

Florida Reef Resilience Program Disturbance Response Monitoring 2021 Quick Look Report

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This report presents data from annual summer surveys conducted between August 9 and
November 5 of 2021



Table of Contents

INTRODUCTION 3

METHODS 4

RESULTS 5

ADULT TARGET CORAL SPECIES 14

 Southeast Florida 15

 Florida Keys..... 16

 Marquesas 17

 Dry Tortugas 18

JUVENILE TARGET CORAL FAMILIES 26

SUMMARY 27

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). Precipitated 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. Collaborating across agencies, universities, and organizations allows for multiple sources of input and expertise and generates transparency across managers and researchers. This is becoming more important as the threats to the reef continually 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 assess the surviving population of corals that were most susceptible to SCTLD. This data will aid in identifying reef areas resilient to SCTLD that have the capability for 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 in the 2021 season. First, it expanded the survey area at each site from two to four belt transects. The two additional transects were specifically designed to target the species most affected by SCTLD, increasing the effort on locating these now rare individuals. Second, a juvenile census of the most SCTLD-susceptible coral families was completed along all four transects. These data will provide an assessment of survivorship and/or post-SCTLD recruitment of these susceptible coral species and determine whether recovery will occur broadly or locally along the reef.

During the 2021 season, 378 sites were surveyed throughout FCR, including the third year of surveys within the Marquesas. This was possible due to the committed efforts of the 2021 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 County,

Palm Beach Zoo, University of Miami's Rosenstiel School of Marine and Atmospheric Science, Shedd Aquarium, and The Nature Conservancy.

This summary report describes the prevalence of coral bleaching, paling, and disease in 2021 as historically assessed through the survey methodology employed by DRM. Last year the 2020 DRM Quick Look Report included a temporal comparison of coral density and diameter for 10 SCTLD-susceptible coral species over a 11-year period. These summaries provided insight into the impacts these species have undergone from SCTLD. These comparisons are presented again with the 2021 data included to update the continued impacts from SCTLD and assess any potential recovery. The 2021 DRM season marked the second year of juvenile coral census of three SCTLD-susceptible (sub)families along all transects at a site. Results from both 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 a random site allocation is not possible. Instead, Marquesas sites in 2021 were selected in the same manner as in 2019 and 2020: chosen *a priori* based on known areas of hardbottom and reef habitat, where coral had been previously documented.

Surveys consisted of four independent 1x10 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 >4cm while Transects 3 and 4 targeted a subset of 10 coral species (>4cm) known to be highly susceptible to SCTLD, including: *Colpophyllia natans*, *Dichocoenia stokesii*, *Diploria labyrinthiformis*, *Meandrina meandrites*, *Mussa angulosa*, *Mycetophyllia aliciae*, *Mycetophyllia ferox*, *Mycetophyllia lamarckiana*, *Pseudodiploria clivosa*, and *P. strigosa*. Juvenile corals belonging to three target (sub)families (Faviinae, Mussinae, Meandrinidae) were tallied for each of Transects 1-4.

At all sites, stony corals >4cm 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, if known, the recognized disease was ascribed. Tissue loss rate and SCTLD disease code (STL) were adopted into the data collection in 2018 to better identify and describe lesions associated with SCTLD.

Prevalence values of bleaching (whole plus partial bleaching), for bleaching and paling combined, and disease were calculated by pooling coral data across Transects 1 and 2 at a 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 that 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 SCTLTD-susceptible coral species and the three juvenile coral families 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 (e.g., excludes 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 378 sites were surveyed across the nine subregions of FCR during the 2021 DRM season (**Table 1**). Six sites were surveyed in Martin County, 29 in Palm Beach, 70 in Broward-Miami, 34 in Biscayne, 50 in the Upper Keys, 26 in the Middle Keys, 74 in the Lower Keys, 35 in the Marquesas, and 54 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**.

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 throughout FCR (**Figure 1**). Across sites, no site had severe bleaching and only 16 sites had moderate bleaching (**Table 2**). Palm Beach and Broward-Miami had the greatest number of sites with moderate bleaching among the subregions.

When paling was included within the bleaching analysis, prevalence values rose to moderate (21-50%) in half of the subregion-zones surveyed in 2021 (**Figure 2**). Pooled by zone, Martin County, Biscayne, the Lower Keys, and the Dry Tortugas subregions had mild (0-20%) bleaching and paling across all zones. Palm Beach, Upper Keys, and Middle Keys had moderate bleaching and paling in over half of the surveyed zones within each of the subregions. The

Broward-Miami and Marquesas subregions had moderate (21-50%) bleaching and paling across all zones.

Across sites, 16 of the 378 sites (4%) were recorded with severe bleaching and paling and 148 sites (39%) were recorded with moderate bleaching and paling (**Table 3**). The Broward-Miami subregion had the highest number of sites with both moderate and severe bleaching and paling.

Table 1. Total number of sites surveyed in each subregion for all DRM summer survey events (2005-2021).

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
Total Summer Survey Sites										3504

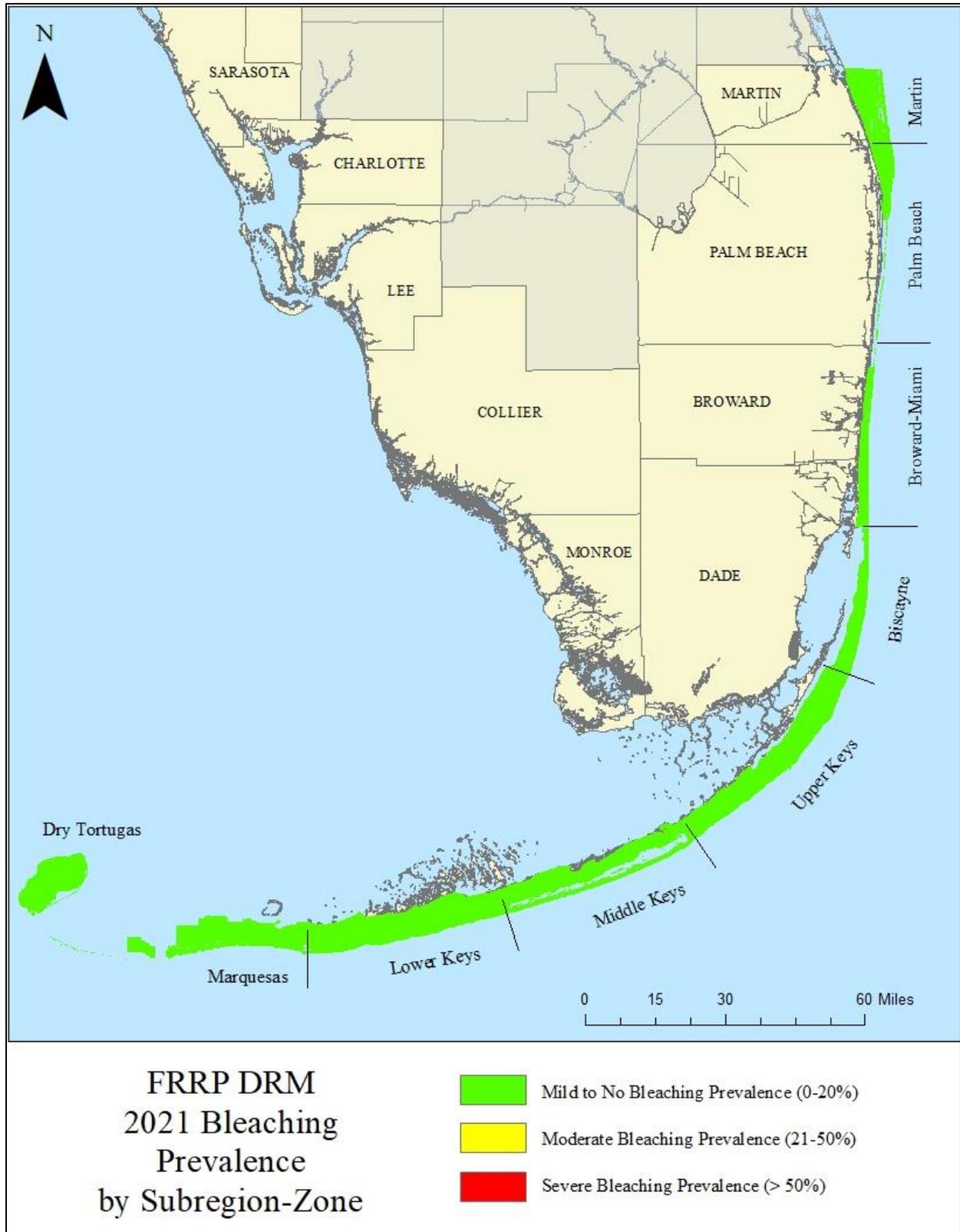


Figure 1. Bleaching prevalence of surveyed coral colonies by subregion-zone.

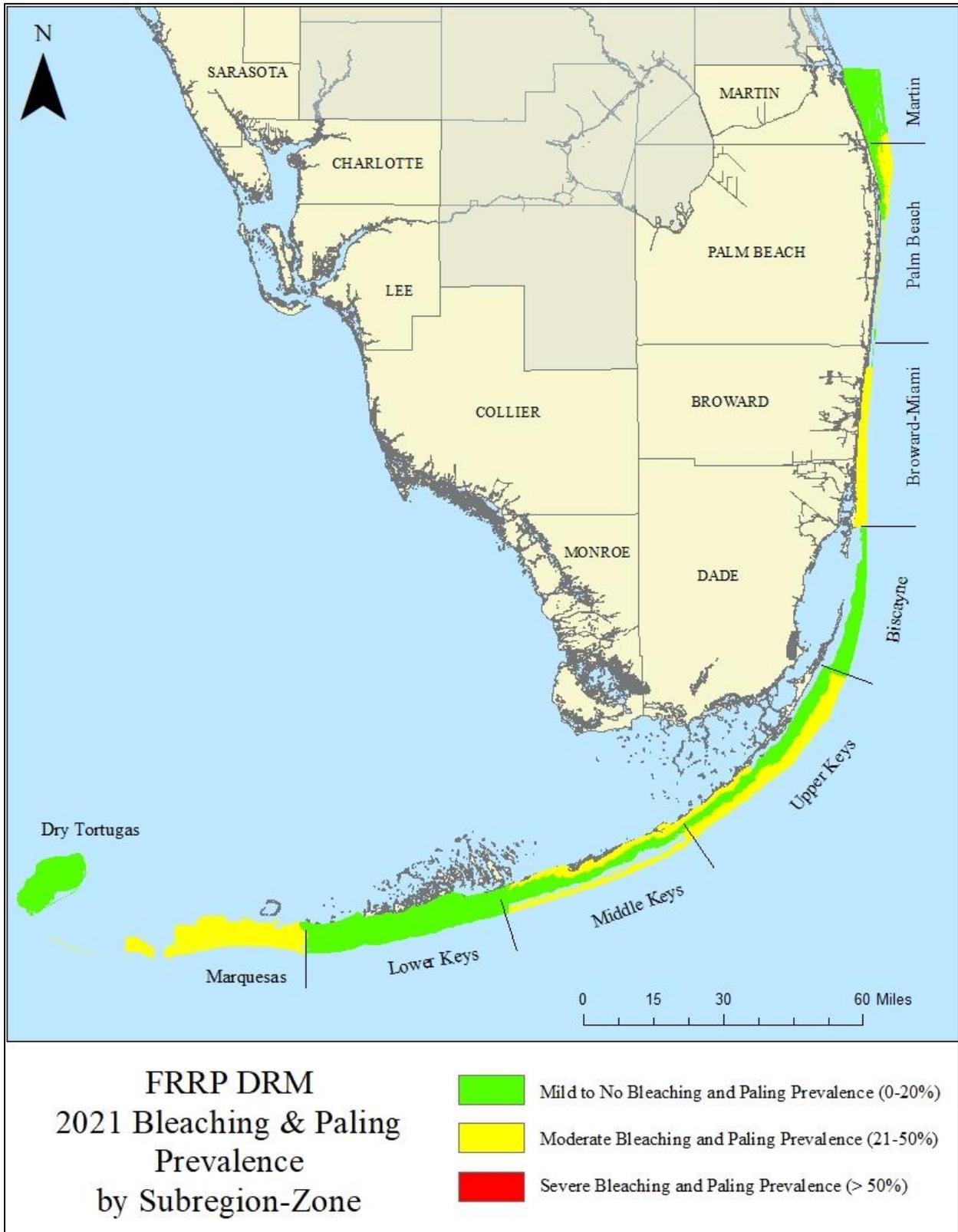


Figure 2. Bleaching and paling prevalence of surveyed coral colonies by subregion-zone.

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	6	0	0
Palm Beach	24	5	0
Broward-Miami	64	6	0
Biscayne	35	0	0
Upper Keys	47	2	0
Middle Keys	26	0	0
Lower Keys	73	1	0
Marquesas	34	1	0
Dry Tortugas	53	1	0
Total Sites	362	16	0

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	6	0	0
Palm Beach	13	14	2
Broward-Miami	31	34	5
Biscayne	26	7	2
Upper Keys	28	21	0
Middle Keys	11	11	4
Lower Keys	49	23	2
Marquesas	14	20	1
Dry Tortugas	36	18	0
Total Sites	214	148	16

The prevalence of disease along Transects 1 and 2 was pooled by zones (**Figure 3**) 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%). All disease prevalence values were calculated from diseases that result in tissue loss and do not include Dark Spot Syndrome or other discoloration conditions. Pooled by zone within each subregion, all prevalence values for diseases resulting in tissue loss were either zero or low, except for the Dry Tortugas subregion, where medium disease prevalence was recorded at both the lagoon and forereef zones (**Figure 3**). When disease prevalence is analyzed by site, only 13 of the 378 surveyed sites had high disease prevalence, 11 of which were located within the Dry Tortugas (**Table 4**). The Dry Tortugas also had the highest number of sites with medium disease prevalence with nine sites.



Figure 3. 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	No TL Disease	Low (>0-5%)	Medium (6-10%)	High (>10%)
Martin	6	0	0	0
Palm Beach	29	0	0	0
Broward-Miami	57	8	4	1
Biscayne	29	6	0	0
Upper Keys	39	9	0	1
Middle Keys	18	8	0	0
Lower Keys	51	23	0	0
Marquesas	17	13	5	0
Dry Tortugas	19	15	9	11
Total Sites	265	82	18	13

Across FCR, 323 corals were recorded with SCTLD and 70% of those colonies (226) were in the Dry Tortugas (**Table 5**). As in 2020, *Siderastrea siderea* and *Montastraea cavernosa* were among the coral species with the highest SCTLD prevalence. Both 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; these factors contribute to the likelihood of finding colonies of these species affected with SCTLD. Sixteen different coral species were recorded with the disease in the Dry Tortugas, with the highest occurrence on *S. siderea* at 29%, followed by *M. cavernosa* at 20%, and then 11% on *P. strigosa*. Other highly susceptible species recorded with the disease in the Dry Tortugas were *C. natans*, *Dendrogyra cylindrus*, *D. labyrinthiformis*, *D. stokesii*, *Eusmilia fastigiata*, *M. meandrites*, *Orbicella faveolata*, and *O. franksi*. Images of coral species recorded with SCTLD in the Dry Tortugas are provided in **Figure 4**.

Outside of the Dry Tortugas, the total number of colonies recorded with SCTLD was low. Only 10 colonies were recorded with SCTLD in Southeast Florida, compared to eight in 2020. Only 30 colonies were recorded with SCTLD in the Florida Keys, compared to 40 recorded in 2020. With 57 colonies recorded with SCTLD, the Marquesas had the second highest number of colonies with the disease; however, this is much lower than the 168 colonies recorded with the disease in 2020, reflecting the transition of this region from the epidemic to the endemic stages of SCTLD.

Other tissue loss diseases recorded along DRM transects in 2021 were Black Band Disease (11 colonies), White Plague Disease (13 colonies), Yellow Band Disease (2 colonies), and Rapid Tissue Loss (four *Acropora cervicornis* colonies). Of the 13 colonies with White Plague Disease, eight were in Dry Tortugas.

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, 51 colonies were recorded with unknown coral disease. The Lower Keys had the most observations, with 16 colonies recorded with unknown coral disease. All other subregions had less than 10 colonies recorded with unknown coral disease.

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

Subregion	Broward-Miami	Biscayne	Upper Keys	Middle Keys	Lower Keys	Marquesas	Dry Tortugas	Total per species
<i>Agaricia agaricites</i>						2	5	7
<i>Colpophyllia natans</i>							13	13
<i>Dendogyra cylindrus</i>							2	2
<i>Dichocoenia stokesii</i>	1						15	16
<i>Diploria labyrinthiformis</i>				1	1		2	4
<i>Eusmilia fastigiata</i>							8	8
<i>Meandrina meandrites</i>							9	9
<i>Montastraea cavernosa</i>	4	2		1	1	30	46	84
<i>Mycetophyllia aliciae</i>					1			1
<i>Orbicella annularis</i>			2					2
<i>Orbicella faveolata</i>	1				5	5	7	18
<i>Orbicella franksi</i>							2	2
<i>Porites astreoides</i>						1	11	12
<i>Porites porites</i>	1						2	3
<i>Pseudodiploria clivosa</i>					1			1
<i>Pseudodiploria strigosa</i>							24	24
<i>Siderastrea siderea</i>	1		2	2	9	16	65	95
<i>Solenastrea bournoni</i>	1						2	3
<i>Stephanocoenia intersepta</i>	1			1	1	3	13	19
Total colonies per Subregion	10	2	4	5	19	57	226	323

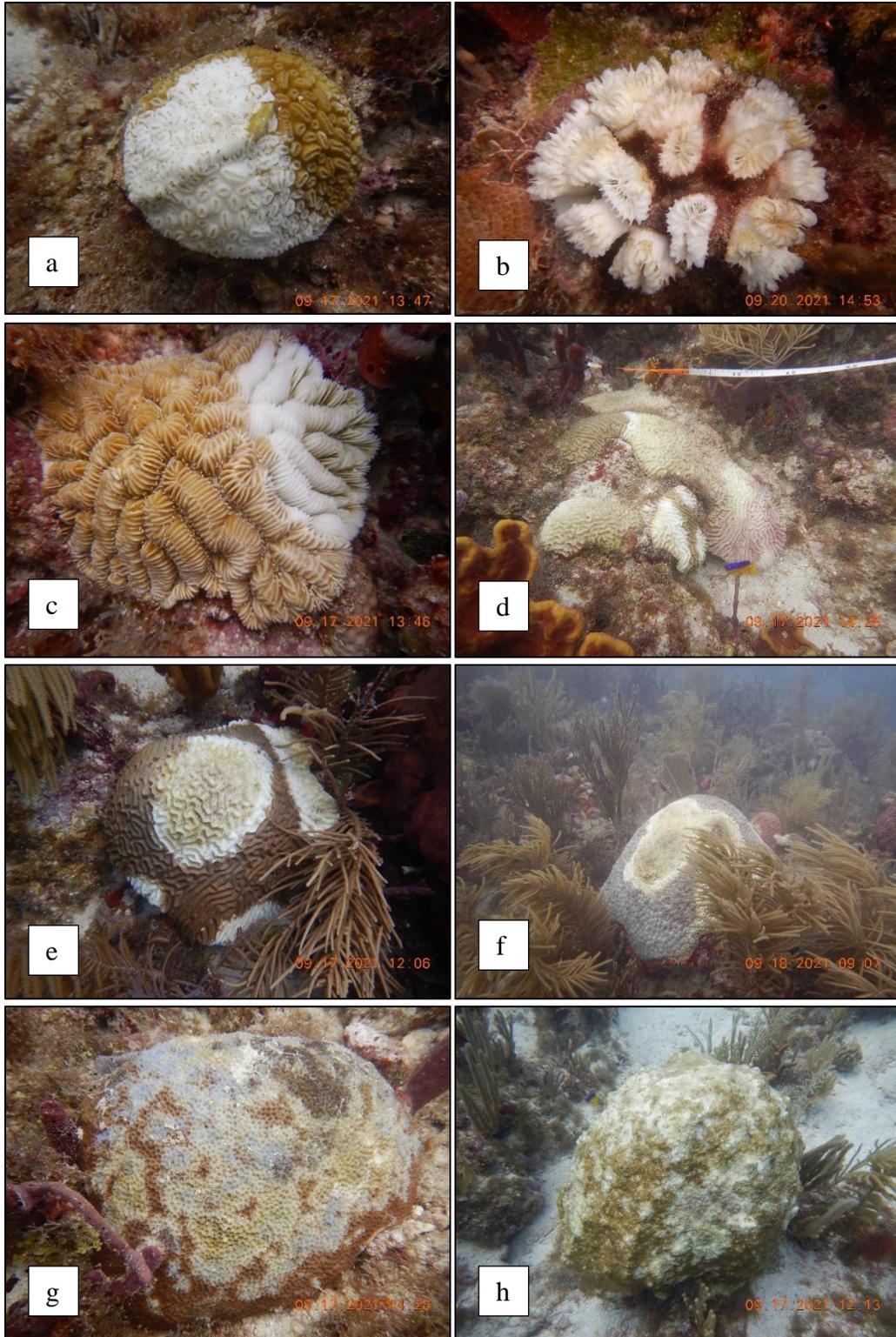


Figure 4. Images of SCTLD observed during the September 2021 DRM survey in the Dry Tortugas. a. *Dichocoenia stokesii* b. *Eusmilia fastigiata*. c. *Meandrina meandrites* d. *Colpophyllia natans*, e. *Pseudodiploria strigosa*, f. *Montastraea cavernosa*, g. *Siderastrea siderea*, h. *Solenastrea bournoni*.

ADULT TARGET CORAL SPECIES

Now that the entirety of FCR is classified as endemic or epidemic for SCTL, it is important to assess the population status of the coral species that were most susceptible to SCTL. Starting in 2020, DRM extended the survey area at each site by adding two belt transects specifically designed to target 10 of the most susceptible species to SCTL (listed in **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 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 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**).

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

Target Species	Year	Southeast 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
<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
<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
<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
<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
<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
<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
<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
<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
<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

Despite the spread of SCTL to the Dry Tortugas, regional density values were similar between 2020 and 2021 (**Table 6**). The similarities in values in the Dry Tortugas was likely due to SCTL having only arrived in the Dry Tortugas in May 2021. It will likely take one or two years after arrival to quantify impacts within the region. Nearly all adult target species were more abundant in the Dry Tortugas than in the Marquesas, Florida Keys or Southeast Florida in 2021.

However, mean densities of *D. stokesii* and *P. clivosa* in the Florida Keys were similar to those found in the Dry Tortugas in 2021 (**Table 6**).

The mean density of *M. meandrites* in Southeast Florida was higher than the mean density found in the Florida Keys and Marquesas regions (**Table 6**). The mean maximum diameter, however, was lowest in Southeast Florida, indicating that smaller colonies made up a greater proportion of the surveyed population. The density of *P. clivosa* was lower in the Marquesas region in both 2020 and 2021 than in any of the other regions. No *P. clivosa* colonies were recorded across the 35 sites surveyed in that region in 2021. This is likely due to the small number of nearshore habitat sites surveyed in the Marquesas, where *P. clivosa* is most commonly found.

In the 2020 DRM Summer Quick Look Report, mean density and mean maximum diameter values were summarized for 11 years (2010-2020) of DRM data within each region to evaluate the impacts from SCTLTD on each target species. The 2021 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 12 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 for 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 SCTLTD and assess the status of heavily impacted species. Density values from 2020 and 2021, 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 three years of data.

Southeast Florida

SCTLTD 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 SCTLTD-susceptible coral species, only *D. stokesii*, *M. meandrites*, and *P. strigosa* had sufficient abundance values across the 12 survey years to interpret any impacts from SCTLTD. The most abrupt changes in both mean density and maximum diameter for the three target species occurred between 2014 and 2016 and

coincided with the epidemic stage of SCTLD in Southeast Florida, when the disease first hit this region and resulted in high prevalence and coral mortality. The most significant impacts of the disease are apparent two to three years after the beginning of the epidemic stage, in essence established a new post-SCTLD baseline in 2017 for these species in Southeast Florida. Therefore, the 2021 survey in Southeast Florida marked the fourth assessment after the post-SCTLD baseline.

Among the target coral species in the Meandrinidae family, *D. stokesii* underwent a dramatic decline in mean density and maximum diameter between 2015 and 2016 (**Figure 7**). Since 2016, *D. stokesii* density has increased gradually with 2021 marking the highest density value since 2015. Mean diameter, however, has remained relatively similar since 2016, suggesting that recruitment and survivorship of juvenile *D. stokesii* is high because the mean maximum diameter is just above the 4cm size; the required minimum size for measuring adults. Mean density and maximum diameter of *M. meandrites* plummeted between 2014 and 2017 (**Figure 8**). After the steep decline in density of *M. meandrites* through 2017, density values have remained below 0.02 colonies per m². In comparison to *D. stokesii*, overall recruitment may be lower for *M. meandrites* but mean maximum diameter has been slowly increasing reflecting positive growth of the colonies that persisted through SCTLD.

Despite some interannual variability across the 12 survey years, annual mean density of *P. strigosa* was clearly higher prior to 2015, with a large decline occurring between 2015 and 2016 (**Figure 11**). Overall, mean maximum diameter has been reduced by ~50% across the 12 survey years. Although mean maximum diameter did increase between 2020 and 2021, it was still relatively low compared to all previous years. The 2021 mean density value was higher than the prior three years (2018, 2019, and 2020).

The other seven target species did not have sufficient abundance in Southeast Florida across most survey years to make any meaningful interpretations about the impact of SCTLD.

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, with the most pronounced effects occurring between 2017 and 2020, when SCTLD was in the epidemic stage in the Middle and Lower Keys. The entirety of the Florida Keys can now be considered endemic, but the timeline for establishing post-SCTLD baselines does vary depending upon subregion (e.g., the Upper Florida Keys post-SCTLD baseline begins after 2017 whereas the Lower Florida Keys won't start until 2021). The losses associated with SCTLD are clearly visible in the mean density changes for six of the target species (*C. natans*, *D. labyrinthiformis*, *D. stokesii*, *M. meandrites*, *P. clivosa*, and *P. strigosa*) when analyzing the data over the last 12 years (excluding the 2017 Irma dataset); **Figures 5-8, 10-11**. For all six species, the lowest mean density was recorded in either 2020 or 2021.

Among the target species in the Meandrinidae family, *D. stokesii* and *M. meandrites*, both species appeared to reach their lowest mean density in 2020. The four-year decline is clearly evident between 2016 to 2020 as SCTLD spread throughout the Florida Keys. Mean density and mean maximum diameter did slightly rise between 2020 and 2021 which likely indicates that the highest mortality rates associated with SCTLD had concluded on these species in 2020. Despite these small increases, the mean density and maximum diameter values for both species in 2021 were much lower in comparison to years prior to the arrival of SCTLD. For both species, similar to Southeast Florida, the results do confirm that some recruitment is occurring after the epidemic stages of SCTLD have passed.

Similar to *D. stokesii* and *M. meandrites*, the target species in the Faviinae subfamily, *D. labyrinthiformis*, *P. clivosa*, and *P. strigosa*, reached their lowest mean density in 2020. The mean density for all three species increased slightly between 2020 and 2021 and even though density was higher in 2021 it was less than all previous years prior to 2018. However, mean maximum diameter for *D. labyrinthiformis* and *P. strigosa* continued to decline between 2020 and 2021 pushing it to its lowest value recorded across the 12 years. This may signify several important aspects regarding the impact of SCTLD on these species. First, lingering infections were still occurring on larger, older colonies which reduce the mean maximum diameter of the population if it wasn't entirely killed after 2020, and second, there may be some juvenile colonies growing beyond the 4cm threshold which would lower the average mean maximum diameter.

Due to the relatively higher density of *C. natans* in the Lower Keys compared to other Keys subregions, the full assessment of mean density changes due to SCTLD was not apparent until 2021. Although the largest declines in mean density of *C. natans* occurred between 2018 and 2019, mean density continued to decrease between 2020 and 2021. In addition, mean maximum diameter also reached its lowest value in 2021 indicating that some larger *C. natans* colonies were being lost due to recurring or slow-moving SCTLD lesions.

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 2021, the mean density of *Mycetophyllia* spp. in the Florida Keys has been relatively consistent (**Figure 9**), suggesting that the impacts from SCTLD have been minimal or difficult to detect compared to other susceptible species. Mean density in 2021 however, was the lowest recorded over the previous 12 survey years, while mean maximum diameter was the highest value recorded.

Marquesas

Initially DRM surveys within the Marquesas region began in 2019 to track the western movement of SCTLD along the reef tract and then continued in 2020 and 2021 to assess its progression towards the Dry Tortugas. In addition, the 2020 and 2021 surveys provide some quantitative estimates of the impacts of SCTLD in the region. DRM continues to monitor the Marquesas as an ecologically important area that connects the Dry Tortugas with the rest of FCR. Despite only three years of DRM data within the Marquesas region, the impacts of SCTLD are apparent for several of the 10 target species.

At the time of the DRM survey event in 2019, SCTLD had not yet been identified in the Marquesas region; however, the disease was at the westernmost extent of the Lower Keys subregion boundary. During the survey in 2020, the disease was found to have spread across the entire extent of the Marquesas. The 2021 survey represents one-year post-epidemic stage in the Marquesas subregion and declines in susceptible species may be ongoing due to either recurring or slow-moving lesions. Complete mortality on larger colonies with SCTLD may take longer and thus require several years after the epidemic stage has concluded to establish post-SCTLD baseline conditions.

In the Marquesas region, the dramatic decline in mean density for *C. natans*, *D. stokesii*, *M. meandrites*, *Mycetophyllia* spp., and *P. strigosa* recorded between 2019 and 2020 continued after 2020 and into 2021. The only exception was for *D. stokesii*, which rose slightly from 2020 to 2021 (**Figures 5, 7-9, 11**). Among the target species, *D. stokesii* suffered the greatest loss in mean density between 2019 and 2020, coupled with a lower mean maximum diameter. Despite the small rise in mean density between 2020 and 2021, the mean maximum diameter of *D. stokesii* was lower in 2021. Mean maximum diameter was also lower in 2021 than in 2020 for *C. natans*, *M. meandrites*, *Mycetophyllia* spp., and *P. strigosa*. The results for all of these target species confirm that ongoing SCTLD infections continued to impact their populations in the Marquesas region between 2020 and 2021.

Diploria labyrinthiformis, *M. angulosa* and *P. clivosa* all had less than 10 total colonies recorded for one or all survey years and therefore impacts from SCTLD were not evaluated for these species in the Marquesas region.

Dry Tortugas

Prior to the 2021 DRM surveys within the Dry Tortugas, National Park Service staff identified SCTLD along the eastern side of the park approximately two miles east of Garden Key in May 2021 (C. Pollock, per communication, June 1, 2021). During the five months between the first observation reported and the DRM cruise, SCTLD spread quickly throughout much of the park. When the DRM surveys were conducted in September, SCTLD was recorded at 33 of the 54 sites surveyed in the park covering the east, west, south and central portions of the park. Eleven of the sites surveyed had >10% prevalence of SCTLD. Of the target colonies, *D. stokesii* had the highest rate of infection with 32% of recorded colonies observed with SCTLD lesions, followed by *M. meandrites* at 25%. At the time of preparing this Quick Look report, mean density and mean maximum diameter of the target species in the Dry Tortugas were relatively consistent with previous years because the majority of colonies with active infections still had some live tissue remaining and would be included in the mean density and maximum diameter summaries (**Figures 5-11**).

The only exception was the mean density of *P. strigosa*, which was remarkably higher in 2021 compared to 2020, even though mean maximum diameter remained relatively the same (**Figure 11**). Mean density of *P. clivosa* did not change much between 2020 and 2021; however, both years were lower than the previous seven survey years (**Figure 10**).

Colpophyllia natans

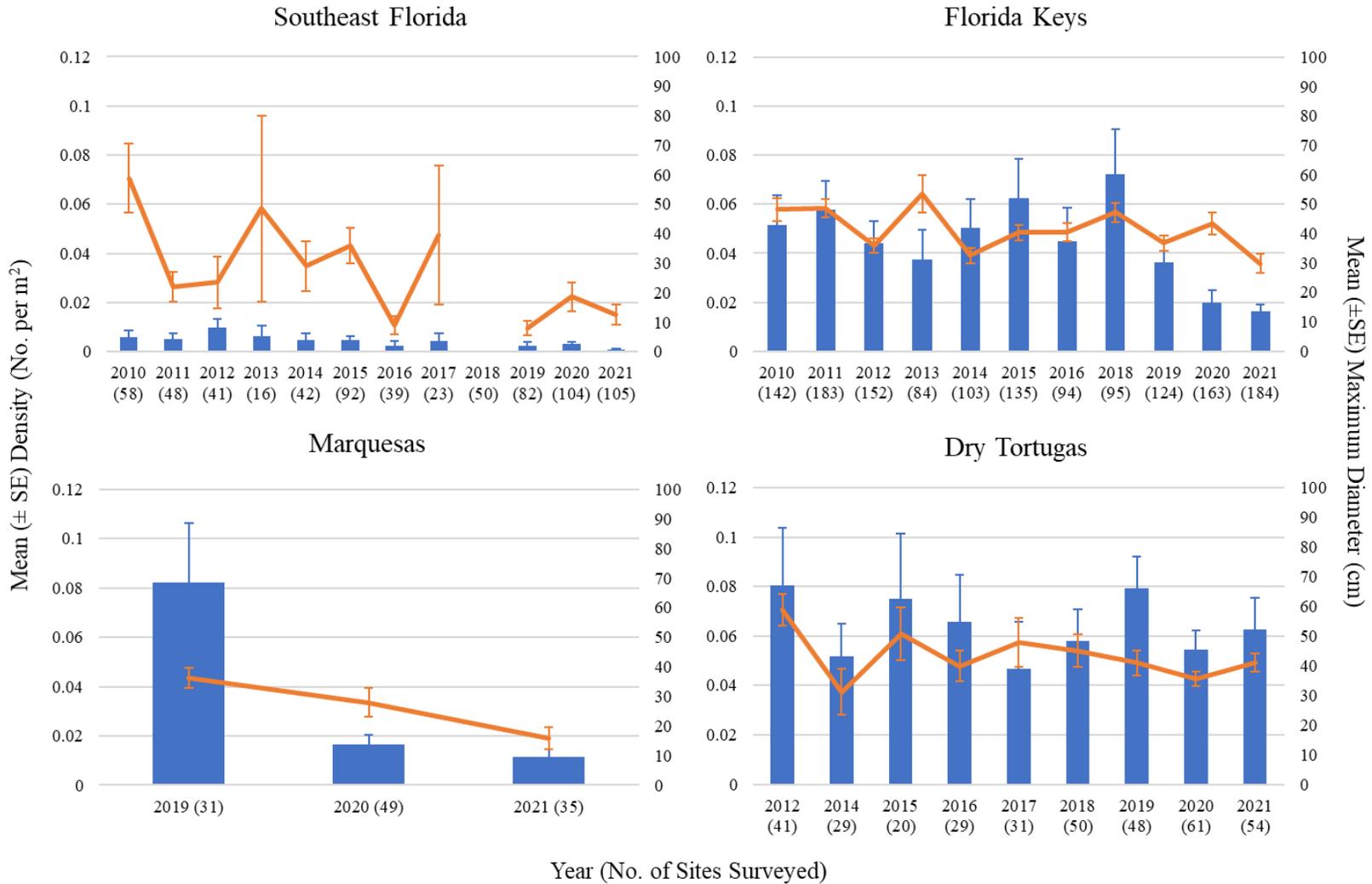


Figure 5. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Colpophyllia natans* across the four regions for each survey year.

Diploria labyrinthiformis

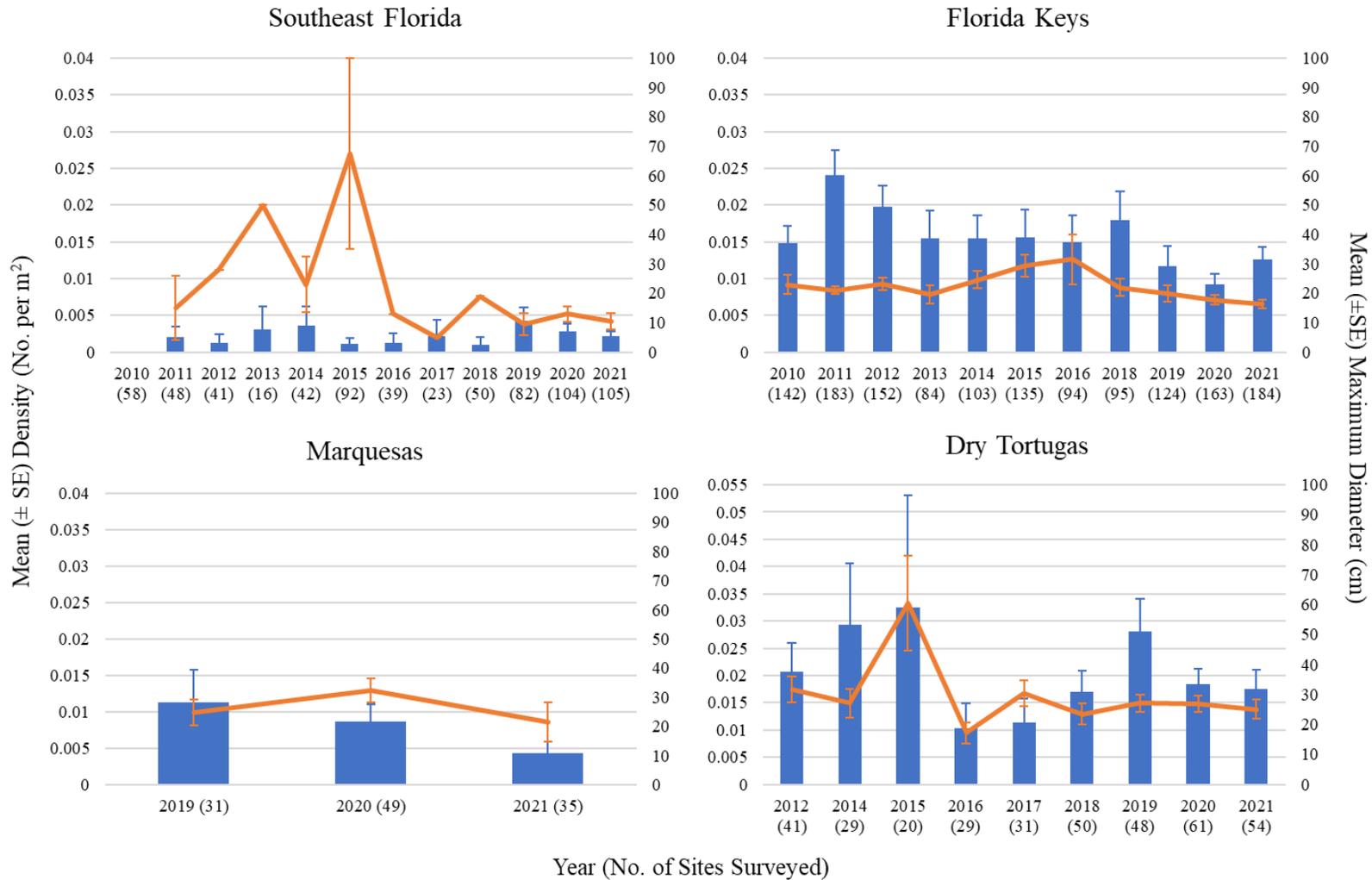


Figure 6. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Diploria labyrinthiformis* across the four regions for each survey year. Note the different primary Y axis scale for Dry Tortugas.

Dichocoenia stokesii

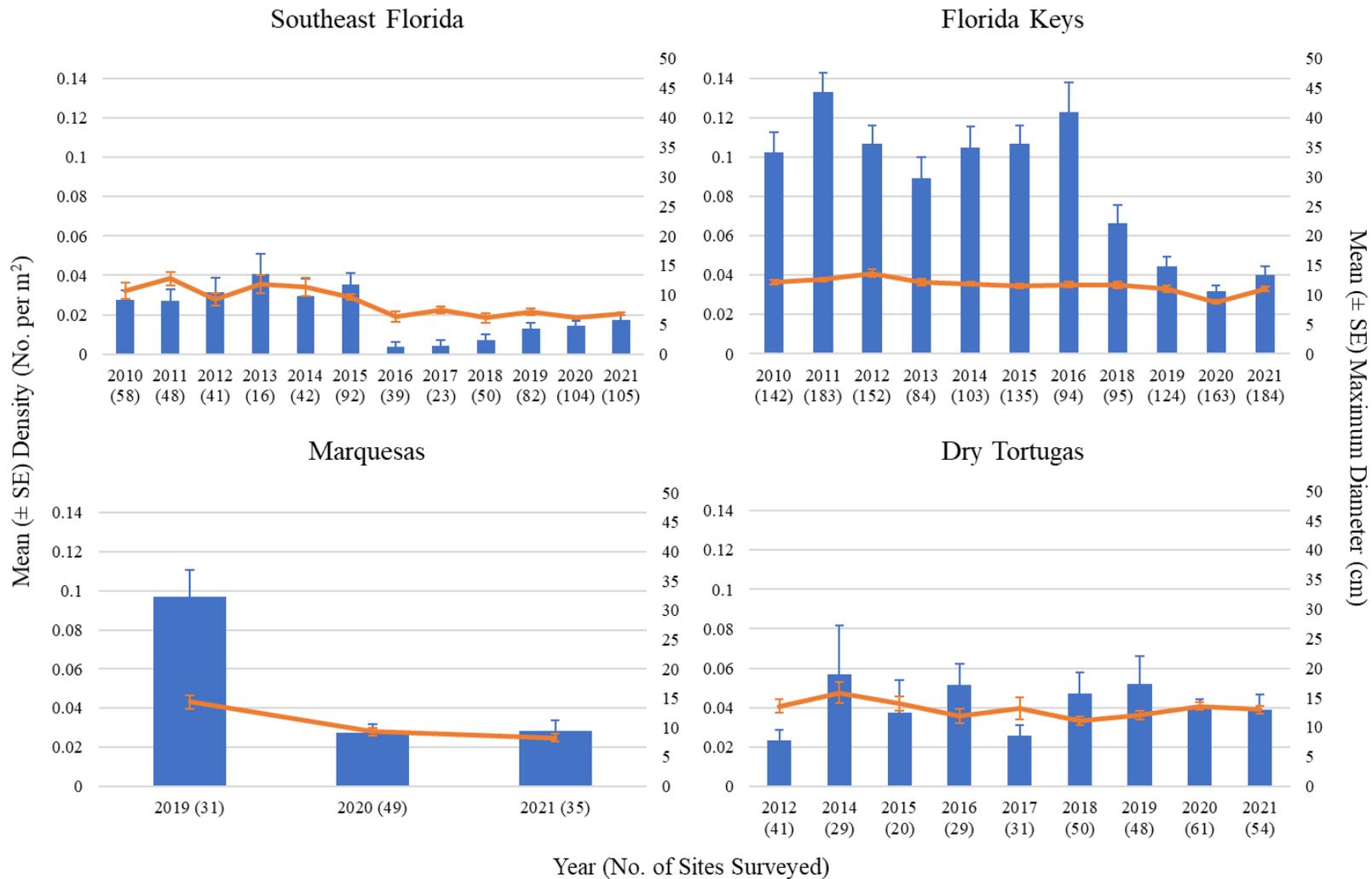


Figure 7. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Dichocoenia stokesii* across the four regions for each survey year.

Meandrina meandrites

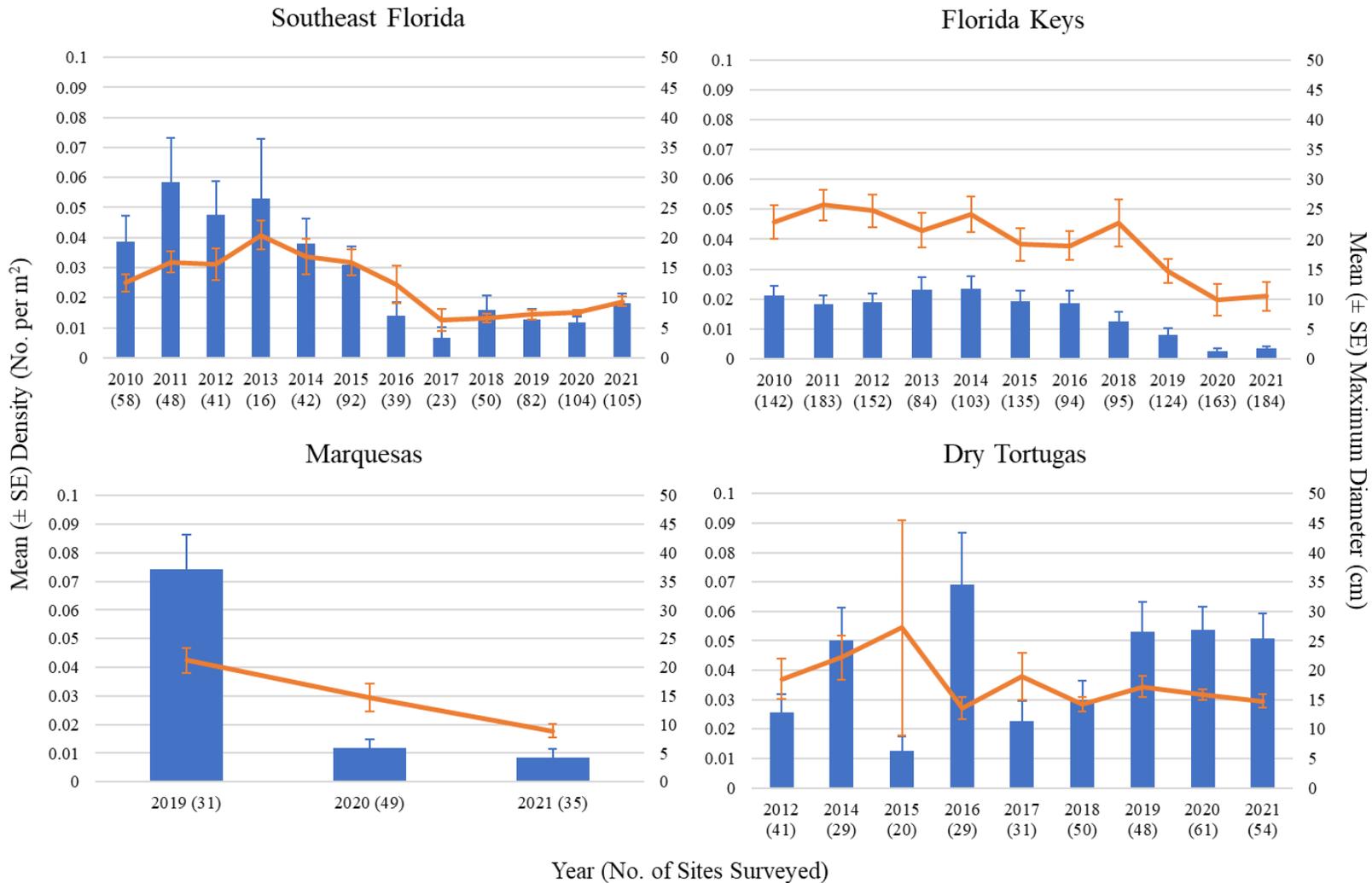


Figure 8. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Meandrina meandrites* across the four regions for each survey year.

Mycetophyllia spp.

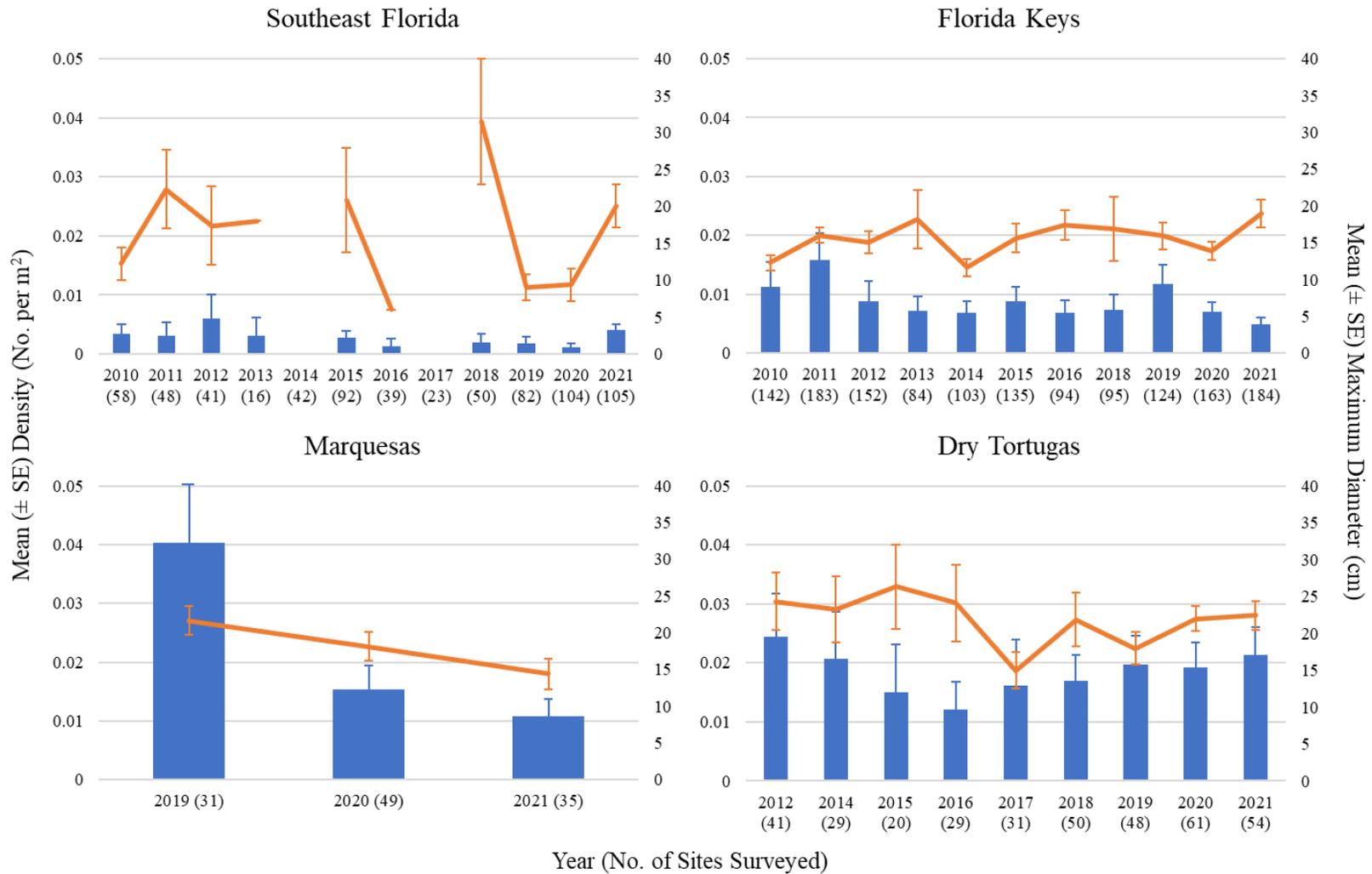


Figure 9. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target genus *Mycetophyllia* spp. (pooled for *M. aliciae*, *M. ferox*, and *M. lamarckiana*) across the four regions for each survey year.

Pseudodiploria clivosa

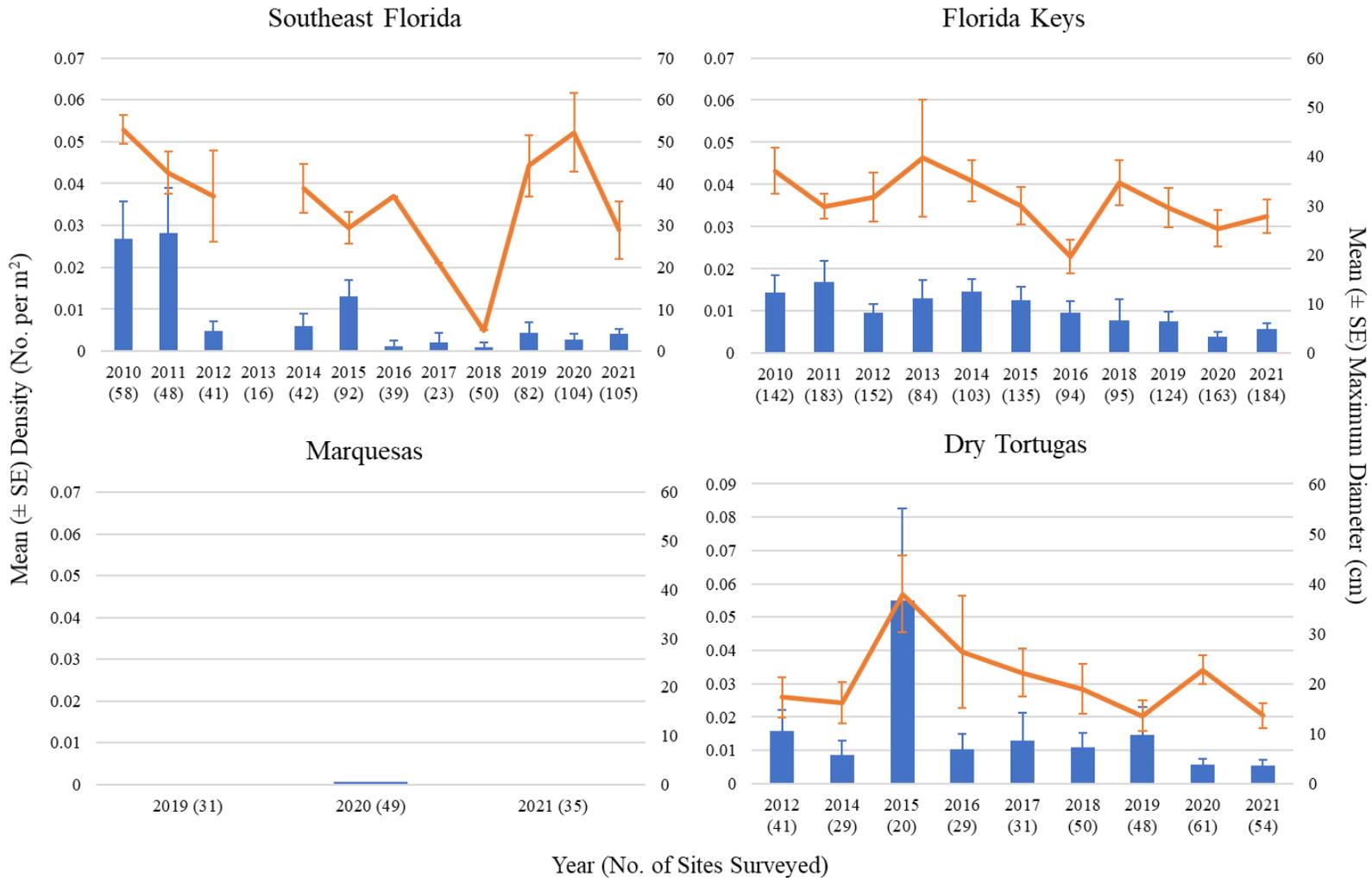


Figure 10. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Pseudodiploria clivosa* across the four regions for each survey year. Note the different primary Y axis scale for Dry Tortugas.

Pseudodiploria strigosa

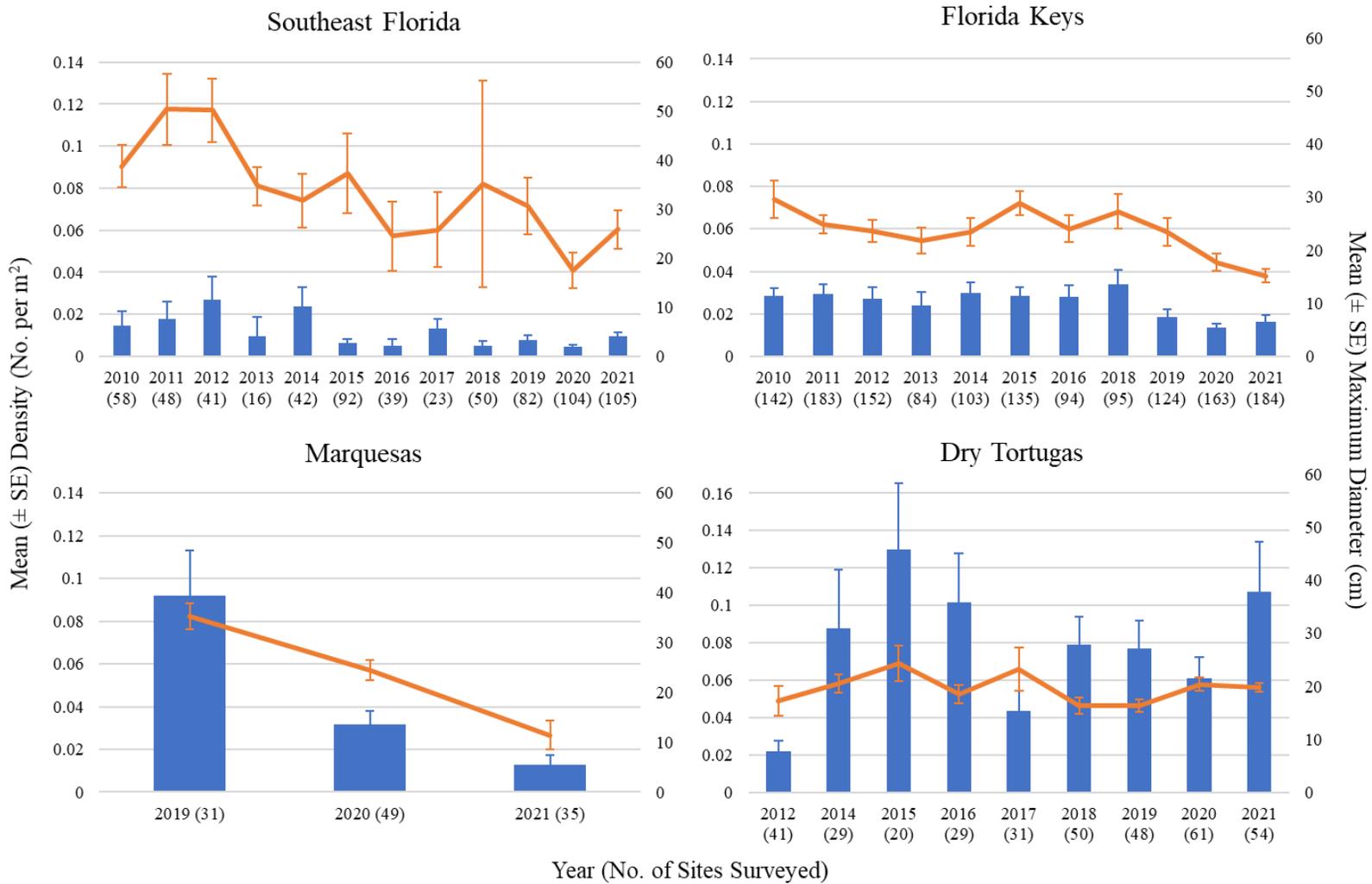


Figure 11. Mean density +/- SE (blue columns, primary Y axis) and mean maximum diameter (orange lines, secondary Y axis) of target species *Pseudodiploria strigosa* across the four regions for each survey year. Note the different primary Y axis scale for Dry Tortugas.

JUVENILE TARGET CORAL FAMILIES

The 2020 survey season marked the first year the DRM program incorporated juvenile coral counts into the survey methods. These counts were continued in 2021. Juveniles of three target coral (sub)families (Meandrinidae, Faviinae, and Mussinae) were enumerated along all four transects. These three families encompass the 10 SCTL D-susceptible coral species that were targeted along Transects 3 and 4. 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
<i>Colpophyllia natans</i>	<i>Isophyllia</i> spp.	<i>Dendrogyra cylindrus</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 378 sites surveyed in 2021, 249 had at least one juvenile colony recorded. Juveniles from two of the target families were present at 78 sites and all three families were observed at 48 sites. At the site level, 42 sites had 10 or more juvenile colonies of the three target families and 10 sites had 20 colonies or more. Juveniles of all three families were recorded across all subregions except for Martin County, where no juvenile corals of any of the target families were recorded, and Palm Beach County where only one Mussinae and nine Meandrinidae colonies were recorded.

In Southeast Florida, juveniles within the Meandrinidae family had a greater density among the three targeted families in both 2020 and 2021 (**Table 8**). Mean density of Meandrinidae juvenile colonies was higher in 2021 than in 2020 while mean density for both Faviinae and Mussinae juvenile colonies were slightly lower compared across years.

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

Target Families	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
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
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

In the Florida Keys mean juvenile density for all three targeted families was higher in 2021 than in 2020, with the largest increase observed in Meandrinidae. Among the target families, Meandrinidae had the highest mean density in the Florida Keys in both 2020 and 2021. The same pattern was seen in Southeast Florida.

In the Marquesas region, mean density of both Faviinae and Meandrinidae juvenile colonies was lower while the mean density of Mussinae colonies was higher between 2020 and 2021. The mean density of both Mussinae and Meandrinidae juveniles was higher in the Marquesas than in the other regions.

Similar to the Marquesas region, mean density of both Faviinae and Meandrinidae juveniles were slightly lower 2021 than in 2020 in the Dry Tortugas while the mean density of Mussinae colonies was higher. Despite a small decrease in the mean density of Faviinae juveniles, the Dry Tortugas still had the highest mean density of any region in both years.

SUMMARY

Bleaching: Bleaching prevalence (pooled for fully bleached or partially bleached colonies) was mild across all subregion-zones in 2021 (**Figure 1**). When corals recorded with paling are included in the assessment, bleaching values were moderate (21-50%) in half of the subregion-zones surveyed (**Figure 2**) and 16 out of 378 sites were recorded with severe (>50%) bleaching and paling. The Broward-Miami subregion had the most bleaching and paling recorded. Compared across the last few years, bleaching prevalence has been mild dating back to 2016 (**Table 9**). Additional information that describes the zones that were surveyed within each subregion over the life of the program are provided on the DRM website on the Surveyor Trainings and Resources page (<https://ocean.floridamarine.org/FRRP/Home/About>).

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

Disease: The prevalence of diseases resulting in tissue loss across all subregion-zones was low in 2021 (0-5% disease prevalence), apart from the Dry Tortugas where SCTLD was first observed in May of 2021. At the time of the DRM surveys in September of 2021, both the lagoon and forereef zones in the Dry Tortugas subregion had medium (6-10%) disease prevalence values (**Figure 3**). The prevalence of diseases resulting in tissue loss was low in Southeast Florida, the Florida Keys, and the Marquesas regions and the total number of colonies recorded with the disease was lower in 2021 than in 2020 in both the Florida Keys and the Marquesas. This is likely due to both the subsidence of SCTLD in those regions and the now smaller populations of highly susceptible species.

The impacts of SCTLD on susceptible species populations were apparent in the time series comparisons in **Figures 5** through **11**, except in the Dry Tortugas, where more time will be required to estimate the full extent of the loss. For the targeted SCTLD-susceptible species with sufficient abundance to identify impacts to the population in each region, those in Southeast Florida saw the greatest drops between 2015 and 2017, the Florida Keys between 2016 and 2020, and the Marquesas between 2019 and 2021.

In Southeast Florida, between 2016 and 2021, the mean density of *D. stokesii* has gradually improved while mean maximum diameter has remained relatively static. This is likely the result of surviving juvenile colonies reaching the 4cm threshold for inclusion into the adult survey and recruitment. Both *M. meandrites* and *P. strigosa* saw a slight rise in mean density and mean maximum diameter from 2020 to 2021, suggesting their populations may have stabilized due to the low prevalence of SCTLD in this region.

In the Florida Keys, mean density also has begun to stabilize for several of the target species. Despite low values over the past two to three years, *D. stokesii*, *D. labyrinthiformis*, *M. meandrites*, *P. clivosa*, and *P. strigosa* had slight increases in density from 2020 to 2021. Of those species, *D. stokesii*, *M. meandrites*, and *P. clivosa* had slight increases in mean maximum diameter from 2020 to 2021 as well, suggesting that surviving colonies are continuing to grow. Despite a small rise in mean density, the mean maximum diameter of *D. labyrinthiformis* and *P. strigosa* continued to decline between 2020 and 2021, which may indicate that recurring or lingering SCTLD infections are slowly removing larger colonies from the population while the growth of surviving juvenile colonies that have reached the 4cm threshold for inclusion into the adult survey reduced the mean maximum diameter. Mean density of *C. natans* continued to decline from 2020 to 2021, however this decline was much less pronounced than the drop between 2018 and 2019 or between 2019 and 2020. Overall, density values for the 10 targeted DRM species remain much lower due to SCTLD; however, there are indications that the worst of the impacts have concluded within the Florida Keys and the populations have begun to stabilize.

Within the Marquesas region, *C. natans*, *D. stokesii*, *M. meandrites*, *P. strigosa*, and *Mycetophyllia* spp. all experienced dramatic declines in mean density from 2019 to 2020, coupled with lower mean maximum diameter values. Although the mean density and mean maximum diameter continued to decline between 2020 and 2021 for each of these species, they were less pronounced than the previous year, likely due to the lower prevalence of SCTLD within the subregion.



During the September 2021 DRM survey in the Dry Tortugas, SCTLD was observed at 33 of the 54 sites surveyed and was documented on 16 susceptible species. Because most of the sites visited were in the epidemic stages of SCTLD, a full assessment of the changes in population density were premature. Many colonies that had active SCTLD lesions still had living tissue, which means they would have been both enumerated and measured in the 2021 survey. Therefore, it will require several years of DRM surveys in the Dry Tortugas to fully quantify the impact of SCTLD since many reefs will still be in the epidemic stage of SCTLD in 2022.

For more information about FRRP and its DRM effort, see the website <http://ocean.floridamarine.org/FRRP/>. For more information about the Summer 2021 DRM results, contact Jennifer Stein at Jennifer.Stein@MyFWC.com.