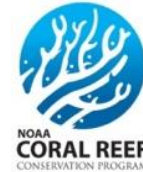


Southeast Florida Coral Reef Evaluation and Monitoring Project



Executive Summary 2023

Overview

- The Southeast Florida Coral Reef Evaluation and Monitoring Project (SECREMP) documents the status and trends within the Kristin Jacobs Coral Reef Ecosystem Conservation Area (Coral ECA) (Miami-Dade, Broward, Palm Beach, and Martin counties) reef system and in 2023 completed its 21st year of annual surveys.
- 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).
- In 2023, 20 of the 22 SECREMP sites were surveyed through established methodologies (see Hayes et al. 2023 for site locations and survey protocols) within four permanently marked 22 m x 1 m stations at all sites (Figure 1). At the remaining two sites, the Martin County sites, stony coral transect surveys were modified to only include the first 10 meters of the transect, due to the large abundance of small *Porites astreoides* colonies and tidally influenced timing constraints. The octocoral, *Xestospongia muta*, and photo transect surveys at these sites were performed according to the established methods presented by Hayes et al. (2023).
- This Executive Summary focuses on 2023 stony coral demographic data post stony coral tissue loss disease (SCTLD) event, which spanned multiple years. Octocoral and *X. muta* density data and stony coral, octocoral, sponge, and macroalgae 2023 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) and for sites (with stations as replicates). A linear mixed effects model (LME) with year as the factor was used to examine changes between 2013 – 2023 within sites. All statistical tests were performed using the R software package (R Core Team 2016). For sites exhibiting statistical differences between years, a Tukey's HSD post-hoc test was performed and significant differences are reported based on Tukey's multiple comparison corrected *p*-values.
- For Martin County sites in 2023, stony coral density was calculated based on only the first 10 meters and was directly comparable to previous years' density measurements, as density controls for area surveyed. Live tissue area (LTA) measurements were not standardized to area

surveyed: any significant change in live tissue area is interpreted within the context of a shorter transect distance.

- Percent cover changes from 2020 to 2023 for the major benthic taxa (stony corals, sponges, octocorals, and macroalgae) were analyzed using generalized linear mixed models in R version 4.3.2. For each taxon, percent cover estimates were modeled using a logistic regression, with year, site, and their interaction as fixed effects. Station was included as a random effect in each model to account for the repeated measures survey design. A pairwise post-hoc analysis was conducted to examine significant site-level changes. A Bonferroni post-hoc adjustment was applied to the α value of 0.05 to account for the multiple comparisons being made at the site level: 22 comparisons were made for each taxon and $\alpha = 0.002273$ was used to determine a significance. No adjustment was made for regional comparisons.

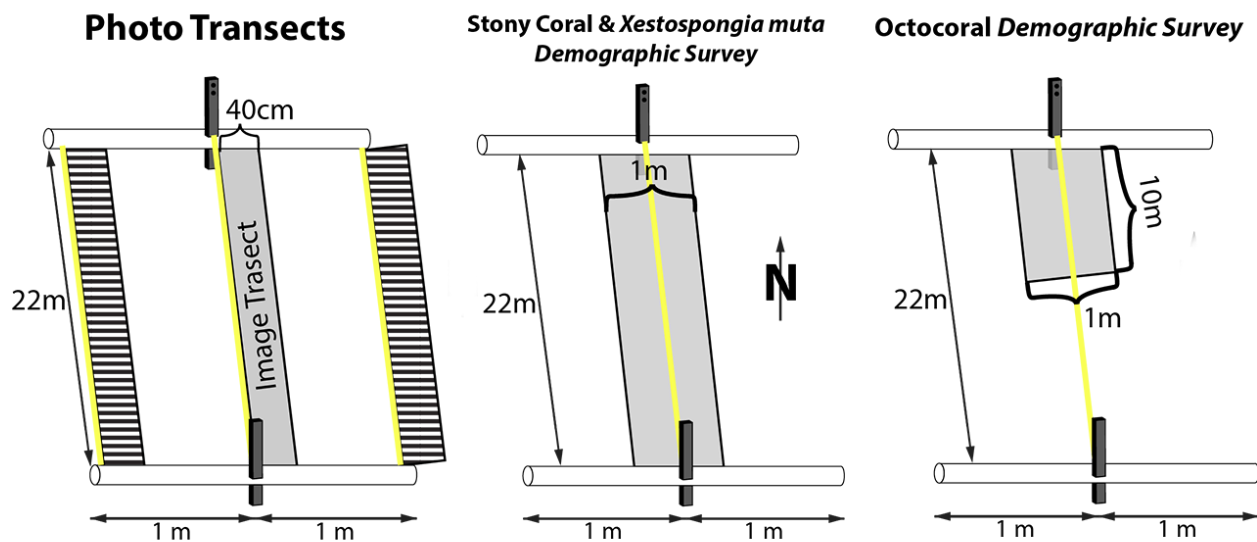


Figure 1. All SECREMP sites consist of four monitoring stations identified by permanent pins. Stations are 22 m x 1 m and are oriented north to south. Photo transects are taken along the east side of the station transect, surveying an 8.8m² area. The hashed photo transects represent additional area surveyed prior to 2014 methods modifications; this area is still surveyed at site BCA. Stony coral and *X. muta* demographic surveys are 22 m x 1 m along the center of the station. Octocoral demographic surveys are 10 m x 1 m along the station center. All demographic surveys were implemented in 2012. Starting in 2023, only the first 10 meters of the stony coral transects were surveyed in Martin County.

Results and Discussion

Stony Coral Demographics

- Twenty-four stony coral species and species complexes were identified region-wide which is similar to total richness identified throughout all project years (Hayes et al. 2023).
- Region-wide mean (\pm SE) stony coral site density (colonies ≥ 4 cm) in 2023 was 2.02 ± 0.34 colonies/m² and mean (\pm SE) site density ranged from 0.50 ± 0.17 colonies/m² (site PB1) to 5.94 ± 0.60 (site BC4). Fifteen sites in 2023 had mean colony density less than 2 colonies/m², while 3 sites (MC1, BC4, DC1) had mean colony density greater than 4 colonies/m² (Table 1).

- Regionally, stony coral density stayed relatively consistent from 2013 to 2015, dropping in 2016 to the lowest recorded regional density, which was the height of the stony coral tissue loss disease (SCTLD) outbreak in Southeast Florida. Density has since increased, where regional density in 2022 and 2023 was significantly higher than all years 2013-2018 (Table 1).
- In 2023, two sites (BCA and DC5) had significantly lower density compared to at least one previous year (Table 1). However, no sites had their minimum recorded density in 2023. Significant differences for all other years were presented in the 2022 comprehensive report (Hayes et al. 2023).
- Colony density increases were also observed (Table 1). In 2023, seventeen sites (MC1, MC2, PB3, PB5, BC2, BC3, BC4, BC5, BC6, DC1, DC2, DC3, DC4, DC5, DC6, DC7, and DC8) had significantly greater densities than at least one previous year. Twelve sites (MC1, MC2, PB5, BC2, BC3, BC4, BC5, BC6, DC1, DC3, DC4, DC6) had their maximum recorded density in 2023. However, increases in density at these sites was primarily driven by increases in only a handful of species including *Porites astreoides*, *Porites porites*, and *Siderastrea siderea* (Table 2).
- *Porites astreoides*, *Siderastrea siderea*, *Montastraea cavernosa*, and *Stephanocoenia intersepta* were the top four contributors to adult stony coral abundance in 2023 in Palm Beach, Broward, and Miami-Dade Counties, accounting for 74% of all corals (≥ 4 cm) recorded in these locations in 2023. *Porites astreoides* was the most abundant coral species in 2023 (928 colonies), followed by *S. siderea* (798 colonies), *Montastraea cavernosa* (370 colonies), and *Stephanocoenia intersepta* (359) (Table 2). Although *M. cavernosa* abundance has increased in recent years, it remains lower than prior to the SCTLD outbreak.
- Of the six most abundant species in Palm Beach, Broward, and Miami-Dade Counties in 2023, *A. agaricites* complex and *P. astreoides* have approximately doubled in abundance since 2013. *Porites porites* abundance has increased fivefold since 2013. *Stephanocoenia intersepta* saw a steady increase by 50% from 2013 to 2023, while *M. cavernosa* abundance has declined by 17% between 2013 and 2023 (Table 2). *Siderastrea siderea* abundance has fluctuated over the years, but has increased by 99% from 2013 to 2023, with peak abundance occurring in 2023 (Table 2).
- Only four coral species (≥ 4 cm) were observed in Martin County in 2023. *Porites astreoides* and *Siderastrea siderea* dominated stony coral abundance counts, comprising 98% of all corals (≥ 4 cm) recorded in Martin County in 2023. *Porites astreoides* was the most abundant coral species in 2023 (161 colonies), followed by *S. siderea* (97 colonies). *Oculina diffusa* and *Isophyllia sinuosa* were also observed, with only two and one colonies seen, respectively (Table 3).
- In Martin County, *P. astreoides* has experienced an approximately 19-fold increase in abundance since 2013. *Siderastrea siderea* abundance has increased by 23% between 2013 and 2023. However, since only the first 10 meters of the stony coral transects were surveyed in 2023 in Martin County, these abundances are underestimations of the true increases.

Pseudodiploria clivosa, which made up 16% of the stony coral abundance (≥ 4 cm) in Martin County in 2013, was not observed in 2023 (Table 3).

- Beginning in the summer of 2014, the Coral ECA experienced an unprecedented stony coral disease event with significant increases in SCTLD prevalence (Figure 2). Disease was first observed in Broward County in 2014, and elevated disease prevalence was subsequently observed across all counties. Miami-Dade and Broward Counties experienced the highest disease prevalence, although sites in Palm Beach and Martin Counties also experienced outbreaks. Regional disease prevalence peaked in 2016 but has since declined and remained below 1% since 2020 (Figure 2).
- In 2023, SCTLD was observed at six of the 22 sites: PB1, BC1, BC4, BC5, DC1, and DC5. This included one colony at each of the former five sites and five colonies at the latter site. This is a slight increase from 2022, where one colony at each of four sites was recorded with SCTLD (Hayes et al. 2023).
- In 2023, species exhibiting SCTLD included *Agaricia agaricites* (6 colonies), *Montastraea cavernosa* (3 colonies), *Stephanocoenia intersepta* (2 colonies), and *Porites astreoides* (1 colony).
- 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 from 2013-2023 (see Hayes et al. 2023 for more LTA calculation details). Region-wide LTAs were also calculated for different SCTLD susceptibility groups as defined by the NOAA Stony Coral Tissue Loss Disease Case Definition (2018).
- A region-wide decline in LTA was initially identified in 2016, and regional LTA from 2017-2023 was significantly lower than the LTA in 2013, 2014, and 2015. For most sites, LTA declined after 2016 and sites with significant losses were found across all counties and all habitats (Figure 3). No significant change in regional LTA has occurred from 2017 to 2023, including sites in Martin County.
- Between 2013 and 2023, thirteen sites throughout Palm Beach, Broward, and Miami-Dade Counties saw significant changes in LTA (PB2, PB3, PB4, PB5, BC1, BC4, BC5, BC6, BCA, DC4, DC5, DC6, and DC8). Eight sites had significantly lower LTA in 2023 than at least one previous year (PB2, PB3, PB4, PB5, BC1, BC4, DC6, and DC8; Figure 3).
- For Martin County, LTA measurements from 2023 were calculated based on the first 10 meters of the survey transect and were directly compared to previous years. Between 2013 and 2023, only one site (MC2) saw a significant decline in LTA. MC2's LTA in 2023 was virtually unchanged compared to the previous year. Although not statistically significant, the large decline in LTA at MC1 seen between 2022 and 2023 can be attributed to the change in methodology surveying only the first 10 meters of the stony coral transect.

Table 1. 2013 – 2023 mean (\pm SE) SECREMP regional (R) and site stony coral colony density (colonies ≥ 4 cm/m²). Bolded site values indicate that the mean for 2023 is significantly higher (linear mixed effects model followed by a Tukey’s HSD test) than the bolded years. Underlined site values indicate that the mean for 2023 is significantly lower (linear mixed effects model followed by a Tukey’s HSD test) than the underlined years. Only significant differences from 2023 sample data are presented, significant differences for all other years are presented in the 2022 comprehensive report.

Site	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
R	1.21 \pm 0.17	1.26 \pm 0.18	1.29 \pm 0.19	1.07 \pm 0.18	1.35 \pm 0.25	1.39 \pm 0.23	1.54 \pm 0.28	1.74 \pm 0.32	1.71 \pm 0.31	1.92 \pm 0.36	2.02 \pm 0.34
MC1	0.95 \pm 0.09	1.06 \pm 0.11	0.98 \pm 0.18	0.98 \pm 0.31	2.18 \pm 0.66	2.82 \pm 0.78	3.70 \pm 1.20	4.35 \pm 1.32	4.89 \pm 1.09	5.44 \pm 1.01	5.68 \pm 2.27
MC2	0.49 \pm 0.06	0.40 \pm 0.05	0.34 \pm 0.09	0.27 \pm 0.05	0.31 \pm 0.08	0.11 \pm 0.05	0.22 \pm 0.05	0.32 \pm 0.10	0.53 \pm 0.13	0.51 \pm 0.09	0.88 \pm 0.27
PB1	0.23 \pm 0.13	0.27 \pm 0.13	0.28 \pm 0.15	0.33 \pm 0.14	0.25 \pm 0.11	0.40 \pm 0.15	0.40 \pm 0.07	0.75 \pm 0.18	0.34 \pm 0.10	0.49 \pm 0.12	0.50 \pm 0.17
PB2	1.07 \pm 0.15	1.24 \pm 0.09	1.57 \pm 0.31	1.07 \pm 0.33	1.03 \pm 0.42	0.86 \pm 0.25	0.82 \pm 0.14	0.68 \pm 0.13	0.72 \pm 0.07	0.84 \pm 0.05	1.02 \pm 0.11
PB3	1.05 \pm 0.31	1.18 \pm 0.34	1.11 \pm 0.29	0.63 \pm 0.22	0.68 \pm 0.23	0.67 \pm 0.19	0.73 \pm 0.17	0.76 \pm 0.24	0.76 \pm 0.25	0.93 \pm 0.28	1.01 \pm 0.24
PB4	1.82 \pm 0.38	1.63 \pm 0.31	1.69 \pm 0.30	1.02 \pm 0.27	1.01 \pm 0.23	1.06 \pm 0.24	1.01 \pm 0.22	1.15 \pm 0.30	1.32 \pm 0.29	1.28 \pm 0.22	1.56 \pm 0.30
PB5	2.30 \pm 0.31	2.18 \pm 0.28	2.08 \pm 0.29	1.58 \pm 0.25	1.65 \pm 0.32	1.75 \pm 0.40	1.77 \pm 0.34	1.85 \pm 0.27	2.06 \pm 0.30	2.28 \pm 0.21	2.60 \pm 0.31
BC1	1.81 \pm 0.35	2.16 \pm 0.33	2.05 \pm 0.34	1.66 \pm 0.30	1.45 \pm 0.34	1.40 \pm 0.33	1.47 \pm 0.33	1.70 \pm 0.29	1.44 \pm 0.30	1.47 \pm 0.35	1.76 \pm 0.44
BC2	0.64 \pm 0.12	0.78 \pm 0.12	0.63 \pm 0.12	0.47 \pm 0.10	0.58 \pm 0.13	0.95 \pm 0.19	0.82 \pm 0.10	1.11 \pm 0.12	0.92 \pm 0.13	0.95 \pm 0.11	1.22 \pm 0.13
BC3	0.75 \pm 0.11	0.76 \pm 0.22	0.59 \pm 0.08	0.42 \pm 0.03	0.61 \pm 0.04	0.83 \pm 0.09	0.72 \pm 0.03	0.85 \pm 0.09	0.93 \pm 0.06	0.92 \pm 0.08	1.06 \pm 0.05
BC4	3.28 \pm 0.32	3.75 \pm 0.22	4.05 \pm 0.31	3.41 \pm 0.12	4.89 \pm 0.41	3.83 \pm 0.18	4.43 \pm 0.16	5.03 \pm 0.23	4.74 \pm 0.29	5.69 \pm 0.38	5.94 \pm 0.60
BC5	1.23 \pm 0.19	1.09 \pm 0.25	1.19 \pm 0.22	0.67 \pm 0.08	0.83 \pm 0.14	0.89 \pm 0.11	1.01 \pm 0.26	1.18 \pm 0.16	1.06 \pm 0.12	1.35 \pm 0.08	1.78 \pm 0.22
BC6	0.64 \pm 0.11	0.57 \pm 0.08	0.56 \pm 0.06	0.43 \pm 0.05	0.41 \pm 0.00	0.45 \pm 0.12	0.50 \pm 0.09	0.59 \pm 0.13	0.69 \pm 0.17	0.68 \pm 0.17	0.91 \pm 0.14
BCA	0.61 \pm 0.18	0.58 \pm 0.17	1.09 \pm 0.40	1.45 \pm 0.17	3.08 \pm 1.10	3.47 \pm 1.15	3.66 \pm 1.28	<u>4.95 \pm 1.44</u>	2.58 \pm 0.72	2.52 \pm 0.58	2.26 \pm 0.53
DC1	1.80 \pm 0.15	2.10 \pm 0.16	2.14 \pm 0.03	2.36 \pm 0.06	2.28 \pm 0.13	2.70 \pm 0.27	2.81 \pm 0.10	3.36 \pm 0.24	3.51 \pm 0.33	4.38 \pm 0.55	4.91 \pm 0.49
DC2	0.88 \pm 0.09	1.08 \pm 0.14	1.07 \pm 0.11	0.83 \pm 0.09	1.03 \pm 0.04	1.10 \pm 0.10	1.16 \pm 0.06	1.07 \pm 0.11	1.34 \pm 0.11	1.14 \pm 0.11	1.20 \pm 0.12
DC3	0.31 \pm 0.09	0.33 \pm 0.03	0.31 \pm 0.06	0.27 \pm 0.07	0.28 \pm 0.01	0.44 \pm 0.03	0.42 \pm 0.01	0.48 \pm 0.06	0.41 \pm 0.05	0.45 \pm 0.04	0.53 \pm 0.04
DC4	0.73 \pm 0.11	0.75 \pm 0.12	0.75 \pm 0.20	0.57 \pm 0.14	0.90 \pm 0.18	0.90 \pm 0.10	0.91 \pm 0.11	0.95 \pm 0.08	1.18 \pm 0.10	1.34 \pm 0.09	1.47 \pm 0.08
DC5	2.56 \pm 0.24	2.53 \pm 0.14	2.33 \pm 0.26	2.40 \pm 0.26	3.28 \pm 0.35	2.94 \pm 0.41	4.01 \pm 0.57	3.64 \pm 0.48	4.73 \pm 0.59	<u>5.54 \pm 0.62</u>	3.77 \pm 0.40
DC6	1.38 \pm 0.26	1.42 \pm 0.25	1.51 \pm 0.25	1.44 \pm 0.33	1.55 \pm 0.35	1.51 \pm 0.25	1.58 \pm 0.27	1.45 \pm 0.18	1.45 \pm 0.25	1.75 \pm 0.21	2.24 \pm 0.46
DC7	1.13 \pm 0.05	1.02 \pm 0.12	1.10 \pm 0.14	0.67 \pm 0.09	0.85 \pm 0.08	0.98 \pm 0.14	1.14 \pm 0.10	1.30 \pm 0.10	1.39 \pm 0.13	1.34 \pm 0.11	1.15 \pm 0.03
DC8	0.92 \pm 0.09	0.81 \pm 0.06	0.90 \pm 0.14	0.56 \pm 0.07	0.48 \pm 0.05	0.60 \pm 0.03	0.61 \pm 0.06	0.73 \pm 0.05	0.52 \pm 0.03	1.00 \pm 0.03	0.93 \pm 0.07

Table 2. Species abundance of stony coral colonies ≥ 4 cm by species from 2013 to 2023 across Palm Beach, Broward, and Miami-Dade Counties. “Region” is the total stony coral abundance of colonies ≥ 4 cm across all species by year in these counties. Species abundance for Martin County can be found in Table 3 below.

Species	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Region	2207	2310	2375	1954	2388	2443	2636	2957	2824	3200	3330
<i>A. agaricites</i> complex	170	177	226	249	454	431	522	631	465	523	358
<i>A. cervicornis</i>	8	22	17	19	19	8	9	9	13	13	19
<i>A. lamarcki</i>	5	4	6	6	3	5	9	6	4	6	4
<i>C. natans</i>	9	7	10	3	2	1	2	4	2	2	2
<i>D. labyrinthiformis</i>	3	2	2	1	1	2	4	2	4	3	2
<i>D. stokesii</i>	75	78	56	8	5	10	17	23	23	34	42
<i>E. fastigiata</i>	3	6	6	4	6	5	6	9	13	14	15
<i>H. cucullata</i>	0	0	0	0	0	1	2	1	0	0	0
<i>M. aliciae</i>	5	4	6	4	4	7	8	9	9	11	14
<i>M. auretenra</i>	28	43	73	67	67	42	33	16	14	25	27
<i>M. cavernosa</i>	445	472	456	248	231	264	265	289	288	327	370
<i>M. decactis</i>	39	43	41	33	41	46	43	51	46	46	41
<i>M. meandrites</i>	114	119	87	5	12	14	28	26	31	35	30
<i>M. lamarckiana</i>	0	0	0	1	0	0	0	0	0	0	0
<i>O. annularis</i> complex	22	21	24	24	21	12	16	13	14	13	18
<i>O. diffusa</i>	2	2	2	1	0	0	0	0	1	1	0
<i>O. robusta</i>	0	0	1	0	0	0	0	0	0	0	0
<i>P. americana</i>	0	0	0	0	0	1	0	0	0	1	0
<i>P. astreoides</i>	538	559	555	608	695	691	752	764	797	838	928
<i>P. clivosa</i>	11	6	6	6	7	3	5	3	1	1	1
<i>P. porites</i>	51	79	116	114	151	119	160	180	189	255	269
<i>P. strigosa</i>	11	12	10	3	4	5	4	8	7	10	9
<i>S. bourmoni</i>	54	57	53	37	27	18	17	17	14	11	16
<i>S. cubensis</i>	3	0	0	1	3	1	2	2	1	3	5
<i>S. intersepta</i>	239	252	258	229	267	299	286	333	333	342	359
<i>S. radians</i>	1	4	3	0	7	3	1	8	1	8	2
<i>S. siderea</i>	371	341	361	283	361	455	445	552	553	678	798

Table 3. Species abundance of stony coral colonies ≥ 4 cm by species from 2013 to 2023 in Martin County. “Region” is the total stony coral abundance of colonies ≥ 4 cm across both Martin County sites. Note that in 2023 the stony coral transect survey length was reduced from 22 meters to 10 meters.

Species	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Region	129	130	117	114	219	269	345	412	553	524	262
<i>I. sinuosa</i>	1	1	3	1	8	2	0	2	3	3	1
<i>M. angulosa</i>	0	0	0	0	0	0	0	0	1	0	0
<i>M. cavernosa</i>	1	1	1	0	1	1	1	1	1	0	0
<i>O. diffusa</i>	6	5	4	4	3	0	1	1	1	1	2
<i>O. robusta</i>	0	0	0	0	0	1	0	0	0	0	0
<i>P. americana</i>	0	0	0	0	1	0	0	1	0	2	2
<i>P. astreoides</i>	8	22	32	39	115	170	258	273	299	339	161
<i>P. clivosa</i>	20	21	24	23	23	0	0	1	0	0	0
<i>P. strigosa</i>	1	0	0	1	1	0	1	0	1	0	0
<i>S. bournoni</i>	1	1	1	1	1	1	1	0	0	1	0
<i>S. intersepta</i>	1	0	0	0	0	0	0	0	0	0	0
<i>S. radians</i>	9	0	7	0	0	0	0	1	0	0	0
<i>S. siderea</i>	79	77	44	41	65	83	83	131	171	176	97
<i>T. coccinea</i>	0	0	0	0	0	0	0	0	0	2	0

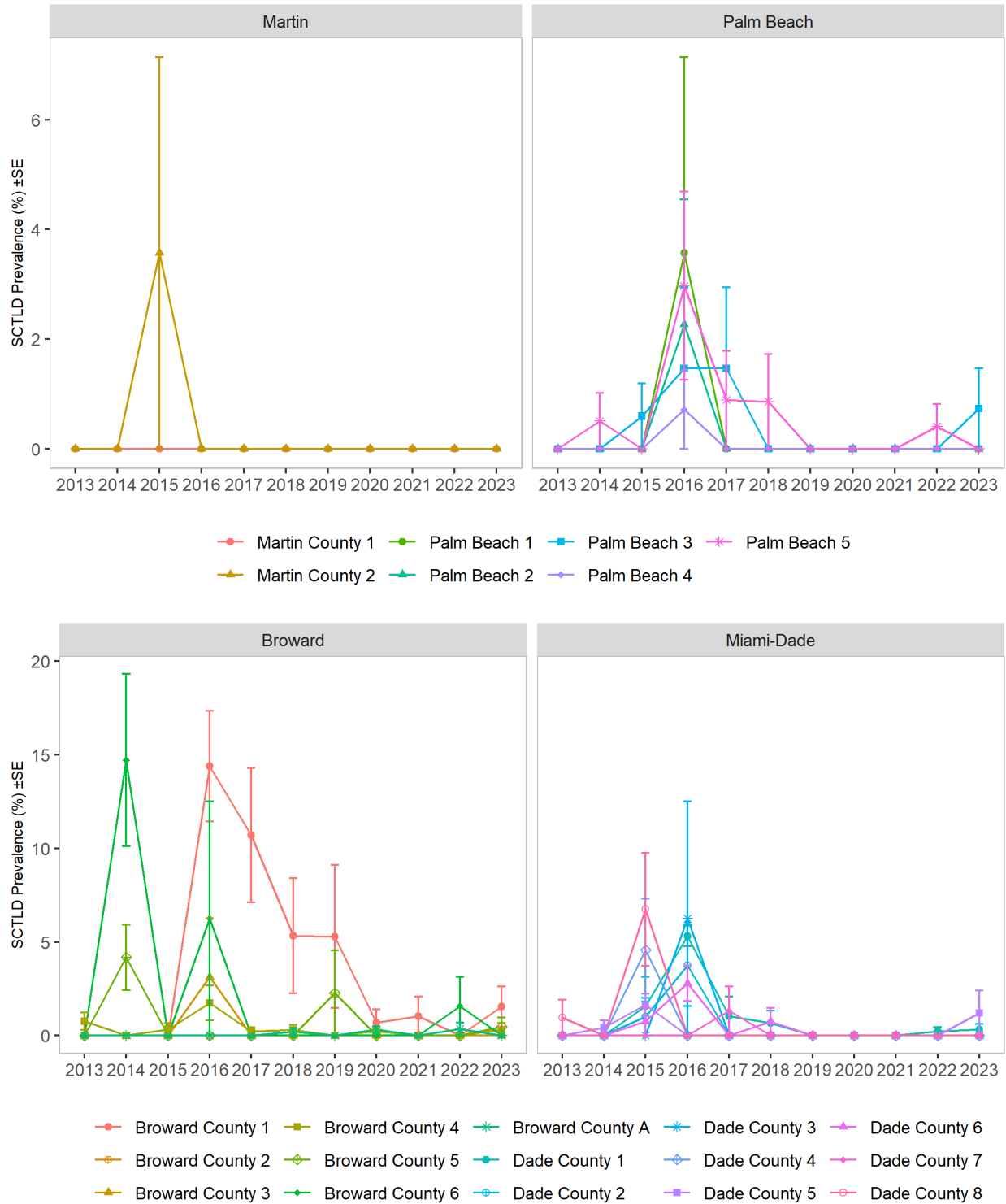


Figure 2. Stony coral tissue loss disease (SCTL D) mean (\pm SE) prevalence (%) from 2013-2023 per 22 m² transect grouped by county. Broward County A does not include *Acropora cervicornis*.

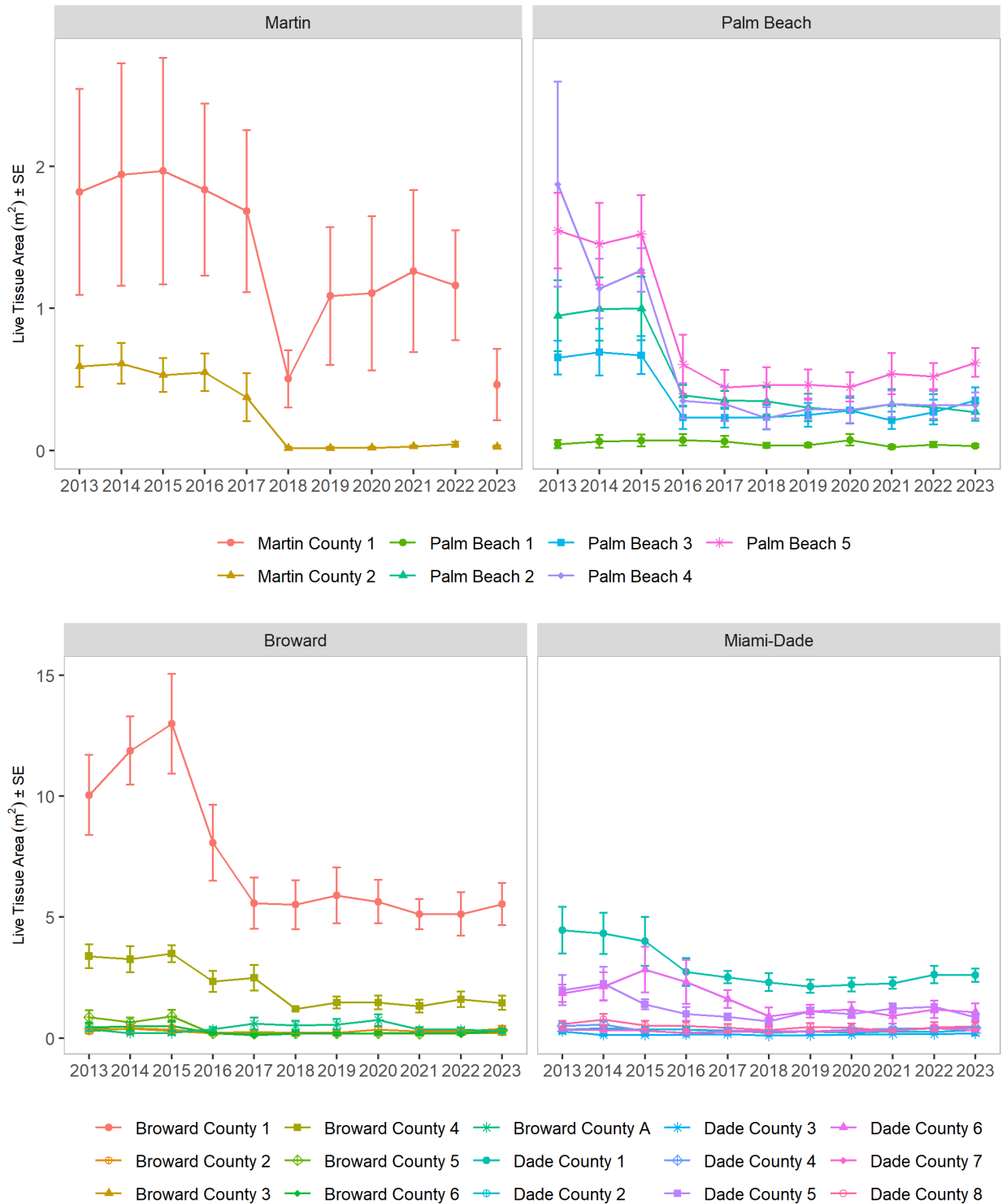


Figure 3. Mean (\pm SE) site LTA (m^2) from 2013-2023 per 22 m^2 transect grouped by county. Broward County A does not include *Acropora cervicornis*. The data points between 2022 and 2023 for Martin County sites are not connected because Martin County LTA measurements for 2023 are based on only 10 m^2 of transect survey area, compared to the 22 m^2 used in all previous years, and thus measurements are not directly comparable.

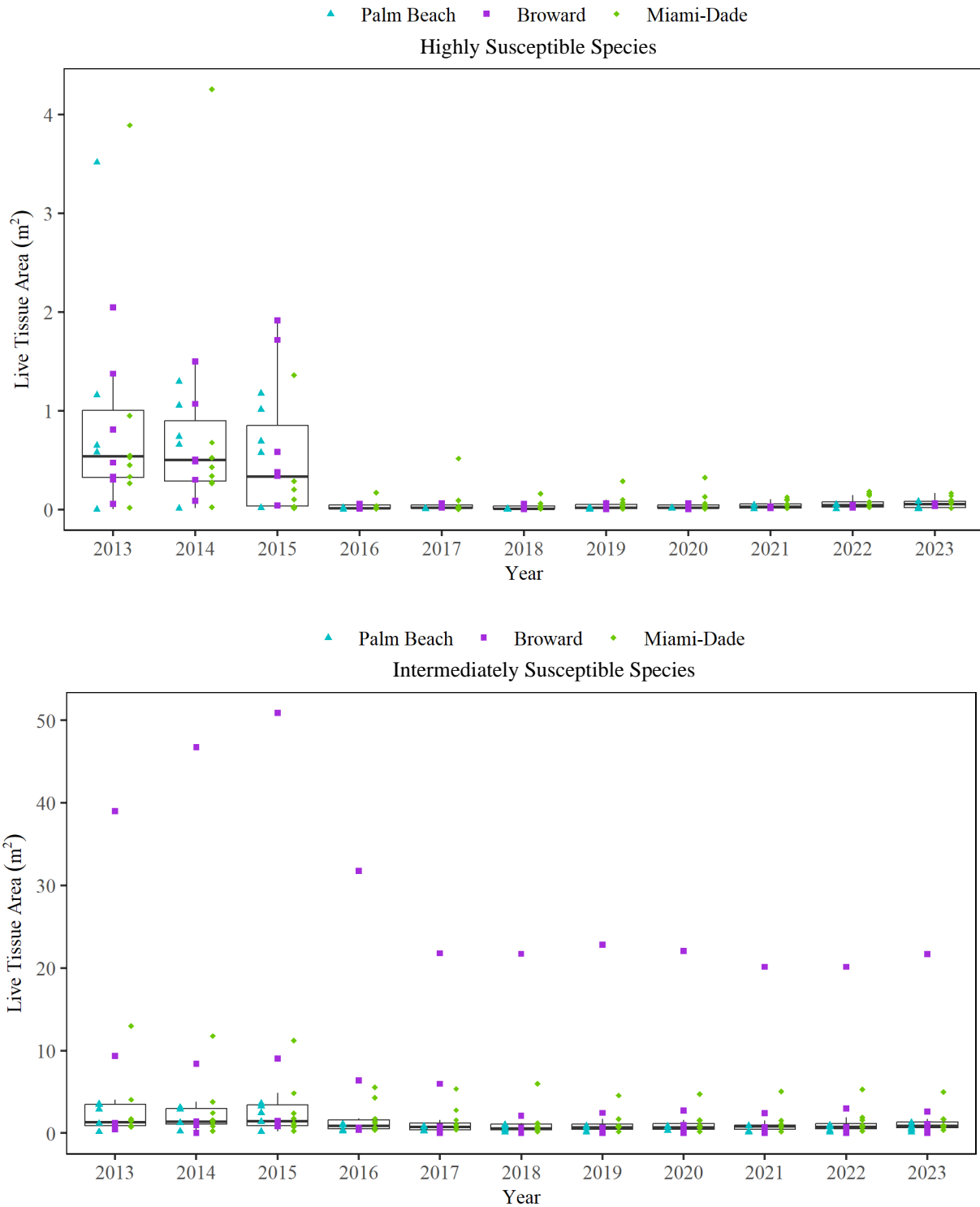


Figure 4. Mean (\pm SE) LTA (m^2) for Highly Susceptible species and Intermediately Susceptible species, respectively, in Palm Beach, Broward, and Miami-Dade Counties. Each point is the LTA at a site colored by county. The middle bar in the boxplot is the median LTA for these locations, the areas above 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 $1.5 \cdot IQR$, where IQR is the inter-quartile range (distance between 1st and 3rd quartiles). Points lying beyond the whiskers are considered outliers. Values for Martin County can be found in Table 4.

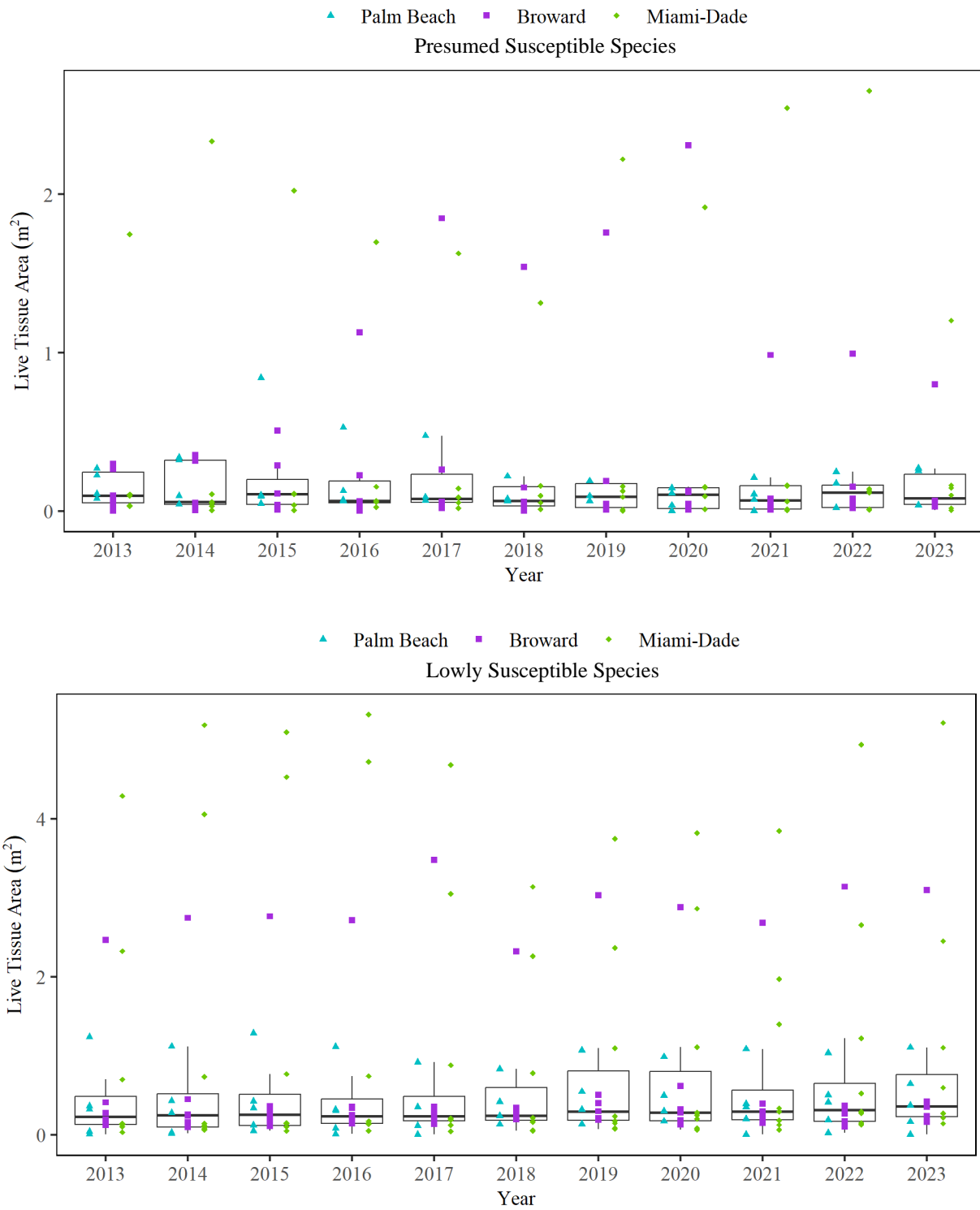


Figure 5. Mean (\pm SE) LTA (m^2) for Presumed Susceptible species and Lowly Susceptible species, respectively, in Palm Beach, Broward, and Miami-Dade Counties. See Figure 4 for boxplot explanation. Values for Martin County can be found in Table 4.

Table 4. Mean site LTA (m²) for the two Martin County sites (MC1 and MC2) from 2013-2023 for each SCTLD Susceptibility group. Note that in 2023 the stony coral transect survey length was reduced from 22 meters to 10 meters.

Susceptibility	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Highly	4.39	4.71	4.49	4.17	3.31	0.00	0.001	0.002	0.006	0.00	0.00
Intermediately	0.22	0.20	0.18	0.15	0.17	0.13	0.14	0.17	0.22	0.28	0.14
Presumed	0.01	0.008	0.02	0.02	0.03	0.003	0.00	0.004	0.009	0.005	0.00
Lowly	0.19	0.19	0.28	0.42	0.60	0.91	2.07	2.07	2.35	2.09	0.83

- Those species defined as Highly Susceptible Species to SCTLD (including *Colpophyllia natans*, *Pseudodiploria strigosa*, *Pseudodiploria clivosa*, and *Meandrina meandrites*) saw significant declines in LTA beginning in 2016 (Figure 4 and Table 4). LTA in 2016-2023 was significantly lower than LTA in 2013 and 2014. These significant declines were recorded across all four counties, and all sites have <0.2 m² of these species remaining, with a total <1 m² (Figure 4 and Table 4).
- Species defined as Intermediately Susceptible to SCTLD (including *Montastraea cavernosa* and *Orbicella* spp. complex) also saw significant declines in LTA. Regional LTA in 2018-2023 was significantly lower than in 2014 and 2015 (Figure 4). Despite losses, *Montastraea cavernosa* has historically been and continues to be the greatest contributor to LTA in the SECREMP region. Martin County did not experience significant declines in Intermediately Susceptible species over the study period (Table 4); this is likely because of the historically low abundance of *M. cavernosa* there, and the more recent increases in *S. siderea*, which is also classified as Intermediately Susceptible.
- Those species classified as Presumed Susceptible to SCTLD did not have any significant changes in regional LTA over the study period. These species include *A. agaricites* complex, *Agaricia lamarcki*, and *Mycetophyllia* spp. However, as many of these species do not contribute a large amount of LTA, changes in these species' LTA are less likely to be captured.
- Although species classified as Lowly Susceptible (including *P. porites* and *P. astreoides*) did not significantly change in regional LTA, there is a noticeable increasing trend. *Porites astreoides* has almost doubled in abundance from 2013 to 2023 and *P. porites* has more than quintupled in Palm Beach, Broward, and Miami-Dade Counties (Table 2). *Porites astreoides* in Martin County have increased more than 19-fold between 2013 and 2023 (Table 3).
- There has been a significant increase in density in 2022 and 2023 compared to all years 2013-2018 (Table 1). This increase in density is driven by small, non-reef building colonies that have not led to significantly increased regional LTA.
- In addition, increases in density are driven predominantly by species not susceptible to SCTLD (Table 1). Those species susceptible to SCTLD have not yet seen any significant recovery post-disease event (Figure 4).

- Beginning in 2018, stony coral colonies <4 cm in diameter were identified to lowest taxonomic level possible and tallied across all SECREMP sites. In 2023, 2235 colonies <4 cm were found in Palm Beach, Broward, and Miami-Dade Counties (Table 5). 978 colonies <4 cm were found in Martin County (Table 6).
- The three most abundant species in 2023 (colonies <4 cm diameter) in Palm Beach, Broward, and Miami-Dade Counties were *Siderastrea* spp. (1171 colonies), *P. astreoides* (316 colonies), and *M. cavernosa* (215 colonies), which made up 76% of all colonies <4 cm recorded at these locations (Table 5). In Martin County in 2023, *Siderastrea* spp. (752 colonies) and *P. astreoides* (224 colonies) colonies dominated colonies <4 cm abundance, comprising more than 99% of all colonies <4 cm recorded there (Table 6).
- Of the 15 species defined as Highly or Intermediately susceptible to SCTLD, seven species/genera had <10 colonies <4 cm recorded across all sites (Table 5). All of these that were documented were found across Palm Beach, Broward, and Miami-Dade Counties. In 2023, seven species (*A. lamarcki*, *A. cervicornis*, *C. natans*, *D. labyrinthiformis*, *H. cucullata*, *I. sinuosa*, and *O. diffusa*) had no colonies <4 cm recorded.

Table 5. Species abundance of stony coral colonies <4 cm from 2018-2023 across Palm Beach, Broward, and Miami-Dade Counties. Region is the total stony coral abundance of colonies <4 cm across all species by year at these locations. Each colony was identified to the lowest taxonomic level possible. See Table 5 for stony coral <4 cm abundances for Martin County.

Species	2018	2019	2020	2021	2022	2023
Region	1542	1504	2128	1895	2284	2235
<i>Agaricia agaricites</i> complex	162	325	375	190	263	210
<i>Acropora cervicornis</i>	0	0	0	1	0	0
<i>Colpophyllia natans</i>	1	0	1	1	2	0
<i>Dichocoenia stokesii</i>	33	21	27	24	23	11
<i>Diploria labyrinthiformis</i>	0	1	2	0	0	0
<i>Eusmilia fastigiata</i>	3	3	1	7	3	2
<i>Helioseris cucullata</i>	0	0	0	2	0	0
<i>Madracis auretenra</i>	16	5	3	3	2	4
<i>Madracis decactis</i>	7	6	5	10	6	8
<i>Montastraea cavernosa</i>	158	170	191	210	200	215
<i>Meandrina meandrites</i>	14	12	8	9	5	3
<i>Mycetophyllia</i> spp.	3	5	7	8	2	3
<i>Orbicella annularis</i> complex	0	0	0	0	1	1
<i>Phyllangia americana</i>	4	0	0	0	0	3
<i>Porites astreoides</i>	202	194	257	319	282	316
<i>Porites porites</i>	52	87	129	113	163	166
<i>Pseudodiploria</i> spp.	7	3	5	5	4	4
<i>Solenastrea bournoni</i>	1	1	3	3	3	5
<i>Scolymia cubensis</i>	1	8	5	5	8	9
<i>Stephanocoenia intersepta</i>	122	94	110	106	120	104
<i>Siderastrea</i> spp.	755	569	999	877	1197	1171
<i>Scleractinia</i> spp.	1	0	0	1	0	0

Table 6. Species abundance of stony coral colonies <4 cm from 2018-2023. Region is the total stony coral abundance of colonies <4 cm across both Martin County sites. Note that in 2023 the stony coral transect survey length was reduced from 22 meters to 10 meters.

Species	2018	2019	2020	2021	2022	2023
Region	530	358	1090	1243	1008	978
<i>Isophyllia sinuosa</i>	0	0	0	0	3	0
<i>Montastraea cavernosa</i>	0	0	1	0	1	0
<i>Mussa angulosa</i>	0	0	0	1	0	0
<i>Oculina diffusa</i>	0	1	1	1	1	0
<i>Phyllangia americana</i>	8	2	1	3	2	0
<i>Porites astreoides</i>	107	38	159	235	351	224
<i>Pseudodiploria</i> spp.	0	1	1	0	0	0
<i>Scolymia cubensis</i>	0	0	0	0	0	1
<i>Siderastrea</i> spp.	415	316	927	1003	647	752
<i>Tabastraea coccinea</i>	0	0	0	0	3	1

Octocoral and Xestospongia muta Density

- Region-wide octocoral density (colonies/m²) from 2015-2017 was significantly greater than in 2013 and 2014. However, in 2018 density was significantly lower than 2017, driven by loss from Hurricane Irma. Octocoral density has since recovered, and density in 2023 was significantly greater than in 2013 and 2020 (Figure 6). Although not statistically significant, regional octocoral density in 2023 is greater than during post-hurricane recovery in 2018 and 2019. Octocoral target species information is available in the 2022 comprehensive report (Hayes et al. 2023).

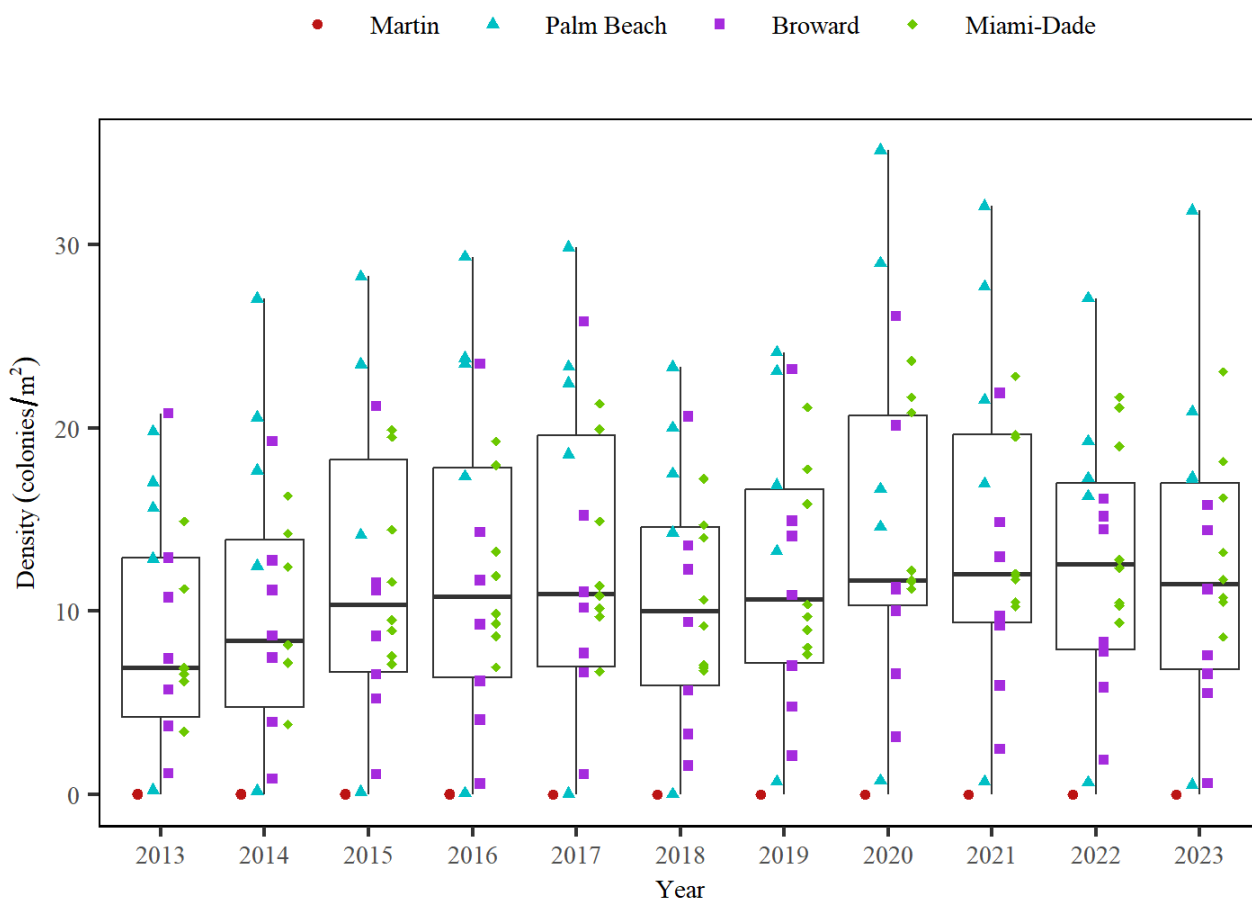


Figure 6. Octocoral density (colonies/m²) across all sites from 2013-2023. See 4 for boxplot explanation.

- Region-wide (all sites pooled) *X. muta* density was significantly greater in 2015, 2016, and 2017 than it was in 2013; density in 2017 was also significantly greater than in 2014. However, as observed with octocorals, in 2018 density was significantly lower than 2017, driven by loss from Hurricane Irma. Density in 2019-2023 was significantly greater than density in 2013, showing recovery post-disturbance (Figure 7).

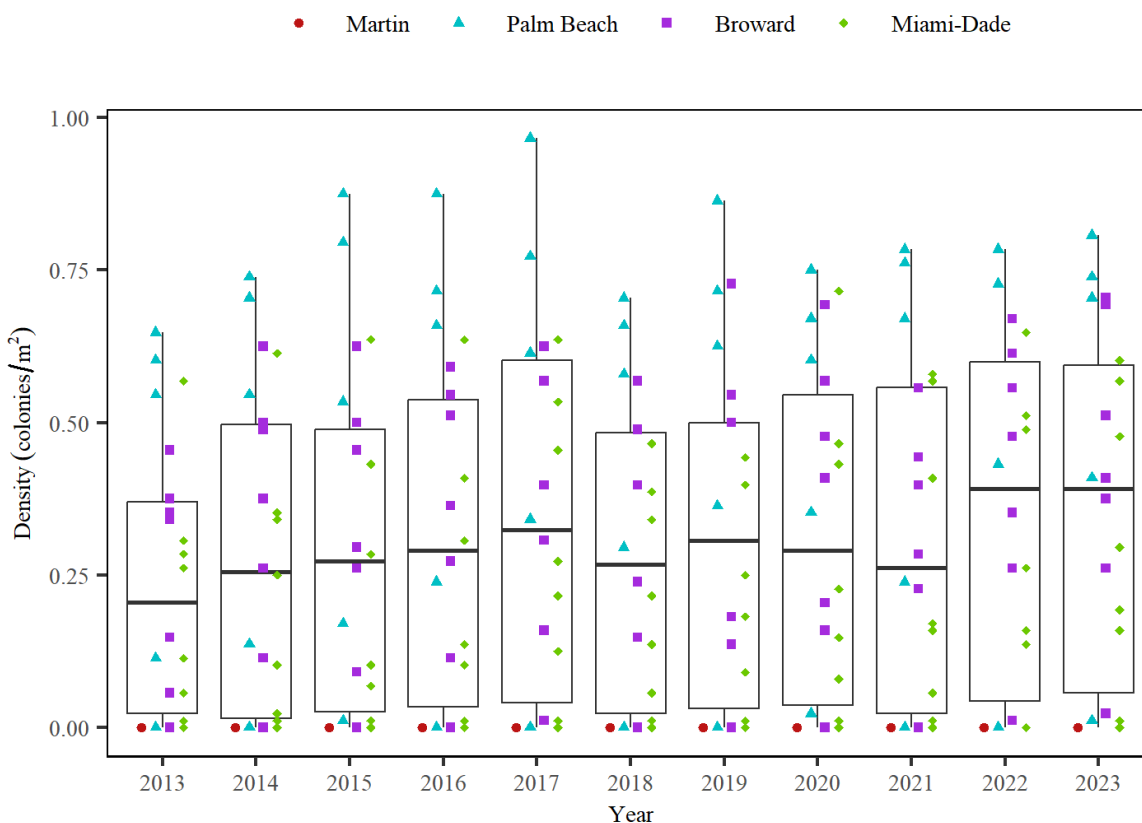


Figure 7. *Xestospongia muta* density (colonies/m²) across all sites from 2013-2023. See Figure 4 for boxplot explanation.

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 (2003-2022) was presented in the 2022 comprehensive report (Hayes et al. 2023).
- In 2023, stony coral percent cover averaged across all SECREMP sites was 1.08% (Figure 8). Region-wide stony coral cover did not significantly change from 2022 to 2023 but did decrease slightly from 1.21% in 2022. Stony coral cover did not significantly increase at any sites but did significantly decrease at one site; cover at BCA decreased from 2.97% in 2022 to 0.99% in 2023 (Table 7). No other sites experienced significant changes: stony coral cover was fairly consistent over time from 2022 to 2023.
- Region-wide octocoral cover significantly decreased from 2022 to 2023 from 8.44% to 8.02% (Figure 8). Octocoral cover significantly increased at one site, PB3, and significantly decreased at 5 sites, BC1, BCA, DC4, DC5, and DC7. Of note is that the sites with decreasing octocoral cover are all in the southernmost counties. While Martin County sites were not included in this analysis because octocorals are generally not present there, four of the five Palm Beach County sites increased in octocoral coverage, though only one (PB3) did so significantly.

- The largest increase in octocoral cover, at PB3, was from 14.48% in 2022 to 17.13% in 2023. The largest decrease in octocoral cover occurred at DC5, from 17.50% in 2022 to 13.30% in 2023, though other sites with significant declines in octocoral cover had similar changes in magnitude (Table 7).
- Changes in macroalgae cover were highly variable which is typical for this taxon and reflects the ephemeral nature of macroalgae. Region-wide macroalgae cover significantly decreased from 17.66% in 2022 to 16.00% in 2023. Six sites (BC1, BC6, BCA, DC5, DC7, PB1) significantly increased in macroalgae cover while eight sites (BC2, DC4, DC6, DC8, MC1, PB2, PB3, PB4) significantly decreased. Sites that significantly increased or decreased are spread throughout the SECREMP region; however, it is notable that four of the seven sites in the Palm Beach and Martin County subregions significantly decreased while only one site increased within these areas. The largest increase in macroalgae cover occurred at PB1 where cover increased from 4.60% in 2022 to 17.33% in 2023 and the largest decrease in octocoral cover occurred at DC6 where cover decreased from 46.88% to 27.88%. In general, decreases in macroalgae cover were greater in magnitude than increase in macroalgae cover (Table 7).
- Region-wide sponge cover did not significantly change, with values of 5.16% in 2022 and 5.20% in 2023 (Figure 8). One site, MC2, significantly increased in sponge cover. This site had the lowest sponge coverage of all sites in 2022, 0.82%. Cover increased at MC2 to 2.02% in 2023, the third lowest value during this survey year. Three sites significantly decreased in sponge cover, all in Miami-Dade County, DC2, DC5, and DC7. The largest decrease in sponge cover occurred at DC7 where cover decreased from 9.53% in 2022, the highest sponge cover of Miami-Dade County sites, to 6.58% in 2023, the second highest value for Miami-Dade County. Although not statistically significant, the largest increase in sponge cover occurred at PB4, from 10.52% in 2022 to 12.49% in 2023 (Table 7).

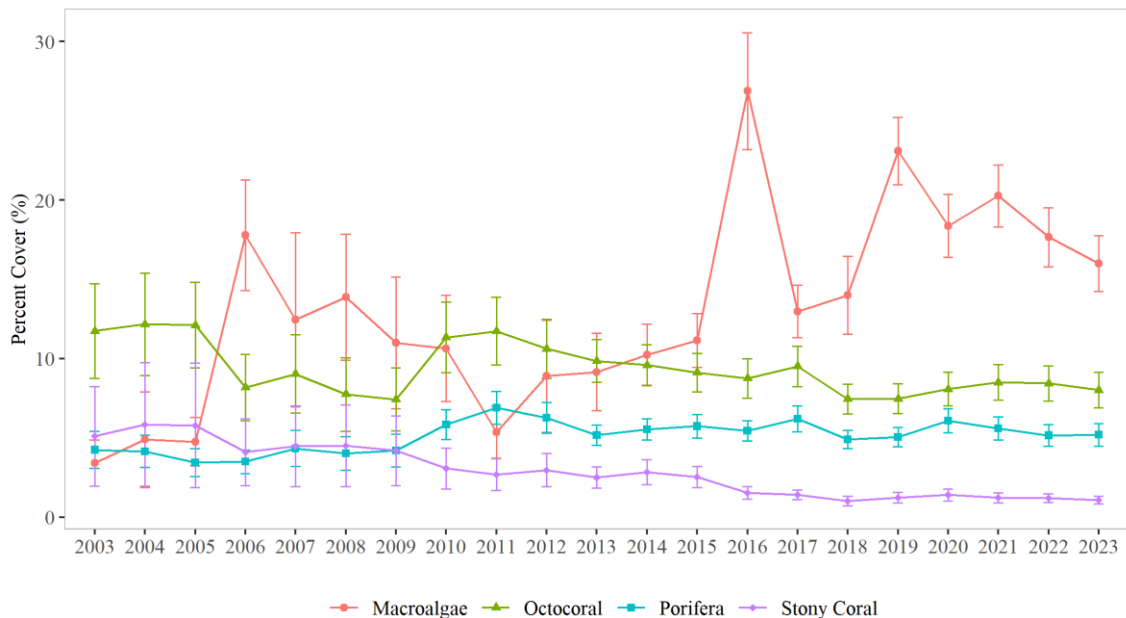


Figure 8. Mean (\pm SE) region-wide annual percent cover of stony coral, octocoral, sponge, and macroalgae (values for each year include all sites sampled that year).

Table 7. Mean (\pm SE) 2023 percent (%) benthic cover of stony coral, octocoral, sponge, and macroalgae. Bolded 2023 cover values with '+' are significantly greater than 2022 and cover values with '-' are significantly lower than 2022.

Site	Stony Coral	Octocoral	Sponge	Macroalgae
MC1	2.28 \pm 0.63	0.00 \pm 0.00	1.29 \pm 0.41	-13.32 \pm 2.67
MC2	0.19 \pm 0.04	0.00 \pm 0.00	+2.02 \pm 0.31	25.02 \pm 0.90
PB1	0.03 \pm 0.03	0.35 \pm 0.14	3.40 \pm 1.55	+17.33 \pm 2.05
PB2	1.21 \pm 0.19	15.94 \pm 2.91	5.08 \pm 0.71	-1.47 \pm 0.25
PB3	0.52 \pm 0.18	+17.13 \pm 0.91	12.57 \pm 0.78	-5.20 \pm 1.23
PB4	0.38 \pm 0.13	16.26 \pm 2.03	12.49 \pm 1.32	-2.50 \pm 0.59
PB5	0.98 \pm 0.25	13.22 \pm 0.85	10.48 \pm 0.94	13.88 \pm 2.58
BC1	5.31 \pm 0.30	-5.70 \pm 0.92	3.01 \pm 0.80	+27.99 \pm 2.70
BC2	0.39 \pm 0.09	5.09 \pm 0.54	5.43 \pm 0.77	-15.67 \pm 3.76
BC3	0.41 \pm 0.15	11.70 \pm 0.61	5.85 \pm 0.49	12.91 \pm 4.62
BC4	2.03 \pm 0.83	3.22 \pm 0.88	3.84 \pm 0.69	24.02 \pm 2.83
BC5	0.49 \pm 0.12	6.87 \pm 0.26	7.66 \pm 0.11	12.00 \pm 1.02
BC6	0.49 \pm 0.14	8.06 \pm 1.07	7.14 \pm 1.54	+16.20 \pm 4.36
BCA	-0.99 \pm 0.10	-0.81 \pm 0.86	1.27 \pm 0.78	+18.13 \pm 1.89
DC1	2.89 \pm 0.19	6.44 \pm 1.00	3.37 \pm 0.15	18.19 \pm 0.98
DC2	0.59 \pm 0.45	10.01 \pm 1.08	-3.66 \pm 0.26	19.36 \pm 3.07
DC3	0.31 \pm 0.07	10.55 \pm 0.39	4.89 \pm 1.23	5.25 \pm 5.81
DC4	0.80 \pm 0.12	-9.84 \pm 0.71	6.81 \pm 0.32	-11.89 \pm 7.84
DC5	0.81 \pm 0.55	-13.30 \pm 0.49	-2.70 \pm 0.28	+22.79 \pm 1.16
DC6	1.34 \pm 0.29	5.61 \pm 1.27	1.55 \pm 0.46	-27.88 \pm 5.47
DC7	0.52 \pm 0.07	-5.93 \pm 0.76	-6.58 \pm 0.48	+31.08 \pm 1.06
DC8	0.91 \pm 0.34	10.41 \pm 0.46	3.32 \pm 1.26	-9.91 \pm 4.74

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