Southeast Florida Coral Reef Evaluation and Monitoring Project

Executive Summary 2019

Overview

- The Southeast Florida Coral Reef Evaluation and Monitoring Project (SECREMP) documents status and trends within the Southeast Florida Coral Reef Ecosystem Conservation Area (ECA) (Miami-Dade, Broward, Palm Beach, and Martin counties) reef system and in 2019 completed its 17th year of annual surveys.

- In 2019, all 22 SECREMP sites were surveyed through established methodologies (see Gilliam et al. 2019 for site locations and survey protocols). All surveys were performed within four permanently marked 22m x 1m stations at all sites (Figure 1).

- Survey methods include (1) photographic transects to quantify percent cover of major benthic taxa (stony corals, sponges, octocorals, macroalgae, etc.) and (2) demographic surveys to quantify abundance, size distribution, and overall condition of stony corals (Scleractinia and Milleporidae), octocorals (Octocorallia), and *Xestospongia muta* (giant barrel sponge).

- This Executive Summary focuses on 2019 stony coral demographic data in response to community changes largely driven by an on-going, multi-year, Stony Coral Tissue Loss Disease (SCTLD) event. Octocoral and *X. muta* density data and stony coral, octocoral, sponge, and macroalgae 2019 benthic cover data are also presented to provide brief resource status information for these coral reef community functional groups.

- Statistical comparisons for stony coral density, disease prevalence, stony coral colony live tissue area, *X. muta* density, and octocoral density were selectively performed region-wide (pooling all sites) for counties (pooling all sites within a county) and sites (stations as replicates). A linear mixed model (LME) was used with year as the factor to examine changes between 2013 – 2019 within counties and sites. All statistical tests were performed using the R software package (R Core Team 2016). For counties and/or sites exhibiting statistical differences between years, a Tukey's HSD post-hoc was performed and significant differences are reported based on Tukey's multiple comparison corrected p-values.

- Percent cover changes from 2018 to 2019 for the major benthic taxa (stony coral, sponges, octocorals and macroalgae) were analyzed using generalized linear mixed models (PROC GLIMMIX) in SAS Enterprise Guide® v7.1. Data for each taxa was square-root transformed and modeled using years and sites (N=22) as fixed effects. For all tests, a Gaussian/normal link function was used and a random residual statement was included to account for the repeated measures design with compound symmetry (CS) defined as the random residual error structure. Pairwise post-hoc comparisons were made to examine changes at individual sites. No p-value adjustments were used for the post-hoc site by site comparisons.

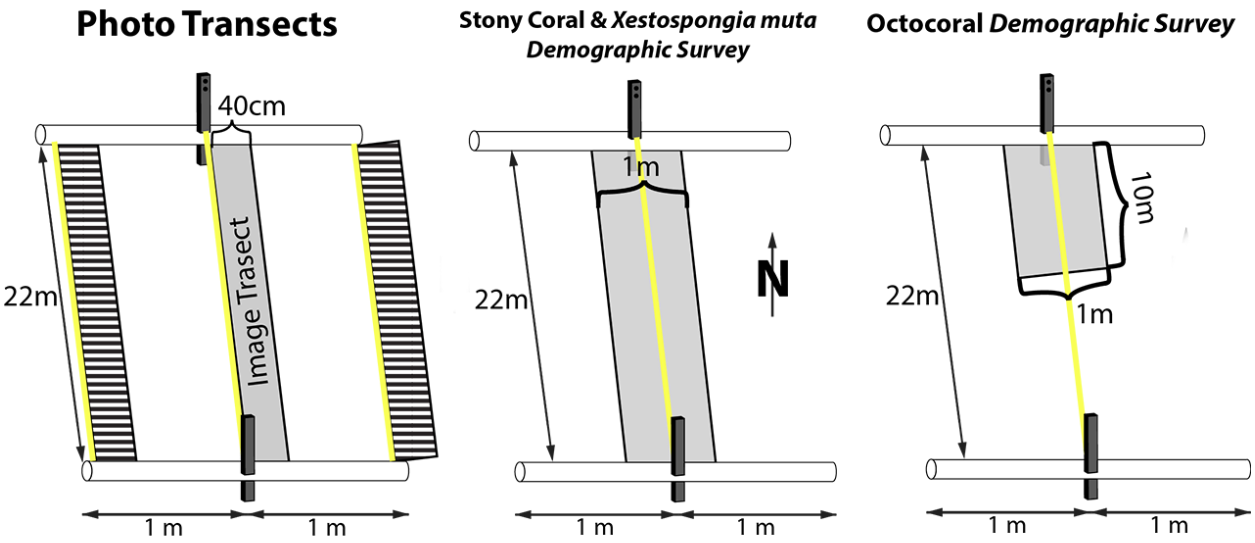

Figure 1. All SECREMP sites consist of four monitoring stations identified by permanent pins. Stations are 22m x 2m and are oriented north to south. Photo transects are taken along the center of the station surveying an 8.8m^2 area. The hashed photo transects represent additional area surveyed prior to 2014 modifications; this area is still surveyed at site BCA. Stony coral and *X. muta* demographic surveys are 22m x 1m along the center of the station. Octocoral demographic surveys are 10m x 1m along the station center. All demographic surveys were implemented in 2012.

Summary

Stony Coral Demographics

- Twenty-five stony coral species were identified region-wide which is similar to total richness identified throughout all project years (Gilliam et al. 2019).

- Region-wide mean (±SE) stony coral density (colonies ≥ 4 cm) in 2019 was 1.54 ± 0.28 colonies/m², and mean (±SE) site density ranged from 0.22 ± 0.05 colonies/m^2 (site MC2) to 4.43 ± 0.16 (BC4). Seventeen sites in 2019 had mean colony density less than 2 colonies/m^2 while 10 sites had mean colony density less than 1 colony/m^2 (Table 1).

- Regionally, no significant changes in stony coral colony density were identified from 2013 to 2015 (Table 1). Stony coral density in 2016, the height of the Stony Coral Tissue Loss Disease (SCTLD) outbreak in Southeast Florida, was significantly lower than in 2019, as 2019 was the maximum regional density recorded across the study period (Table 1).

- In 2019, five sites (MC2, PB3, PB4, BC1, and DC8) had significantly lower density compared to at least one previous year (Table 1). However, no sites had their minimum recorded density in 2019. Significant differences for all other years was presented in the 2018 comprehensive report (Gilliam et al. 2019).

- Colony density increases were also determined (Table 1). In 2019, seven sites (MC1, BC2, BC4, BCA, DC1, DC4, and DC5) had significantly greater densities than at least one previous year. Five sites (MC1, BCA, DC1, DC4, and DC5) had their maximum recorded density in

2019. However, increases in density at these sites was primarily driven by increases in only three species, *Porites astreoides, Siderastrea siderea* and *Agaricia agaricites* (Table 2).

- In 2019, just three of the 25 species identified region-wide accounted for 69% of total stony coral abundance; *P. astreoides* (1011 colonies), *S. siderea* (528 colonies) and *A. agaricites* (512 colonies) (Table 2). The six most abundant coral species account for 93% of 2019 total abundance; in contrast, the six most abundant species only accounted for 84% of total abundance in 2013 (Table 2). The six most abundant coral species in 2019 included *P. astreoides, S. siderea, A. agaricites, Stephanocoenia intersepta, Montastraea cavernosa,* and *Porites porites* (Table 2). Prior to 2015 *Meandrina meandrites* was annually one the six most abundant species. However, in 2015, *M. meandrites* was replaced by *P. porites*. Additionally, *M. cavernosa* was previously the third most abundant species, but in 2019, was the fifth most abundant species (Table 2). *M. meandrites* and *M. cavernosa* abundance declines were driven by whole colony mortality associated with the on-going SCTLD disease event.

Table 1. 2013 – 2019 mean (±SE) SECREMP regional (R) and site stony coral colony density (colonies ≥4cm/m²). Bolded site values indicate the mean for 2019 is significantly higher (Linear Mixed Model followed by a Tukey's HSD test) from other bolded years. Underlined site values indicate the mean for 2019 is significantly lower (Linear Mixed Model followed by a Tukey's HSD test) from other underlined years. Only significant differences from 2019 sample data is presented, significant differences for all other years is presented in the 2018 comprehensive report.

Site	2013	2014	2015	2016	2017	2018	2019
R	1.21 ± 0.17	1.26 ± 0.18	1.29 ± 0.19	**1.07 ± 0.18**	1.35 ± 0.25	1.39 ± 0.23	**1.54 ± 0.28**
MC1	**0.95 ± 0.09**	**1.06 ± 0.11**	**0.98 ± 0.18**	**0.98 ± 0.31**	2.18 ± 0.66	2.82 ± 0.78	**3.70 ± 1.20**
MC2	0.49 ± 0.06	0.40 ± 0.05	0.34 ± 0.09	0.27 ± 0.05	0.31 ± 0.08	0.11 ± 0.05	0.22 ± 0.05
PB1	0.23 ± 0.13	0.27 ± 0.13	0.28 ± 0.15	0.33 ± 0.14	0.25 ± 0.11	0.40 ± 0.15	0.40 ± 0.07
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	0.82 ± 0.14
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	0.73 ± 0.17
PB4	1.82 ± 0.38	1.63 ± 0.31	1.69 ± 0.30	1.02 ± 0.27	1.01 ± 0.23	1.06 ± 0.24	1.01 ± 0.22
PB5	2.30 ± 0.31	2.18 ± 0.28	2.08 ± 0.29	1.58 ± 0.25	1.65 ± 0.32	1.75 ± 0.40	1.77 ± 0.34
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	1.47 ± 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	**0.82 ± 0.10**
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	0.72 ± 0.03
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	**4.43 ± 0.16**
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	1.01 ± 0.26
BC6	0.64 ± 0.11	0.57 ± 0.08	0.56 ± 0.06	0.43 ± 0.05	0.41 ± 0.00	0.45 ± 0.12	0.50 ± 0.09
BCA	**0.61 ± 0.18**	**0.58 ± 0.17**	**1.09 ± 0.40**	**1.45 ± 0.17**	3.08 ± 1.10	3.47 ± 1.15	**3.66 ± 1.28**
DC1	**1.80 ± 0.15**	**2.10 ± 0.16**	**2.14 ± 0.03**	2.36 ± 0.06	**2.28 ± 0.13**	2.70 ± 0.27	**2.81 ± 0.10**
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	1.16 ± 0.06
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	0.42 ± 0.01
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	**0.91 ± 0.11**
DC5	**2.56 ± 0.24**	**2.53 ± 0.14**	**2.33 ± 0.26**	**2.40 ± 0.26**	3.28 ± 0.35	**2.94 ± 0.41**	**4.01 ± 0.57**
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	1.58 ± 0.27
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	1.14 ± 0.10
DC8	0.92 ± 0.09	0.81 ± 0.06	0.90 ± 0.14	0.56 ± 0.07	0.48 ± 0.05	0.60 ± 0.03	0.61 ± 0.06

Table 2. Region-wide (all sites pooled) species abundance of stony coral colonies ≥ 4 cm by species from 2013 to 2019. Region is the total stony coral abundance of colonies ≥ 4 cm across all species by year.

Species	2013	2014	2015	2016	2017	2018	2019
Region	2334	2433	2488	2064	2607	2699	2982
A. agaricites	167	165	208	237	403	389	512
A. cervicornis	8	22	17	19	19	8	9
A. fragilis	3	11	18	12	51	42	10
A. lamarcki	5	4	6	6	3	5	9
C. natans	9	7	10	3	2	1	2
D. labyrinthiformis	3	2	2	1	1	2	4
D. stokesii	75	78	55	8	5	10	17
E. fastigiata	3	6	6	4	6	5	6
H. cucullata	0	0	0	0	0	1	2
I. sinuosa	1	1	3	1	8	2	0
M. aliciae	5	4	6	4	4	7	8
M. auretenra	28	43	73	67	67	42	33
M. cavernosa	446	472	457	248	232	265	266
M. decactis	39	43	41	33	41	46	43
M. meandrites	114	118	85	5	12	14	28
M. lamarckiana	0	0	0	1	0	0	0
O. annularis complex	22	21	24	24	21	11	16
O. diffusa	8	7	7	5	3	0	1
O. robusta	0	0	0	0	0	1	0
P. americana	0	0	0	0	1	1	0
P. astreoides	546	581	587	647	810	860	1011
P. clivosa	31	27	30	29	30	3	5
P. porites	51	79	116	114	151	119	160
P. strigosa	12	12	10	4	5	5	5
S. bournoni	55	58	54	38	28	19	18
S. cubensis	3	0	0	1	3	1	2
S. intersepta	240	250	258	229	267	299	286
S. radians	10	4	10	0	8	3	1
S. siderea	450	418	405	324	426	538	528

- Prior to the 2019 sampling year, the ECA experienced an unprecedented stony coral disease event with significant increases in SCTLD prevalence beginning summer of 2014 (Table 3).

- In 2019 SCTLD was only observed at two of the 22 sites, and no site level significant increases of SCTLD in 2019 (Table 3). This is a decrease from 2018 where six sites were recorded with SCTLD (Gilliam et al. 2019). Both sites with SCTLD infections were in Broward County; BC1 had a prevalence of 5.29 ± 3.83% while BC5 prevalence was 2.27 ± 2.27% (Table 3). Site BC1 had 6 diseased colonies: 3 *Montastraea cavernosa*, 2 *Orbicella annularis* species complex, and 1 *Solenastrea bournoni*; BC5 only had 1 *M. cavernosa* with SCTLD.

- Region-wide SCTLD prevalence increased every year from 2013 to 2016 with a significant increase from a site mean of 0.86 ± 0.34% in 2015 to 2.60 ± 0.75% in 2016 (Table 3). Prevalence then decreased each year to 2019 where there was a site mean of 0.26 ± 0.22%.

Table 3. Stony Coral Tissue Loss Disease (SCTLD) mean (± SE) prevalence (%) at the regional (R, all sites pooled) and site level from 2013 – 2019. Bolded site values indicate the mean for that year is significantly higher than at least one other year (Linear Mixed Effects Model followed by a Tukey's HSD test). (DC = Miami-Dade; BC = Broward; PB = Palm Beach; MC = Martin).

Site	2013	2014	2015	2016	2017	2018	2019
R	0.09 ± 0.06	0.78 ± 0.58	0.86 ± 0.34	**2.60 ± 0.75**	0.69 ± 0.47	0.43 ± 0.30	0.26 ± 0.22
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	0.00 ± 0.00
MC2	0.00 ± 0.00	0.00 ± 0.00	3.57 ± 3.57	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
PB1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	3.57 ± 3.57	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
PB2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	2.27 ± 2.27	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
PB3	0.00 ± 0.00	0.00 ± 0.00	0.60 ± 0.60	1.47 ± 1.47	1.47 ± 1.47	0.00 ± 0.00	0.00 ± 0.00
PB4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.71 ± 0.71	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
PB5	0.00 ± 0.00	0.52 ± 0.52	0.00 ± 0.00	2.97 ± 1.72	0.89 ± 0.89	0.86 ± 0.86	0.00 ± 0.00
BC1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	**14.39 ± 2.95**	**10.70 ± 3.60**	5.38 ± 3.11	5.29 ± 3.83
BC2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
BC3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	3.13 ± 3.13	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
BC4	0.76 ± 0.46	0.00 ± 0.00	0.33 ± 0.33	1.74 ± 0.92	0.22 ± 0.22	0.29 ± 0.29	0.00 ± 0.00
BC5	0.00 ± 0.00	4.18 ± 1.74	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	2.27 ± 2.27
BC6	0.00 ± 0.00	**12.61 ± 2.41**	0.00 ± 0.00	6.25 ± 6.25	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
BCA	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.20 ± 0.20	0.00 ± 0.00
DC1	0.00 ± 0.00	0.00 ± 0.00	1.56 ± 1.56	**5.32 ± 0.55**	1.04 ± 1.04	0.66 ± 0.66	0.00 ± 0.00
DC2	0.00 ± 0.00	0.00 ± 0.00	1.00 ± 1.00	3.75 ± 2.19	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
DC3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	6.25 ± 6.25	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
DC4	0.00 ± 0.00	0.00 ± 0.00	**4.56 ± 2.76**	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
DC5	0.00 ± 0.00	0.42 ± 0.42	**1.63 ± 0.59**	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
DC6	0.00 ± 0.00	0.00 ± 0.00	0.76 ± 0.76	**2.78 ± 0.95**	0.00 ± 0.00	0.74 ± 0.74	0.00 ± 0.00
DC7	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.32 ± 1.32	0.00 ± 0.00	0.00 ± 0.00
DC8	0.96 ± 0.96	0.00 ± 0.00	**6.76 ± 3.01**	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

- To provide an additional metric to evaluate changes to the stony coral community, colony width, height and percent mortality (sum of old and recent) were used to calculate total stony coral live tissue area (LTA) for each site for 2013-2019 (see Gilliam et al. 2019 for more LTA calculation details). Region-wide LTAs were also calculated for all stony coral species or species groups (all *Orbicella* species were grouped) for 2013-2019.

- A region-wide decline in LTA was initially identified in 2016 (Gilliam et al. 2017), and LTA continued to decline region-wide such that 2017, 2018, and 2019 were significantly lower than years 2013-2015. For a majority of sites, LTA declined after 2016 (Figure 2).

- Eleven (MC2, PB2, PB3, PB4, PB5, BC1, BC3, BC4, BC5, DC4, and DC8) of the 22 sites had significant LTA losses after 2016. Sites with significant losses were found across all counties and all habitats (Figure 2).

- During the disease event, 6 species (*Colpophyllia natans, Dichocoenia stokesii*, *Orbicella annularis* species complex, *M. meandrites, M. cavernosa,* and *Solenastrea bournoni*) were determined to have a significant decrease in LTA. *Porites porites* was the only species that had a significant increase in LTA between 2013 and 2019. *Porites astreoides* and *A. agaricites* both had increases in LTA, but at a regional level, these increases were not significant. This could be a result of the small size of new colonies thus have a small contribution to LTA.

- *Colpophyllia natans* LTA drastically declined in 2016. In 2019, *C. natans* was only recorded in two sites, BC4 and DC1 (Figure 3). Previously, *C natans* was recorded in up to eight sites across three counties (Palm Beach, Broward, and Miami-Dade).

- *Dichocoenia stokesii* LTA has declined since 2013 with significant LTA loss first documented in 2015 (Figure 3). LTA declines were consistent with significant decreases in *D. stokesii* densities. Although only 5 colonies (>4cm diameter) remained in 2017, by 2019, 17 colonies were identified across the sites indicating some recovery response.

- *Orbicella annularis* complex LTA peaked in 2015, followed by a decline until reaching a minimum in 2018 (Figure 4). LTA in 2018 and 2019 was significantly lower than in 2015, and by 2019 all but one site (BC1) had less than 1 m^2 of live tissue.

- *Montastraea cavernosa* LTA declined in 2016, with continual LTA loss in 2017, 2018 and 2019 where LTA in 2019 was the lowest recorded since 2013 (Figure 4). *Montastraea cavernosa* is often the greatest contributor to LTA in the SECREMP region and was believed to be one of the more robust corals; therefore, it is particularly concerning to have documented a significant decline in LTA region-wide for the species.

- *Meandrina meandrites* has also declined since 2013 and significant LTA loss was first documented in 2016 (Figure 5). Similar to *D. stokesii*, *M. meandrites* declines were first identified in 2015, and the decline was consistent with significant losses in colony density. In 2014, 19 sites had *M. meandrites* colonies, but in 2016, only three sites still had living colonies. In 2019, 11 colonies were identified across three sites in Palm Beach, Broward and Miami-Dade counties.

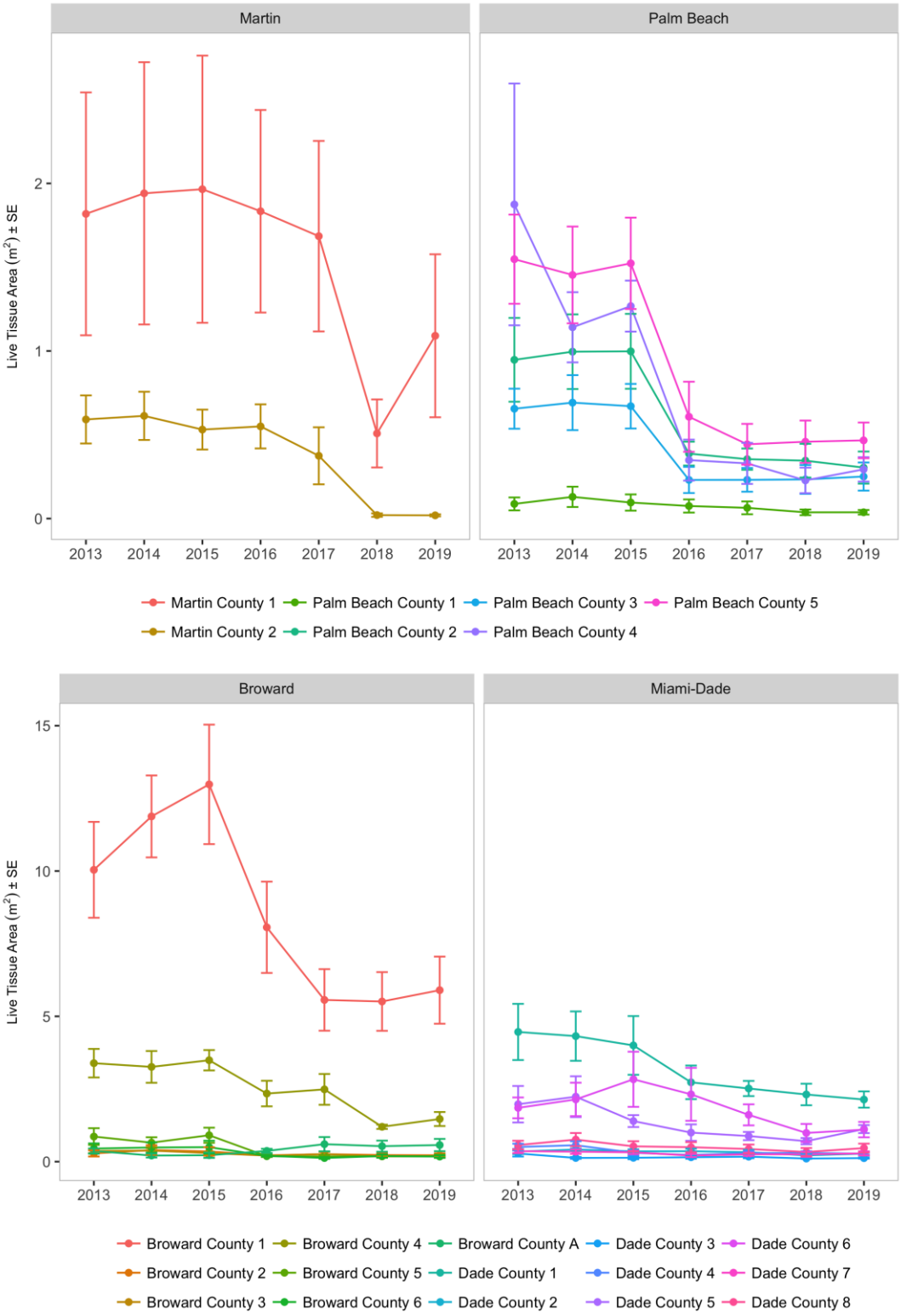

Figure 2. Mean (±SE) site LTA (m^2) from 2013-2019 per 22 m^2 transect grouped by county. Broward County A does include *Acropora cervicornis*.

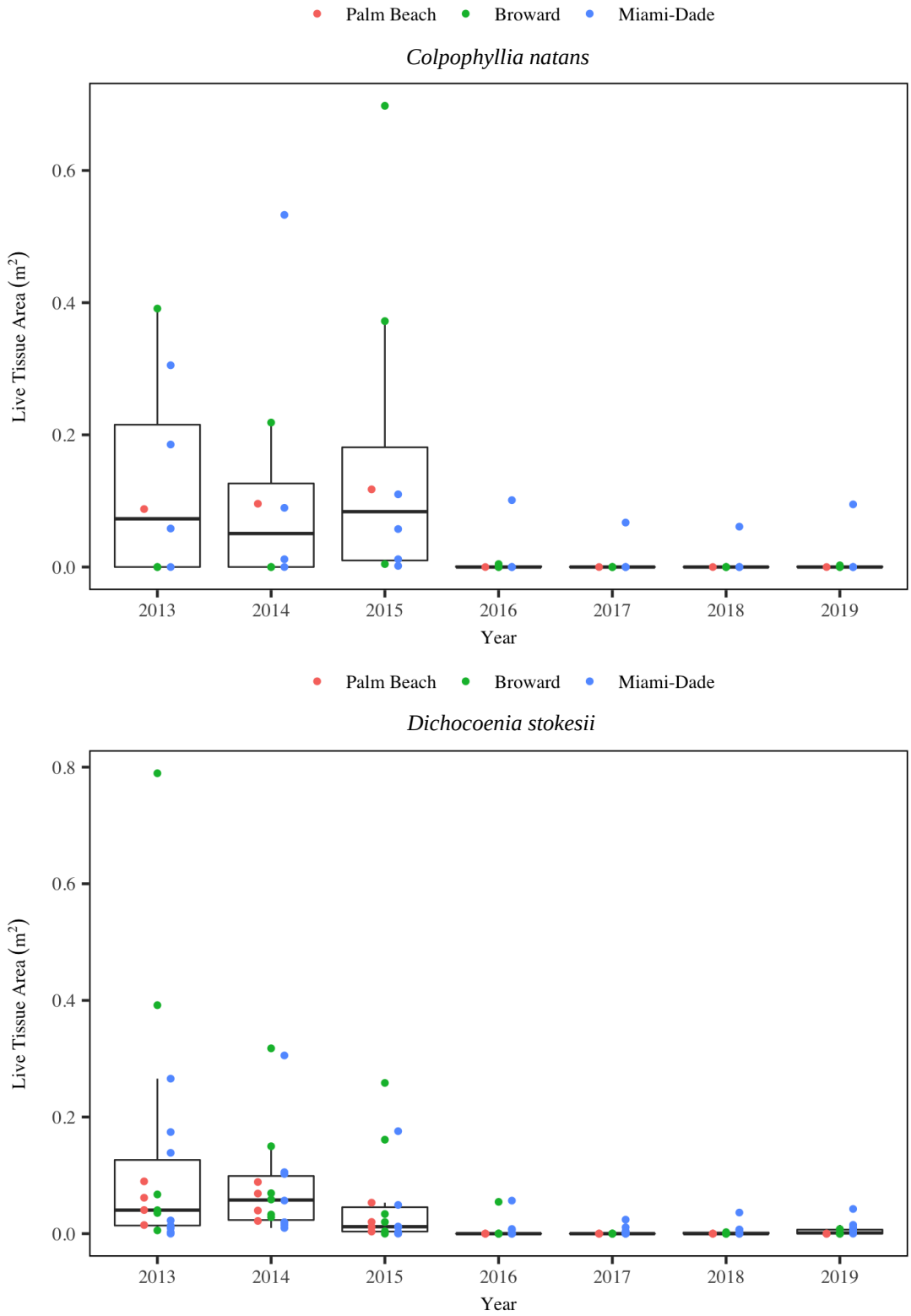

Figure 3. Mean (±SE) region-wide LTA (m^2) for *Colpophyllia natans* and *Dichocoenia stokesii*, respectfully. Each point is the LTA at a site colored by county. The middle bar in the boxplot is the median LTA for the region, the areas above and below the median, hinges, represent the 1st and 3rd quartiles, 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.

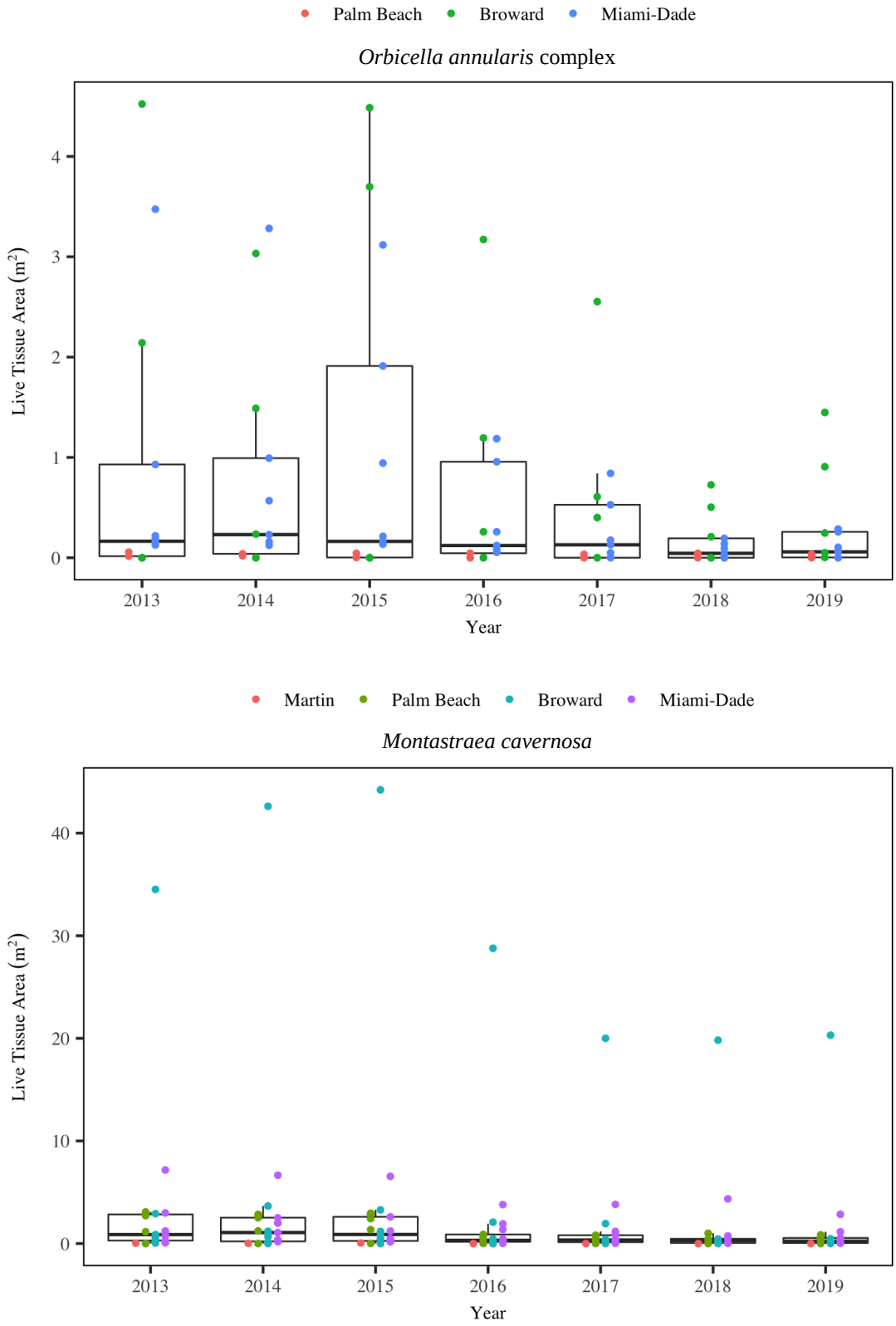

Figure 4. Mean (±SE) region-wide LTA (m^2) for *Orbicella annularis* complex and *Montastraea cavernosa*, respectfully. See Figure 3 for boxplot explanation.

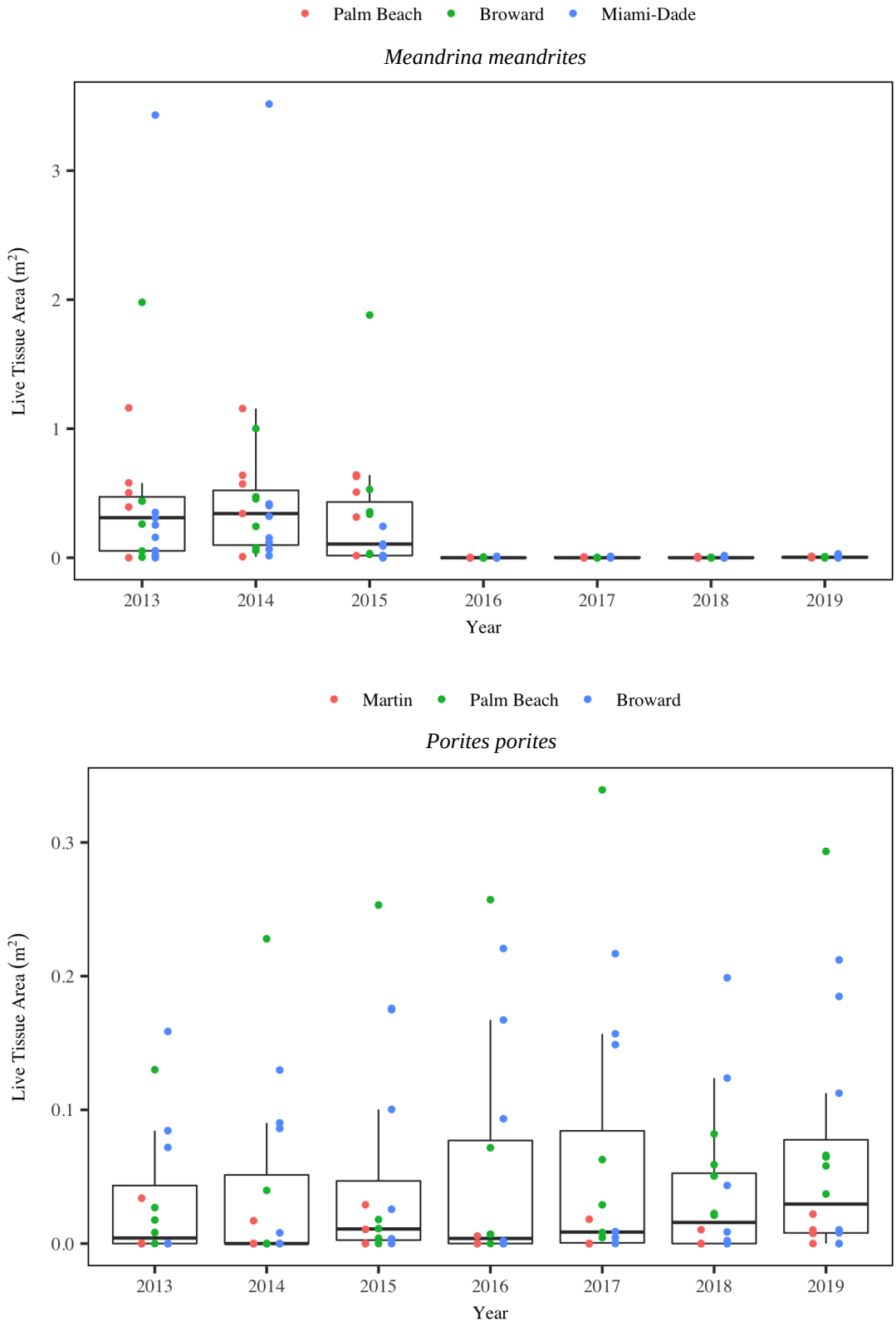

Figure 5. Mean (±SE) region-wide LTA (m^2) for *Meandrina meandrites* and *Porites porites*, respectfully. See Figure 3 for boxplot explanation.

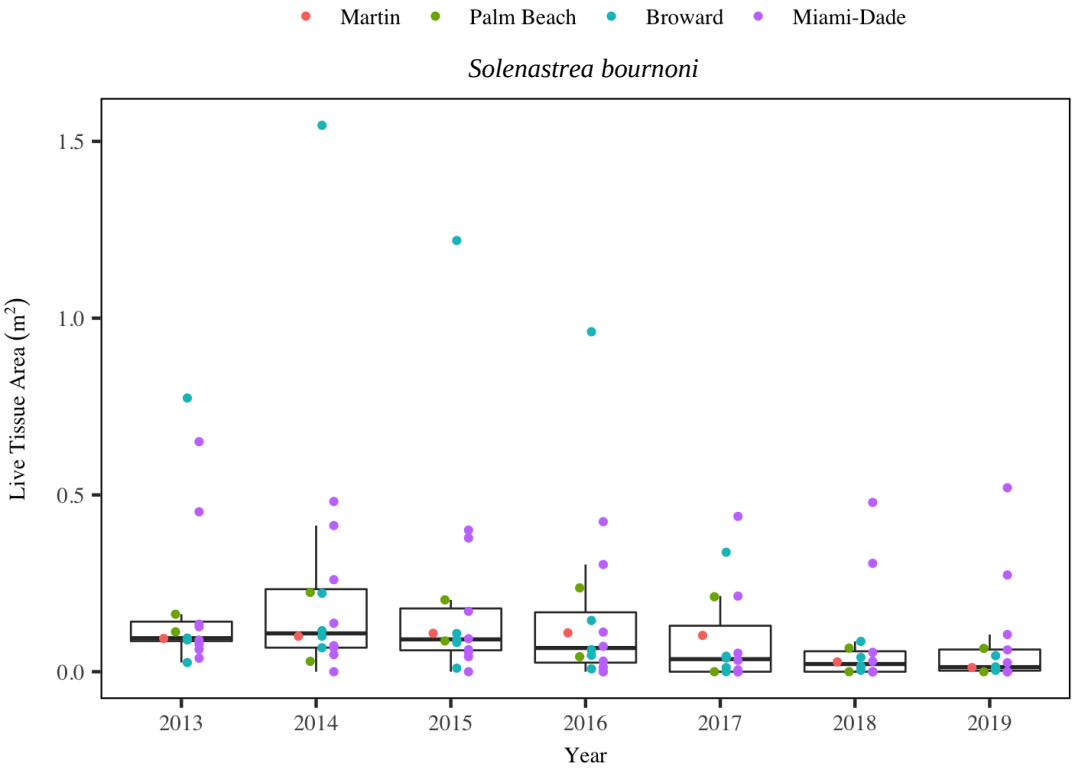

Figure 6. Mean (±SE) region-wide LTA (m^2) for *Solenastrea bournoni*. See Figure 3 for boxplot explanation.

- *Porites porites* was the only species with a significant LTA increase, with 2019 significantly greater than 2013 (Figure 5). Since 2013, there has been a general increase in total *P. porites* abundance (increase from 51 colonies in 2013 to 160 colonies in 2019) and the number of sites (eight in 2013 and 13 in 2019) with the species.

- *Solenastrea bournoni* LTA was significantly greater in 2014 than in 2018 and 2019. Total *S. bournoni* abundance has decreased from a maximum of 58 colonies in 2014 to a minimum of 18 in 2019, and the number of sites with *S. bournoni* colonies has decreased from 16 in 2013 to 12 in 2019.

- Beginning in 2018, stony coral colonies <4 cm in diameter were identified to lowest taxonomic level and tallied across all SECREMP sites. In 2018 a total of 2064 colonies <4 cm were tallied and in 2019 a total of 1862 colonies were found (Table 4).

Table 4. Region-wide (all sites pooled) abundance of stony coral colonies < 4 cm in 2018 and 2019. Region (R) is the total stony coral abundance of colonies < 4 cm across all species by year. Each colony was identified to lowest taxonomic level possible.

Species	2018	2019
Region	2064	1862
A. agaricites	150	318
A. cervicornis	0	0
A. fragilis	12	7
A. lamarcki	0	0
C. natans	1	0
D. labyrinthiformis	0	1
D. stokesii	33	21
E. fastigiata	3	3
H. cucullata	0	0
I. sinuosa	0	0
M. aliciae	0	4
M. auretenra	16	5
M. cavernosa	158	170
M. decactis	7	6
M. meandrites	14	12
M. lamarckiana	1	0
Mycetophyllia spp.	0	1
O. annularis complex	0	0
O. diffusa	0	1
O. robusta	0	0
P. americana	12	2
P. astreoides	309	232
P. clivosa	0	1
P. porites	52	87
P. strigosa	2	1
Pseudodiploria spp.	0	2
S. bournoni	1	1
S. cubensis	1	8
S. intersepta	122	94
S. radians	6	1
S. siderea	1164	884

- The three most abundance species in 2019 (colonies <4cm dia) were *S. siderea* (884), *A. agaricites* (318) and *P. astreoides* (232); these three species accounted for 77% of all juvenile species identified (Table 4). These three species were also the three most abundant species ≥4cm diameter (Table 2).

- Of the six species that had significant declines in LTA, four species had colonies < 4cm recorded in 2019 (*D. stokesii*, *M. meandrites, M. cavernosa,* and *S. bournoni*); while two species *C. natans,* and *O. annularis* species complex, did not have any juvenile colonies recorded (Table 4).

Octocoral and Xestospongia muta Density

- Region-wide (all sites pooled) octocoral density (colonies/m²) was significantly greater in 2015, 2016, 2017, and 2019 than in 2013 and 2014; density in 2018 was significantly lower than 2016 and 2017 (Figure 7). Octocoral target species information is available in the 2018 comprehensive report (Gilliam et al. 2019).

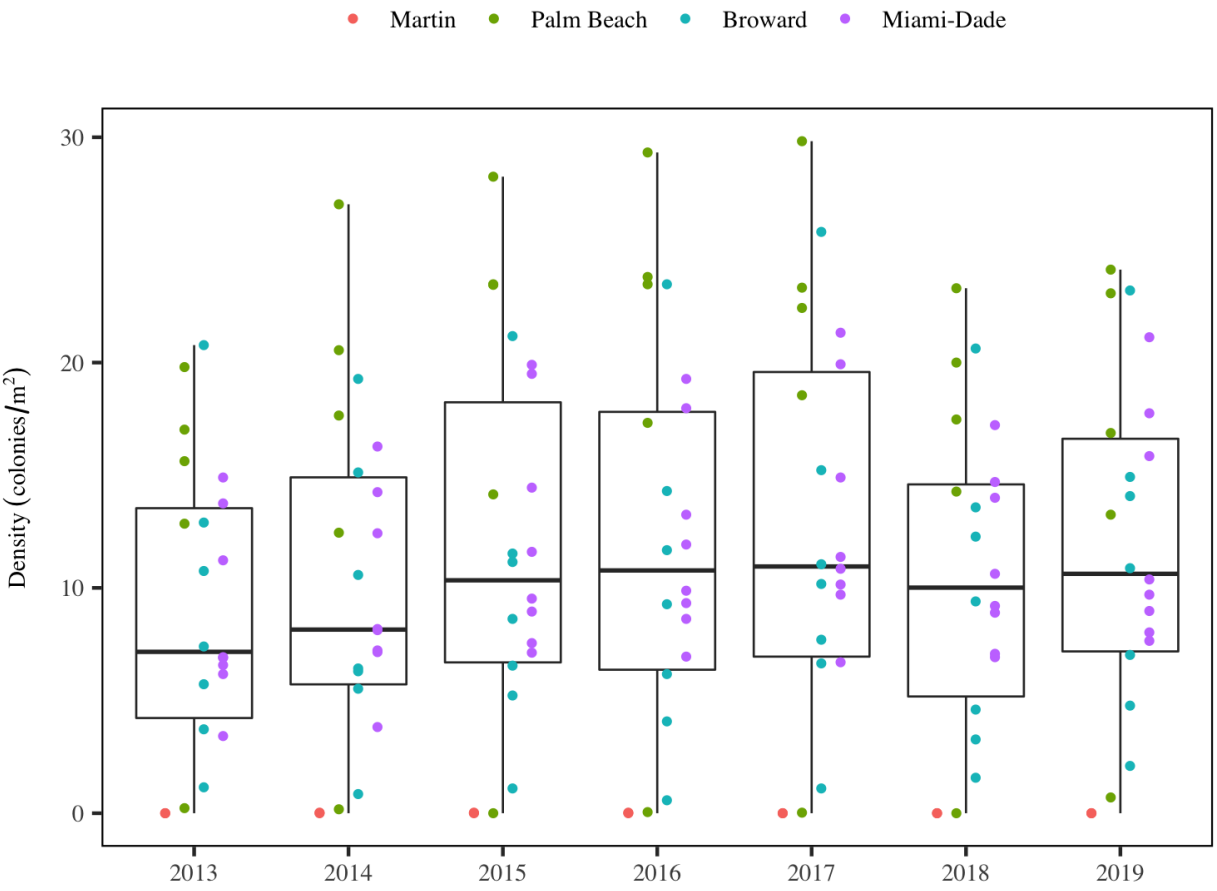

Figure 7. Octocoral density (colonies/m^2) across all sites from 2013-2019. See Figure 3 for boxplot explanation.

- Region-wide (all sites pooled) *X. muta* density was significantly greater in 2015, 2016, 2017, and 2019 than in 2014; density in 2017 was significantly greater than in 2014, 2015 and 2018 (Figure 8).

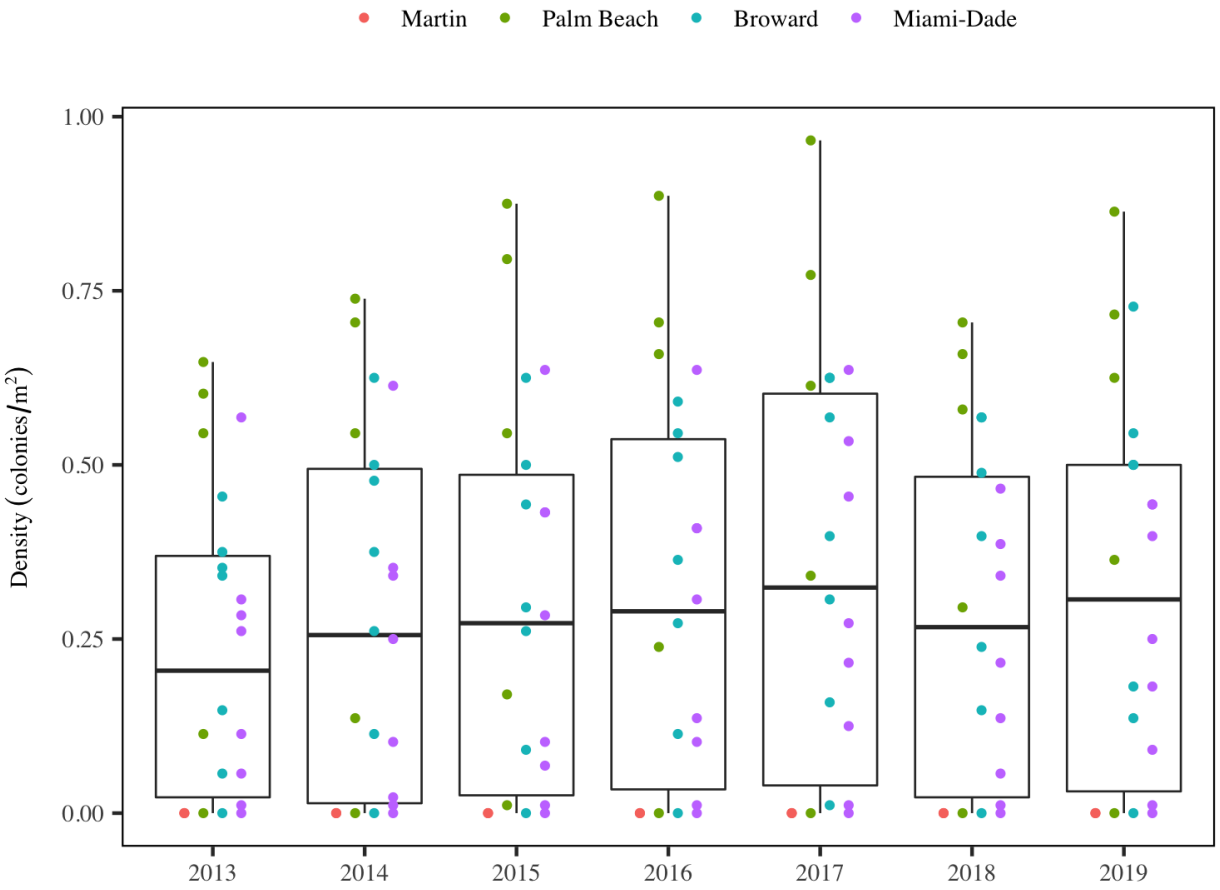

Figure 8. *Xestospongia muta* density (colonies/m^2) across all sites from 2013-2019. See Figure 3 for boxplot explanation.

Functional Group Benthic Cover

- Long-term trends in benthic functional group (stony coral, octocoral, sponges, and macroalgae) cover are not presented in this Executive Summary. Long-term trend analysis (2003-2018) was presented in the 2018 comprehensive report (Gilliam et al. 2019).

- In 2019, region-wide stony coral cover was 1.24 ± 0.33% (Figure 9) and was significantly higher than 2018 mean cover (1.02 ± 0.29%). At the site level, no sites had a significant decrease in stony coral cover from 2018 to 2019. Four sites (MC1, BC4, BCA, and DC5) had significantly higher cover in 2019 compared to 2018 (Table 5), all four of these sites also had significant increases in density (Table 1). These increases can be primarily attributed to only two species; at BCA this increase in cover and density is almost exclusively driven by increases in *A. agaricites*, while at MC1 this increase was exclusively driven by increases in *P. astreoides*. The increases at BC4 was mostly driven by increases in *P. astreoides* with some increase in *A. agaricites*, while DC5 had increases mostly driven by *A. agaricites* with additional increases in *P. astreoides.*

- Region-wide octocoral cover in 2019 was 7.47 ± 0.94% (Figure 9. Mean (±SE) region-wide annual percent cover of stony coral, octocoral, sponge, and macroalgae (values for each year include all sites sampled that year).Figure 9) and was not significantly different from 2018 mean cover (7.45 ± 0.94%). At the site level mixed changes in octocoral cover were found. Significant increases were found at DC6, DC8, and BC1 whereas PB2, BC3, and DC1 all decreased in cover. The largest changes were found at DC8 where octocoral cover increased by 3.8% and at PB2 where cover decreased by 5.43%.

- Region-wide sponge cover in 2019 (5.06 ± 0.61%) (Figure 9) was not significantly different than 2018 mean cover (4.90 ± 0.58%). At the site level, five sites (BC5, BC6, DC5, DC6, and DC7) had significant increases in 2019 compared to 2018, while no sites had significant decreases (Table 5).

- In 2019, region-wide macroalgae cover increased significantly from 14.00 ± 2.45% in 2018 to 23.09 ± 2.13%, which was the second highest cover of macroalgae recorded across study years (Figure 9). A significant increase in macroalgae cover was found at 12 sites (MC1, MC2, PB1, PB2, PB3, PB5, BC1, BC2, BC3, DC2, DC3, and DC4) that encompassed all four counties (Table 5). Only two sites had significant decreases in macroalgae cover from 2018 to 2019 (DC5 and DC6).

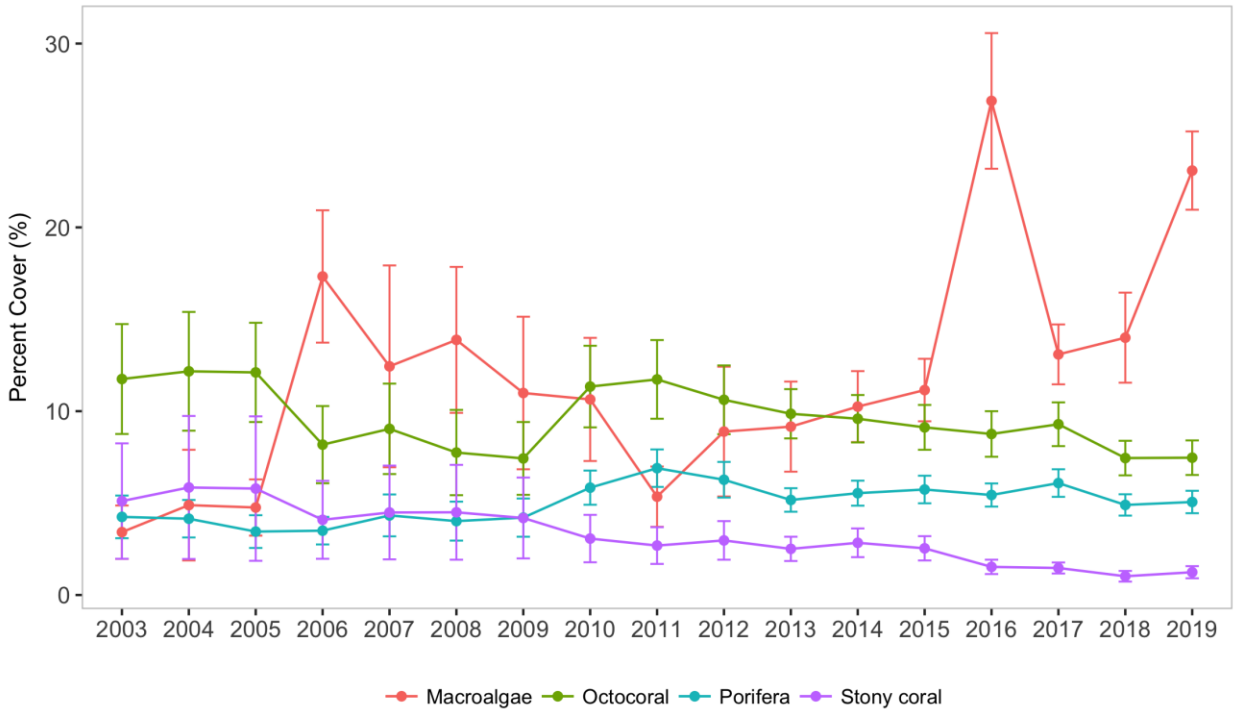

Figure 9. Mean (±SE) region-wide annual percent cover of stony coral, octocoral, sponge, and macroalgae (values for each year include all sites sampled that year).

Table 5. Mean (±SE) 2019 percent benthic cover for of stony coral, octocoral, sponge, and macroalgae. Bolded 2019 cover values with '+' are significantly greater than 2018 and cover values with '-' are significantly lower than 2018.

Site	Stony Coral	Octocoral	Sponge	Macroalgae
MC1	**+ 1.84 ± 1.14**	0.03 ± 0.03	2.65 ± 0.89	**+ 39.04 ± 5.97**
MC2	0.03 ± 0.03	0.03 ± 0.03	1.64 ± 0.48	**+ 43.02 ± 7.55**
PB1	0.10 ± 0.07	0.06 ± 0.06	2.41 ± 1.43	**+ 10.90 ± 3.16**
PB2	0.67 ± 0.23	**- 8.93 ± 2.75**	4.81 ± 0.16	**+ 19.47 ± 5.48**
PB3	0.47 ± 0.24	10.06 ± 0.91	12.63 ± 1.11	**+ 16.09 ± 2.31**
PB4	0.38 ± 0.11	12.31 ± 0.27	9.98 ± 0.99	6.82 ± 2.45
PB5	0.70 ± 0.13	12.58 ± 1.03	8.28 ± 1.25	**+ 27.20 ± 3.07**
BC1	6.48 ± 0.89	**+ 9.93 ± 0.65**	3.22 ± 0.48	**+ 23.12 ± 1.88**
BC2	0.38 ± 0.07	5.65 ± 0.84	5.29 ± 0.60	**+ 23.45 ± 2.74**
BC3	0.36 ± 0.15	**- 7.83 ± 1.12**	5.01 ± 0.21	**+ 24.22 ± 4.56**
BC4	**+ 2.65 ± 0.79**	2.43 ± 0.74	3.50 ± 0.82	23.69 ± 2.70
BC5	0.39 ± 0.17	6.81 ± 0.76	**+ 8.63 ± 0.73**	9.71 ± 0.96
BC6	0.36 ± 0.11	13.42 ± 0.90	**+ 5.80 ± 0.23**	13.06 ± 2.55
BCA	**+ 4.29 ± 0.87**	2.00 ± 0.28	1.43 ± 0.08	6.03 ± 2.05
DC1	2.21 ± 0.70	**- 6.51 ± 0.82**	3.07 ± 0.40	25.21 ± 8.80
DC2	0.51 ± 0.17	8.83 ± 0.65	3.57 ± 0.23	**+ 38.27 ± 2.81**
DC3	0.31 ± 0.15	7.84 ± 1.18	3.85 ± 0.54	**+ 30.11 ± 11.62**
DC4	1.04 ± 0.17	10.64 ± 0.65	5.93 ± 0.83	**+ 21.67 ± 2.81**
DC5	**+ 1.09 ± 0.30**	9.83 ± 1.29	**+ 4.72 ± 0.68**	**- 24.02 ± 3.96**
DC6	1.60 ± 0.50	**+ 6.65 ± 0.55**	**+ 2.93 ± 0.68**	**- 27.26 ± 3.54**
DC7	0.31 ± 0.16	6.50 ± 0.67	**+ 7.99 ± 1.77**	32.28 ± 2.30
DC8	1.04 ± 0.31	**+ 15.36 ± 0.86**	3.87 ± 0.34	23.25 ± 2.00

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