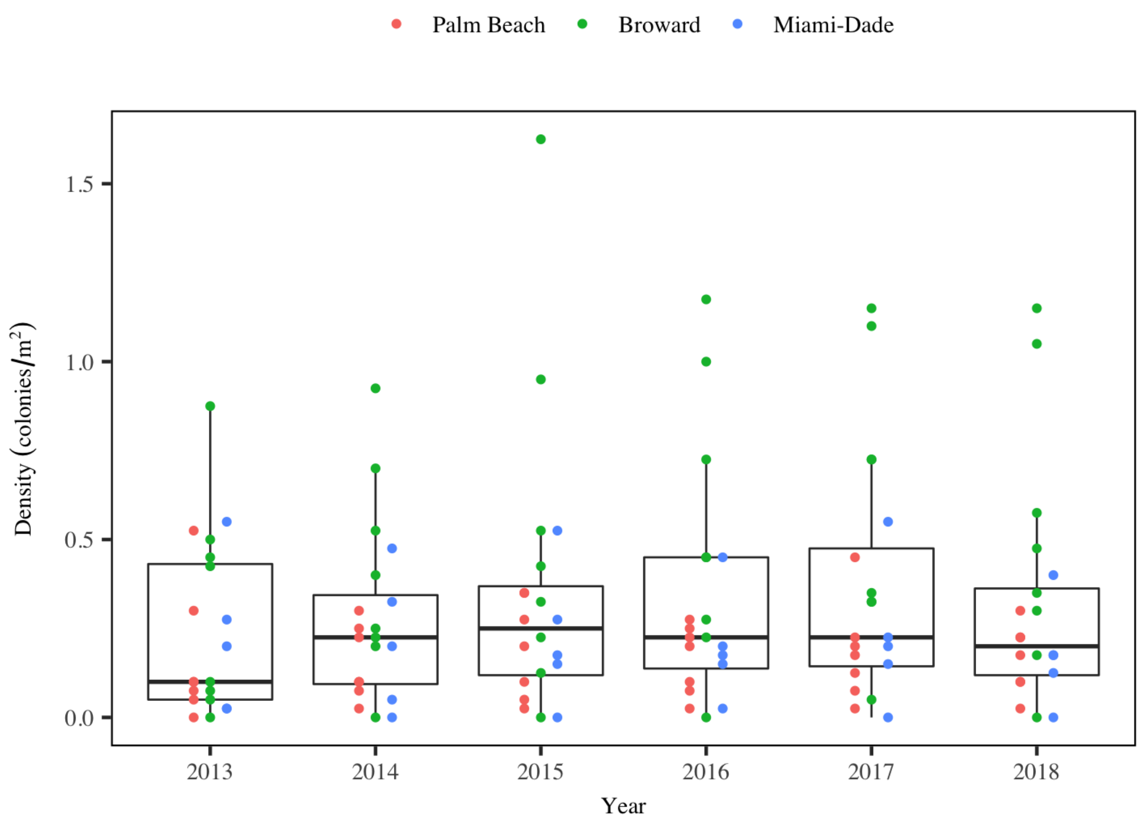

Figure 19. *Gorgonia ventalina* regional density (colonies/m^2) distribution 2013 to 2018. Each point is the density at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Only sites that have had the species were included. Densities were significantly higher in 2017 than in 2013 (Tukey post-hoc: $p < 0.05$; see Appendix 10 for statistical p-values).

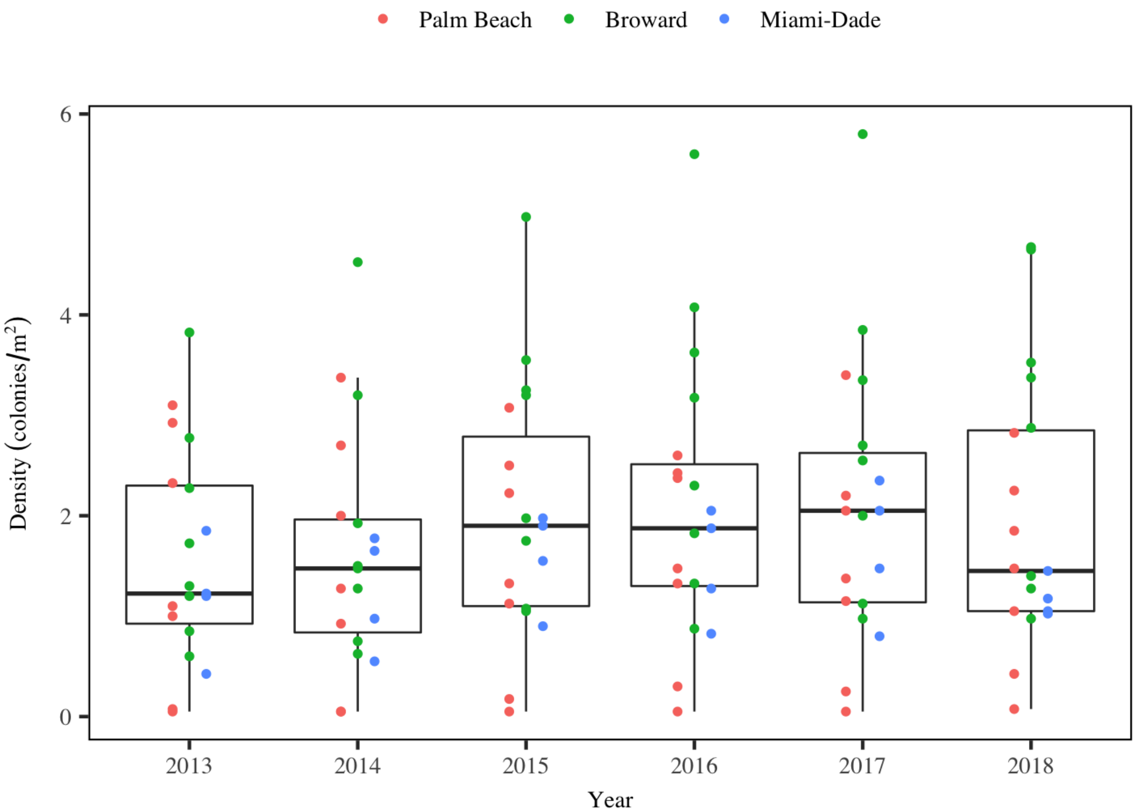

Figure 20. *Antillogorgia americana* regional density (colonies/m^2) distribution 2013 to 2018. Each point is the density at a site colored by county. For an explanation of the box and whisker components please see the caption for Figure 7. Only sites that have had the species were included. Densities were significantly higher 2015 and 2016 than in 2013 (Tukey post-hoc: $p < 0.05$; see Appendix 10 for statistical p-values).

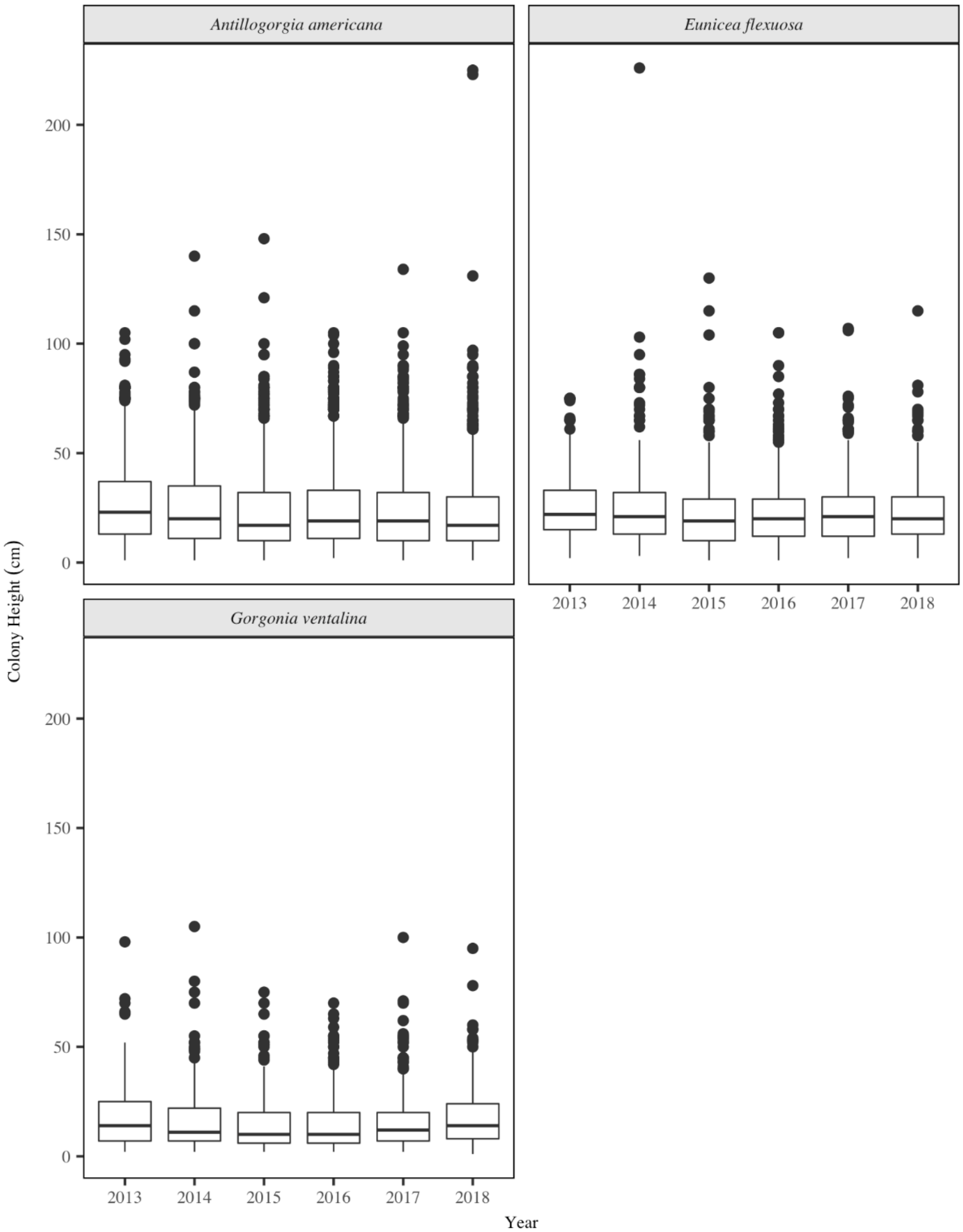

Figure 21. Octocoral target species colony height distribution 2013 to 2018. The middle bar in the boxplot is the median height for the region, the areas above and below the median, hinges, represent the 1st and 3rd quartiles, respectively. The whiskers, upper and lower, extend from the hinge to the largest value no greater than 1.5*IQR, where IQR in the inter-quartile range (distance between 1st and 3rd quartiles). Points lying beyond the whiskers are considered outliers. No significant difference between years was identified for *Gorgonia ventalina* (Linear mixed-effects model: $p > 0.05$; see Appendix 12 for statistical p-values). *Eunicea flexuosa* was significantly lower in 2015 than 2013 and 2014; *Antillogorgia americana* was significantly higher in 2013 than all other years and 2014 was significantly higher than 2018 (Tukey post-hoc: $p < 0.05$; see Appendix 12 for statistical p-values).

Barrel Sponge (*Xestospongia muta*)

A significant region-wide change in *X. muta* density (Figure 22) was identified where 2013 (0.31 ± 0.05 sponges/m²) was significantly lower than 2015 (0.30 ± 0.06 sponges/m²), 2016 (0.31 ± 0.06 sponges/m²), 2017 (0.35 ± 0.06 sponges/m²), and 2018 (0.28 ± 0.05 sponges/m²). Additionally, 2017 was significantly higher than 2014 (0.28 ± 0.06 sponges/m²) and 2018 (Linear mixed-effects model ANOVA: $p < 0.05$; see Appendix 7 for region mean values and Appendix 8 for statistical p-values). *Xestospongia muta* were identified at all sites except those on the nearshore ridge complex habitat: MC1, MC2, PB1, BCA, and DC8. The three sites with the highest densities in 2018 were all Palm Beach sites (PB3: 0.58 ± 0.16 sponges/m²; PB4: 0.58 ± 0.15 sponges/m²; and PB5: 0.66 ± 0.08 sponges/m²), and all had greater than 0.57 sponges/m² (see Appendix 7 for site mean values).

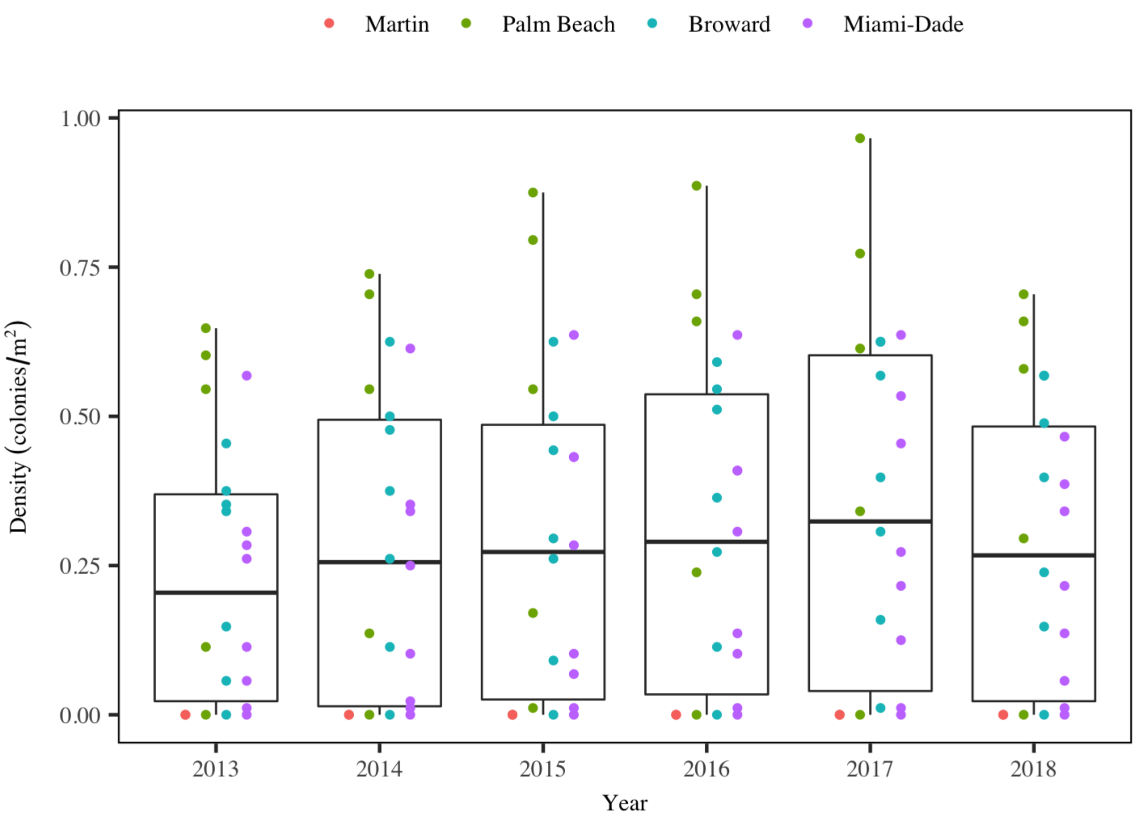

Figure 22. *Xestospongia muta* regional density (sponges/m^2) distribution 2013 to 2018. Each point is the density at a site colored by county. For an explanation of the box and whisker components, see the caption for Figure 7. Density in 2013 was significantly lower than 2015, 2016, 2017 and 2018; 2017 was significantly higher than 2014 and 2018 (Tukey post-hoc: $p < 0.05$; see Appendix 7 for region mean values and Appendix 8 for statistical p-values).

Sponge and Macroalgae Percent Cover

Analysis of macroalgae cover from 2017 to 2018 showed no significant change at the regional level (two-way mixed model ANOVA: $p > 0.05$, see Appendix 1 for region wide and site mean values and Appendix 2 for statistical p-values). However, at the site level, five sites (DC3, BC1, BC2, BC3 and PB5) had a significant decrease from 2017 to 2018 while six sites (DC1, DC2, DC5, DC6, DC7 and MC2) had a significant increase (two-way mixed model ANOVA: $p > 0.05$, see Appendix 1 for region wide and site mean values and Appendix 2 for statistical p-values).

Macroalgae cover was more variable than both stony coral and octocoral cover but generally increased across most site groups throughout the course of monitoring (Figure 23). For site group A, time interval I had the lowest macroalgae cover (4.74 ± 1.30) and cover was significantly less than all other time intervals ($P < 0.0001$ for all comparisons) whereas time interval V had the highest cover (21.00 ± 3.41) and cover was significantly greater than all other time intervals ($P < 0.0001$ for all comparisons). Time interval II was not significantly different from intervals III or IV, but time interval IV was significantly greater than interval III, though only marginally ($P = 0.046$). Site group B, the Martin County site, show a contrasting trend to all other site groups with macroalgae cover steadily decreasing across all time intervals. The highest cover was found in the first time interval, interval II (41.42 ± 2.76), and the lowest cover was found in the final time interval (17.02 ± 3.45). Time intervals II, III, and IV were not significantly different from each other but were all significantly greater than interval V, the final time interval ($P < 0.0001$ for all comparisons). Site group C (9.81 ± 3.00) significantly increased across the three time intervals of monitoring (interval III to interval IV, 13.6 ± 2.31, $P = 0.0002$; interval IV to interval V, 22.12 ± 3.14, $P = 0.0038$), and site group D, also increased from time interval IV (18.76 ± 1.57) to time interval V (31.62 ± 2.75, $P < 0.0001$). Site BCA followed a trend of increasing macroalgae cover throughout the course of monitoring, with the lowest cover found in time interval I (0.92 ± 0.51) and the highest cover found in time interval V (6.76 ± 1.98). Time interval IV and V were both greater than time interval I ($P = 0.0148$ and $P = 0.0009$, respectively).

Year to year analysis of regional sponge cover showed a significant decrease from 2017 to 2018 (two-way mixed model ANOVA: $p > 0.05$, see Appendix 1 for region wide and site mean values and Appendix 2 for statistical p-values). Four sites (DC5, BC4, PB1 and PB3) had a significant decrease in sponge cover, while one site (BCA) had a significant increase (two-way mixed model ANOVA: $p > 0.05$, see Appendix 1 for region wide and site mean values and Appendix 2 for statistical p-values).

The percent cover of sponges was the most consistent through time of all taxa groups examined (Figure 24). In general sponge cover was highest in time interval III (2010-2012). For site group A, time interval I had the lowest cover, 4.35 ± 0.59, which was significantly less than time interval III, IV, and V ($P < 0.0001$ for all comparisons). Time interval II, 4.82 ± 0.59, was not found to be different from interval I but was also significantly less than time intervals III, IV and V ($P < 0.0001$ for all comparisons). The highest sponge cover was found in time interval III (6.15 ± 0.66) though this value was not significantly greater than either of the final two time intervals, IV and V (5.53 ± 0.54, 5.75 ± 0.56, respectively). Martin county sites, site group B, followed the same general trend as all other site groups

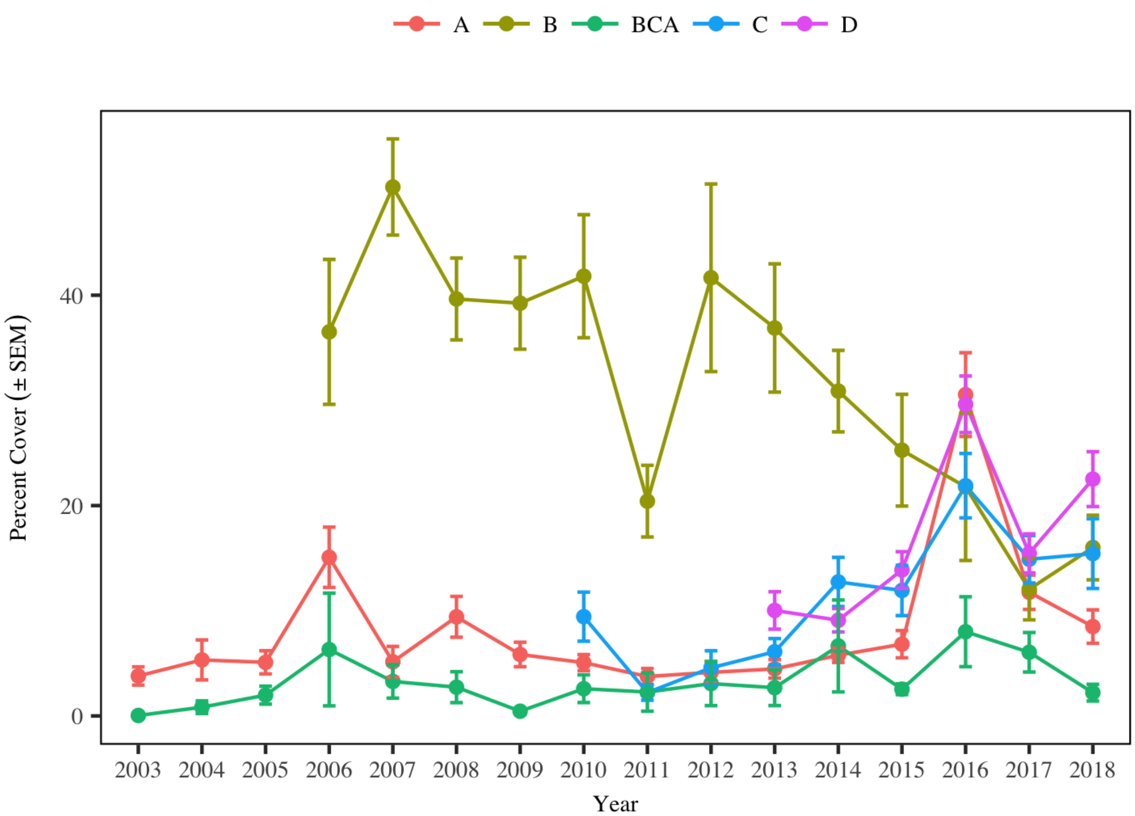

Figure 23. Mean macroalgae percent cover (±SEM) for Group A, B, BCA, C and D

with the lowest value occurring in the first time interval, interval II (1.96 ± 0.29), and cover significantly increasing to its the highest value in time interval III (3.31 ± 0.55, P = 0.0007). Cover decreased slightly from time interval III to intervals IV and V, neither of which were significantly different from any other time interval. For both site group C and D no significant differences among time intervals were found. For site group C values ranged from a high of 9.37 ± 1.07 in time interval III to a low of 8.39 ± 0.89 in time interval V, and for site group D values were 4.78 ± 0.52 for time interval IV and 4.84 ± 0.48 for time interval V. For site BCA, the highest sponge cover was also found in time interval III (1.99 ± 0.54) and the lowest cover was found in time interval I (0.38 ± 0.06). Sponge cover significantly increased from time interval I to interval II (P = 0.005) and again from interval II to interval III (P = 0.0434). The final two time intervals, IV and V, were both significantly greater than time interval I (P = 0.0002 and P = 0.0001, respectively) though neither were significantly different from interval II or III.

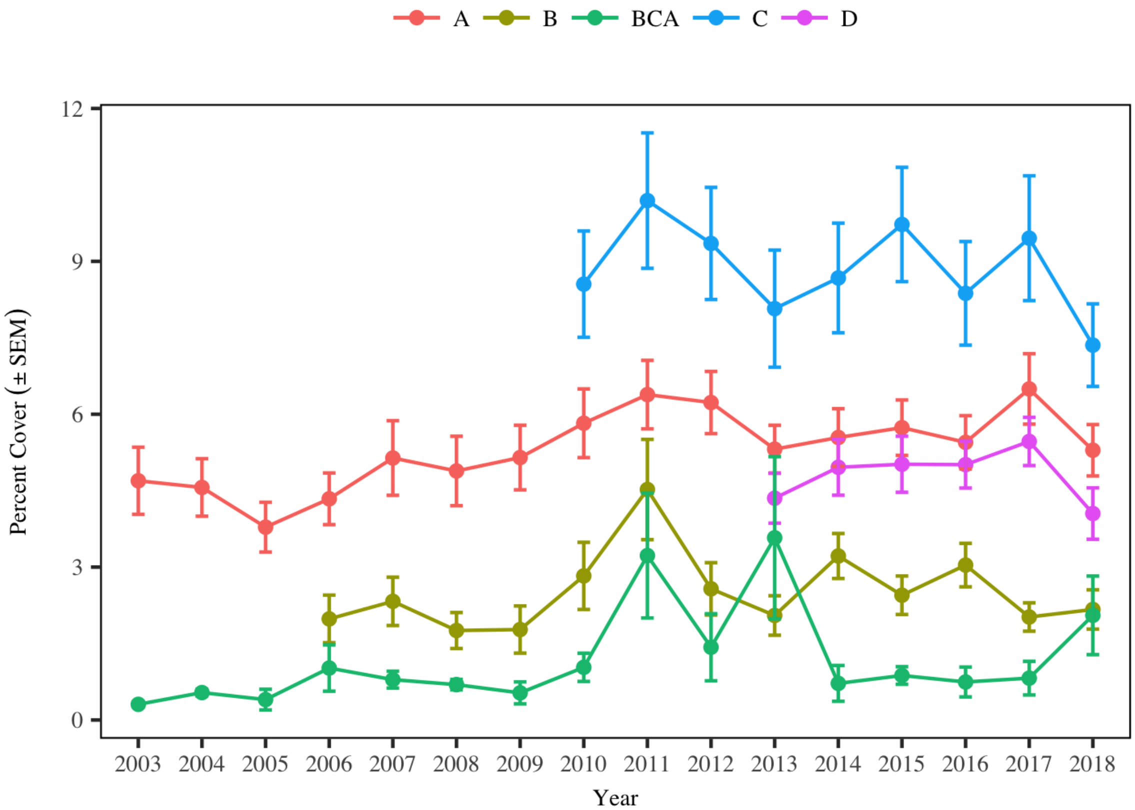

Figure 24. Mean porifera percent cover (±SEM) for Group A, B, BCA, C and D.

Site Benthic Temperature

During the 2018 sites visits, all but three temperature loggers were successfully recovered. All sites however had at least one logger left in 2018 and data were downloaded for all 22 sites. Broward County 4 had both loggers lost during Hurricane Irma in September of 2017 and thus new loggers were deployed at the site in November of 2017. The 2018 sample dates shown in Table 1 were the same dates that temperature loggers were collected and redeployed at each of the 22 sites. Figures 25-28 display the mean daily temperatures for the 22 sites by county (Martin: Figure 25; Palm Beach:
Figure 26; Broward: Figure 27; Miami-Dade: Figure 28). These figures illustrate the general warming trend (as expected) at all sites from February to August/September. Figure 25 also shows that the two Martin County sites tend to have lower winter temperatures (as low as 14°C in winter 2010) while much of the remaining year is similar to the southern counties.

Table 5 presents the dates and maximum and minimum temperatures (°C) for each site from late winter 2007 into summer 2018. For 18 sites, the maximum temperature was recorded in August 2014 (all ≥ 30.9°C) with one additional site in September 2014 (MC1: 30.6°C) (Table 5; also see Figures 24-27). One site (DC8: 32.4 °C) had the maximum temperature recorded in August 2017. The same six sites had temperatures recorded over 30.5°C for multiple days in both 2016 and 2017, a decrease from all 22 sites in 2014 and 16 sites in 2015 (Table 6; 2018 was not included because a full year of temperature data was not collected at the time each site was sampled).

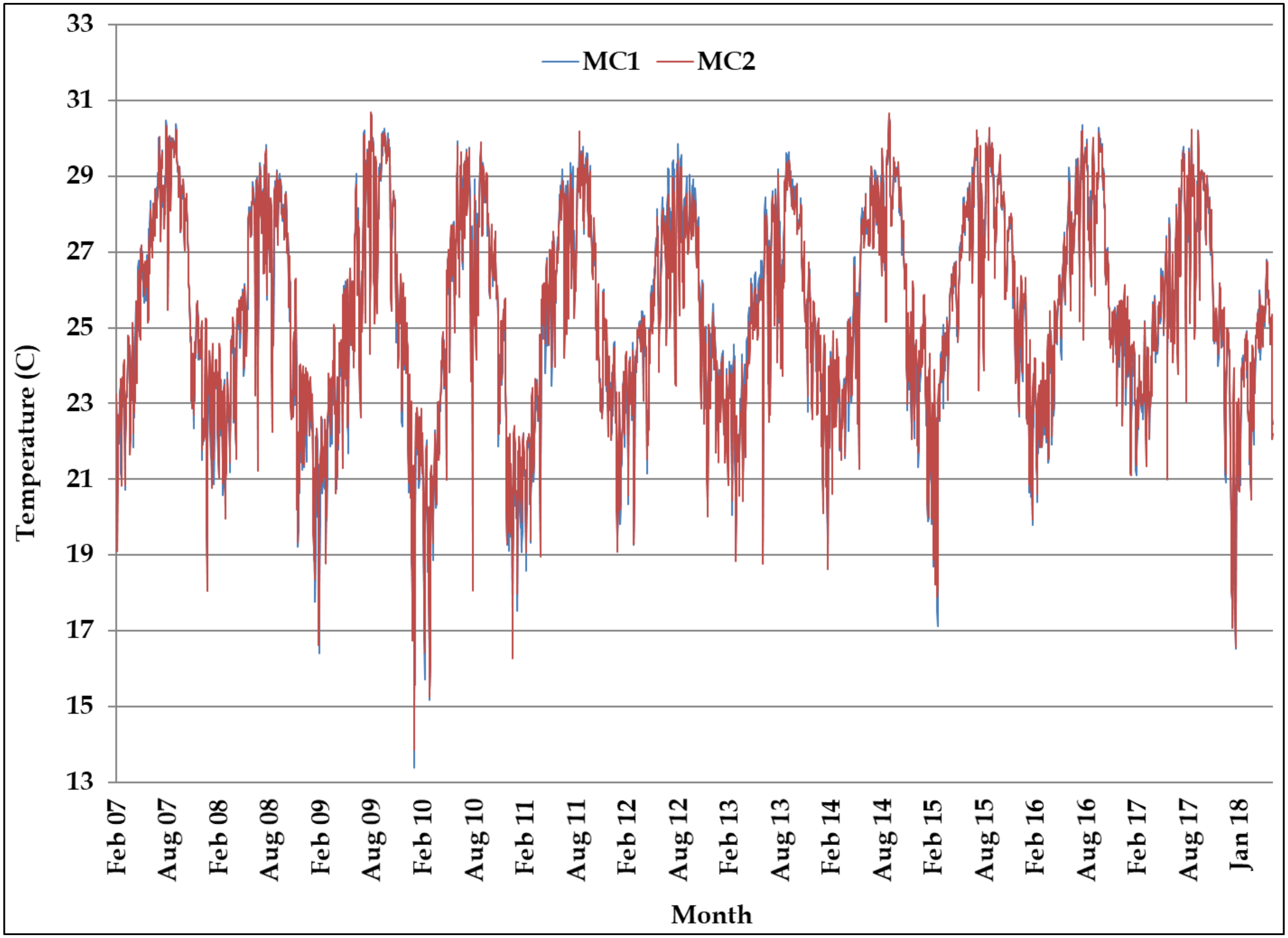

Figure 25. Mean daily temperatures for Martin County sites (°C), February 2007 – May 2018.

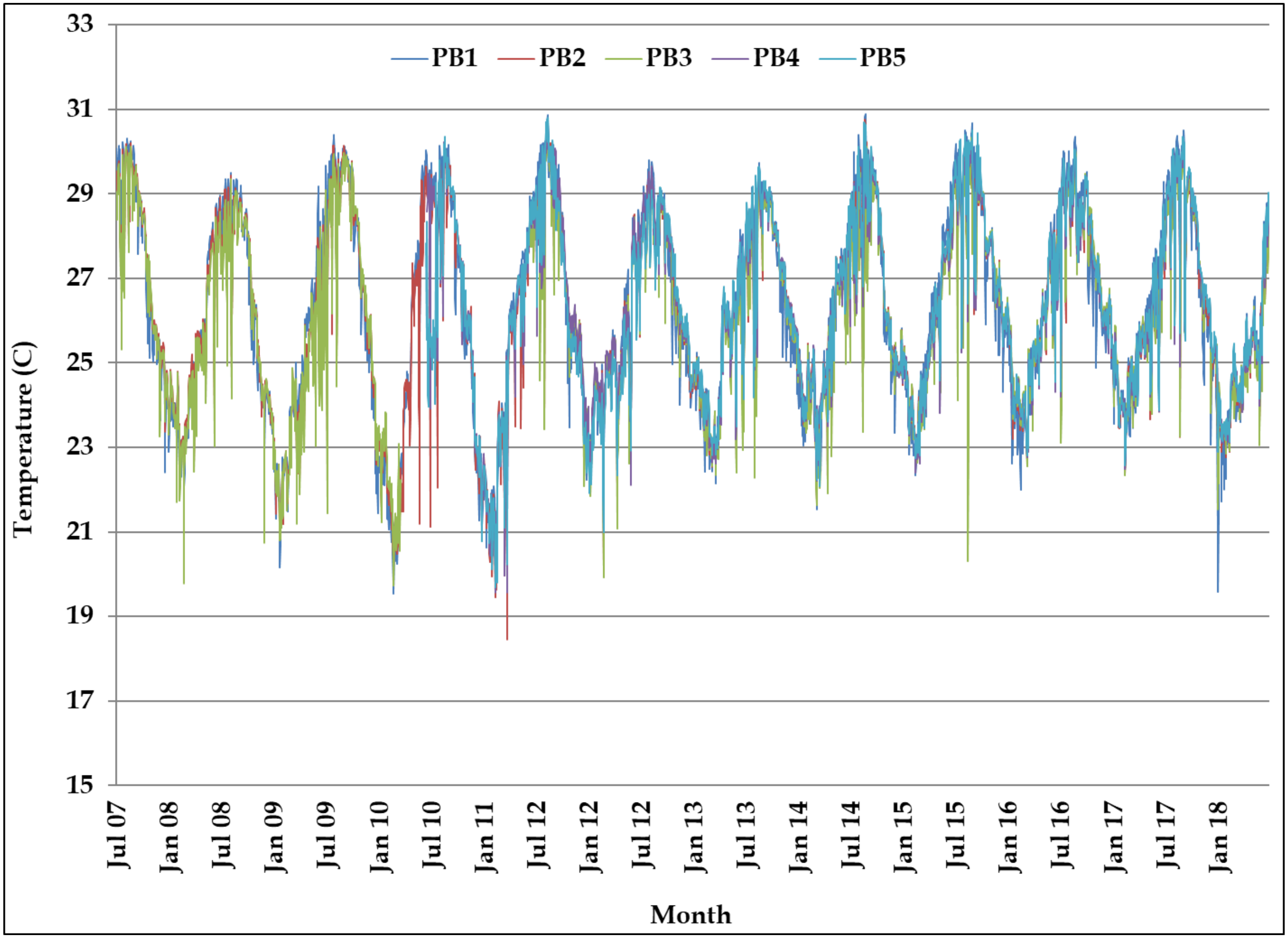

Figure 26. Mean daily temperatures for the Palm Beach County sites (°C), July 2007 – June 2018.

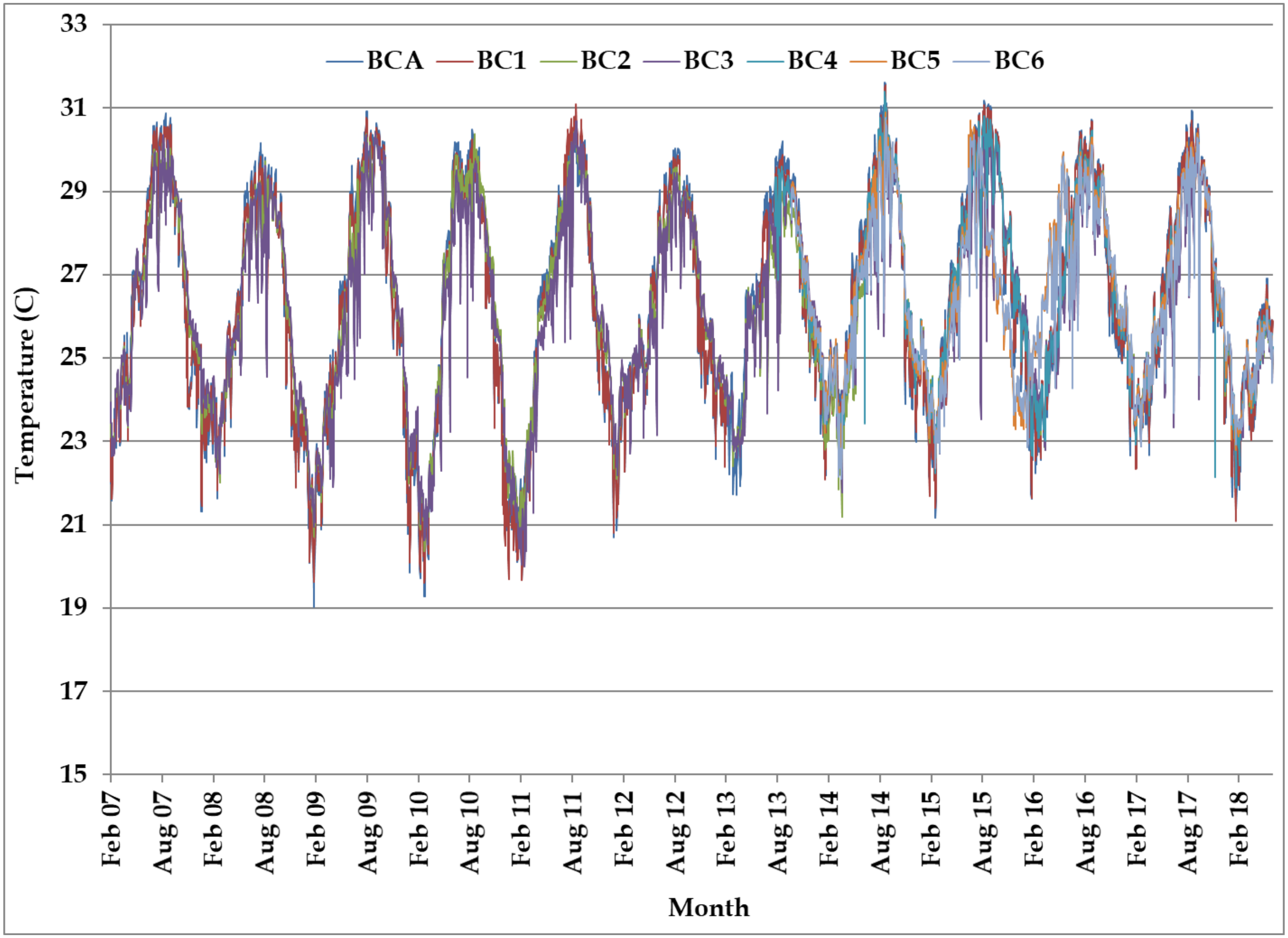

Figure 27. Mean daily temperatures for the Broward County sites (°C), February 2007 – May 2018.

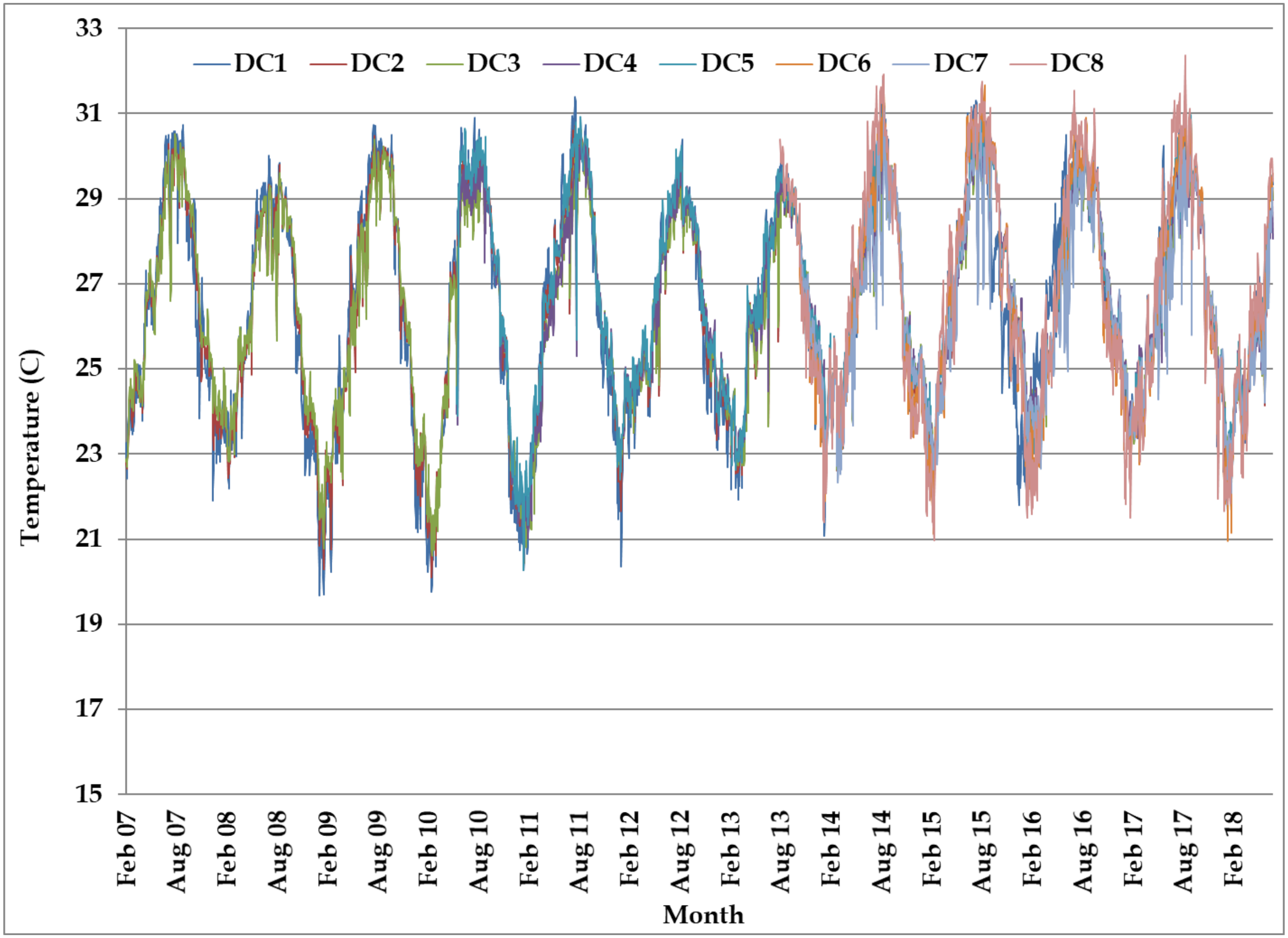

Figure 28. Mean daily temperatures for the Miami-Dade County sites (°C), February 2007 – June 2018.

Table 5. Maximum and minimum water temperatures (°C) and dates for the 22 sites with temperature loggers recording winter 2007 through May 2018.

	Maximum		**Minimum**	
Site	**Temp**	**Date**	**Temp**	**Date**
DC1	31.9	21 Aug 14	19.7	23 Jan 09
DC2	31.2	25 Aug 14	20.1	4 Mar 10
DC3	31.3	24 Aug 14	20.4	1 Feb 11
DC4	31.2	24 Aug 14	20.3	31 Jan 11
DC5	31.4	24 Aug 14	20.3	31 Jan 11
DC6	31.7	22 Aug 14	21.0	19 Jan 18
DC7	31.2	25 Aug 14	22.1	1 Feb 18
DC8	32.4	18 Aug 17	21.0	22 Feb 15
BCA	31.6	24 Aug 14	19.0	6 Feb 09
BC1	31.6	25 Aug 14	19.6	5 Mar 10
BC2	31.2	25 Aug 14	20.4	5 Mar 10
BC3	30.9	25 Aug 14	20.0	22 Feb 11
BC4	31.4	24 Aug 14	21.9	21 Jan 18
BC5	30.9	25 Aug 14	22.3	23 Mar 14
BC6	30.8	26 Aug 14	22.1	23 Mar 14
PB1	30.9	30 Aug 14	19.5	6 Mar 10
PB2	30.8	29 Aug 14	18.5	5 Apr 11
PB3	30.6	29 Aug 14	19.7	7 Mar 10
PB4	30.8	22 Aug 11	19.6	5 Apr 11
PB5	30.8	25 Aug 11	19.7	22 Feb 11
MC1	30.6	1 Sept 14	13.4	11 Jan 10
MC2	30.7	11 Aug 09	13.8	11 Jan 10

Table 6. Number of days per year with water temperature ≥ 30.5°C for the 22 sites with temperature loggers recording winter 2007 through 2017 (NA = sites not established) (2018 is not included because a full year of temperature data was not collected at the time each site was sampled).

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
DC1	11	0	7	5	18	0	0	29	33	13	9
DC2	0	0	0	0	6	0	0	8	20	0	0
DC3	1	0	0	0	1	0	0	7	5	0	0
DC4	0	0	0	0	1	0	0	9	12	0	0
DC5	0	0	0	2	8	0	0	18	15	1	11
DC6	NA	NA	NA	NA	NA	NA	0	18	49	11	11
DC7	NA	NA	NA	NA	NA	NA	0	6	5	0	0
DC8	NA	NA	NA	NA	NA	NA	0	41	64	30	50
BCA	21	0	7	0	0	0	0	22	36	4	11
BC1	8	0	6	0	13	0	0	19	30	3	6
BC2	0	0	0	0	1	0	0	7	3	0	0
BC3	0	0	0	0	2	0	0	4	1	0	0
BC4	NA	NA	NA	NA	NA	NA	0	12	13	0	0
BC5	NA	NA	NA	NA	NA	NA	0	6	3	0	0
BC6	NA	NA	NA	NA	NA	NA	0	4	0	0	0
PB1	0	0	0	0	0	6	0	4	3	0	0
PB2	0	0	0	0	0	2	0	3	0	0	0
PB3	0	0	0	0	0	0	0	1	0	0	0
PB4	0	0	0	0	0	5	0	1	0	0	0
PB5	0	0	0	0	0	7	0	4	1	0	0
MC1	0	0	1	0	0	0	0	3	0	0	0
MC2	0	0	2	0	0	0	0	3	0	0	0

Discussion

The coral reef ecosystem within the Southeast Florida Coral Reef Ecosystem Conservation Area (Coral ECA) is the northern extension of the Florida Reef Tract (FRT) and is a high-latitude system near the environmental threshold for significant coral reef growth. Coral ECA reefs generally have similar stony coral species richness, but reduced stony coral cover compared to the Florida Keys and Dry Tortugas (southern portions of the Florida Reef Tract) (Ruzicka et al. 2010; Ruzicka et al. 2012). Benthic cover by octocorals and macroalgae is similar throughout the FRT, while sponges appear to contribute more to cover in southeast Florida than in the Florida Keys or Dry Tortugas (Ruzicka et al. 2010; Ruzicka et al. 2012; Ruzicka et al. 2013).

Prior to the 2018 sampling year, the Coral ECA experienced significant stony coral community declines with significant losses determined for all stony coral metrics examined (cover, LTA, and density) at regional and site levels. In 2018 further significant losses were recorded in stony coral cover and live tissue area (LTA). A stony coral disease event, driven by Stony Coral Tissue Loss Disease (SCTLD) (https://floridadep.gov/rcp/coral/documents/coral-disease-outbreak-faq-v52), was reported offshore southeast Florida in 2014 and continued through 2016 (Kabay 2016, Precht et al. 2016, Walton et al. 2018) and 2017 (Gilliam et al. 2018). Although mean site disease prevalence was less than 1% in 2018, this multi-year event was still affecting the region. Similar to years 2014-2017, this disease event was very likely the greatest contributing factor to the significant loss of stony coral colonies and LTA identified within the SECREMP sites.

Regionally, the year to year analysis determined stony coral cover significantly decreased from 2017 to 2018, and the long-term trend analysis determined a significant decrease during the 2016-2018 time period for nearly all site groups. During the time period 2015 to 2018 there was an estimated 57% loss in mean region-wide cover. Three sites had a significant loss in cover and an additional 15 sites exhibited declines from 2017 to 2018, although not statistically significant. Stony coral live tissue areas (LTA) were estimated to provide an additional and perhaps more sensitive metric for describing changes to the amount of live tissue in the region. Region-wide (all sites and colonies pooled) LTA significantly declined in 2016 with no significant recovery through 2018. There was a significant 40% loss in LTA from 2015 to 2018. For 10 sites, 2017 had the lowest estimated LTA and for six sites the lowest estimated LTA occurred in 2018 (Appendix 4).

Loss of *Montastraea cavernosa* is of particular concern because the species contributes greatly to stony coral benthic cover and LTA, and this species is present in all four southeast Florida counties and reef habitats. *Montastraea cavernosa* is also one of the more common large (~>50 cm diameter) colony forming species, and has commonly been described as a 'robust' species capable of surviving in variable habitats and conditions. Region-wide in 2018, 13 colonies were identified with disease visually consistent with SCTLD, and 11 were *M. cavernosa*. Although there was no continued significant *M. cavernosa* LTA loss in 2018, the continued recording of diseased colonies of this species remains of particular concern. The only other colonies identified with SCTLD in 2018 were two *Orbicella faveolata* (*Montastraea annularis* complex) colonies, although not common within all sample sites, this species can be an important reef building and structure contributing species throughout

Florida. *Meandrina meandrites* and *D. stokesii* were also examined in detail. Although commonly in much lower densities than *M. cavernosa*, *M. meandrites* and *D. stokesii* are frequently found throughout southeast Florida in all four reef habitats and all counties. *Meandrina meandrites* and *D. stokesii* were also two initial species reported as dramatically impacted by the disease event (Precht et al. 2016, Walton et al. 2018). The 2016 and 2017 sampling event documented significant declines in colony density and LTA for both species, with no significant LTA recovery yet occurring in the 2018 sampling. An example highlighting these losses in terms of abundance, in 2013 114 *M. meandrites* colonies and 75 *D. stokesii* were identified within the 22 SECREMP sites by 2016 their abundances dropped to five and eight colonies, respectively. In 2018 abundance did increase slightly with 14 *M. meandrites* and 10 *D. stokesii* colonies within the sample sites. The only species with region-wide significant increases in LTA were *Porites astreoides* and *Siderastrea siderea*. These species generally exist as small colonies and do not contribute as much to reef complexity as other species. The increases in these small, weedy species also contributed greatly to the lack of significant, annual, region-wide change in stony coral density.

Declines in the stony coral community were not confined to any one area and this regional scale loss is of great concern. Stony coral cover, density and LTA declines were observed in Martin, Palm Beach, Broward and Miami-Dade counties. These losses were also observed in all habitats, which range in depth from 3 to 21 meters. The rate of decline is also of concern as significant losses have been observed over relatively short time periods. There were notable losses of *M. cavernosa*, *S. siderea*, *M. meandrites* and *D. stokesii* observed in 2015 (Gilliam et al. 2016) with even greater declines from 2015 to 2016 and then again from 2016 to 2017. There was some positive results from 2018 and conditions appear to be improving with a decrease disease prevalence in 2018. Region-wide disease prevalence was below 1% and only 14 colonies (of 2 species) were recorded with SCTLD. *Meandrina meandrites* and *D. stokesii* colony (≥ 4 cm diameter) abundance was greater in 2018 than in 2017 and no further significant loss in LTA was determined. No species were completely lost from the project, and as shown in Table 4 small colonies (< 4 cm diameter) of a number of species most susceptible to SCTLD were recorded in a number of sites in multiple counties.

There is no clear relationship between the changes documented in the stony coral community and the octocoral or sponge communities. Octocoral cover has generally decreased through time, and for site Groups C, D and BCA the last time interval (2016-2018) had significantly lower cover than previous years. In contrast, region-wide octocoral density in 2015, 2016, and 2017 was significantly greater than in 2013 and 2014. However, in 2018 the first decrease in octocoral density was recorded. This decline maybe the result of physical removal from surge and wave energy associated with the passing of Hurricane Irma, a category 4 hurricane, in September 2017. Significant changes were identified for all three target species, and *G. ventalina* and *A. americana* both had significant increases in density in 2017. Although all three species had declines in 2018, none were significant. There are likely a number of factors contributing to the contrast between the cover results and colony density. Benthic cover estimates derived from transect images in this project include octocoral canopy; therefore, larger-taller colonies will contribute greatly to percent cover estimates. All colonies with living tissue regardless of size contribute equally to colony density estimates. *Antillogorgia americana* mean colony height was significantly greater in 2013 than all the following years; however, colony density in later years (2016 and 2017) was greater than in 2013 and 2014. These results indicate that the region experienced a decline in colony size and/or an increase in partial mortality in the larger size classes, both of which would contribute to reduced cover, and likely an increase smaller colony abundance.

Xestospongia muta, the giant barrel sponge, density region-wide has generally increased with 2015-2018 mean densities significantly greater than 2013, and 2017 significantly greater than 2014. There was, however, a significant decrease in *X. muta* density from 2017-2018. Similar to the decline in octocoral density in 2018, the passing of Hurricane Irma likely contributed greatly to the *X. muta* density decline.

Macroalgae cover was more variable than both stony coral and octocorals cover but generally increased across most site groups across the course of monitoring, with the last time interval (2016-2018) having significantly higher macroalgae cover than previous time intervals. The Martin County site group had a contrasting trend were macroalgae cover steadily decreased across all time intervals. Interpreting temporal changes in macroalgae cover through annual visits is challenging as macroalgae cover can change significantly in short time periods. These data do indicate that region-wide conditions appear to becoming more favorable to macroalgae growth. These changing conditions may include increased nutrients, water temperatures, substrate availability and a host of other factors not specifically addressed in this project.

The percent cover of sponges was the most temporally consistent across the taxa examined, and there was no region-wide consistent temporal trends identified among the site groups. The conditions driving the changes to the stony coral community and macroalgae cover do not appear to be, at the current level of examination, impacting the sponge communities.

SECREMP is an annual monitoring program and annual programs are designed to provide current status and long-term trend information. Capturing the processes that contribute to the changes in conditions and long-term trends is a challenge for annual sampling. However, there are compelling data and observations that supports that the significant stony coral declines from 2014 through 2018 were driven by a multi-year disease event. Region-wide stony coral disease prevalence increased from 1.0% in 2013 to a peak prevalence of 4.4% in 2016. Prevalence decreased in 2017 (1.1%) and again in 2018 (0.8%). The increase in disease prevalence from 2013 to 2016 was driven by what is now described as Stony Coral Tissue Loss Disease (https://floridadep.gov/rcp/coral/documents/coral-disease-outbreak-faq-v52), a rapidly spreading white disease of unknown etiology. This disease has now spread through the most the entire Florida Reef Tract (https://floridadep.gov/rcp/coral/content/stony-coral-tissue-loss-sctl-disease-response). Additionally, the loss of almost all known (>90%) pillar corals, *Dendrogyra cylindrus*, offshore southeast Florida is another example of the dramatic and significant impact this event has had on the stony coral community (Kabay 2016).

Diseased individuals are a normal part of all populations, but unfortunately, disease outbreaks appear to be becoming a greater and more common threat. There have been a number of environmental factors reported as potentially increasing the risk of disease and mortality above normal levels, including elevated water temperatures, various water quality parameters, and increased sedimentation and turbidity. Over the course of the SECREMP monitoring effort the maximum water temperatures were recorded in August 2014 for 19 of 22 sites. Additionally, more days with water temperatures above 30.5˚C, a temperature above which bleaching has been recorded in the Florida Keys (Manzello et al. 2007), were reported in summer 2015 and 2016 than all previous years. Elevated water temperatures for two consecutive summers most certainly affected southeast Florida reefs as they have been suggested to affect reefs in the Keys (Van Woesik and McCaffrey 2017). Southeast Florida reefs are also offshore of a highly urbanized area driving increased nutrient loading from urban runoff and defining the ever increasing need for marine construction projects (beach nourishment, port dredging, etc.). Coastal nutrient loading has been shown to contribute to increased levels of disease and mortality (Vega Thurber et al. 2014) as well as increased marine construction project related sediments (Pollack et al. 2014, Miller et al. 2016). All the factors and/or conditions that may be potentially contributing to the reported disease outbreak cannot be defined or evaluated. A combination of factors is most likely driving the disease event. Additionally, not all coral mortality documented in this report was caused by disease; other stressors, environmental and biological, most certainly contributed to some mortality across the region and/or at specific sites.

The southeast Florida reefs 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 and supported over 61,300 jobs in Miami-Dade, Broward, Palm Beach, and Martin Counties (Johns et al. 2001, 2004). Notably, Johns et al. (2001) indicated 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 as evident from the data presented. This coastal area is highly urbanized, which combined with dredging for beach nourishment, inlet and port channel deepening, and maintenance 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 threat to reef areas as damage from fishing gear and anchoring can be severe. 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. Fiber optic cables deployed across the reefs (Jaap 2000) and ships grounding and anchoring on reefs cause extensive and often long-lasting damage (Gilliam and Moulding 2012).

The chronic nature of disturbances to and the significant economic value of southeast Florida reefs requires comprehensive, long-term monitoring to be conducted to define and quantify change and to help identify threats to the ecosystem. The region-wide information generated during the annual SECREMP site visits provide scientifically valid status and trend data designed to assist local resource managers in understanding the condition of the resources and possible 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 incident-specific monitoring are necessary if resource managers are to develop sound management plans for coral reefs that allow continued use and realization of the economic value of these fragile marine ecosystems. The value for a long-term region-wide monitoring program is highlighted by the information, albeit concerning, presented in this report. Relying on project-related monitoring efforts would not have provided the regional scale picture of the dramatic stony coral community losses or have been able to put current conditions in context with long-term trends.

The expansion of CREMP to include sites in Broward, Miami-Dade, Palm Beach, and Martin Counties through SECREMP, has insured that a suite of parameters is being monitored for much of the FRT. As a monitoring project under the NOAA Coral Reef Conservation Program Cooperative Agreement for the southeast Florida coast, SECREMP will continue to provide valuable southeast Florida coral reef status and long-term trend data. SECREMP provides resource managers with the critical information required to manage this valuable, yet increasingly threatened, natural resource. The data presented in this report clearly demonstrate that the northern extension of the FRT is threatened more than ever and requires an elevated level of concern and action to identify and reduce stressors.

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Appendices

Appendix 1. Mean cover by site (R= region-wide comparison; BC = Broward County; DC = Miami-Dade County; PB = Palm Beach County; MC = Martin County). Region-wide values are calculated as an average of the sum of each site. Site level values are calculated as an average of the stations. For cover data for years prior to 2010 see Gilliam et al. (2013)

		2010	2011	2012	2013	2014	2015	2016	2017	2018
Variable	**Level**	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Stony Coral	R (n=10)	4.05 ± 1.07	3.43 ± 0.82	3.62 ± 0.84	3.37 ± 0.74	3.83 ± 0.82	3.37 ± 0.74	1.80 ± 0.40	1.47 ± 0.28	1.44 ± 0.33
	R (n=16,22)	3.15 ± 0.87	2.72 ± 0.68	2.95 ± 0.69	2.54 ± 0.54	2.83 ± 0.61	2.54 ± 0.54	1.52 ± 0.32	1.46 ± 0.30	1.03 ± 0.29
	DC1	3.24 ± 0.86	3.64 ± 1.82	4.57 ± 1.27	4.24 ± 0.92	5.44 ± 1.65	5.33 ± 2.54	2.70 ± 0.76	2.83 ± 0.35	2.50 ± 0.32
	DC2	0.93 ± 0.20	1.15 ± 0.22	0.95 ± 0.20	0.95 ± 0.48	1.55 ± 0.40	1.22 ± 0.29	0.76 ± 0.20	0.73 ± 0.19	0.50 ± 0.05
	DC3	0.27 ± 0.06	0.15 ± 0.09	0.50 ± 0.17	0.24 ± 0.07	0.40 ± 0.17	0.19 ± 0.09	0.22 ± 0.11	0.36 ± 0.13	0.24 ± 0.11
	DC4	1.18 ± 0.42	1.00 ± 0.34	1.76 ± 0.32	1.52 ± 0.50	1.36 ± 0.56	1.32 ± 0.37	1.09 ± 0.12	1.01 ± 0.23	0.78 ± 0.15
	DC5	2.29 ± 0.24	1.49 ± 0.24	1.73 ± 0.46	1.59 ± 0.28	2.94 ± 1.08	1.16 ± 0.29	0.70 ± 0.06	0.94 ± 0.12	0.40 ± 0.06
	DC6	NA ± NA	NA ± NA	NA ± NA	2.50 ± 0.48	2.86 ± 0.80	3.24 ± 0.84	2.72 ± 0.69	2.22 ± 0.65	1.28 ± 0.42
	DC7	NA ± NA	NA ± NA	NA ± NA	0.51 ± 0.09	0.50 ± 0.17	0.42 ± 0.04	0.16 ± 0.07	0.45 ± 0.07	0.34 ± 0.18
	DC8	NA ± NA	NA ± NA	NA ± NA	1.51 ± 0.55	1.51 ± 0.34	1.18 ± 0.24	1.36 ± 0.51	1.04 ± 0.27	0.97 ± 0.40
	BC1	10.45 ± 1.67	10.99 ± 2.08	10.80 ± 1.39	12.67 ± 1.93	12.27 ± 1.73	12.35 ± 1.17	7.28 ± 1.38	4.92 ± 0.86	6.43 ± 1.47
	BC2	0.64 ± 0.31	0.81 ± 0.32	0.66 ± 0.39	0.73 ± 0.43	0.78 ± 0.21	0.89 ± 0.47	0.38 ± 0.10	0.35 ± 0.11	0.46 ± 0.17
	BC3	0.23 ± 0.10	0.34 ± 0.06	0.74 ± 0.15	0.69 ± 0.32	0.61 ± 0.22	0.69 ± 0.32	0.41 ± 0.31	0.33 ± 0.12	0.24 ± 0.09
	BC4	NA ± NA	NA ± NA	NA ± NA	4.04 ± 0.92	4.23 ± 0.88	4.38 ± 1.13	3.49 ± 0.67	3.82 ± 0.57	1.71 ± 0.36
	BC5	NA ± NA	NA ± NA	NA ± NA	1.49 ± 0.30	1.08 ± 0.39	1.43 ± 0.20	0.16 ± 0.03	0.31 ± 0.12	0.23 ± 0.05
	BC6	NA ± NA	NA ± NA	NA ± NA	0.76 ± 0.19	0.58 ± 0.23	0.60 ± 0.22	0.31 ± 0.09	0.53 ± 0.16	0.39 ± 0.10
	BCA	21.38 ± 2.41	14.51 ± 1.52	15.13 ± 2.75	10.93 ± 1.67	13.85 ± 1.69	9.88 ± 2.06	4.75 ± 1.06	3.41 ± 0.90	2.44 ± 0.54
	PB1	0.15 ± 0.09	0.00 ± 0.00	0.07 ± 0.05	0.11 ± 0.06	0.03 ± 0.03	0.10 ± 0.07	0.10 ± 0.07	0.06 ± 0.04	0.03 ± 0.03
	PB2	1.94 ± 0.42	1.49 ± 0.48	1.54 ± 0.41	1.68 ± 0.38	2.09 ± 0.66	2.04 ± 0.42	0.87 ± 0.23	1.14 ± 0.31	1.00 ± 0.38
	PB3	1.23 ± 0.16	1.19 ± 0.22	1.20 ± 0.39	1.49 ± 0.45	1.27 ± 0.43	1.04 ± 0.12	0.57 ± 0.10	0.59 ± 0.20	0.59 ± 0.17
	PB4	1.12 ± 0.29	1.32 ± 0.41	1.65 ± 0.52	1.70 ± 0.42	1.73 ± 0.42	1.56 ± 0.54	0.40 ± 0.12	1.44 ± 1.15	0.48 ± 0.15
	PB5	1.55 ± 0.18	1.68 ± 0.32	1.93 ± 0.27	1.94 ± 0.58	2.35 ± 0.37	2.04 ± 0.45	0.79 ± 0.24	0.60 ± 0.10	0.58 ± 0.31
	MC1	2.35 ± 1.23	2.94 ± 1.33	3.14 ± 1.66	2.97 ± 1.47	3.60 ± 1.96	3.60 ± 1.67	2.98 ± 1.32	3.94 ± 1.14	0.89 ± 0.55
	MC2	1.46 ± 0.50	0.82 ± 0.24	0.80 ± 0.30	1.52 ± 0.63	1.12 ± 0.39	1.31 ± 0.38	1.23 ± 0.56	1.13 ± 0.80	0.15 ± 0.15

Appendix 1. Continued

		2010	2011	2012	2013	2014	2015	2016	2017	2018
Variable	**Level**	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Octocoral	R (n=10)	10.47 ± 1.45	10.49 ± 1.21	9.62 ± 1.08	8.63 ± 0.94	8.90 ± 0.92	8.46 ± 0.94	8.34 ± 0.93	9.16 ± 0.99	7.65 ± 0.74
	R (n=16,22)	11.35 ± 1.50	11.75 ± 1.42	10.63 ± 1.28	9.88 ± 1.07	9.60 ± 1.02	9.14 ± 0.97	8.76 ± 0.95	9.29 ± 1.19	7.46 ± 0.94
	DC1	8.37 ± 1.37	10.92 ± 1.77	10.00 ± 0.64	8.34 ± 0.49	12.08 ± 1.49	9.45 ± 1.95	9.67 ± 0.72	9.37 ± 1.12	9.04 ± 1.29
	DC2	10.97 ± 1.06	19.58 ± 2.42	12.38 ± 1.34	11.37 ± 0.47	12.04 ± 0.86	12.44 ± 0.79	8.49 ± 0.47	11.79 ± 1.54	7.06 ± 0.76
	DC3	6.38 ± 0.87	7.07 ± 1.12	8.66 ± 1.48	8.38 ± 0.94	7.97 ± 1.42	9.19 ± 2.11	9.98 ± 0.48	11.50 ± 0.94	8.95 ± 0.45
	DC4	14.52 ± 1.10	16.78 ± 1.29	16.49 ± 1.95	14.58 ± 1.36	12.15 ± 1.11	12.26 ± 0.78	12.34 ± 1.48	12.32 ± 0.64	9.92 ± 0.86
	DC5	16.70 ± 1.60	18.86 ± 1.76	16.53 ± 4.20	16.74 ± 2.27	12.93 ± 1.42	12.67 ± 2.41	15.26 ± 1.17	15.39 ± 1.56	11.11 ± 2.08
	DC6	NA ± NA	NA ± NA	NA ± NA	9.37 ± 1.47	7.04 ± 0.93	7.55 ± 0.92	6.87 ± 0.56	8.69 ± 0.68	4.94 ± 0.52
	DC7	NA ± NA	NA ± NA	NA ± NA	8.09 ± 1.64	7.73 ± 0.33	11.79 ± 1.82	5.39 ± 0.70	6.65 ± 0.84	6.18 ± 1.28
	DC8	NA ± NA	NA ± NA	NA ± NA	15.82 ± 1.84	14.11 ± 2.03	13.12 ± 0.62	12.23 ± 0.85	14.43 ± 1.40	11.56 ± 1.06
	BC1	8.56 ± 1.18	6.71 ± 0.87	7.54 ± 0.46	7.36 ± 0.43	7.10 ± 0.56	5.74 ± 1.00	5.42 ± 0.74	6.32 ± 0.66	7.82 ± 0.44
	BC2	5.28 ± 0.37	7.75 ± 1.88	5.77 ± 0.44	4.69 ± 0.87	7.98 ± 0.96	5.18 ± 0.45	5.01 ± 0.63	8.48 ± 1.19	7.25 ± 1.38
	BC3	15.28 ± 1.29	12.49 ± 0.68	13.99 ± 1.16	13.12 ± 0.48	8.65 ± 1.68	9.28 ± 1.29	9.95 ± 0.90	9.38 ± 1.33	10.45 ± 1.49
	BC4	NA ± NA	NA ± NA	NA ± NA	4.28 ± 0.58	4.20 ± 0.68	4.61 ± 0.51	5.03 ± 0.68	4.58 ± 0.76	2.14 ± 0.42
	BC5	NA ± NA	NA ± NA	NA ± NA	6.76 ± 0.95	8.41 ± 0.76	6.51 ± 0.79	5.52 ± 0.48	7.05 ± 0.88	5.70 ± 0.41
	BC6	NA ± NA	NA ± NA	NA ± NA	16.44 ± 1.40	16.79 ± 0.80	13.22 ± 0.49	13.69 ± 1.04	14.09 ± 1.16	11.64 ± 0.68
	BCA	2.45 ± 0.38	2.85 ± 0.47	2.37 ± 0.37	2.96 ± 0.65	2.85 ± 0.40	2.25 ± 0.53	1.19 ± 0.23	1.13 ± 0.23	1.77 ± 0.22
	PB1	0.00 ± 0.00	0.00 ± 0.00	0.26 ± 0.16	0.00 ± 0.00	0.00 ± 0.00	0.10 ± 0.07	0.00 ± 0.00	0.06 ± 0.06	0.00 ± 0.00
	PB2	26.45 ± 6.56	18.96 ± 3.97	20.29 ± 5.63	17.12 ± 5.12	18.45 ± 4.22	18.61 ± 3.56	16.63 ± 3.29	18.80 ± 4.19	14.36 ± 3.14
	PB3	20.96 ± 4.33	18.58 ± 4.20	14.93 ± 1.88	12.99 ± 1.89	11.91 ± 1.72	12.41 ± 1.36	17.03 ± 0.63	14.80 ± 1.71	9.80 ± 1.85
	PB4	22.76 ± 2.33	20.53 ± 1.44	18.44 ± 1.47	18.93 ± 2.10	22.03 ± 2.11	20.71 ± 1.29	19.12 ± 2.36	15.40 ± 3.57	11.84 ± 2.18
	PB5	22.77 ± 1.18	26.71 ± 2.13	22.38 ± 0.67	19.81 ± 1.27	16.62 ± 0.25	14.05 ± 1.95	13.88 ± 1.14	14.18 ± 1.21	12.62 ± 1.57
	MC1	0.11 ± 0.08	0.14 ± 0.14	0.03 ± 0.03	0.12 ± 0.12	0.02 ± 0.02	0.05 ± 0.03	0.03 ± 0.03	0.00 ± 0.00	0.00 ± 0.00
	MC2	0.08 ± 0.08	0.00 ± 0.00	0.08 ± 0.08	0.00 ± 0.00	0.03 ± 0.03	0.00 ± 0.00	0.03 ± 0.03	0.00 ± 0.00	0.00 ± 0.00

Appendix 1. Continued

		2010	2011	2012	2013	2014	2015	2016	2017	2018
Variable	**Level**	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Sponge	R (n=10)	5.34 ± 0.65	6.07 ± 0.63	5.75 ± 0.60	5.14 ± 0.45	5.06 ± 0.56	5.25 ± 0.54	4.98 ± 0.52	5.93 ± 0.68	4.97 ± 0.48
	R (n=16,22)	5.83 ± 0.67	6.91 ± 0.73	6.25 ± 0.67	5.18 ± 0.54	5.52 ± 0.58	5.75 ± 0.61	5.43 ± 0.54	6.09 ± 0.76	4.90 ± 0.58
	DC1	3.70 ± 1.03	4.32 ± 0.84	3.74 ± 0.72	2.64 ± 0.48	2.66 ± 0.33	3.34 ± 0.38	3.17 ± 0.18	2.88 ± 0.35	3.37 ± 0.51
	DC2	5.19 ± 0.78	7.26 ± 1.44	7.34 ± 1.20	4.93 ± 0.35	4.97 ± 0.52	5.69 ± 0.33	5.88 ± 0.70	6.38 ± 1.21	4.59 ± 1.04
	DC3	4.54 ± 1.09	4.95 ± 1.15	6.09 ± 0.73	5.47 ± 0.91	3.59 ± 0.90	3.19 ± 0.84	4.86 ± 1.45	4.55 ± 1.14	4.00 ± 0.67
	DC4	7.75 ± 1.30	5.89 ± 0.97	6.78 ± 0.64	7.50 ± 1.54	7.34 ± 1.44	8.64 ± 1.39	7.74 ± 1.57	8.14 ± 0.26	6.64 ± 0.46
	DC5	4.26 ± 0.84	6.46 ± 1.06	5.25 ± 0.84	3.50 ± 0.57	4.22 ± 0.95	5.72 ± 1.08	5.02 ± 1.38	5.72 ± 1.23	3.36 ± 0.52
	DC6	NA ± NA	NA ± NA	NA ± NA	2.28 ± 0.38	2.14 ± 0.37	1.75 ± 0.24	2.42 ± 0.19	3.02 ± 0.29	1.84 ± 0.52
	DC7	NA ± NA	NA ± NA	NA ± NA	7.52 ± 1.10	7.47 ± 1.48	8.60 ± 0.60	7.82 ± 0.66	7.73 ± 1.01	6.18 ± 1.40
	DC8	NA ± NA	NA ± NA	NA ± NA	2.58 ± 0.28	3.19 ± 0.43	3.60 ± 0.27	3.78 ± 0.70	3.48 ± 0.30	3.07 ± 0.60
	BC1	3.52 ± 0.51	4.90 ± 0.80	3.78 ± 0.38	3.25 ± 0.30	3.72 ± 0.57	3.70 ± 0.82	3.17 ± 0.73	3.29 ± 0.11	3.63 ± 0.57
	BC2	5.25 ± 0.86	6.21 ± 0.33	4.46 ± 0.19	5.22 ± 0.50	5.67 ± 0.63	6.55 ± 0.90	4.45 ± 0.58	6.79 ± 0.71	5.74 ± 0.96
	BC3	7.34 ± 2.15	6.21 ± 0.75	8.15 ± 1.88	6.42 ± 0.50	5.09 ± 0.55	5.84 ± 0.39	4.48 ± 0.51	6.00 ± 0.82	6.37 ± 0.44
	BC4	NA ± NA	NA ± NA	NA ± NA	3.01 ± 0.35	3.93 ± 0.48	3.90 ± 0.93	3.52 ± 0.53	4.59 ± 0.07	2.47 ± 0.54
	BC5	NA ± NA	NA ± NA	NA ± NA	6.92 ± 0.51	7.11 ± 1.14	7.30 ± 1.05	7.00 ± 0.86	8.08 ± 1.07	6.29 ± 0.91
	BC6	NA ± NA	NA ± NA	NA ± NA	3.80 ± 0.70	5.92 ± 1.34	4.96 ± 0.89	5.53 ± 0.42	5.89 ± 0.59	4.46 ± 1.40
	BCA	1.03 ± 0.28	3.23 ± 1.22	1.43 ± 0.66	3.58 ± 1.59	0.72 ± 0.35	0.87 ± 0.17	0.75 ± 0.29	0.82 ± 0.33	2.05 ± 0.77
	PB1	0.98 ± 0.69	1.36 ± 0.55	1.57 ± 0.96	1.82 ± 1.02	3.47 ± 1.87	3.01 ± 1.29	3.98 ± 2.10	5.65 ± 3.11	2.40 ± 1.36
	PB2	8.20 ± 1.46	7.28 ± 1.05	7.76 ± 0.22	7.44 ± 0.45	8.47 ± 0.71	7.92 ± 0.87	7.24 ± 0.48	8.13 ± 1.15	6.31 ± 0.92
	PB3	13.68 ± 1.22	14.98 ± 2.03	13.17 ± 1.02	10.65 ± 0.88	12.26 ± 1.59	12.39 ± 1.22	11.80 ± 0.93	14.78 ± 1.37	11.24 ± 1.60
	PB4	11.79 ± 2.39	13.99 ± 2.90	13.84 ± 1.78	12.69 ± 2.79	13.34 ± 2.17	14.76 ± 2.44	13.24 ± 1.88	13.23 ± 4.10	10.48 ± 0.71
	PB5	10.41 ± 1.62	14.43 ± 1.79	11.53 ± 1.95	8.60 ± 1.28	9.79 ± 0.75	9.78 ± 1.40	7.49 ± 0.86	10.73 ± 1.04	8.94 ± 1.59
	MC1	2.41 ± 0.97	3.17 ± 0.95	2.06 ± 0.40	1.54 ± 0.33	2.72 ± 0.43	1.88 ± 0.47	2.72 ± 0.17	2.14 ± 0.21	2.59 ± 0.59
	MC2	3.24 ± 0.98	5.87 ± 1.55	3.09 ± 0.95	2.56 ± 0.64	3.72 ± 0.75	3.01 ± 0.48	3.36 ± 0.87	1.90 ± 0.55	1.75 ± 0.48

Appendix 1. Continued

		2010	2011	2012	2013	2014	2015	2016	2017	2018
Variable	**Level**	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Macroalgae	R (n=10)	4.82 ± 0.71	3.60 ± 0.71	4.04 ± 0.94	4.29 ± 0.81	5.86 ± 0.73	6.40 ± 1.18	28.30 ± 3.75	11.19 ± 1.50	7.87 ± 1.46
	R (n=16,22)	10.60 ± 2.28	5.36 ± 1.20	8.88 ± 2.54	9.15 ± 1.89	10.27 ± 1.51	11.16 ± 1.65	26.90 ± 3.02	13.11 ± 1.63	13.98 ± 2.46
	DC1	9.51 ± 2.52	10.76 ± 3.45	3.86 ± 1.17	15.26 ± 3.42	3.60 ± 0.62	2.88 ± 1.09	17.85 ± 2.70	2.30 ± 0.34	20.91 ± 3.72
	DC2	4.85 ± 1.16	4.90 ± 2.71	2.31 ± 1.25	5.73 ± 2.70	5.59 ± 1.84	4.28 ± 1.60	67.44 ± 3.03	9.46 ± 2.74	23.70 ± 4.23
	DC3	4.85 ± 1.05	0.47 ± 0.47	0.35 ± 0.10	1.13 ± 0.37	6.49 ± 0.94	3.57 ± 0.61	67.34 ± 3.52	15.03 ± 5.94	2.23 ± 1.77
	DC4	2.01 ± 0.79	0.84 ± 0.53	2.10 ± 0.73	2.22 ± 0.68	8.38 ± 2.02	5.21 ± 1.76	21.26 ± 7.35	7.75 ± 1.70	11.52 ± 2.54
	DC5	20.87 ± 4.12	5.42 ± 2.19	14.69 ± 2.44	7.06 ± 2.81	25.18 ± 2.48	25.72 ± 2.95	27.62 ± 4.12	22.37 ± 4.30	36.29 ± 2.57
	DC6	NA ± NA	NA ± NA	NA ± NA	10.02 ± 0.80	9.80 ± 0.74	12.66 ± 2.70	31.97 ± 1.76	6.35 ± 2.07	40.39 ± 3.18
	DC7	NA ± NA	NA ± NA	NA ± NA	2.53 ± 0.85	6.44 ± 1.41	8.91 ± 2.96	42.23 ± 3.74	12.39 ± 2.87	30.15 ± 6.36
	DC8	NA ± NA	NA ± NA	NA ± NA	6.28 ± 0.91	7.79 ± 2.43	15.44 ± 4.11	26.53 ± 6.43	16.04 ± 4.62	14.23 ± 0.91
	BC1	12.23 ± 2.99	7.60 ± 1.52	17.37 ± 3.92	7.04 ± 1.37	7.81 ± 1.07	15.21 ± 3.76	32.24 ± 6.36	27.00 ± 2.79	14.34 ± 3.40
	BC2	3.10 ± 0.84	3.12 ± 1.72	9.09 ± 2.49	3.21 ± 0.80	6.13 ± 1.61	7.42 ± 2.80	25.62 ± 4.39	9.71 ± 1.68	0.90 ± 0.25
	BC3	4.79 ± 1.80	1.89 ± 1.55	1.89 ± 0.52	1.88 ± 0.45	12.20 ± 2.59	11.55 ± 9.45	37.08 ± 8.75	21.96 ± 3.41	1.38 ± 0.74
	BC4	NA ± NA	NA ± NA	NA ± NA	26.08 ± 3.20	18.87 ± 2.12	22.91 ± 1.84	40.16 ± 3.74	28.11 ± 1.89	21.40 ± 3.12
	BC5	NA ± NA	NA ± NA	NA ± NA	10.92 ± 3.37	7.31 ± 0.58	18.71 ± 5.42	27.21 ± 4.90	10.10 ± 0.70	11.43 ± 3.99
	BC6	NA ± NA	NA ± NA	NA ± NA	4.36 ± 1.21	4.39 ± 0.55	4.63 ± 0.70	9.67 ± 2.53	19.75 ± 4.45	17.50 ± 6.10
	BCA	2.59 ± 1.31	2.27 ± 1.82	3.07 ± 2.09	2.69 ± 1.70	6.66 ± 4.37	2.54 ± 0.51	8.01 ± 3.32	6.05 ± 1.88	2.21 ± 0.79
	PB1	1.46 ± 1.46	0.16 ± 0.10	0.40 ± 0.34	0.28 ± 0.16	1.75 ± 1.45	3.66 ± 0.94	1.43 ± 0.89	2.98 ± 1.13	2.40 ± 0.56
	PB2	2.05 ± 0.98	1.25 ± 0.42	0.31 ± 0.20	0.60 ± 0.31	1.19 ± 0.38	3.38 ± 1.38	9.87 ± 3.19	3.49 ± 1.75	2.38 ± 0.98
	PB3	2.76 ± 1.62	3.63 ± 0.75	1.73 ± 0.64	5.12 ± 0.89	7.21 ± 1.30	9.46 ± 2.56	16.10 ± 3.32	13.93 ± 3.33	8.24 ± 1.76
	PB4	2.54 ± 0.43	2.08 ± 0.67	0.74 ± 0.38	3.22 ± 0.65	2.22 ± 0.47	6.07 ± 3.16	8.39 ± 0.83	7.75 ± 2.17	4.04 ± 1.25
	PB5	12.34 ± 3.22	0.55 ± 0.31	0.76 ± 0.27	11.91 ± 1.80	15.19 ± 1.38	10.72 ± 1.41	30.30 ± 4.52	21.73 ± 2.79	9.89 ± 1.20
	MC1	36.06 ± 3.21	21.84 ± 6.57	33.36 ± 6.87	23.38 ± 6.52	23.05 ± 2.77	26.35 ± 8.89	12.21 ± 7.54	10.09 ± 3.72	9.81 ± 3.31
	MC2	47.55 ± 11.29	19.00 ± 3.11	49.96 ± 16.68	50.38 ± 3.07	38.72 ± 4.63	24.18 ± 7.20	31.35 ± 10.52	14.02 ± 4.83	22.21 ± 2.71

Appendix 2. Year to year model estimation of change in stony coral, octocoral, sponge, and macroalgae percent cover per year (±SEM) by region and by site from 2017 to 2018. (R= region-wide comparison; DC = Miami-Dade County; BC = Broward County; PB = Palm Beach County; MC = Martin County).

Variable	Level	DF	t	p	Significant Change
Stony Coral	**R**	**66**	**4.92**	**<0.0001**	↓
	DC1	66	0.27	0.6067	-
	DC2	66	0.39	0.5366	-
	DC3	66	0.28	0.5963	-
	DC4	66	0.33	0.5701	-
	DC5	66	2.93	0.0918	-
	DC6	66	3.26	0.0756	-
	DC7	66	0.92	0.3402	-
	DC8	66	0.12	0.7276	-
	BC1	66	2.28	0.1362	-
	BC2	66	0.12	0.7341	-
	BC3	66	0.4	0.53	-
	BC4	**66**	**10.82**	**0.0016**	↓
	BC5	66	0.08	0.7834	-
	BC6	66	0.23	0.6367	-
	BCA	66	1.85	0.1783	-
	PB1	66	0.19	0.6648	-
	PB2	66	0.2	0.6532	-
	PB3	66	0	0.9886	-
	PB4	66	2.04	0.1578	-
	PB5	66	0.12	0.7304	-
	MC1	**66**	**35.8**	**<.0001**	↓
	MC2	**66**	**10.29**	**0.0021**	↓
Octocoral	**R**	**66**	**6.23**	**<0.0001**	↓
	DC1	66	0.08	0.7839	-
	DC2	**66**	**12.7**	**0.0007**	↓
	DC3	66	3.35	0.0718	-
	DC4	66	2.89	0.0936	-
	DC5	**66**	**8.28**	**0.0054**	↓
	DC6	**66**	**11.41**	**0.0012**	↓
	DC7	66	0.3	0.5832	-
	DC8	66	3.39	0.0703	-
	BC1	66	1.79	0.1849	-
	BC2	66	1.17	0.2833	-
	BC3	66	0.61	0.4389	-
	BC4	**66**	**9.93**	**0.0024**	↓
	BC5	66	1.41	0.2399	-
	BC6	66	2.45	0.1225	-
	BCA	66	1.59	0.2116	-
	PB1	66	0.34	0.5643	-
	PB2	**66**	**6.24**	**0.015**	↓
	PB3	**66**	**11.79**	**0.001**	↓
	PB4	**66**	**4.11**	**0.0467**	↓
	PB5	66	1.1	0.2989	-
	MC1	66	0	1	-
	MC2	66	0	1	-

Appendix 2. Continued

Variable	Level	DF	t	p	Significant Change
Sponge	**R**	**66**	**4.77**	**<0.0001**	↓
	DC1	66	0.36	0.5509	-
	DC2	66	3	0.088	-
	DC3	66	0.18	0.6722	-
	DC4	66	1.58	0.2125	-
	DC5	**66**	**5.84**	**0.0185**	↓
	DC6	66	3.48	0.0667	-
	DC7	66	2.12	0.1497	-
	DC8	66	0.35	0.5552	-
	BC1	66	0.11	0.7424	-
	BC2	66	1.08	0.3014	-
	BC3	66	0.16	0.6918	-
	BC4	**66**	**7.47**	**0.008**	↓
	BC5	66	2.28	0.136	-
	BC6	66	2.87	0.0949	-
	BCA	**66**	**5.71**	**0.0197**	↑
	PB1	**66**	**11.61**	**0.0011**	↓
	PB2	66	2.34	0.1305	-
	PB3	**66**	**5.24**	**0.0253**	↓
	PB4	66	0.93	0.3374	-
	PB5	66	1.97	0.1647	-
	MC1	66	0.25	0.6219	-
	MC2	66	0.07	0.7932	-
Variable	**Level**	**DF**	**t**	**p**	
Macroalgae	R	66	0.55	0.5833	-
	DC1	**66**	**29.42**	**<.0001**	↑
	DC2	**66**	**11.1**	**0.0014**	↑
	DC3	**66**	**18.24**	**<.0001**	↓
	DC4	66	1.09	0.2993	-
	DC5	**66**	**5.89**	**0.018**	↑
	DC6	**66**	**50.06**	**<.0001**	↑
	DC7	**66**	**12.03**	**0.0009**	↑
	DC8	66	0.03	0.8558	-
	BC1	**66**	**7.03**	**0.01**	↓
	BC2	**66**	**15.16**	**0.0002**	↓
	BC3	**66**	**43.59**	**<.0001**	↓
	BC4	66	1.63	0.2061	-
	BC5	66	0	0.9574	-
	BC6	66	0.42	0.521	-
	BCA	66	3.13	0.0815	-
	PB1	66	0.05	0.8268	-
	PB2	66	0.24	0.625	-
	PB3	66	2.13	0.1491	-
	PB4	66	1.93	0.1697	-
	PB5	**66**	**7.34**	**0.0086**	↓
	MC1	66	0.01	0.9097	-
	MC2	**66**	**4.13**	**0.0461**	↑

Appendix 3. Long term model estimation of change in stony coral, octocoral, sponge, and macroalgae percent cover per year (±SEM) region-wide and by site from 2003 to 2016 (10 sites), 2006 to 2016 (12 sites), and 2010 – 2016 (16 sites). Significant trends in cover are bolded and indicated as increasing (↑), decreasing (↓), or no significant change (-) in the Trend column (R= region-wide comparison; BC = Broward County; DC = Miami-Dade County; PB = Palm Beach County; MC = Martin County).

Stony Coral						
Site Group A (PB1, PB2, PB3, BC1, BC2, BC 3, DC1, DC2, DC3) IV > I, II & III > V						
Time interval	Time interval	Est.	SE	DF	t	P
I (2004-2006)	II (2007-2009)	-0.0017	0.0034	502	-0.49	0.9879
I (2004-2006)	III (2010-2012)	-0.007	0.0036	502	-1.95	0.2939
I (2004-2006)	**IV (2013-2015)**	**-0.0168**	**0.0036**	**502**	**-4.7**	**<.0001**
I (2004-2006)	**V (2016-2018)**	**0.0172**	**0.0036**	**502**	**4.81**	**<.0001**
II (2007-2009)	III (2010-2012)	-0.0053	0.0034	502	-1.58	0.5107
II (2007-2009)	**IV (2013-2015)**	**-0.0152**	**0.0034**	**502**	**-4.51**	**<.0001**
II (2007-2009)	**V (2016-2018)**	**0.0189**	**0.0034**	**502**	**5.62**	**<.0001**
III (2010-2012)	**IV (2013-2015)**	**-0.0099**	**0.0036**	**502**	**-2.75**	**0.0479**
III (2010-2012)	**V (2016-2018)**	**0.0242**	**0.0036**	**502**	**6.76**	**<.0001**
IV (2013-2015)	**V (2016-2018)**	**0.0341**	**0.0036**	**502**	**9.51**	**<.0001**
Site Group B (MC1, MC2) No Significant Differences						
Time interval	Time interval	Est.	SE	DF	t	P
II (2007-2009)	III (2010-2012)	0.003	0.0144	18	0.21	0.9968
II (2007-2009)	IV (2013-2015)	-0.0103	0.0183	18	-0.56	0.9427
II (2007-2009)	V (2016-2018)	0.0213	0.0266	18	0.8	0.8538
III (2010-2012)	IV (2013-2015)	-0.0132	0.0072	18	-1.83	0.291
III (2010-2012)	V (2016-2018)	0.0183	0.0183	18	1	0.7516
IV (2013-2015)	V (2016-2018)	0.0315	0.0189	18	1.67	0.3676
Site Group C (PB4, PB5, DC4, DC5) III & IV > V						
Time interval	Time interval	Est.	SE	DF	t	P
III (2010-2012)	IV (2013-2015)	-0.0041	0.0048	118.1	-0.86	0.6692
III (2010-2012)	**V (2016-2018)**	**0.0419**	**0.0048**	**118.1**	**8.76**	**<.0001**
IV (2013-2015)	**V (2016-2018)**	**0.046**	**0.0048**	**118.1**	**9.56**	**<.0001**
Site Group D (BC4, BC5, BC6, DC6, DC7, DC8) IV > V						
Time interval	Time interval	Est.	SE	DF	t	P
IV (2013-2015)	**V (2016-2018)**	**0.0293**	**0.0042**	**114**	**6.91**	**<.0001**

Appendix 3. Continued

Site Group BCA I > II > III > IV > V						
Time interval	Time interval	Est.	SE	DF	t	P
I (2004-2006)	**II (2007-2009)**	**0.0776**	**0.0156**	**56**	**4.99**	**<.0001**
I (2004-2006)	**III (2010-2012)**	**0.2035**	**0.0166**	**56**	**12.24**	**<.0001**
I (2004-2006)	**IV (2013-2015)**	**0.2719**	**0.0166**	**56**	**16.36**	**<.0001**
I (2004-2006)	**V (2016-2018)**	**0.4229**	**0.0166**	**56**	**25.44**	**<.0001**
II (2007-2009)	**III (2010-2012)**	**0.1259**	**0.0156**	**56**	**8.1**	**<.0001**
II (2007-2009)	**IV (2013-2015)**	**0.1943**	**0.0156**	**56**	**12.49**	**<.0001**
II (2007-2009)	**V (2016-2018)**	**0.3452**	**0.0156**	**56**	**22.2**	**<.0001**
III (2010-2012)	**IV (2013-2015)**	**0.0684**	**0.0166**	**56**	**4.11**	**0.0012**
III (2010-2012)	**V (2016-2018)**	**0.2194**	**0.0166**	**56**	**13.2**	**<.0001**
IV (2013-2015)	**V (2016-2018)**	**0.151**	**0.0166**	**56**	**9.08**	**<.0001**

Octocoral						
Site Group A (PB1, PB2, PB3, BC1, BC2, BC 3, DC1, DC2, DC3) I > III > IV & V, I > II > V						
Time interval	Time interval	Est.	SE	DF	t	P
I (2004-2006)	**II (2007-2009)**	**0.0409**	**0.0053**	**499.8**	**7.68**	**<.0001**
I (2004-2006)	**III (2010-2012)**	**0.0332**	**0.0057**	**499.8**	**5.85**	**<.0001**
I (2004-2006)	**IV (2013-2015)**	**0.0539**	**0.0057**	**499.8**	**9.53**	**<.0001**
I (2004-2006)	**V (2016-2018)**	**0.0557**	**0.0057**	**499.8**	**9.84**	**<.0001**
II (2007-2009)	III (2010-2012)	-0.0077	0.0053	499.8	-1.44	0.6019
II (2007-2009)	IV (2013-2015)	0.013	0.0053	499.8	2.45	0.1035
II (2007-2009)	**V (2016-2018)**	**0.0148**	**0.0053**	**499.8**	**2.78**	**0.0444**
III (2010-2012)	**IV (2013-2015)**	**0.0207**	**0.0057**	**499.8**	**3.65**	**0.0026**
III (2010-2012)	**V (2016-2018)**	**0.0225**	**0.0057**	**499.8**	**3.96**	**0.0008**
IV (2013-2015)	**V (2016-2018)**	**0.0018**	**0.0057**	**499.8**	**0.31**	**0.998**
Site Group B (MC1, MC2) No Test, All values near zero						
Site Group C (PB4, PB5, DC4, DC5) III > IV > V						
Time interval	Time interval	Est.	SE	DF	t	P
III (2010-2012)	**IV (2013-2015)**	**0.0399**	**0.0074**	**117.9**	**5.39**	**<.0001**
III (2010-2012)	**V (2016-2018)**	**0.0648**	**0.0075**	**118**	**8.65**	**<.0001**
IV (2013-2015)	**V (2016-2018)**	**0.0249**	**0.0075**	**118**	**3.33**	**0.0033**
Site Group D (BC4, BC5, BC6, DC6, DC7, DC8) IV > V						
Time interval	Time interval	Est.	SE	DF	t	P
IV (2013-2015)	**V (2016-2018)**	**0.0275**	**0.0054**	**114**	**5.14**	**<.0001**

Appendix 3. Continued

Site Group BCA III & IV > V						
Time interval	Time interval	Est.	SE	DF	t	P
I (2004-2006)	II (2007-2009)	0.0073	0.0086	56	0.85	0.9147
I (2004-2006)	III (2010-2012)	-0.0133	0.0092	56	-1.44	0.6033
I (2004-2006)	IV (2013-2015)	-0.0134	0.0092	56	-1.44	0.602
I (2004-2006)	V (2016-2018)	0.026	0.0092	56	2.81	0.0514
II (2007-2009)	III (2010-2012)	-0.0207	0.0086	56	-2.39	0.1335
II (2007-2009)	IV (2013-2015)	-0.0207	0.0086	56	-2.39	0.1329
II (2007-2009)	V (2016-2018)	0.0186	0.0086	56	2.15	0.2121
III (2010-2012)	IV (2013-2015)	0	0.0092	56	0	1
III (2010-2012)	**V (2016-2018)**	**0.0393**	**0.0092**	**56**	**4.25**	**0.0008**
IV (2013-2015)	**V (2016-2018)**	**0.0393**	**0.0092**	**56**	**4.25**	**0.0007**

Macroalgae						
Site Group A (PB1, PB2, PB3, BC1, BC2, BC 3, DC1, DC2, DC3) V > IV > III > I, V > II > I						
Time interval	Time interval	Est.	SE	DF	t	P
I (2004-2006)	**II (2007-2009)**	**-0.0701**	**0.012**	**108**	**-5.86**	**<.0001**
I (2004-2006)	**III (2010-2012)**	**-0.0713**	**0.0131**	**108**	**-5.43**	**<.0001**
I (2004-2006)	**IV (2013-2015)**	**-0.1048**	**0.0107**	**108**	**-9.77**	**<.0001**
I (2004-2006)	**V (2016-2018)**	**-0.2438**	**0.0133**	**108**	**-18.38**	**<.0001**
II (2007-2009)	III (2010-2012)	-0.0012	0.0145	108	-0.08	1
II (2007-2009)	IV (2013-2015)	-0.0347	0.0139	108	-2.49	0.1
II (2007-2009)	**V (2016-2018)**	**-0.1737**	**0.0127**	**108**	**-13.67**	**<.0001**
III (2010-2012)	**IV (2013-2015)**	**-0.0336**	**0.012**	**108**	**-2.81**	**0.046**
III (2010-2012)	**V (2016-2018)**	**-0.1725**	**0.0127**	**108**	**-13.62**	**<.0001**
IV (2013-2015)	**V (2016-2018)**	**-0.139**	**0.0109**	**108**	**-12.78**	**<.0001**
Site Group B (MC1, MC2) II, III & IV > V						
Time interval	Time interval	Est.	SE	DF	t	P
II (2007-2009)	III (2010-2012)	0.0637	0.0406	90	1.57	0.4012
II (2007-2009)	IV (2013-2015)	0.0604	0.0406	90	1.49	0.4487
II (2007-2009)	**V (2016-2018)**	**0.2609**	**0.0406**	**90**	**6.43**	**<.0001**
III (2010-2012)	IV (2013-2015)	-0.0033	0.0434	90	-0.08	0.9998
III (2010-2012)	**V (2016-2018)**	**0.1972**	**0.0434**	**90**	**4.55**	**<.0001**
IV (2013-2015)	**V (2016-2018)**	**0.2005**	**0.0434**	**90**	**4.63**	**<.0001**

Appendix 3. Continued

Site Group C (PB4, PB5, DC4, DC5) V > IV > III						
Time interval	Time interval	Est.	SE	DF	t	P
III (2010-2012)	**IV (2013-2015)**	**-0.681**	**0.1661**	**120**	**-4.1**	**0.0002**
III (2010-2012)	**V (2016-2018)**	**-1.2262**	**0.1661**	**120**	**-7.38**	**<.0001**
IV (2013-2015)	**V (2016-2018)**	**-0.5451**	**0.1661**	**120**	**-3.28**	**0.0038**
Site Group D (BC4, BC5, BC6, DC6, DC7, DC8) V >IV						
Time interval	Time interval	Est.	SE	DF	t	P
IV (2013-2015)	**V (2016-2018)**	**-0.1276**	**0.0174**	**114**	**-7.34**	**<.0001**
Site Group BCA V & IV > I						
Time interval	Time interval	Est.	SE	DF	t	P
I (2004-2006)	II (2007-2009)	-0.0625	0.0368	56	-1.7	0.4431
I (2004-2006)	III (2010-2012)	-0.1031	0.0394	56	-2.62	0.0801
I (2004-2006)	**IV (2013-2015)**	**-0.1291**	**0.0394**	**56**	**-3.28**	**0.0148**
I (2004-2006)	**V (2016-2018)**	**-0.1646**	**0.0394**	**56**	**-4.18**	**0.0009**
II (2007-2009)	III (2010-2012)	-0.0406	0.0368	56	-1.1	0.804
II (2007-2009)	IV (2013-2015)	-0.0666	0.0368	56	-1.81	0.3792
II (2007-2009)	V (2016-2018)	-0.1021	0.0368	56	-2.77	0.0558
III (2010-2012)	IV (2013-2015)	-0.0259	0.0394	56	-0.66	0.9642
III (2010-2012)	V (2016-2018)	-0.0615	0.0394	56	-1.56	0.5273
IV (2013-2015)	V (2016-2018)	-0.0355	0.0394	56	-0.9	0.8945

Sponges						
Site Group A (PB1, PB2, PB3, BC1, BC2, BC 3, DC1, DC2, DC3) III, IV & V > I & II						
Time interval	Time interval	Est.	SE	DF	t	P
I (2004-2006)	II (2007-2009)	-0.0008	0.005	498.8	-0.16	0.9999
I (2004-2006)	**III (2010-2012)**	**-0.0341**	**0.0053**	**498.8**	**-6.42**	**<.0001**
I (2004-2006)	**IV (2013-2015)**	**-0.0251**	**0.0053**	**498.8**	**-4.72**	**<.0001**
I (2004-2006)	**V (2016-2018)**	**-0.0286**	**0.0053**	**498.8**	**-5.38**	**<.0001**
II (2007-2009)	**III (2010-2012)**	**-0.0333**	**0.0049**	**498.8**	**-6.75**	**<.0001**
II (2007-2009)	**IV (2013-2015)**	**-0.0243**	**0.0049**	**498.8**	**-4.92**	**<.0001**
II (2007-2009)	**V (2016-2018)**	**-0.0278**	**0.0049**	**498.8**	**-5.63**	**<.0001**
III (2010-2012)	IV (2013-2015)	0.009	0.0053	498.8	1.71	0.4257
III (2010-2012)	V (2016-2018)	0.0055	0.0053	498.8	1.05	0.8326
IV (2013-2015)	V (2016-2018)	-0.0035	0.0053	498.8	-0.67	0.9634

Appendix 3. Continued

Site Group B (MC1, MC2) III > II						
Time interval	Time interval	Est.	SE	DF	t	P
II (2007-2009)	**III (2010-2012)**	**-0.0398**	**0.0099**	**90**	**-4**	**0.0007**
II (2007-2009)	IV (2013-2015)	-0.0227	0.0099	90	-2.28	0.1096
II (2007-2009)	V (2016-2018)	-0.0175	0.0099	90	-1.76	0.3013
III (2010-2012)	IV (2013-2015)	0.0171	0.0106	90	1.61	0.3803
III (2010-2012)	V (2016-2018)	0.0223	0.0106	90	2.1	0.1612
IV (2013-2015)	V (2016-2018)	0.0052	0.0106	90	0.49	0.9604
Site Group C (PB4, PB5, DC4, DC5) No Significant Differences						
Time interval	Time interval	Est.	SE	DF	t	P
III (2010-2012)	IV (2013-2015)	0.0093	0.011	24	0.85	0.6784
III (2010-2012)	V (2016-2018)	0.0127	0.0101	24	1.26	0.4286
IV (2013-2015)	V (2016-2018)	0.0034	0.008	24	0.43	0.9038
Site Group D (BC4, BC5, BC6, DC6, DC7, DC8) No Significant Differences						
Time interval	Time interval	Est.	SE	DF	t	P
IV (2013-2015)	V (2016-2018)	-0.0025	0.0043	114	-0.57	0.5693
Site Group BCA IV & V > I, III > II > I						
Time interval	Time interval	Est.	SE	DF	t	P
I (2004-2006)	**II (2007-2009)**	**-0.8958**	**0.2454**	**56**	**-3.65**	**0.005**
I (2004-2006)	**III (2010-2012)**	**-1.6017**	**0.2624**	**56**	**-6.1**	**<.0001**
I (2004-2006)	**IV (2013-2015)**	**-1.2286**	**0.2624**	**56**	**-4.68**	**0.0002**
I (2004-2006)	**V (2016-2018)**	**-1.2563**	**0.2624**	**56**	**-4.79**	**0.0001**
II (2007-2009)	**III (2010-2012)**	**-0.7058**	**0.2454**	**56**	**-2.88**	**0.0434**
II (2007-2009)	IV (2013-2015)	-0.3327	0.2454	56	-1.36	0.658
II (2007-2009)	V (2016-2018)	-0.3604	0.2454	56	-1.47	0.5869
III (2010-2012)	IV (2013-2015)	0.3731	0.2624	56	1.42	0.6163
III (2010-2012)	V (2016-2018)	0.3454	0.2624	56	1.32	0.6822
IV (2013-2015)	V (2016-2018)	-0.0277	0.2624	56	-0.11	1

Appendix 4. Stony coral live tissue area (m^2) by region and site. For region-wide values the live tissue area of all colonies within a site were summed and the average of all sites taken. Site values are the sum of the live tissue area of all colonies within a station and the average of the stations.

	2013			**2014**			**2015**			**2016**			**2017**			**2018**		
Level	Mean ± SE (m^2)			Mean ± SE (m^2)			Mean ± SE (m^2)			Mean ± SE (m^2)			Mean ± SE (m^2)			Mean ± SE (m^2)		
R	6.11	±	1.87	6.38	±	2.16	6.48	±	2.36	4.20	±	1.50	3.53	±	1.09	3.89	±	1.50
DC1	4.46	±	0.97	4.32	±	0.85	4.00	±	1.01	2.73	±	0.58	2.52	±	0.26	3.26	±	0.52
DC2	0.35	±	0.09	0.42	±	0.03	0.36	±	0.07	0.36	±	0.09	0.32	±	0.08	0.27	±	0.06
DC3	0.28	±	0.10	0.13	±	0.03	0.13	±	0.05	0.15	±	0.05	0.17	±	0.05	0.14	±	0.01
DC4	0.50	±	0.11	0.57	±	0.14	0.30	±	0.08	0.23	±	0.07	0.29	±	0.08	0.56	±	0.29
DC5	1.98	±	0.63	2.23	±	0.70	1.40	±	0.21	1.00	±	0.28	0.88	±	0.14	0.90	±	0.09
DC6	1.85	±	0.36	2.14	±	0.58	2.83	±	0.95	2.32	±	0.91	1.61	±	0.36	1.57	±	0.30
DC7	0.36	±	0.07	0.34	±	0.08	0.32	±	0.05	0.21	±	0.05	0.25	±	0.05	0.33	±	0.14
DC8	0.57	±	0.15	0.76	±	0.23	0.53	±	0.18	0.50	±	0.17	0.43	±	0.15	0.44	±	0.15
BC1	10.04	±	1.65	11.88	±	1.41	12.98	±	2.06	8.06	±	1.57	5.56	±	1.06	8.20	±	1.51
BC2	0.28	±	0.10	0.40	±	0.17	0.35	±	0.15	0.22	±	0.05	0.26	±	0.08	0.36	±	0.11
BC3	0.37	±	0.07	0.38	±	0.12	0.29	±	0.05	0.21	±	0.05	0.26	±	0.09	0.28	±	0.05
BC4	3.39	±	0.49	3.26	±	0.55	3.49	±	0.35	2.34	±	0.44	2.49	±	0.53	1.55	±	0.11
BC5	0.86	±	0.29	0.65	±	0.19	0.91	±	0.26	0.19	±	0.02	0.18	±	0.04	0.21	±	0.05
BC6	0.45	±	0.18	0.49	±	0.17	0.50	±	0.22	0.20	±	0.03	0.13	±	0.03	0.24	±	0.06
BCA	0.37	±	0.09	0.21	±	0.07	0.22	±	0.09	0.37	±	0.07	0.60	±	0.25	0.55	±	0.20
PB1	0.09	±	0.04	0.13	±	0.06	0.10	±	0.05	0.08	±	0.04	0.06	±	0.04	0.04	±	0.02
PB2	0.95	±	0.25	1.00	±	0.22	1.00	±	0.22	0.39	±	0.07	0.35	±	0.06	0.61	±	0.17
PB3	0.65	±	0.12	0.69	±	0.16	0.67	±	0.13	0.23	±	0.08	0.23	±	0.07	0.29	±	0.10
PB4	1.87	±	0.72	1.14	±	0.21	1.27	±	0.15	0.35	±	0.12	0.33	±	0.12	0.35	±	0.08
PB5	1.55	±	0.27	1.45	±	0.29	1.52	±	0.27	0.61	±	0.21	0.45	±	0.12	0.63	±	0.20
MC1	1.82	±	0.72	1.94	±	0.78	1.97	±	0.80	1.83	±	0.60	1.68	±	0.57	0.58	±	0.23
MC2	0.59	±	0.14	0.61	±	0.14	0.53	±	0.12	0.55	±	0.13	0.37	±	0.17	0.06	±	0.05

Appendix 5. Regional stony coral live tissue area of select species. Live tissue area was summed at each site and the regional live tissue area is the average of all sites.

	2013	2014	2015	2016	2017	2018
Species	Mean ± SE (m^2)	Mean ± SE (m^2)	Mean ± SE (m^2)	Mean ± SE (m^2)	Mean ± SE (m^2)	Mean ± SE (m^2)
D. stokesii	0.10 ± 0.04	0.07 ± 0.02	0.04 ± 0.01	0.01 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Montastrea (Orbicella) annularis complex	0.54 ± 0.26	0.46 ± 0.20	0.67 ± 0.29	0.33 ± 0.16	0.24 ± 0.12	0.18 ± 0.07
M. cavernosa	2.89 ± 1.55	3.26 ± 1.91	3.28 ± 1.98	1.94 ± 1.29	1.45 ± 1.90	2.03 ± 1.34
M. meandrites	0.47 ± 0.17	0.46 ± 0.16	0.26 ± 0.09	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
P. astreoides	0.54 ± 0.17	0.53 ± 0.17	0.56 ± 0.17	0.56 ± 0.16	0.62 ± 0.19	0.69 ± 0.20
S. bournoni	0.14 ± 0.04	0.18 ± 0.07	0.14 ± 0.06	0.12 ± 0.05	0.07 ± 0.03	0.07 ± 0.03
S. siderea	0.32 ± 0.10	0.26 ± 0.08	0.30 ± 0.09	0.24 ± 0.07	0.25 ± 0.07	0.34 ± 0.08

Appendix 6. Stony coral live tissue area statistics

Linear Mixed Effects Model ANOVA results

Variable	**Level**	**Intercept**	**Year**	**Variable**	**Level**	**Intercept**	**Year**
Region	DF	1	5	*Montastrea (Orbicella) annularis* complex	DF	1	5
	F	8.51937	6.72377		F	5.796284	2.525132
	P	0.0043	<.0001		P	0.0178	0.0336
D. stokesii	DF	1	5	*M. cavernosa*	DF	1	5
	F	8.680699	6.609987		F	2.755508	3.420313
	P	0.004	<.0001		P	0.0999	0.0067
M. meandrites	DF	1	5	*S. bournoni*	DF	1	5
	F	10.476324	6.380179		F	8.090701	2.737152
	P	0.0016	<.0001		P	0.0053	0.023
P. astreoides	DF	1	5	*S. siderea*	DF	1	5
	F	11.29134	2.43343		F	13.585623	2.765112
	P	0.0011	0.0395		P	0.0004	0.0218

Appendix 6. Continued

Tukey post hoc Test

Variable	Years	Est.	SE	z	P > |z|
Region	2014 - 2013	0.276227	0.753801	0.3665	0.9991
	2015 - 2013	0.392682	0.753801	0.5209	0.9954
	2016 - 2013	-1.902182	0.753801	-2.5235	0.1173
	2017 - 2013	-2.595909	0.753801	-3.4438	0.0076
	2018 - 2013	-2.274364	0.753801	-3.0172	0.0307
	2015 - 2014	0.116455	0.753801	0.1545	1.0000
	2016 - 2014	-2.178409	0.753801	-2.8899	0.0447
	2017 - 2014	-2.872136	0.753801	-3.8102	0.0019
	2018 - 2014	-2.550591	0.753801	-3.3836	0.0094
	2016 - 2015	-2.294864	0.753801	-3.0444	0.0282
	2017 - 2015	-2.988591	0.753801	-3.9647	0.0010
	2018 - 2015	-2.667045	0.753801	-3.5381	0.0054
	2017 - 2016	-0.693727	0.753801	-0.9203	0.9415
	2018 - 2016	-0.372182	0.753801	-0.4937	0.9964
	2018 - 2017	0.321545	0.753801	0.4266	0.9982
D. stokesii	2014 - 2013	-0.029738	0.022169	-1.341	0.7618
	2015 - 2013	-0.060646	0.022169	-2.736	0.0684
	2016 - 2013	-0.092634	0.022169	-4.179	<0.001
	2017 - 2013	-0.096417	0.022169	-4.349	<0.001
	2018 - 2013	-0.09536	0.022169	-4.302	<0.001
	2015 - 2014	-0.030908	0.022169	-1.394	0.7305
	2016 - 2014	-0.062896	0.022169	-2.837	0.0518
	2017 - 2014	-0.066679	0.022169	-3.008	0.0316
	2018 - 2014	-0.065622	0.022169	-2.96	0.0363
	2016 - 2015	-0.031988	0.022169	-1.443	0.7006
	2017 - 2015	-0.035771	0.022169	-1.614	0.5895
	2018 - 2015	-0.034714	0.022169	-1.566	0.6212
	2017 - 2016	-0.003784	0.022169	-0.171	1
	2018 - 2016	-0.002726	0.022169	-0.123	1
	2018 - 2017	0.001057	0.022169	0.048	1

Appendix 6. Continued

Variable	Years	Est.	SE	z	P > |z|
M. cavernosa	2014 - 2013	0.36456	0.58879	0.619	0.9897
	2015 - 2013	0.38252	0.58879	0.65	0.9871
	2016 - 2013	-0.9562	0.58879	-1.624	0.5826
	2017 - 2013	-1.44206	0.58879	-2.449	0.1396
	2018 - 2013	-0.86301	0.58879	-1.466	0.6862
	2015 - 2014	0.01796	0.58879	0.031	1
	2016 - 2014	-1.32075	0.58879	-2.243	0.218
	2017 - 2014	-1.80662	0.58879	-3.068	0.0263
	2018 - 2014	-1.22757	0.58879	-2.085	0.2951
	2016 - 2015	-1.33872	0.58879	-2.274	0.2047
	2017 - 2015	-1.82458	0.58879	-3.099	0.0238
	2018 - 2015	-1.24553	0.58879	-2.115	0.2791
	2017 - 2016	-0.48587	0.58879	-0.825	0.963
	2018 - 2016	0.09319	0.58879	0.158	1
	2018 - 2017	0.57905	0.58879	0.983	0.9233
Montastrea (Orbicella) annularis complex	2014 - 2013	-0.07561	0.1655	-0.457	0.9975
	2015 - 2013	0.13086	0.1655	0.791	0.9692
	2016 - 2013	-0.20464	0.1655	-1.237	0.819
	2017 - 2013	-0.2963	0.1655	-1.79	0.472
	2018 - 2013	-0.35774	0.1655	-2.162	0.2561
	2015 - 2014	0.20647	0.1655	1.248	0.8132
	2016 - 2014	-0.12903	0.1655	-0.78	0.971
	2017 - 2014	-0.22069	0.1655	-1.333	0.7664
	2018 - 2014	-0.28213	0.1655	-1.705	0.5286
	2016 - 2015	-0.3355	0.1655	-2.027	0.3266
	2017 - 2015	-0.42716	0.1655	-2.581	0.1019
	2018 - 2015	-0.4886	0.1655	-2.952	0.0372
	2017 - 2016	-0.09166	0.1655	-0.554	0.9938
	2018 - 2016	-0.1531	0.1655	-0.925	0.9402
	2018 - 2017	-0.06144	0.1655	-0.371	0.9991

Appendix 6. Continued

Variable	Years	Est.	SE	z	P > |z|
S. bournoni	2014 - 2013	0.036638	0.036661	0.999	0.9183
	2015 - 2013	0.001327	0.036661	0.036	1
	2016 - 2013	-0.023439	0.036661	-0.639	0.988
	2017 - 2013	-0.072389	0.036661	-1.975	0.3569
	2018 - 2013	-0.068841	0.036661	-1.878	0.4158
	2015 - 2014	-0.035311	0.036661	-0.963	0.9295
	2016 - 2014	-0.060077	0.036661	-1.639	0.5727
	2017 - 2014	-0.109028	0.036661	-2.974	0.0349
	2018 - 2014	-0.105479	0.036661	-2.877	0.0462
	2016 - 2015	-0.024766	0.036661	-0.676	0.9847
	2017 - 2015	-0.073716	0.036661	-2.011	0.336
	2018 - 2015	-0.070168	0.036661	-1.914	0.3933
	2017 - 2016	-0.048951	0.036661	-1.335	0.7653
	2018 - 2016	-0.045402	0.036661	-1.238	0.8179
	2018 - 2017	0.003549	0.036661	0.097	1
S. siderea	2014 - 2013	-0.055438	0.034388	-1.612	0.5904
	2015 - 2013	-0.019442	0.034388	-0.565	0.9932
	2016 - 2013	-0.074191	0.034388	-2.157	0.2579
	2017 - 2013	-0.068576	0.034388	-1.994	0.3455
	2018 - 2013	0.025669	0.034388	0.746	0.976
	2015 - 2014	0.035996	0.034388	1.047	0.902
	2016 - 2014	-0.018753	0.034388	-0.545	0.9943
	2017 - 2014	-0.013138	0.034388	-0.382	0.9989
	2018 - 2014	0.081107	0.034388	2.359	0.171
	2016 - 2015	-0.054749	0.034388	-1.592	0.6038
	2017 - 2015	-0.049134	0.034388	-1.429	0.7094
	2018 - 2015	0.045111	0.034388	1.312	0.7787
	2017 - 2016	0.005615	0.034388	0.163	1
	2018 - 2016	0.09986	0.034388	2.904	0.0429
	2018 - 2017	0.094245	0.034388	2.741	0.0675

Appendix 7. Stony coral, octocoral and *Xestospongia muta* density data region and by site. Regional density was calculated as an average of all sites, where site is the sum of all four stations. Site level values were calculated as an average of the four stations.

		2013	**2014**	**2015**	**2016**	**2017**	**2018**
Variable	**Level**	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Stony Coral	R	1.21 ± 0.16	1.26 ± 0.18	1.29 ± 0.19	1.07 ± 0.17	1.35 0.25	1.43 0.25
	DC1	1.80 ± 0.15	2.10 ± 0.16	2.15 ± 0.03	2.36 ± 0.06	2.28 ± 0.13	2.70 ± 0.27
	DC2	0.88 ± 0.09	1.08 ± 0.14	1.07 ± 0.11	0.83 ± 0.09	1.03 ± 0.04	1.10 ± 0.10
	DC3	0.31 ± 0.09	0.33 ± 0.03	0.31 ± 0.06	0.27 ± 0.07	0.28 ± 0.01	0.44 ± 0.03
	DC4	0.73 ± 0.11	0.75 ± 0.12	0.75 ± 0.20	0.57 ± 0.14	0.90 ± 0.18	0.90 ± 0.10
	DC5	2.56 ± 0.24	2.53 ± 0.14	2.33 ± 0.26	2.40 ± 0.26	3.28 ± 0.34	2.94 ± 0.41
	DC6	1.38 ± 0.26	1.42 ± 0.25	1.51 ± 0.25	1.44 ± 0.33	1.55 ± 0.35	1.51 ± 0.25
	DC7	1.13 ± 0.05	1.02 ± 0.12	1.10 ± 0.14	0.67 ± 0.09	0.85 ± 0.08	0.98 ± 0.14
	DC8	0.92 ± 0.09	0.81 ± 0.06	0.91 ± 0.15	0.56 ± 0.07	0.48 ± 0.05	0.60 ± 0.03
	BC1	1.81 ± 0.35	2.16 ± 0.33	2.05 ± 0.34	1.66 ± 0.30	1.45 ± 0.34	1.40 ± 0.33
	BC2	0.64 ± 0.12	0.78 ± 0.12	0.63 ± 0.12	0.47 ± 0.10	0.58 ± 0.13	0.95 ± 0.19
	BC3	0.75 ± 0.11	0.76 ± 0.22	0.59 ± 0.08	0.42 ± 0.03	0.61 ± 0.04	0.83 ± 0.09
	BC4	3.28 ± 0.32	3.75 ± 0.22	4.05 ± 0.31	3.41 ± 0.12	4.89 ± 0.41	3.83 ± 0.18
	BC5	1.23 ± 0.19	1.09 ± 0.25	1.19 ± 0.22	0.67 ± 0.08	0.83 ± 0.14	0.89 ± 0.11
	BC6	0.64 ± 0.11	0.59 ± 0.07	0.56 ± 0.06	0.43 ± 0.05	0.41 ± 0.00	0.45 ± 0.12
	BCA	0.61 ± 0.18	0.58 ± 0.17	1.09 ± 0.40	1.46 ± 0.17	3.08 ± 1.10	4.30 ± 1.37
	PB1	0.23 ± 0.15	0.27 ± 0.17	0.28 ± 0.15	0.33 ± 0.14	0.25 ± 0.11	0.40 ± 0.15
	PB2	1.07 ± 0.15	1.24 ± 0.09	1.57 ± 0.31	1.07 ± 0.33	1.03 ± 0.42	0.86 ± 0.25
	PB3	1.05 ± 0.31	1.18 ± 0.34	1.11 ± 0.29	0.63 ± 0.22	0.68 ± 0.23	0.67 ± 0.19
	PB4	1.82 ± 0.38	1.63 ± 0.31	1.71 ± 0.29	1.02 ± 0.27	1.01 ± 0.23	1.06 ± 0.24
	PB5	2.30 ± 0.31	2.19 ± 0.29	2.08 ± 0.29	1.58 ± 0.25	1.65 ± 0.32	1.75 ± 0.40
	MC1	0.96 ± 0.09	1.06 ± 0.11	0.98 ± 0.18	0.98 ± 0.31	2.18 ± 0.66	2.82 ± 0.78
	MC2	0.49 ± 0.05	0.40 ± 0.05	0.34 ± 0.09	0.27 ± 0.05	0.31 ± 0.08	0.15 ± 0.03

Appendix 7. Continued

		2013	2014	2015	2016	2017	2018
Variable	**Level**	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Octocoral	R	8.68 ± 1.34	9.97 ± 1.55	11.51 ± 1.77	11.85 ± 1.83	12.58 ± 1.85	10.41 ± 1.50
	DC1	6.93 ± 1.42	8.18 ± 0.74	11.60 ± 1.52	13.25 ± 1.28	11.38 ± 1.19	10.63 ± 1.09
	DC2	9.17 ± 0.23	14.25 ± 1.80	19.50 ± 2.07	17.98 ± 1.44	19.93 ± 1.91	14.70 ± 1.77
	DC3	6.18 ± 1.43	7.23 ± 1.23	7.55 ± 1.36	9.33 ± 0.44	10.15 ± 1.19	9.20 ± 0.97
	DC4	11.23 ± 2.52	12.43 ± 3.18	14.45 ± 2.60	11.93 ± 1.00	14.90 ± 2.36	14.00 ± 2.03
	DC5	6.58 ± 1.19	7.15 ± 0.80	8.95 ± 0.91	8.63 ± 0.96	9.70 ± 0.58	7.08 ± 0.73
	DC6	6.90 ± 0.75	8.13 ± 0.97	9.53 ± 1.83	9.88 ± 1.65	10.85 ± 1.38	6.93 ± 0.99
	DC7	3.43 ± 0.26	3.83 ± 0.14	7.13 ± 0.47	6.95 ± 0.41	6.62 ± 0.48	7.12 ± 0.79
	DC8	14.90 ± 1.45	16.28 ± 1.70	19.90 ± 1.91	19.28 ± 1.41	21.33 ± 1.48	17.23 ± 2.84
	BC1	10.75 ± 0.79	11.15 ± 0.99	11.15 ± 0.96	11.68 ± 0.88	11.05 ± 1.30	13.58 ± 0.81
	BC2	7.40 ± 1.11	8.65 ± 1.30	8.63 ± 1.65	9.28 ± 1.99	9.58 ± 1.51	8.74 ± 1.65
	BC3	12.90 ± 1.06	12.75 ± 1.30	11.53 ± 1.40	14.30 ± 1.89	13.66 ± 2.08	12.12 ± 1.40
	BC4	3.73 ± 0.61	3.95 ± 0.97	5.23 ± 0.58	4.08 ± 0.68	7.54 ± 1.45	5.24 ± 2.32
	BC5	5.73 ± 0.53	7.45 ± 0.56	6.55 ± 0.63	6.18 ± 0.71	7.70 ± 1.37	6.75 ± 0.78
	BC6	20.78 ± 3.78	19.28 ± 1.91	21.18 ± 2.13	23.48 ± 0.88	25.80 ± 1.02	20.63 ± 2.76
	BCA	1.15 ± 0.51	0.85 ± 0.39	1.10 ± 0.54	0.58 ± 0.28	1.10 ± 0.46	1.58 ± 0.50
	PB1	0.23 ± 0.14	0.18 ± 0.09	0.00 ± 0.00	0.05 ± 0.03	0.03 ± 0.03	0.00 ± 0.00
	PB2	17.03 ± 3.85	20.55 ± 5.32	23.45 ± 5.59	23.48 ± 4.99	23.33 ± 4.55	17.48 ± 3.77
	PB3	12.85 ± 3.19	12.45 ± 2.56	14.15 ± 2.39	17.33 ± 3.14	18.55 ± 3.20	14.28 ± 2.32
	PB4	15.63 ± 2.32	17.65 ± 1.09	23.48 ± 2.48	23.80 ± 4.01	22.43 ± 2.93	20.00 ± 0.81
	PB5	19.80 ± 2.36	27.03 ± 4.61	28.25 ± 4.98	29.33 ± 3.83	29.83 ± 3.38	23.30 ± 2.11
	MC1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	MC2	0.00 ± 0.00	0.03 ± 0.03	0.03 ± 0.03	0.03 ± 0.03	0.00 ± 0.00	0.00 ± 0.00

Appendix 7. Continued

		2013	2014	2015	2016	2017	2018
Variable	**Level**	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
X. muta	R	0.24 ± 0.05	0.28 ± 0.06	0.30 ± 0.06	0.31 ± 0.06	0.35 ± 0.06	0.28 ± 0.05
	DC1	0.11 ± 0.07	0.03 ± 0.03	0.07 ± 0.04	0.10 ± 0.04	0.13 ± 0.04	0.06 ± 0.01
	DC2	0.31 ± 0.02	0.35 ± 0.04	0.43 ± 0.04	0.41 ± 0.06	0.45 ± 0.06	0.34 ± 0.05
	DC3	0.26 ± 0.07	0.25 ± 0.07	0.28 ± 0.07	0.31 ± 0.11	0.27 ± 0.08	0.22 ± 0.08
	DC4	0.57 ± 0.04	0.61 ± 0.05	0.64 ± 0.03	0.64 ± 0.03	0.64 ± 0.03	0.47 ± 0.04
	DC5	0.15 ± 0.02	0.10 ± 0.03	0.10 ± 0.03	0.14 ± 0.06	0.22 ± 0.02	0.14 ± 0.04
	DC6	0.05 ± 0.00	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
	DC7	0.28 ± 0.05	0.34 ± 0.03	0.43 ± 0.04	0.41 ± 0.06	0.53 ± 0.02	0.39 ± 0.08
	DC8	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	BC1	0.11 ± 0.07	0.11 ± 0.06	0.09 ± 0.04	0.11 ± 0.05	0.16 ± 0.07	0.15 ± 0.11
	BC2	0.35 ± 0.05	0.50 ± 0.05	0.50 ± 0.07	0.51 ± 0.08	0.57 ± 0.09	0.57 ± 0.08
	BC3	0.34 ± 0.04	0.63 ± 0.08	0.63 ± 0.11	0.55 ± 0.12	0.63 ± 0.14	0.49 ± 0.10
	BC4	0.15 ± 0.02	0.26 ± 0.04	0.26 ± 0.04	0.27 ± 0.06	0.31 ± 0.05	0.24 ± 0.06
	BC5	0.45 ± 0.11	0.48 ± 0.14	0.44 ± 0.11	0.59 ± 0.09	0.63 ± 0.08	0.57 ± 0.12
	BC6	0.38 ± 0.10	0.38 ± 0.11	0.30 ± 0.10	0.36 ± 0.11	0.40 ± 0.08	0.40 ± 0.07
	BCA	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00
	PB1	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	PB2	0.15 ± 0.04	0.14 ± 0.04	0.17 ± 0.02	0.24 ± 0.03	0.34 ± 0.05	0.30 ± 0.07
	PB3	0.55 ± 0.10	0.55 ± 0.10	0.61 ± 0.14	0.66 ± 0.13	0.61 ± 0.11	0.58 ± 0.16
	PB4	0.60 ± 0.10	0.63 ± 0.10	0.64 ± 0.11	0.64 ± 0.11	0.69 ± 0.11	0.58 ± 0.15
	PB5	0.65 ± 0.05	0.74 ± 0.09	0.88 ± 0.07	0.89 ± 0.06	0.97 ± 0.11	0.66 ± 0.08
	MC1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	MC2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

Appendix 8. Stony coral, octocoral and Xestospongia muta density statistics.

Linear Mixed Effects Model ANOVA results.

Variable	Level	Intercept	Year
Stony Coral	DF	1	5
	F	46.99892	1.8868063
	P	<.0001	0.1028
Octocoral	DF	1	5
	F	44.92898	15.35918
	P	<.0001	<.0001
Xestospongia Muta	DF	1	5
	F	28.33159	11.44499
	P	<.0001	<.0001

Tukey post hoc Test.

Variable	Years	Est.	SE	z	P > |z|
Octocoral	2014 - 2013	0.980681818	0.480004179	2.04307	0.3178317
	2015 - 2013	2.521590909	0.480004179	5.25327	<0.001
	2016 - 2013	2.860227273	0.480004179	5.95875	<0.001
	2017 - 2013	3.588636364	0.480004179	7.47626	<0.001
	2018 - 2013	1.418181818	0.480004179	2.95452	0.0369152
	2015 - 2014	1.540909091	0.480004179	3.2102	0.0165612
	2016 - 2014	1.879545455	0.480004179	3.91569	0.0012419
	2017 - 2014	2.607954545	0.480004179	5.43319	<0.001
	2018 - 2014	0.4375	0.480004179	0.91145	0.9437421
	2016 - 2015	0.338636364	0.480004179	0.70549	0.9813497
	2017 - 2015	1.067045455	0.480004179	2.22299	0.2269929
	2018 - 2015	1.103409091	0.480004179	-2.29875	0.1942063
	2017 - 2016	0.728409091	0.480004179	1.51751	0.6528066
	2018 - 2016	1.442045455	0.480004179	-3.00424	0.0319163
	2018 - 2017	2.170454545	0.480004179	-4.52174	<0.001

Appendix 8. Continued.

Tukey post hoc Test.

Variable	**Years**	**Est.**	**SE**	**z**	**P > |z|**
Xestospongia muta	2014 - 2013	0.042355372	0.015212131	2.78432	0.060014
	2015 - 2013	0.060950413	0.015212131	4.0067	<0.001
	2016 - 2013	0.075413223	0.015212131	4.95744	<0.001
	2017 - 2013	0.108987603	0.015212131	7.16452	<0.001
	2018 - 2013	0.046487603	0.015212131	3.05596	0.02729
	2015 - 2014	0.018595041	0.015212131	1.22238	0.826096
	2016 - 2014	0.033057851	0.015212131	2.17312	0.250213
	2017 - 2014	0.066632231	0.015212131	4.3802	<0.001
	2018 - 2014	0.004132231	0.015212131	0.27164	0.999801
	2016 - 2015	0.01446281	0.015212131	0.95074	0.933139
	2017 - 2015	0.04803719	0.015212131	3.15782	0.019846
	2018 - 2015	-0.01446281	0.015212131	-0.95074	0.933124
	2017 - 2016	0.03357438	0.015212131	2.20708	0.234224
	2018 - 2016	-0.02892562	0.015212131	-1.90148	0.401205
	2018 - 2017	-0.0625	0.015212131	-4.10856	<0.001

Appendix 9. Octocoral target species mean density.

	2013	2014	2015	2016	2017	2018
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
G. ventalina	0.26 ± 0.06	0.30 ± 0.06	0.37 ± 0.09	0.34 ± 0.07	0.38 ± 0.08	0.34 ± 0.07
A. americana	1.57 ± 0.24	1.61 ± 0.27	1.98 ± 0.28	2.07 ± 0.31	2.08 ± 0.32	1.97 ± 0.31
E. flexuosa	0.68 ± 0.15	0.84 ± 0.22	1.02 ± 0.31	0.96 ± 0.27	0.94 ± 0.28	0.69 ± 0.21

Appendix 10. Octocoral density statistics.

Linear Mixed Effects Model ANOVA results.

Variable	**Level**	**Intercept**	**Year**
G. ventalina	DF	1	5
	F	21.90107	3.14957668
	P	<.0001	0.0113
A. americana	DF	1	5
	F	47.39607	4.99747
	P	<.0001	4.00E-04
E. flexuosa	DF	1	5
	F	12.84220	2.5062911
	P	0.0005	0.0358

Appendix 10. Continued.

Tukey post hoc Test.

Variable	Years	Est.	SE	z	P > |z|
G. ventalina	2014 - 2013	0.0325	0.03596	0.90376	0.9456755
	2015 - 2013	0.09875	0.03596	2.74603	0.0666552
	2016 - 2013	0.0875	0.03596	2.43319	0.1447452
	2017 - 2013	0.1225	0.03596	3.40646	0.0085942
	2018 - 2013	0.07	0.03596	1.94655	0.3736797
	2015 - 2014	0.06625	0.03596	1.84227	0.4383804
	2016 - 2014	0.055	0.03596	1.52943	0.6451685
	2017 - 2014	0.09	0.03596	2.50271	0.123216
	2018 - 2014	0.0375	0.03596	1.0428	0.9034532
	2016 - 2015	-0.01125	0.03596	-0.31284	0.9996025
	2017 - 2015	0.02375	0.03596	0.66044	0.9861413
	2018 - 2015	-0.02875	0.03596	-0.79948	0.9676827
	2017 - 2016	0.035	0.03596	0.97328	0.9264824
	2018 - 2016	-0.0175	0.03596	-0.48664	0.996646
	2018 - 2017	-0.0525	0.03596	-1.45991	0.6899232
A. americana	2014 - 2013	0.040789474	0.14518	0.28096	0.9997653
	2015 - 2013	0.410526316	0.14518	2.82768	0.0531789
	2016 - 2013	0.502631579	0.14518	3.4621	0.007241
	2017 - 2013	0.509210526	0.14518	3.50742	0.0060369
	2018 - 2013	0.398684211	0.14518	2.74612	0.0664572
	2015 - 2014	0.369736842	0.14518	2.54673	0.1109183
	2016 - 2014	0.461842105	0.14518	3.18115	0.0183074
	2017 - 2014	0.468421053	0.14518	3.22646	0.0157595
	2018 - 2014	0.357894737	0.14518	2.46516	0.1346666
	2016 - 2015	0.092105263	0.14518	0.63442	0.988455
	2017 - 2015	0.098684211	0.14518	0.67973	0.9842207
	2018 - 2015	-0.011842105	0.14518	-0.08157	0.9999995
	2017 - 2016	0.006578947	0.14518	0.04532	1
	2018 - 2016	-0.103947368	0.14518	-0.71598	0.9800827
	2018 - 2017	-0.110526316	0.14518	-0.7613	0.9738821

Appendix 10. Continued.

Tukey post hoc Test.

Variable	Years	Est.	SE	z	P > |z|
E. flexuosa	2014 - 2013	0.163157895	0.10621	1.53615	0.640768
	2015 - 2013	0.289473684	0.10621	2.72543	0.070301
	2016 - 2013	0.230263158	0.10621	2.16796	0.252757
	2017 - 2013	0.217105263	0.10621	2.04408	0.317257
	2018 - 2013	0.017105263	0.10621	0.16105	0.999985
	2015 - 2014	0.126315789	0.10621	1.18928	0.842204
	2016 - 2014	0.067105263	0.10621	0.63181	0.988672
	2017 - 2014	0.053947368	0.10621	0.50792	0.995894
	2018 - 2014	-0.146052632	0.10621	-1.37511	0.742126
	2016 - 2015	-0.059210526	0.10621	-0.55748	0.993645
	2017 - 2015	-0.072368421	0.10621	-0.68136	0.984045
	2018 - 2015	-0.272368421	0.10621	-2.56439	0.105907
	2017 - 2016	-0.013157895	0.10621	-0.12388	0.999996
	2018 - 2016	-0.213157895	0.10621	-2.00691	0.33815
	2018 - 2017	-0.2	0.10621	-1.88303	0.412542

Appendix 11. Octocoral target species mean height.

	2013	2014	2015	2016	2017	2018
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
G. ventalina	18.3 ± 1.1	16.5 ± 1.0	14.8 ± 0.8	15.2 ± 0.8	16.4 ± 0.8	17.7 ± 0.9
A. americana	27.1 ± 0.5	25.1 ± 0.5	23.2 ± 0.5	23.8 ± 0.4	23.3 ± 0.4	21.9 ± 0.5
E. flexuosa	24.9 ± 0.6	24.4 ± 0.7	21.5 ± 0.6	22.3 ± 0.5	22.9 ± 0.5	23.1 ± 0.6

Appendix 12.Octocoral height statistics

Linear Mixed Effects Model ANOVA results.

Variable	**Level**	**Intercept**	**Year**
G. ventalina	DF	1	5
	F	71.42457	2.1178323
	P	<.0001	0.0608
A. americana	DF	1	5
	F	500.18931	12.56942
	P	<.0001	<.0001
E. flexuosa	DF	1	5
	F	660.19127	3.7812292
	P	<.0001	0.002

Appendix 12. Continued.

Tukey post hoc Test.

Variable	Years	Est.	SE	z	P > |z|
A. americana	2014 - 2013	-2.050503313	0.701824485	-2.92168	0.040392
	2015 - 2013	-3.828299316	0.668639966	-5.7255	<0.001
	2016 - 2013	-3.187135775	0.662775002	-4.80877	<0.001
	2017 - 2013	-3.573353805	0.662886077	-5.3906	<0.001
	2018 - 2013	-4.917748489	0.672623241	-7.3113	<0.001
	2015 - 2014	-1.777796003	0.664795032	-2.6742	0.080283
	2016 - 2014	-1.136632462	0.658388779	-1.72638	0.513494
	2017 - 2014	-1.522850491	0.657259836	-2.31697	0.186648
	2018 - 2014	-2.867245176	0.667998243	-4.29229	<0.001
	2016 - 2015	0.641163542	0.620649439	1.03305	0.906678
	2017 - 2015	0.254945512	0.620544956	0.41084	0.998502
	2018 - 2015	-1.089449173	0.630113411	-1.72897	0.511839
	2017 - 2016	-0.38621803	0.613163009	-0.62988	0.988793
	2018 - 2016	-1.730612714	0.622514312	-2.78004	0.060477
	2018 - 2017	-1.344394685	0.622420558	-2.15995	0.256228
E. flexuosa	2014 - 2013	-0.428137142	0.860339226	-0.49764	0.996254
	2015 - 2013	-3.075124396	0.840304985	-3.65953	0.0034133
	2016 - 2013	-2.155359406	0.847087212	-2.54444	0.1110682
	2017 - 2013	-1.596565742	0.851907038	-1.87411	0.4171526
	2018 - 2013	-1.296200191	0.902618518	-1.43604	0.7041272
	2015 - 2014	-2.646987253	0.785845285	-3.36833	0.0097765
	2016 - 2014	-1.727222264	0.796412032	-2.16875	0.2516913
	2017 - 2014	-1.1684286	0.800107628	-1.46034	0.6889031
	2018 - 2014	-0.868063049	0.853409018	-1.01717	0.9120837
	2016 - 2015	0.919764989	0.766464115	1.20001	0.8365189
	2017 - 2015	1.478558654	0.76901191	1.92267	0.3871193
	2018 - 2015	1.778924205	0.826073296	2.15347	0.259326
	2017 - 2016	0.558793664	0.780866967	0.71561	0.9800449
	2018 - 2016	0.859159215	0.836258957	1.02738	0.9085721
	2018 - 2017	0.300365551	0.838138911	0.35837	0.9992255

Appendix 13. Results of statistical analyses for each taxa and each site grouping (Group A = PB1, PB2, PB3, BC1, BC2, BC3, DC1, DC2, DC3, Group B = MC1, MC2, Group C = PB4, PB5, DC4, DC5, Group D = BC4, BC5, BC6, DC6, DC7, DC8, Group BCA = BCA). The mean ± SE is pooled for all sites within each site grouping and years for each time interval. Significant results are specified. Non-significant results are not included.

Stony Coral

	A (2003-2005)	**B (2006-2009)**	**III (2010-2012)**	**IV (2013-2015)**	**V (2016-2018)**	
Grp A	2.09 ± 0.65	2.19 ± 0.61	2.22 ± 0.63	2.63 ± 0.73	1.35 ± 0.37	**D > A, B & C > E**
Grp B		1.96 ± 0.16	1.92 ± 0.42	2.35 ± 0.48	1.72 ± 0.58	No Significant Differences
Grp C			1.56 ± 0.11	1.77 ± 0.14	0.77 ± 0.09	**C & D > E**
Grp D				1.82 ± 0.32	1.19 ± 0.27	**D > E**
Grp BCA	37.07 ± 2.68	28.16 ± 1.45	16.54 ± 1.86	11.43 ± 1.43	3.58 ± 0.77	**A > B > C > D > E**

Octocoral

	A (2003-2005)	**B (2006-2009)**	**III (2010-2012)**	**IV (2013-2015)**	**V (2016-2018)**	
Grp A	13.12 ± 1.71	10.60 ± 1.17	11.04 ± 1.30	9.33 ± 0.95	9.16 ± 0.91	**A > C > D & E; A > B > E**
Grp B		0.01 ± 0.01	0.07 ± 0.02	0.04 ± 0.02	0.01 ± 0.01	No Test - All values near zero
Grp C			19.46 ± 1.04	16.12 ± 1.02	13.61 ± 0.71	**C > D > E**
Grp D				9.77 ± 1.00	8.13 ± 0.89	**D > E**
Grp BCA	1.97 ± 0.23	1.79 ± 0.23	2.31 ± 0.15	2.32 ± 0.26	1.30 ± 0.13	**C & D > E**

Appendix 13. continued

Macroalgae

	A (2003-2005)	**B (2006-2009)**	**III (2010-2012)**	**IV (2013-2015)**	**V (2016-2018)**	
Grp A	4.74 ± 1.30	8.82 ± 1.36	7.45 ± 1.27	8.49 ± 0.81	21.00 ± 3.41	**E > D > C > A; E > B > A**
Grp B		41.42 ± 2.76	35.03 ± 5.28	34.95 ± 4.66	17.02 ± 3.45	**B, C & D > E**
Grp C			9.81 ± 3.00	13.60 ± 2.13	22.12 ± 3.14	**E > D > C**
Grp D				18.76 ± 1.57	31.62 ± 2.75	**E > D**
Grp BCA	0.92 ± 0.51	3.09 ± 1.28	3.91 ± 0.62	5.03 ± 1.76	6.76 ± 1.98	**E & D > A**

Sponges

	A (2003-2005)	**B (2006-2009)**	**III (2010-2012)**	**IV (2013-2015)**	**V (2016-2018)**	
Grp A	4.35 ± 0.59	4.82 ± 0.59	6.15 ± 0.66	5.53 ± 0.54	5.75 ± 0.56	**C, D & E > A & B**
Grp B		1.96 ± 0.29	3.31 ± 0.55	2.57 ± 0.32	2.41 ± 0.25	**C > B**
Grp C			9.37 ± 1.07	8.82 ± 1.01	8.39 ± 0.89	No Significant Differences
Grp D				4.78 ± 0.52	4.84 ± 0.48	No Significant Differences
Grp BCA	0.38 ± 0.06	0.86 ± 0.12	1.99 ± 0.54	1.73 ± 0.82	1.35 ± 0.36	**D & E > A; C > B > A**