

Florida Reef Resilience Program Disturbance Response Monitoring 2022 Quick Look Report

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This report presents data from annual summer surveys conducted between August 8 and November 4 of 2022.

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INTRODUCTION

The Florida Reef Resilience Program (FRRP) is a collaborative effort among local, state, and federal environmental managers, scientists, conservation organizations, and reef stakeholders to develop resilience-based management strategies for anticipating and addressing climate change and other stressors on Florida's Coral Reef (FCR). Prompted by the severe coral bleaching event in the Florida Keys in 2005, the FRRP developed the Disturbance Response Monitoring (DRM) program to annually assess reef condition during the months of peak thermal stress. Since 2005, the partners of the DRM program have documented the extent and severity of coral bleaching and disease along the reef tract.

The primary goals of the DRM program have always been to provide a condition report and the annual status of bleaching along the reef tract. This information is used to identify resilient areas of the reef, promote appropriate management or conservation strategies of reef areas based on resilience, and aid management in research and restoration decisions. In addition to the extensive dataset the DRM program provides, it offers the opportunity for partners from across the jurisdictions of FCR to work together under a unified effort. This collaboration across agencies, universities, and organizations allows for multiple sources of input and expertise, as well as generates transparency across managers and researchers. This type of collaboration is becoming more important as the threats to the reef continue to grow.

During its tenure, the DRM program has modified its experimental design to account for new disturbances and has specifically adapted its protocols in response to the outbreak of stony coral tissue loss disease (SCTLD). Now that the entire reef tract is epidemic (i.e., actively undergoing SCTLD at a high rate of infection) or endemic (i.e., the epidemic stage of SCTLD has concluded), an additional focus has been added to the goals of DRM to assess the surviving population of corals that were most susceptible to SCTLD. These data will aid in identifying reef areas resilient to SCTLD and capable of natural recovery, as well as impacted reef areas that can support restoration and recovery after SCTLD has subsided. To accommodate these new goals, DRM instituted several changes to the survey design beginning in the 2020 season and continued through the 2022 season. First, the survey area at each site was expanded from two to four belt transects. The two additional transects were specifically designed to target the species most affected by SCTLD, thus increasing the effort on locating these now rare individuals. Second, a juvenile census of the most SCTLD-susceptible coral families was added along all four transects. These data will provide an assessment of survivorship and/or the post-SCTLD recruitment of these susceptible coral species, which could determine whether recovery will occur broadly or locally along the reef.

During the 2022 season, 450 sites were surveyed throughout FCR, including a fourth year of surveys within the Marquesas. This accomplishment was possible due to the committed efforts of the 2022 partners, including Biscayne National Park, Broward County, Dry Tortugas National Park, Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, Islamorada Conservation and Restoration Education, John Pennekamp Coral Reef State Park, Keys Marine Laboratory, Miami-Dade County, Mote Marine Laboratory, National

Oceanic and Atmospheric Administration, Nova Southeastern University, Palm Beach Zoo, and University of Miami's Rosenstiel School of Marine and Atmospheric Science.

This summary report describes the prevalence of coral bleaching, paling, and disease in 2022 as historically assessed through the survey methodology employed by DRM. For the past two years, annual DRM Quick Look Reports included a temporal comparison of coral density and diameter for 10 SCTL D-susceptible coral species over a now 13-year period. These summaries provided insight into the impacts these species experienced due to SCTL D outbreaks. These comparisons are presented again with the 2022 data included, to update the continued impacts from SCTL D and assess any potential recovery. The 2022 DRM season marked the third year of a juvenile coral census for three SCTL D-susceptible (sub)families along all transects at a site. The species *Montastraea cavernosa* was added to the juvenile coral census in 2022. Results from all three years are presented in this report.

METHODS

The DRM program surveys coral populations using a probabilistic sampling design based on how corals are distributed spatially within and across different regions, subregions, and zones of FCR. Regions include Southeast Florida, Florida Keys, Marquesas, and Dry Tortugas. Reef zones were classified by cross-shelf position, distance from shore, and depth, while subregions were stratified latitudinally. The Southeast Florida region includes the Martin, Palm Beach, and Broward-Miami subregions and the Florida Keys region includes the Biscayne, Upper Keys, Middle Keys, and Lower Keys subregions. Each year, new sites are randomly selected from this spatial framework. This sampling design is applied to all regions except the Marquesas, where, due to its remote location, detailed benthic habitat maps are not available, and random site allocation is not possible. Instead, Marquesas sites in 2022 were selected in the same manner as in 2019-2021: chosen *a priori* based on known areas of hardbottom and reef habitat, where coral had been previously documented.

Surveys consisted of four independent 1 x 10 m belt transects that were haphazardly placed within a 50 x 50 m sample area. Transects 1 and 2 included surveys of all stony coral species ≥ 4 cm, while Transects 3 and 4 targeted a subset of 10 coral species (≥ 4 cm) known to be highly susceptible to SCTL D, including: *Colpophyllia natans*, *Dichocoenia stokesii*, *Diploria labyrinthiformis*, *Meandrina meandrites*, *Mussa angulosa*, *Mycetophyllia aliciae*, *Mycetophyllia ferox*, *Mycetophyllia lamarckiana*, *Pseudodiploria clivosa*, and *P. strigosa*. Juvenile corals (< 4 cm) belonging to three target (sub)families (Faviinae, Mussinae, Meandrinidae) and one species (*M. cavernosa*) were tallied for each of Transects 1-4.

At all sites, stony corals ≥ 4 cm were measured for size (maximum diameter and height), assessed for bleaching (whole or partial colony areas of complete color loss), or paling (a precursor to bleaching where coral color is lighter than normal), disease, and percent mortality. Percent mortality was assigned as either old mortality, recent mortality due to disease, or recent mortality due to other biotic or abiotic factors. If disease was the cause of recent mortality, surveyors described the rate of tissue loss spread and recorded the recognized disease, if known. The tissue

loss rate and SCTL D disease code (STL) were adopted into the data collection in 2018 to better identify and describe lesions associated with SCTL D.

Prevalence values for bleaching (whole plus partial bleaching), the combination of bleaching and paling, and disease were calculated by pooling coral data across Transects 1 and 2 at each site and by zone within each subregion. Prevalence values represent the percent of corals affected along Transects 1 and 2 within a site or zone population. Prevalence values were compared across zones and subregions to identify spatial differences in coral bleaching and paling, as well as spatial patterns in disease prevalence.

Paling is included in a separate prevalence analysis, which combines bleaching and paling, because any visible loss of color indicates significant stress on a coral colony. It is advised, however, that paling results be interpreted with caution, due to the subjectivity inherent in how surveyors across the wide range of DRM partners interpret variations in coral color in the field.

Density values for the 10 target SCTL D-susceptible coral species and the target juvenile coral families and species were calculated by pooling the total count across all four transects and dividing by 40m. The density for all sites and for each of the target adult coral species was averaged for each region (Southeast Florida, Florida Keys, Marquesas, and Dry Tortugas) and then compared across the past 12 years of DRM summer survey data (i.e., excluding targeted survey efforts such as post-Hurricane Irma or winter surveys). Mean maximum diameter for each of the target adult coral species was calculated similarly to density and compared across the past 12 years of DRM summer survey data. Mean density values of the target juvenile families were calculated by region.

RESULTS

A total of 450 sites were surveyed across the nine subregions of FCR during the 2022 DRM season (**Table 1**). Fourteen sites were surveyed in Martin County, 30 in Palm Beach, 114 in Broward-Miami, 31 in Biscayne, 63 in the Upper Keys, 41 in the Middle Keys, 88 in the Lower Keys, 20 in the Marquesas, and 49 in the Dry Tortugas. The total number of sites surveyed in each subregion across all historic DRM summer survey events is presented in **Table 1**.

Table 1. Total number of sites surveyed in each subregion for all DRM summer survey events (2005-2022).

Year	Martin	Palm Beach	Broward-Miami	Biscayne	Upper Keys	Middle Keys	Lower Keys	Marquesas	Dry Tortugas	Total
2005	3	3	25	14	17	8	25			95
2006	6	2	25	29	29	10	20			121
2007		11	25	25	24	13	31	6	14	149
2008	6	7	50	25	42	31	43			204
2009	6	12	45	42	44	24	48		36	257
2010	6	8	44	32	44	22	44			200
2011	6	6	37	43	55	31	54		5	237
2012	6	3	32	31	58	29	34		41	234
2013		4	12	26	21	16	21			100
2014	2	6	34	19	25	17	42		29	174
2015	6	8	80	28	23	21	63		20	249
2016	6	7	26	9	13	32	40		29	162
2017			23			5	15		31	74
2018		3	47	22	33	11	29		50	195
2019		15	67	15	37	18	54	31	48	285
2020	13	20	83	10	38	32	85	47	61	389
2021	6	29	70	34	50	26	74	35	54	378
2022	14	30	114	31	63	41	88	20	49	450
Total Summer Survey Sites										3953

The prevalence of colonies along Transects 1 and 2 that were bleached (partially or fully bleached) or were bleaching and/or paling (combined), was pooled by zones (**Figures 1 and 2**) and by sites (**Tables 2 and 3**) within each subregion. Prevalence values were broken into three categories: mild (0-20%), moderate (21-50%), and severe (>50%). Pooled by subregion-zone, the prevalence of bleached and partially bleached corals (excluding pale colonies) was mild through the Dry Tortugas, Marquesas, Lower Keys and Middle Keys (**Figure 1**). Moderate bleaching occurred on the Forereef and Offshore Patch Reefs in the Upper Keys and Biscayne. In Southeast Florida, moderate bleaching occurred on the Inner, Middle and Outer Reefs of the Broward-Miami subregion. Further north in Palm Beach and Martin County, the Deep Ridge Complex and Nearshore Reef had severe bleaching, respectively. Severe bleaching in Palm Beach and Martin was mostly driven by the sites dominated by *Siderastrea siderea* and *S. radians*. Pooled by site, 132 sites had moderate bleaching and 16 had severe bleaching (**Table 2**). The number of sites with moderate and severe bleaching in 2022 substantially increased from 2021, where no sites had severe bleaching and only 16 sites had moderate bleaching.

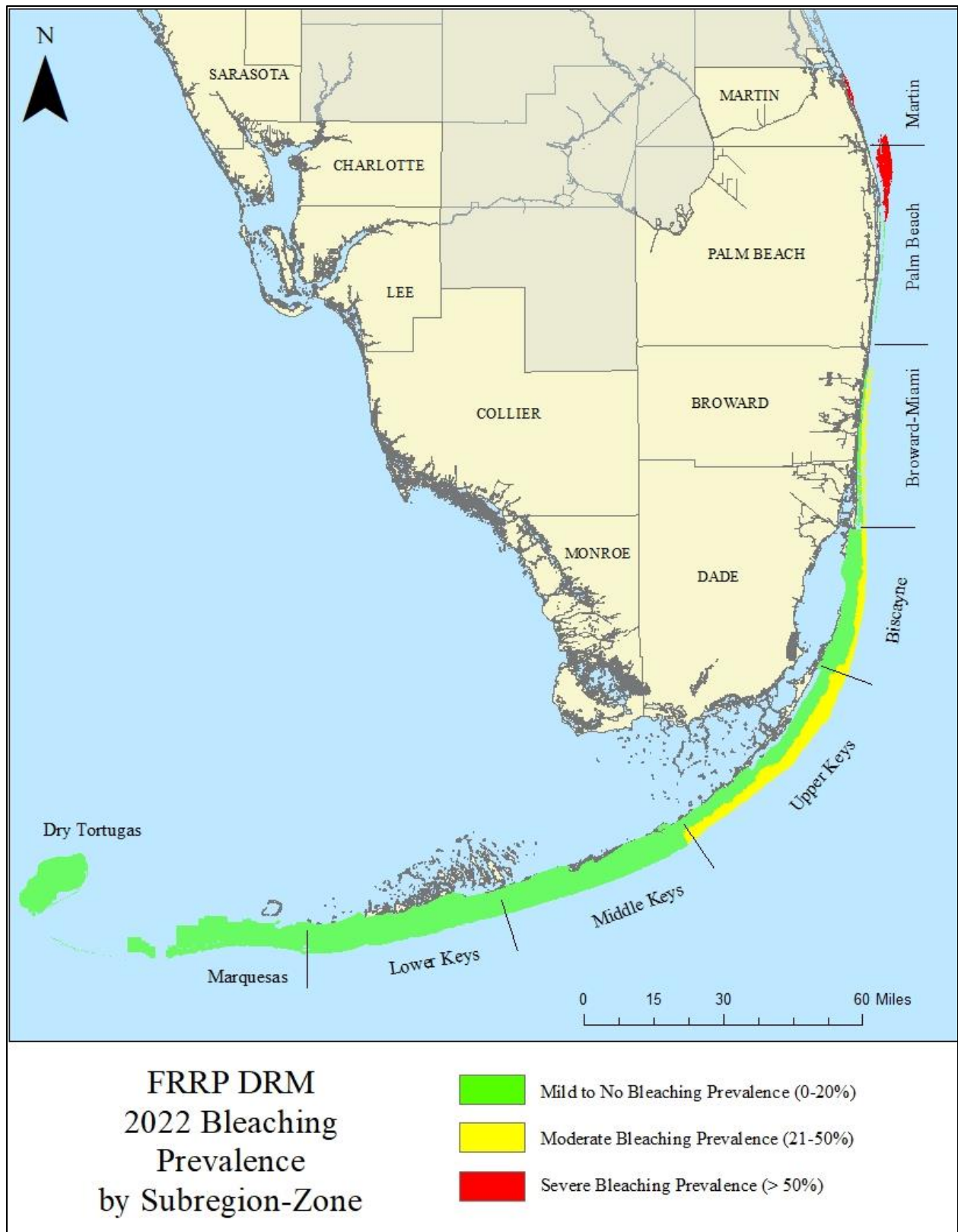


Figure 1. Bleaching prevalence of surveyed coral colonies by subregion-zone.

Table 2. Total number of sites within each subregion recorded with mild, moderate, or severe bleaching prevalence of coral colonies.

Subregion	Mild (0-20%)	Moderate (21-50%)	Severe (>50%)
Martin	4	5	5
Palm Beach	19	8	3
Broward-Miami	58	51	5
Biscayne	17	13	1
Upper Keys	36	26	1
Middle Keys	36	5	0
Lower Keys	84	4	0
Marquesas	17	3	0
Dry Tortugas	31	17	1
Total Sites	302	132	16

When paling was included within the bleaching analysis, prevalence values rose to moderate (21-50%) in 70% of the subregion-zones surveyed in 2022 (**Figure 2**). When corals are pooled by subregion-zone, all zones of the Dry Tortugas, Marquesas, and Broward-Miami had moderate bleaching and paling. Again, the Nearshore zone of Martin County and the Deep Ridge of Palm Beach experienced severe bleaching and paling. From the Lower Keys up through Biscayne, the forereef zone was moderately bleached, along with the midchannel patch reef and offshore patch reef zones within the Middle Keys and Biscayne subregions. Overall, bleaching and paling was substantially worse in 2022 compared to the past several years, especially on the outer reef zones.

Across sites, 90 experienced severe bleaching and paling and 218 sites experienced moderate bleaching and paling, totaling almost 70% of the sites surveyed in 2022 (**Table 3**). In the Broward-Miami subregion 75% of the surveyed sites were severely or moderately bleached and pale. Images of coral species recorded as bleaching or paling in Broward-Miami are provided in **Figure 3**.

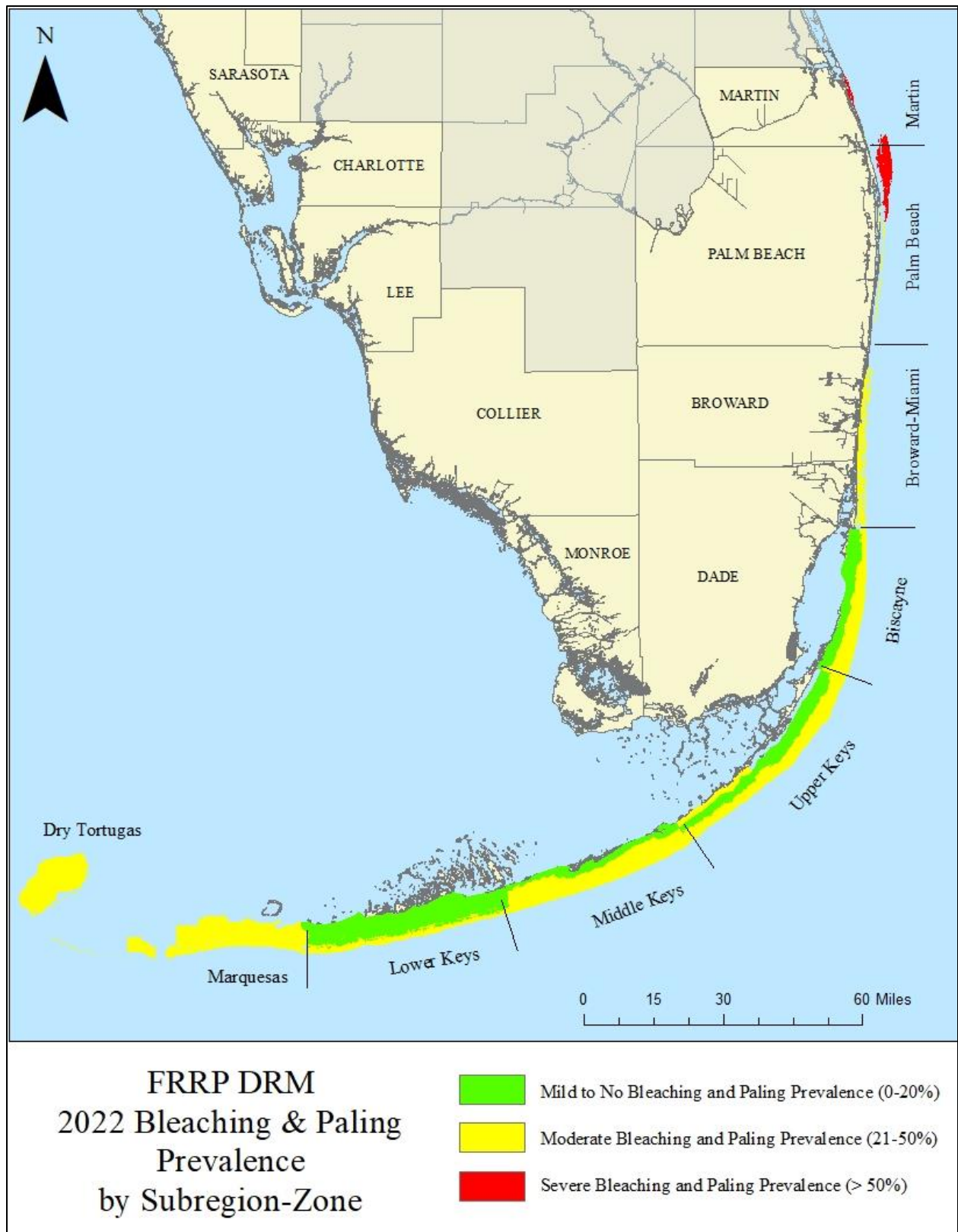


Figure 2. Bleaching and paling prevalence of surveyed coral colonies by subregion-zone.

Table 3. Total number of sites within each subregion recorded with mild, moderate, or severe bleaching and paling prevalence of coral colonies.

Subregion	Mild (0-20%)	Moderate (21-50%)	Severe (>50%)
Martin	1	3	10
Palm Beach	3	19	8
Broward-Miami	29	55	30
Biscayne	13	11	7
Upper Keys	18	25	20
Middle Keys	16	21	4
Lower Keys	53	31	4
Marquesas	3	17	0
Dry Tortugas	6	36	7
Total Sites	142	218	90

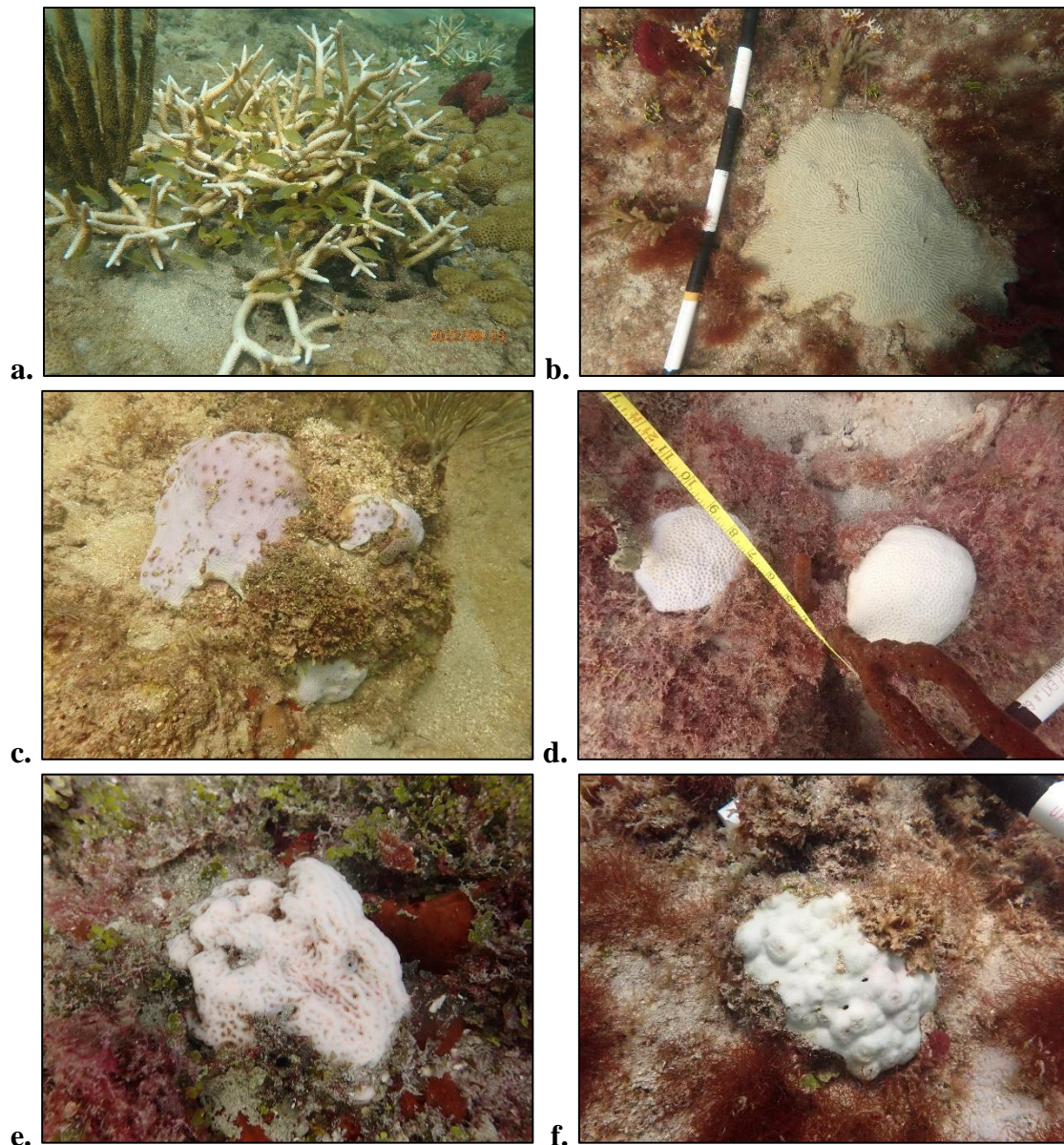


Figure 3. Images of bleached, partially bleached, and pale colonies in the Broward-Miami subregion. **a.** pale *Acropora cervicornis* off Broward County (photo credit: Mark Hartman of Broward County), **b.** pale *P. clivosa* off Miami-Dade County (photo credit: Miami-Dade County DERM, photos b-f), **c.** bleached *S. siderea*, **d.** bleached *S. siderea* colonies, **e.** bleached *A. agaricites*, and **f.** bleached *Porites astreoides*.

The prevalence of disease along Transects 1 and 2 was pooled by zones (**Figure 4**) and by sites (**Table 4**) within each subregion. Prevalence values were broken into four categories: no tissue loss disease (0%), low (>0-5%), medium (6-10%), and high (>10%). Disease prevalence values were calculated only from diseases that result in tissue loss and, therefore, do not include Dark Spot Syndrome or other discoloration conditions. Pooled by zone within each subregion, all disease prevalence values were either zero or low (**Figure 4**). When disease prevalence was analyzed by site, only 15 of the 450 surveyed sites had medium disease prevalence and four had

high disease prevalence. The nine sites with medium disease prevalence and 2 sites with high disease prevalence were located in the Dry Tortugas, where SCTLD is still epidemic and made up 85% of tissue loss disease cases. The Lower Keys subregion had the highest number of sites with low disease prevalence.

Across FCR, 102 corals were recorded with SCTLD (**Table 5**). This number is less than a third of the total colonies recorded in 2021 (323 total colonies) with the disease. From Southeast Florida down through the Marquesas, only 29 corals were recorded with SCTLD. In the Dry Tortugas, 73 corals were recorded with SCTLD; however, this was far less than the 226 corals recorded with the disease during the 2021 DRM survey. As seen in 2020 and 2021, *M. cavernosa*, *S. siderea*, and *Orbicella faveolata* were among the coral species with the highest SCTLD prevalence. All three of these species are highly abundant in most habitats of FCR, and colonies typically display sub-acute to chronic rates of lesion progression when affected with SCTLD. As a result, there is an increased likelihood of finding colonies of these species affected with SCTLD. Across the reef tract, thirteen different species were recorded with the disease.



Figure 4. Tissue loss disease prevalence of surveyed coral colonies by subregion-zone.

Table 4. Total number of sites within each subregion recorded with low, medium, or high disease prevalence.

Subregion	None (0%)	Low (>0-5%)	Medium (6-10%)	High (>10%)
Martin	14	0	0	0
Palm Beach	30	0	0	0
Broward-Miami	98	9	5	2
Biscayne	29	2	0	0
Upper Keys	56	7	0	0
Middle Keys	36	5	0	0
Lower Keys	59	28	1	0
Marquesas	15	5	0	0
Dry Tortugas	26	12	9	2
Total Sites	363	68	15	4

Table 5. Total number of colonies of each species observed with SCTLD in each subregion. Only those subregions where SCTLD was observed are listed.

Species	Biscayne	Broward-Miami	Upper Keys	Middle Keys	Lower Keys	Marquesas	Dry Tortugas	Total per species
<i>Agaricia agaricites</i>	0	0	0	1	0	0	0	1
<i>Colpophyllia natans</i>	0	0	0	0	0	0	3	3
<i>Dichocoenia stokesii</i>	1	0	0	0	0	0	1	2
<i>Diploria labyrinthiformis</i>	0	0	0	0	0	1	0	1
<i>Montastraea cavernosa</i>	0	0	1	0	2	0	26	29
<i>Orbicella annularis</i>	0	0	2	0	0	0	0	2
<i>Orbicella faveolata</i>	0	3	0	0	5	1	11	20
<i>Orbicella franksi</i>	0	0	0	0	0	1	8	9
<i>Porites astreoides</i>	0	0	0	1	0	0	1	2
<i>Pseudodiploria strigosa</i>	0	0	0	0	0	0	5	5
<i>Siderastrea siderea</i>	0	1	0	3	2	0	18	24
<i>Solenastrea bournoni</i>	0	1	0	0	0	0	0	1
<i>Stephanocoenia intersepta</i>	0	1	0	0	0	2	0	3
Total colonies per Subregion	1	6	3	5	9	5	73	102

Other tissue loss diseases recorded along DRM transects in 2022 were Black Band Disease (21 colonies), White Plague Disease (2 colonies), White Band Disease (7 colonies of *Acropora cervicornis*), and Rapid Tissue Loss (three *A. cervicornis* colonies).

In the DRM program, a disease condition is described as “Unknown” if the symptoms do not fall under any of the defined coral disease descriptions. Across the reef tract, 54 colonies were recorded with unknown coral disease. The Lower Keys had the most observations, with 27 colonies recorded with unknown coral disease. All other subregions had less than 10 colonies recorded with unknown coral disease.

ADULT TARGET CORAL SPECIES

Now that the entirety of FCR is classified as endemic or epidemic for SCTLD, it is important to assess the population status of the coral species most susceptible to SCTLD. Starting in 2020, DRM extended the survey area at each site by adding two belt transects specifically designed to target 10 of the most SCTLD susceptible species (**Table 6**). This resulted in four, 1 x 10m transects per site (40m² total survey area per site for these species). This level of effort was maintained in 2021 and 2022 to strengthen the estimates for calculating density changes and increase the survey area for recording juveniles.

Density for each target species was calculated by summing the species count across all four transects at each site. The mean density and maximum diameter for each species were then averaged across all sites within each region (Southeast Florida, Florida Keys, Marquesas, and Dry Tortugas; **Figures 5-11**).

The mean density of adult target species in the Faviinae subfamily (*C. natans*, *D. labyrinthiformis*, *P. clivosa*, and *P. strigosa*) in 2022 were lowest in Southeast Florida and highest in the Florida Keys, except for *P. strigosa*, which had higher densities in the Dry Tortugas (**Table 6**). For *C. natans* and *D. labyrinthiformis*, density values in the Dry Tortugas were similar to those in the Marquesas. *Pseudodiploria strigosa* had the highest density in the Dry Tortugas among all target species in all regions; however, this was still the lowest density value for *P. strigosa* since 2017 in the Dry Tortugas.

The mean density of adult target species in the Meandrinidae family (*D. stokesii* and *M. meandrites*) in 2022 was relatively high in Southeast Florida compared to the other target species in that region (**Table 6**). *Meandrina meandrites* had the highest density in Southeast Florida among the target species but the second lowest mean maximum diameter after *D. stokesii*. *Dichocoenia stokesii* had the highest density in the Florida Keys and Marquesas among all the target species, while *M. meandrites* density values were relatively low in the Florida Keys, Marquesas, and Dry Tortugas.

Among the target species in the Mussinae subfamily, only *M. aliciae* and *M. lamarkiana* were recorded in all four regions during the 2022 survey (**Table 6**). *Mycetophyllia ferox* was only recorded in the Florida Keys (6 colonies) and *M. angulosa* was only recorded in the Florida Keys (4 colonies) and Dry Tortugas (1 colony). *Mycetophyllia aliciae* was the most abundant of the Mussinae target species, with its largest density recorded in the Marquesas in 2022.

Table 6. Mean (\pm SE) density of the 10 target SCTLD-susceptible species in each region in 2020, 2021, and 2022.

Target Species	Year	SE Florida	Florida Keys	Marquesas	Dry Tortugas
<i>Colpophyllia natans</i>	2020	0.003 \pm 0.001	0.02 \pm 0.005	0.016 \pm 0.004	0.055 \pm 0.008
	2021	0.001 \pm 0	0.016 \pm 0.003	0.011 \pm 0.003	0.063 \pm 0.013
	2022	0.002 \pm 0.001	0.023 \pm 0.004	0.009 \pm 0.003	0.01 \pm 0.004
<i>Dichocoenia stokesii</i>	2020	0.014 \pm 0.003	0.032 \pm 0.003	0.028 \pm 0.004	0.04 \pm 0.005
	2021	0.017 \pm 0.003	0.04 \pm 0.005	0.029 \pm 0.005	0.039 \pm 0.008
	2022	0.018 \pm 0.002	0.036 \pm 0.003	0.028 \pm 0.005	0.011 \pm 0.003
<i>Diploria labyrinthiformis</i>	2020	0.003 \pm 0.001	0.009 \pm 0.001	0.009 \pm 0.002	0.018 \pm 0.003
	2021	0.002 \pm 0.001	0.013 \pm 0.002	0.004 \pm 0.002	0.018 \pm 0.003
	2022	0.002 \pm 0.001	0.014 \pm 0.002	0.011 \pm 0.005	0.01 \pm 0.003
<i>Meandrina meandrites</i>	2020	0.012 \pm 0.002	0.003 \pm 0.001	0.012 \pm 0.003	0.054 \pm 0.008
	2021	0.018 \pm 0.003	0.004 \pm 0.001	0.009 \pm 0.003	0.051 \pm 0.008
	2022	0.022 \pm 0.003	0.003 \pm 0.001	0.001 \pm 0.001	0.006 \pm 0.002
<i>Mussa angulosa</i>	2020	0 \pm 0	0.002 \pm 0.001	0.004 \pm 0.002	0.005 \pm 0.001
	2021	0 \pm 0	0.002 \pm 0.001	0.001 \pm 0.001	0.003 \pm 0.001
	2022	0 \pm 0	0 \pm 0	0 \pm 0	0.001 \pm 0.001
<i>Mycetophyllia aliciae</i>	2020	0.001 \pm 0	0.004 \pm 0.001	0.014 \pm 0.004	0.015 \pm 0.003
	2021	0.004 \pm 0.001	0.003 \pm 0.001	0.011 \pm 0.003	0.018 \pm 0.004
	2022	0.004 \pm 0.001	0.004 \pm 0.001	0.015 \pm 0.005	0.005 \pm 0.002
<i>Mycetophyllia ferox</i>	2020	0 \pm 0	0 \pm 0	0 \pm 0	0.002 \pm 0.001
	2021	0 \pm 0	0 \pm 0	0 \pm 0	0 \pm 0
	2022	0 \pm 0	0.001 \pm 0	0 \pm 0	0 \pm 0
<i>Mycetophyllia lamarckiana</i>	2020	0 \pm 0	0.002 \pm 0.001	0.002 \pm 0.001	0.002 \pm 0.001
	2021	0 \pm 0	0.001 \pm 0.001	0 \pm 0	0.003 \pm 0.002
	2022	0 \pm 0	0.002 \pm 0.001	0.001 \pm 0.001	0.001 \pm 0.001
<i>Pseudodiploria clivosa</i>	2020	0.003 \pm 0.001	0.004 \pm 0.001	0.001 \pm 0.001	0.006 \pm 0.002
	2021	0.004 \pm 0.001	0.006 \pm 0.002	0 \pm 0	0.006 \pm 0.002
	2022	0.004 \pm 0.001	0.007 \pm 0.002	0 \pm 0	0.004 \pm 0.002
<i>Pseudodiploria strigosa</i>	2020	0.004 \pm 0.001	0.014 \pm 0.002	0.032 \pm 0.006	0.061 \pm 0.011
	2021	0.01 \pm 0.002	0.016 \pm 0.003	0.013 \pm 0.005	0.107 \pm 0.027
	2022	0.008 \pm 0.001	0.019 \pm 0.003	0.021 \pm 0.007	0.048 \pm 0.007

Despite the spread of SCTLD to the Dry Tortugas in May of 2021, regional density values between 2020 and 2021 were similar (**Table 6**). These similarities were likely due to SCTLD having only arrived in the Dry Tortugas four months prior to the 2021 DRM survey event in September. Density values in 2022, however, were lower than the previous two years for all target species, likely due to the disease. In 2021, nearly all adult target species were more abundant in the Dry Tortugas than in the Marquesas, Florida Keys or Southeast Florida. In 2022, abundance in the Dry Tortugas was similar to those in the Florida Keys or Marquesas regions. The total number of colonies recorded with SCTLD was much lower in 2022 compared to 2021, likely due to the loss in abundance of highly susceptible species.

In the 2020 and 2021 DRM Summer Quick Look Reports, mean density and mean maximum diameter values were summarized for 11 and 12 years (2010-2021) of DRM data within each region to evaluate the impacts from SCTLD on each target species. The 2022 mean density and mean maximum diameter values were incorporated into the time series figures and are included as **Figures 5** through **11** in this report.

If less than 10 total colonies of any of the 10 target species were recorded for a majority of the 13 survey years within a region, that species or species complex was omitted from the time series for that corresponding region. Abundance values of *M. angulosa* were too low across all regions and survey years and was therefore omitted for all regions. *Mycetophyllia* spp. (*M. aliciae*, *M. ferox*, and *M. lamarckiana*) were pooled together due to the low total colony counts for each species in each region. In Southeast Florida, *C. natans*, *D. labyrinthiformis*, and *P. clivosa* were also omitted from the time series comparison because of low abundance values. In the Marquesas, *D. labyrinthiformis* and *P. clivosa* were also omitted. As a result, **Figures 5** through **11** plot the mean density (primary Y axis, columns) and mean maximum diameter (secondary Y axis, lines) for six target species and *Mycetophyllia* spp. complex across the survey years (X axis). While low abundance of some species will limit statistical appraisals of changes in abundance, the graphs are provided for general reference to aid in understanding the impacts of SCTLD and assess the status of heavily impacted species. Density values from 2020, 2021, and 2022 were calculated from four 1 x 10m transects; for prior years, data are from two 1 x 10m transects.

There are some years in which DRM was not executed in all regions of FCR. In the Dry Tortugas, DRM data was not collected in 2010, 2011, and 2013. Due to the impacts of Hurricane Irma in the Florida Keys, the 2017 survey effort did not employ the traditional stratified sampling design; therefore, these data were omitted from the time series in the Florida Keys region. Finally, DRM monitoring in the Marquesas began in 2019, providing only four years of data.

Southeast Florida

SCTLD was first documented in Southeast Florida in 2014 off Miami-Dade County and spread throughout the region over the next two years. Of the target SCTLD-susceptible coral species, only *D. stokesii*, *M. meandrites*, and *P. strigosa* had sufficient abundance values across the 13 survey years to interpret SCTLD impacts (**Figures 6**, **8**, and **11** respectively). The most abrupt changes in mean density and maximum diameter for these three species occurred between 2014 and 2016. These changes coincided with the epidemic stage of SCTLD in Southeast Florida, when the disease first hit this region and resulted in high disease prevalence and coral mortality. The most significant impacts of the disease were apparent two to three years after the beginning of the epidemic stage, establishing a new post-SCTLD baseline in 2017 for these species in Southeast Florida. Therefore, the 2022 survey in Southeast Florida marked the fifth assessment after the post-SCTLD baseline.

Among the target coral species in the Meandrinidae family, both *D. stokesii* and *M. meandrites* underwent a decline in mean density and maximum diameter between 2015 and 2017 (**Figures 6** and **8**). Since their initial decline caused by SCTLD, both species have experienced steady

increases in density while diameter has remained relatively constant. This suggests that both species are recruiting and juvenile colonies are surviving.

Density and maximum diameter of *P. strigosa* in Southeast Florida has been variable across survey years. There was a marked decline in density starting in 2015 and the values have remained similar through 2022. Maximum diameter, however, is experiencing a declining trend, indicative of the loss of larger colonies over time.

Florida Keys

SCTLD first spread into the Biscayne and Upper Florida Keys subregions during the winter of 2016. It then progressed west through the Middle Keys and reached the Lower Keys subregion in 2018. Because the progression of SCTLD took several years to move through the Florida Keys, the reductions in mean density for the target species were evident over multiple years. The most pronounced disease impacts occurred between 2017 and 2020, when SCTLD was in the epidemic stage in the Middle and Lower Keys. The entirety of the Florida Keys is now considered endemic, but the timeline for establishing post-SCTLD baselines varies depending on subregion (e.g., the Upper Florida Keys post-SCTLD baseline begins after 2017 whereas the Lower Florida Keys began in 2021). The losses associated with SCTLD are clearly visible in the mean density changes over the last 13 years (excluding the 2017 Irma dataset) for six of the target species (*C. natans*, *D. labyrinthiformis*, *D. stokesii*, *M. meandrites*, *P. clivosa*, and *P. strigosa*; **Figures 5-8, 10-11**). For all six species, the lowest mean density was recorded in either 2020 or 2021.

Across all target species with sufficient density values for interpretation, populations in the Florida Keys are beginning to stabilize, as density values are either unchanged over the past two years or slowly increasing. Among the target coral species in the Faviinae subfamily (*C. natans*, *D. labyrinthiformis*, *P. clivosa*, and *P. strigosa*), all experienced increases in density from 2021 to 2022. Mean maximum diameter also increased among the target members of Faviinae in the Florida Keys except for *D. labyrinthiformis*, which declined to its lowest value recorded over the past 13 years. These low values indicate that some juvenile *D. labyrinthiformis* colonies may be growing beyond the 4cm threshold, which would lower the average mean max diameter. In addition, the density values of *D. labyrinthiformis* are approaching values similar to those prior to the epidemic phase of SCTLD, which also suggests the survival of juvenile colonies reaching the 4cm threshold.

Density values of target coral species in the Meandrinidae family (*D. stokesii* and *M. meandrites*) have remained stable at relatively low values since 2020. Maximum diameter for both species is also stabilizing around 10cm. This value is close to the pre-SCTLD values for *D. stokesii* but an almost 15cm drop for *M. meandrites* from values prior to the initial impacts from SCTLD.

Due to their low abundance, *Mycetophyllia* spp. (*M. aliciae*, *M. ferox*, and *M. lamarckiana*) in the Keys were pooled together to calculate mean density and mean maximum diameter. From 2012 to 2022, the mean density of *Mycetophyllia* spp. in the Florida Keys has been relatively consistent (**Figure 9**), suggesting that SCTLD impacts were minimal or difficult to detect compared to other susceptible species. Mean density in 2021, however, was the lowest value

recorded over the previous 12 survey years, while mean maximum diameter was the highest value recorded.

Marquesas

Surveys in the Marquesas region began in 2019 to track the western movement of SCTL D towards the Dry Tortugas. During the 2019 survey event, SCTL D had not yet been identified in the region; however, the disease was at the westernmost extent of the Lower Keys subregion boundary at that time. During the survey in 2020, the disease had spread across the entire extent of the Marquesas. The 2021 and 2022 survey events represent the one and two-year post-epidemic stage in the Marquesas.

From 2019 to 2021, declines in density of the target species were ongoing except for *D. stokesii*, which has remained mostly stable from 2020 to 2022 after its initial decline between 2019 and 2020 (**Figure 6**). *Colpophyllia natans* and *M. meandrites* continued to decline in density and diameter from 2021 to 2022, with their lowest values recorded in 2022 in the Marquesas (**Figures 5 and 8**).

Mycetophyllia spp. and *P. strigosa* had their lowest densities and diameters in 2021 in the Marquesas region (**Figures 9 and 11**). In 2022, both *Mycetophyllia* spp. and *P. strigosa* increased in density and diameter but were still well below their pre-epidemic density values.

Dry Tortugas

Prior to the 2021 DRM surveys within the Dry Tortugas, National Park Service staff identified SCTL D along the eastern side of the park, approximately two miles east of Garden Key in May 2021 (C. Pollock, personal communication, June 1, 2021). During the five months between the first observation reported and the DRM cruise, SCTL D spread quickly throughout much of the park. When the DRM surveys were conducted in September of 2021, SCTL D was recorded at 33 of the 54 sites surveyed, covering the east, west, south, and central portions of the park. Of the target colonies, *D. stokesii* had the highest rate of infection, with 32% of recorded colonies observed with SCTL D lesions, followed by *M. meandrites* at 25%. During the 2021 survey event, however, mean density and mean maximum diameter of the target species in the Dry Tortugas were relatively consistent with previous years. This was because most colonies with active infections still had some live tissue remaining and were therefore included in the mean density and maximum diameter summaries (**Figures 5-11**).

Across all target species, the density values recorded in 2022 were the lowest ever recorded across the 10 survey years, except for *P. strigosa* in 2012 and 2017. Among the hardest hit by the disease were *C. natans*, *M. meandrites*, and *Mycetophyllia* spp., which all declined to less than a third of their density values recorded in 2021. Maximum diameter also declined among all the target species, except for *C. natans* and *P. clivosa*. *C. natans* experienced an increase in maximum diameter, presumably due to the larger colonies remaining in the population that had not yet completely succumbed to the disease. Of the *C. natans* colonies recorded in the Dry Tortugas in 2022, all colonies over 100cm in diameter were recorded with SCTL D.

The density of *P. clivosa* has been variable over the past 10 survey years but relatively lower over the past three years. This suggests that something else besides SCTL D may have impacted

P. clivosa colonies in the Dry Tortugas between 2019 and 2020. The lower density values may also be a relic of the sampling design, where lagoon habitats are sampled less than the forereef due to smaller spatial coverage. *Pseudodiploria clivosa* are more commonly found in the lagoon habitats within the Dry Tortugas where only 12 sites were surveyed in 2022 compared to the 37 forereef sites surveyed. Mean maximum diameter was likely also variable over the past three years due to the low colony counts.

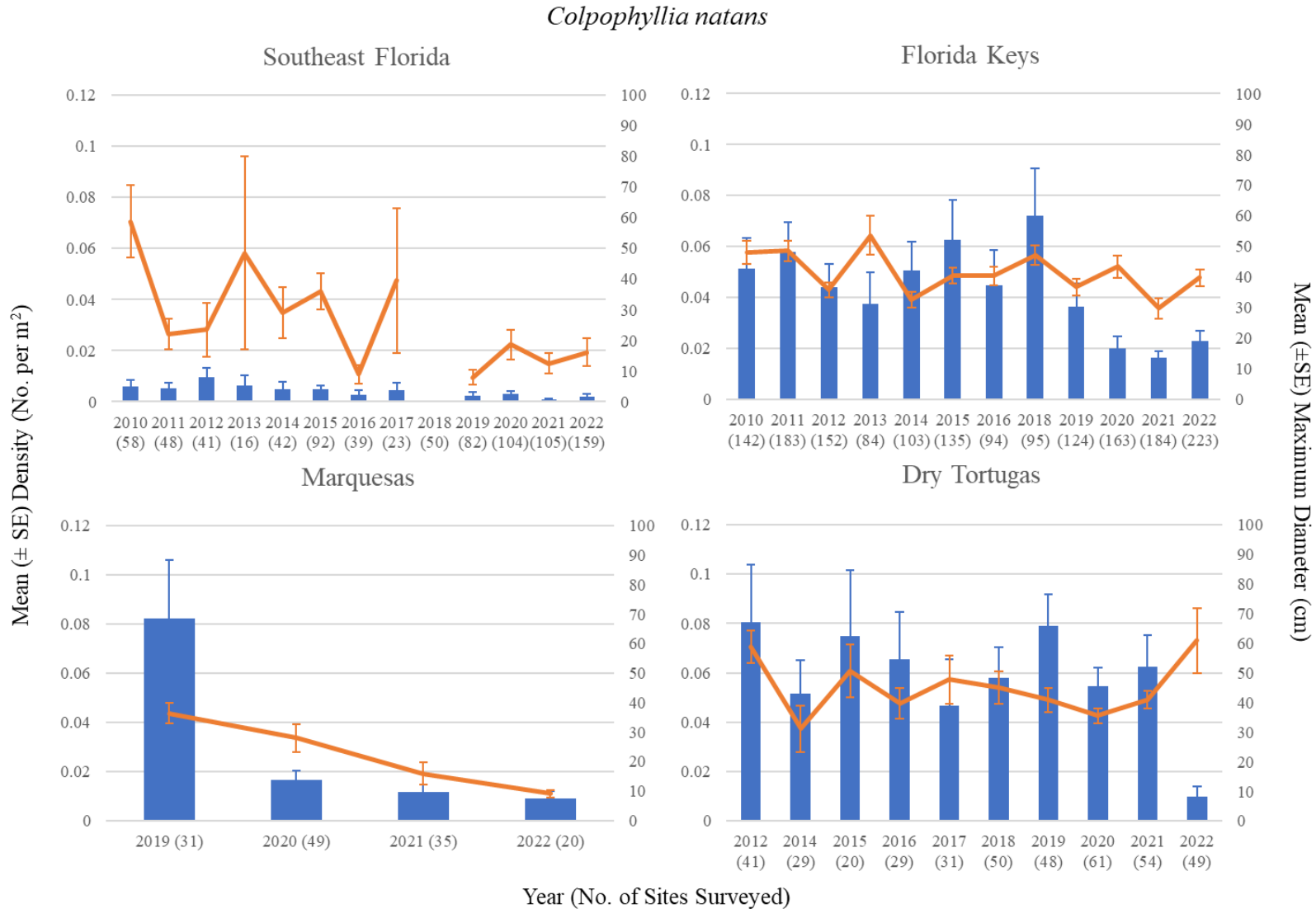


Figure 5. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Colpophyllia natans* across the four regions for each survey year.

Dichocoenia stokesii

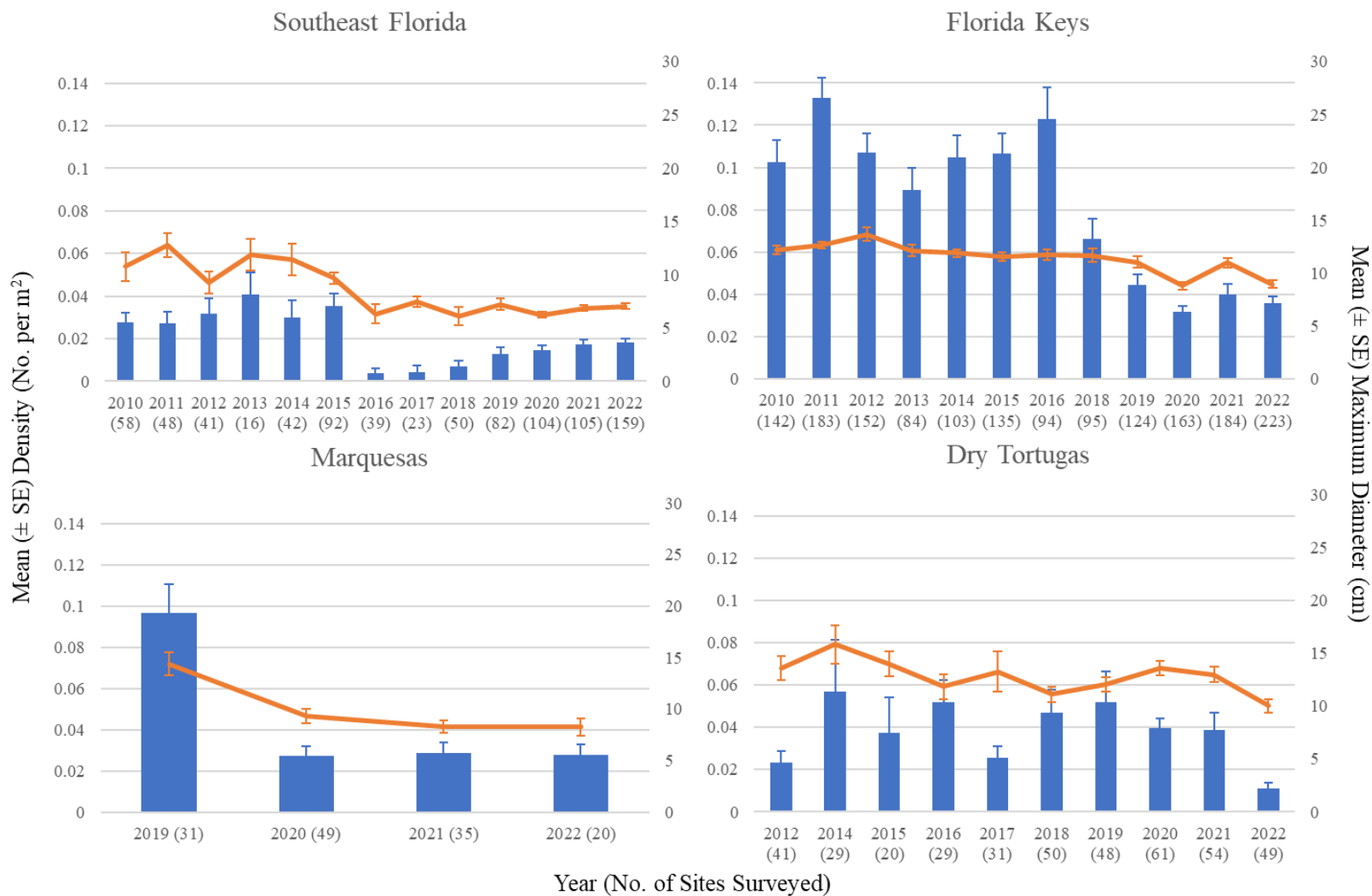


Figure 6. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Dichocoenia stokesii* across the four regions for each survey year.

Diploria labyrinthiformis

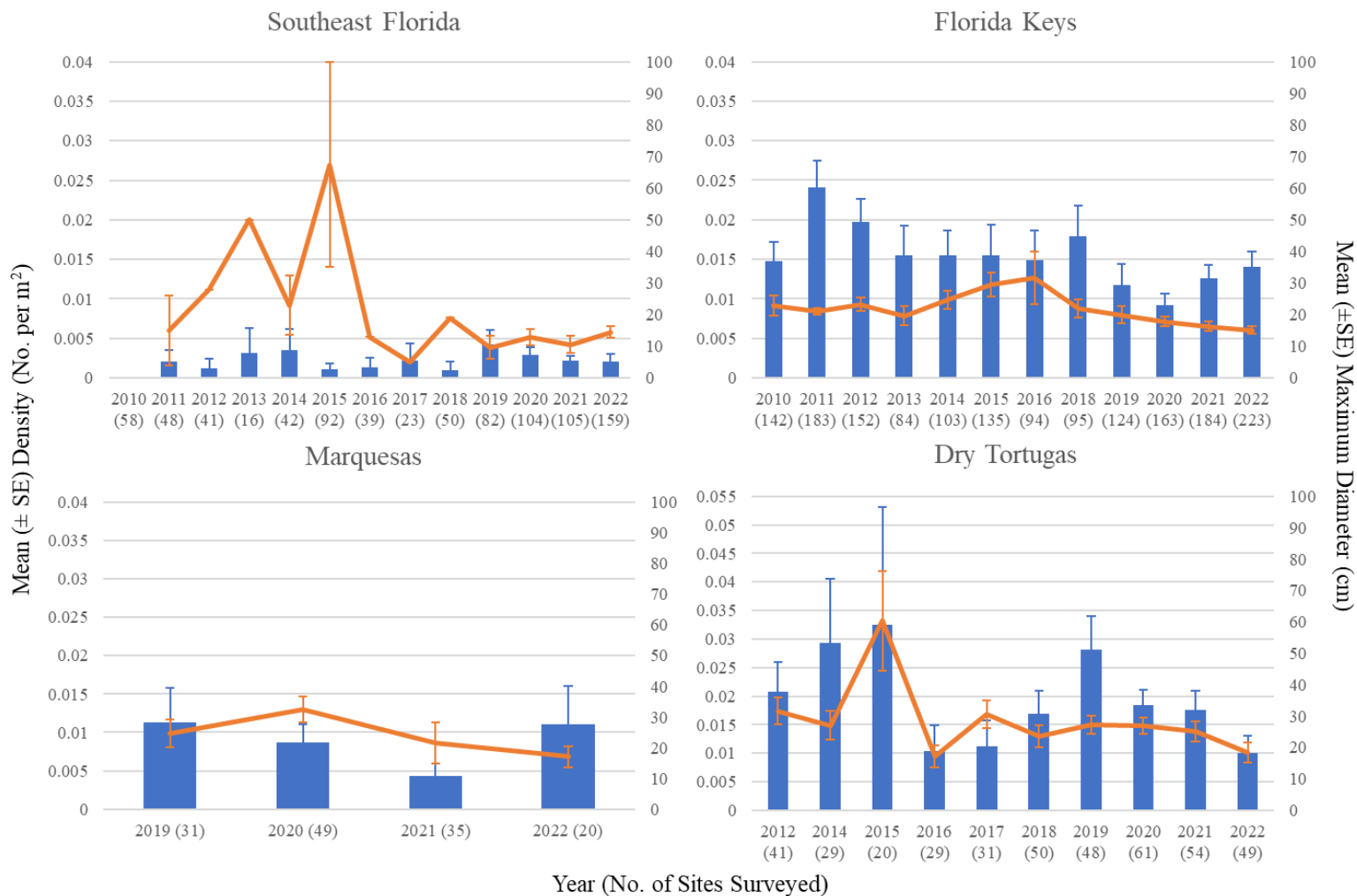


Figure 7. Mean density \pm SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Diploria labyrinthiformis* across the four regions for each survey year. Note the different primary Y axis scale for Dry Tortugas.

Meandrina meandrites

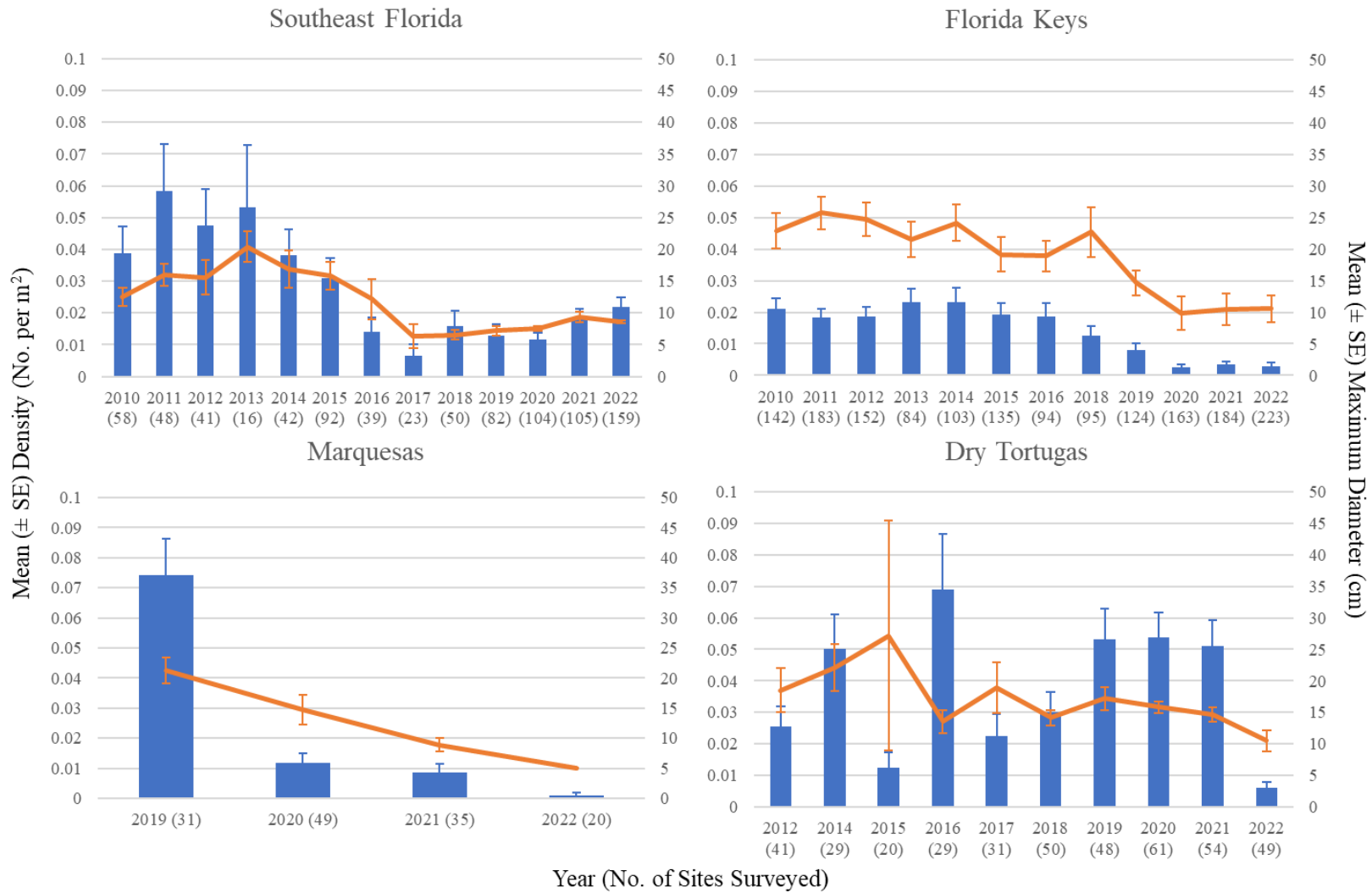


Figure 8. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Meandrina meandrites* across the four regions for each survey year.

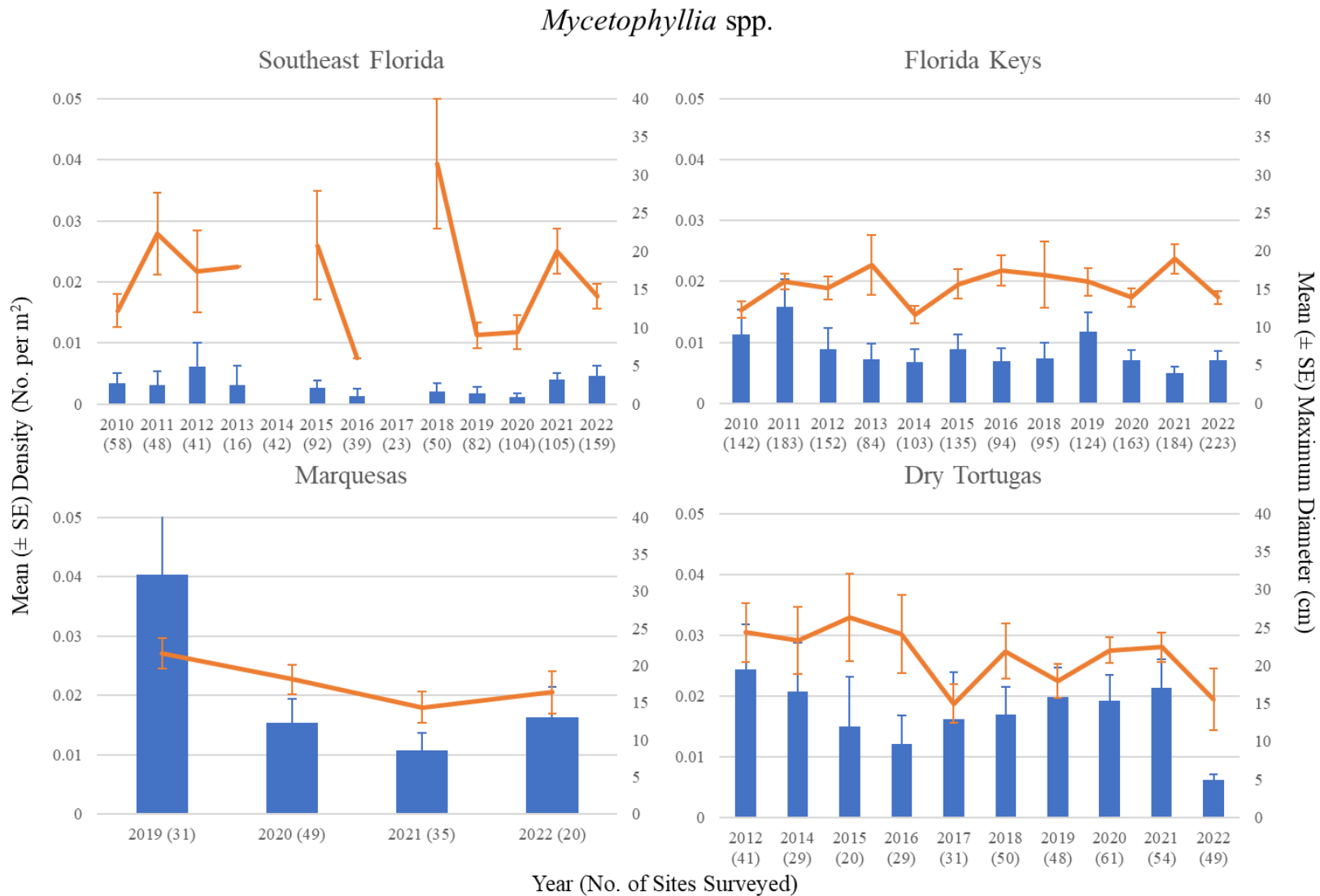


Figure 9. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target genus *Mycetophyllia* spp. (pooled for *M. aliciae*, *M. ferox*, and *M. lamarckiana*) across the four regions for each survey year.

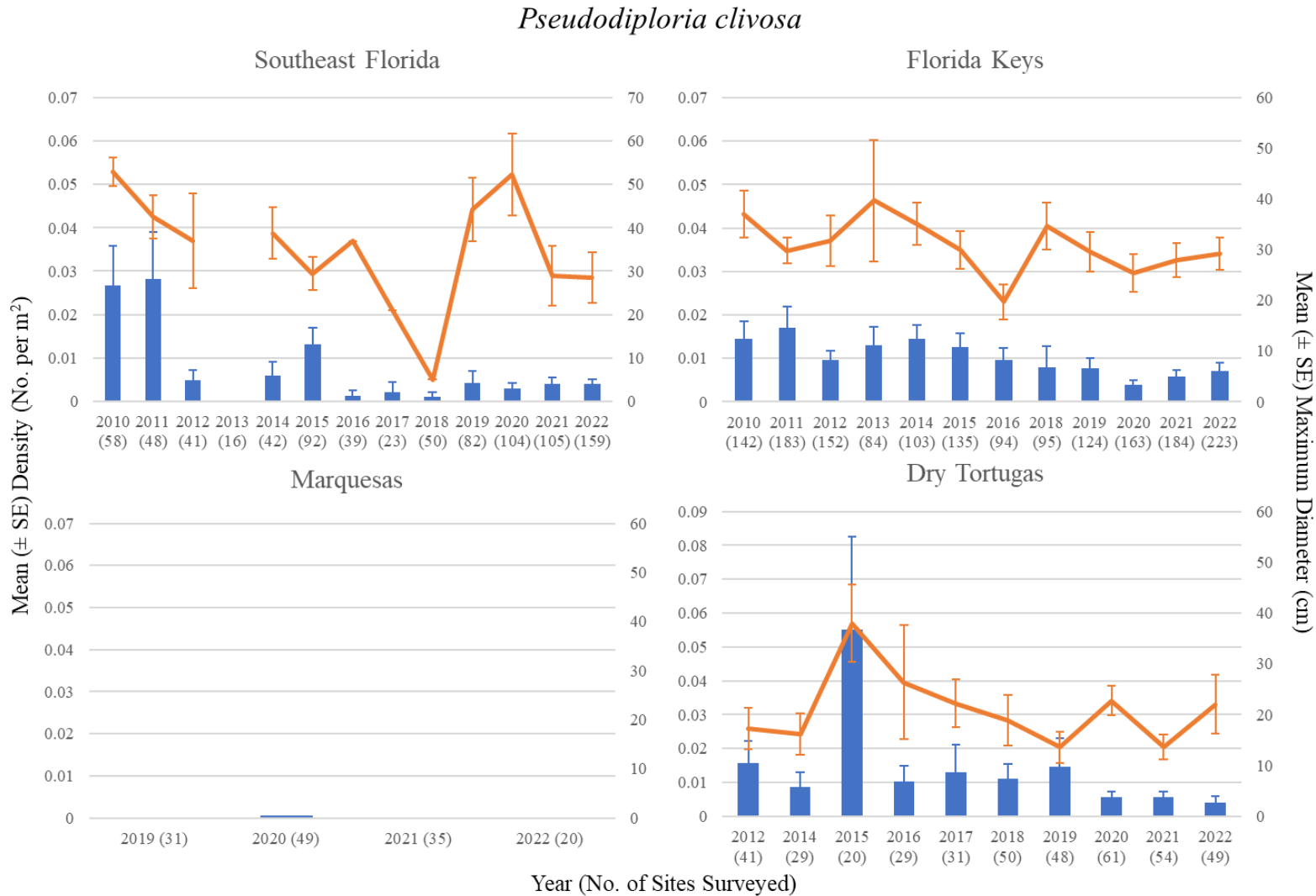


Figure 10. Mean density \pm SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Pseudodiploria clivosa* across the four regions for each survey year. Note the different primary Y axis scale for Dry Tortugas.

Pseudodiploria strigosa

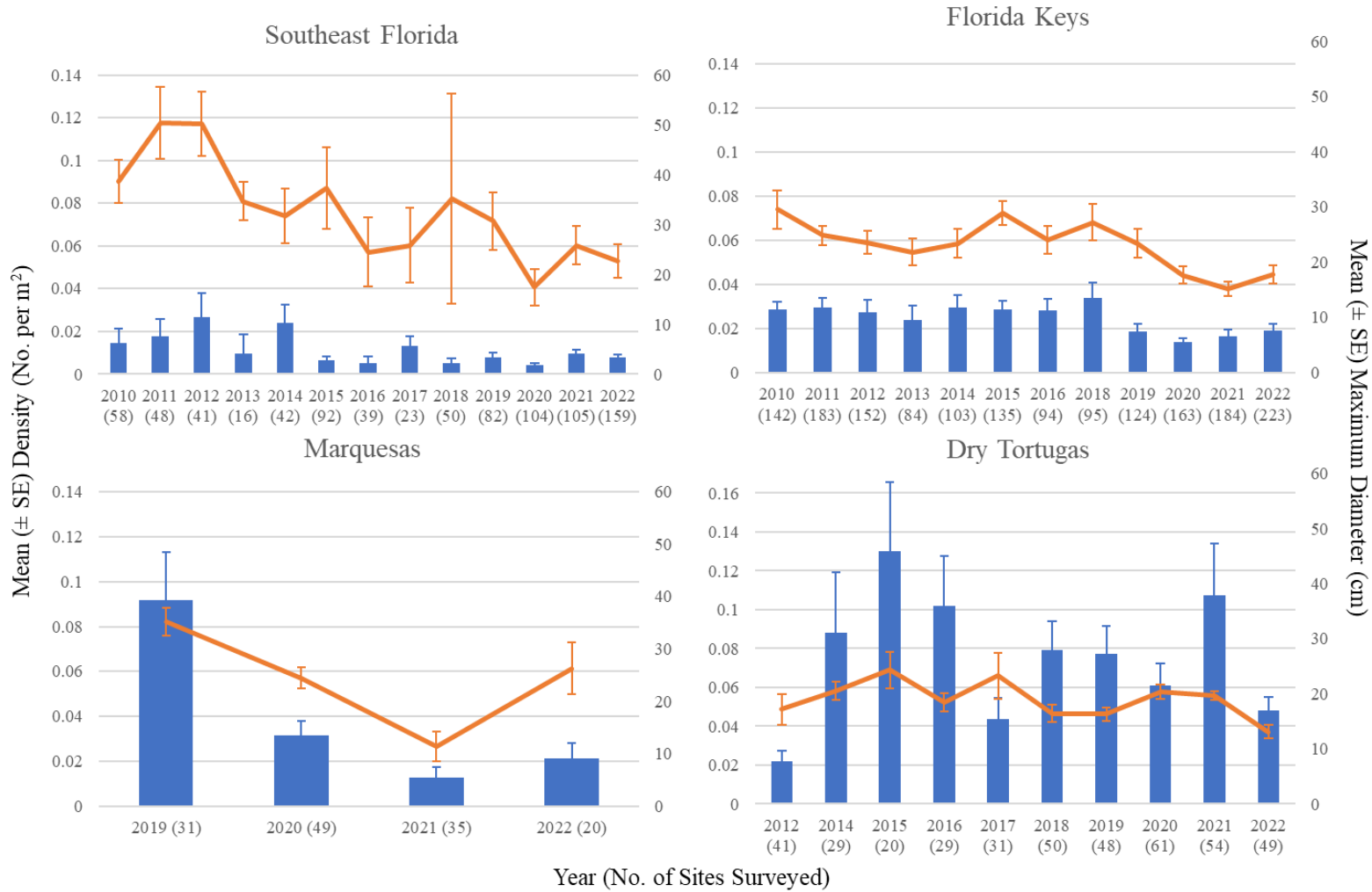


Figure 11. Mean density \pm SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Pseudodiploria strigosa* across the four regions for each survey year. Note the different primary Y axis scale for Dry Tortugas.

JUVENILE TARGET CORALS

Starting in 2020, the DRM program incorporated juvenile coral counts of three SCTL D susceptible coral (sub)families into the survey methods. For the 2022 DRM survey, the species *Montastraea cavernosa* was also added to the juvenile coral counts. These (sub)families and species were enumerated along all four transects during the 2022 survey. The three (sub)families encompass the 10 SCTL D-susceptible coral species targeted along Transects 3 and 4.

Montastraea cavernosa, another SCTL D susceptible species and the only member in its family (Montastraeidae) in Florida, is relatively easy to identify at small sizes (<4cm) and was therefore added to the survey count. *Montastraea cavernosa* is not considered a rare species and is very common in most reef habitats. A list of coral species included within each target (sub)family is included in **Table 7**.

Table 7. List of coral species included under each target juvenile (sub)family.

Faviinae	Mussinae	Meandrinidae	Montastraeidae
<i>Colpophyllia natans</i>	<i>Isophyllia</i> spp.	<i>Dendrogyra cylindrus</i>	<i>Montastraea cavernosa</i>
<i>Diploria labyrinthiformis</i>	<i>Mussa angulosa</i>	<i>Dichocoenia stokesii</i>	
<i>Favia fragum</i>	<i>Mycetophyllia</i> spp.	<i>Eusmilia fastigiata</i>	
<i>Manicina areolata</i>	<i>Scolymia</i> spp.	<i>Meandrina</i> spp.	
<i>Pseudodiploria</i> spp.			

Across the 450 sites surveyed in 2022, 368 (82%) had at least one juvenile colony recorded. Juveniles from all four target families were present at 55 sites, 116 sites had three of the families present, and 120 sites had two of the target families present. Fifty-one sites had more than 20 total juvenile target colonies and 17 of those sites had more than 30 total colonies. Many of the sites with high juvenile counts were in the Marquesas region and the counts were dominated by *M. cavernosa* juveniles. *Montastraea cavernosa* had the highest mean density among the target juveniles across all regions in 2022 (**Table 8**). Second to *M. cavernosa* was the Meandrinidae family, which had greater densities in Southeast Florida, Florida Keys, and Marquesas regions compared to Mussinae or Faviinae across all three years. Faviinae and Mussinae, however, had greater densities than Meandrinidae in the Dry Tortugas.

In Southeast Florida, Faviinae, Mussinae, and Meandrinidae juvenile densities have remained relatively similar across all three survey years (**Table 8**). In the Florida Keys, both Faviinae and Mussinae also remained relatively similar in density across all three years, while Meandrinidae density has been increasing each year. Density of juvenile *M. cavernosa* in the Florida Keys, though slightly higher, was similar to the density found in Southeast Florida.

Table 8. Mean (\pm SE) density by region of the three-target juvenile (sub)families, which are highly SCTL D susceptible, and *Montastraea cavernosa*.

Target Juveniles	Year	Southeast Florida	Florida Keys	Marquesas	Dry Tortugas
Faviinae	2020	0.003 \pm 0.001	0.03 \pm 0.004	0.048 \pm 0.019	0.057 \pm 0.011
	2021	0.002 \pm 0.001	0.035 \pm 0.005	0.04 \pm 0.01	0.05 \pm 0.007
	2022	0.003 \pm 0.001	0.038 \pm 0.004	0.085 \pm 0.017	0.041 \pm 0.007
Meandrinidae	2020	0.009 \pm 0.002	0.038 \pm 0.004	0.076 \pm 0.012	0.032 \pm 0.006
	2021	0.014 \pm 0.002	0.052 \pm 0.008	0.07 \pm 0.016	0.022 \pm 0.004
	2022	0.013 \pm 0.002	0.064 \pm 0.006	0.126 \pm 0.021	0.018 \pm 0.004
Mussinae	2020	0.006 \pm 0.002	0.014 \pm 0.004	0.067 \pm 0.015	0.032 \pm 0.008
	2021	0.003 \pm 0.001	0.015 \pm 0.004	0.078 \pm 0.018	0.041 \pm 0.01
	2022	0.008 \pm 0.002	0.02 \pm 0.003	0.166 \pm 0.041	0.019 \pm 0.005
<i>Montastraea cavernosa</i>	2022	0.079 \pm 0.009	0.091 \pm 0.008	0.5 \pm 0.076	0.18 \pm 0.026

Among the regions, the Marquesas had the highest densities of all four juvenile groups across all three survey years except for Faviinae in 2020 and 2021, when the Dry Tortugas had slightly greater densities (**Table 8**). From 2020 to 2022, the densities of Faviinae, Meandrinidae, and Mussinae juvenile corals have increased in the Marquesas region; density of Mussinae juveniles more than doubled from 2020 to 2022 and Meandrinidae density increased by more than 50% from 2020 to 2022.

From 2020 to 2022, the density of Faviinae and Meandrinidae juveniles decreased in the Dry Tortugas (**Table 8**). Density of Mussinae juveniles in the Dry Tortugas in 2022 was less than half of the density recorded in 2021. Density of *M. cavernosa* juveniles in the Dry Tortugas during the 2022 survey was substantially higher than the other three (sub)families, however, this density value was less than half of what was recorded in the Marquesas.

SUMMARY

Bleaching: Bleaching prevalence (pooled for fully bleached or partially bleached colonies) was highest on the northern half of the reef tract, with severe bleaching on Martin County’s nearshore reef and Palm Beach County’s Deep Ridge. Severe bleaching has not been recorded at the subregion-zone level since the 2014 and 2015 bleaching events. South of the Palm Beach subregion, moderate bleaching occurred on the Inner, Middle, and Outer reef in the Broward-Miami subregion and the Offshore Patch Reefs and Forereefs of the Biscayne and Upper Keys subregions. The 2022 survey had the most moderately bleached subregion-zones since the 2014 and 2015 bleaching events (**Table 9**). In the severely bleached zones of Martin and Palm Beach subregions, bleaching was primarily driven by small colonies of *Siderastrea radians* and *S. siderea*. Only two of the bleached colonies in the Martin Nearshore zone had a width greater than 10cm and only 1 bleached colony was greater than 20cm in the Palm Beach Deep Ridge zone.

When corals recorded with paling were included in the assessment, bleaching values were moderate in 21 of the 29 subregion-zones surveyed (**Table 9**). There was severe bleaching and paling in Martin County and Northern Palm Beach and moderate bleaching and paling extended down through the Lower Keys, Marquesas, and Dry Tortugas. In the Keys, Moderate bleaching was mainly focused on the outer reef zones, while all zones in the Marquesas and Dry Tortugas were moderately bleached and pale.

Overall, 2022 was a moderate bleaching year compared to all other surveys since the last bleaching event in 2015. Although bleaching and paling was prevalent, 2022 was not as severe as the 2014 or 2015 bleaching events. The vast majority of bleaching occurred on the species *S. siderea* and *Agaricia agaricites*, which comprised over half of the bleached and pale colonies recorded across the reef tract.

Table 9. Number of subregion-zones recorded with mild, moderate, or severe bleaching prevalence, and combined bleaching and paling prevalence, for each DRM summer survey event.

DRM Summer Survey	Bleaching Prevalence			Bleaching and Paling Prevalence			Total Subregion-Zones Sampled
	Mild (0-20%)	Moderate (21-50%)	Severe (>50%)	Mild (0-20%)	Moderate (21-50%)	Severe (>50%)	
2005	9	6	1	1	10	5	16
2006	20	0	0	16	4	0	20
2007	27	1	1	16	12	1	29
2008	21	0	0	17	4	0	21
2009	23	2	0	9	16	0	25
2010	22	0	0	15	7	0	22
2011	20	5	0	7	16	2	25
2012	23	1	0	21	3	0	24
2013	23	0	0	16	7	0	23
2014	7	13	8	2	9	17	28
2015	14	14	1	4	14	11	29
2016	28	0	0	13	14	1	28
2018	24	2	0	9	14	3	26
2019	31	0	0	14	16	1	31
2020	24	1	0	8	15	2	25
2021	30	0	0	15	15	0	30
2022	20	7	2	6	21	2	29

Disease: The prevalence of diseases resulting in tissue loss across all subregion-zones was low in 2022 (0-5% disease prevalence), and the overall number of colonies with tissue loss was lower than what was recorded in 2021. Despite the introduction of SCTLD in the Dry Tortugas in May 2021, there were only 2 severely diseased sites and nine sites with medium disease prevalence in 2022. Of the colonies with tissue loss diseases, SCTLD made up 85% of the cases in the Dry Tortugas. The species recorded most with SCTLD were *M. cavernosa*, *S. siderea*, and *Orbicella faveolata*. In 2021, 226 colonies were recorded with SCTLD in the Dry Tortugas while in 2022

only 73 were recorded with the disease. This indicated that the worst of the epidemic stage of the disease had spread through most of the Dry Tortugas by early 2022 because the number of corals recorded with lesions had begun to decrease by September of 2022, likely due to the loss of highly susceptible species.

Across the reef tract, 102 colonies were recorded with SCTLD during the 2022 survey with 73 of those observations from the Dry Tortugas. From Biscayne through the Marquesas, no subregion had more than 9 total colonies recorded with SCTLD. Across the entirety of the reef, 13 species were recorded with SCTLD in 2022 compared to 19 species in 2021. The frequency of SCTLD observations were highest on *M. cavernosa*, *S. siderea*, and *O. faveolata* with all three species having greater than 10 colonies recorded with SCTLD.

Other tissue loss diseases recorded along DRM transects in 2022 were Black Band Disease (21 colonies), White Plague Disease (2 colonies), White Band Disease (7 *Acropora cervicornis* colonies in Broward-Miami), and Rapid Tissue Loss (3 *A. cervicornis* colonies).

In the DRM program, a disease condition is described as “Unknown” if the symptoms do not fall under any of the defined coral disease descriptions. Across the reef tract, 54 colonies were recorded with unknown coral disease similar to 2021 with 51 colonies. The Lower Keys had the most observations of unknown coral disease in both 2022 and 2021. All other subregions had less than 10 colonies recorded with unknown coral disease in 2022. These observations may prove helpful in identifying new disturbances or diseases on the reef and are important to document to aid in future disease investigations and research.

From the time series figures for the highly susceptible SCTLD species, density values look to have stabilized and even slightly increased for some species in Southeast Florida and the Florida Keys. Both regions have been endemic to SCTLD for several years, allowing small or juvenile corals that survived the initial passing of the disease to reach 4cm in size, in addition to possible recruitment of new colonies. For several species like *D. labyrinthiformis*, *D. stokesii*, and *M. meandrites*, density values have slightly increased in Southeast Florida in recent years, but the mean maximum diameter remains similar, indicating that smaller corals are beginning to grow past the 4cm threshold and be recorded in the adult population.

In the Marquesas region, the density of some of the target species (*P. strigosa*, *D. stokesii*, and *Mycetophyllia* spp.) appears to have stabilized, while others continued to decline (*C. natans* and *M. meandrites*). Mean maximum diameter of both *C. natans* and *M. meandrites* continued to decline to their lowest values in the Marquesas region. The Marquesas has been in the endemic phase for less than three years but is still losing some large colonies of *C. natans* and *M. meandrites* to SCTLD.

Overall, the prevalence of SCTLD has continued to decline across the reef tract, even in the Dry Tortugas, where it had only been present for a little over a year at the time of the 2022 survey. The decline in SCTLD across the reef tract is likely due to the substantial loss of many SCTLD susceptible colonies but may also indicate a decline in the cause of the disease, which is still unknown.

Despite the loss of adult susceptible species over the past several years, densities of juvenile colonies belonging to the susceptible families have been steady over the past three DRM surveys, except in the Dry Tortugas. The density of juvenile Faviinae, Mussinae, and Meandrinidae were all higher in 2022 than 2020 in Southeast Florida, the Florida Keys, and the Marquesas. Unfortunately, in the Dry Tortugas, density for all three families were lower in 2022 than in 2020, likely due to SCTL D. The 2022 survey marked the first year that *M. cavernosa* was added to the juvenile counts. Juvenile *M. cavernosa* were far more abundant than Faviinae, Mussinae, and Meandrinidae, which was expected due to *M. cavernosa* being a common and abundant species in most habitats. However, with SCTL D prevalence greater on adult *M. cavernosa* than on any other species in both 2021 and 2022, collecting juvenile abundance takes on added importance because it helps us understand if impacts to the adult population by SCTL D will lower recruitment and reduce the size of the juvenile population.

For more information about FRRP and its DRM effort, see the website <http://ocean.floridamarine.org/FRRP/>. For more information about the Summer 2022 DRM results, contact Jennifer Stein at Jennifer.Stein@MyFWC.com.