

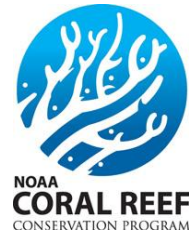
Florida Reef Resilience Program

Disturbance Response Monitoring



Quick Look Report:

Summer 2019



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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 users to develop resilience-based management strategies for anticipating and addressing climate change and other stressors on Florida's coral reefs. Precipitated by the severe coral bleaching event in the Florida Keys in 2005, the FRRP developed the Disturbance Response Monitoring (DRM) program to assess reef condition annually during the months of peak thermal stress. Since 2005, the partners of the DRM program have conducted annual surveys to document the extent and severity of coral bleaching and disease on the Florida Reef Tract (FRT).

The primary goals of the DRM program have always been to provide a condition report and the annual status of bleaching along the FRT. This information is used to identify resilient areas of the reef, promote appropriate management or conservation strategies of more resilient and less reef areas, 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 the FRT 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 FRT continually grow.

During its tenure, the DRM program has modified its experimental design to account for new disturbances and has adapted its protocols in response to the outbreak of Stony Coral Tissue Loss Disease (SCTLD). SCTLD is a lethal coral disease that, since 2014, has spread through nearly the entire FRT with the exception of the Dry Tortugas (at the time of writing this report in early 2020). The cause of the disease remains unknown, but it is affecting over half of the coral species found on the FRT. The large network of partners in the DRM program offers a unique opportunity to assess SCTLD on a broad scale across the FRT. The assessments can be completed in a three-month period, which offers a rapid and time sensitive evaluation of FRT condition and SCTLD distribution and prevalence.

The DRM program uses multiple resources to help predict the onset of coral bleaching and the presence of coral disease, including SCTLD, prior to the start of the survey season. In July of 2019, the NOAA Coral Reef Watch Bleaching Alert System reported a bleaching ‘*Watch*’ for Southeast Florida mainland reefs and a ‘*Warning*’ for Florida Keys reefs, due to rapidly increasing sea surface temperatures. While temperatures in Southeast Florida had increased enough to put the area under a bleaching ‘*Warning*’ by mid-August, those temperatures leveled out and decreased by the end of September. In contrast, temperatures in the Florida Keys experienced a sharp increase through the month of August, putting the region under a bleaching ‘*Alert Level I*’ and eventually ‘*Alert Level II*’ by the end of the month.

Prior to the start of the 2019 DRM survey season, SCTLD had been reported spreading west in the Lower Keys (FWC & FKNMS divers, pers. comm.), but there were no reports of it in the Marquesas. However, this may have been due to underreporting because of the difficulty in accessing that region, and only a few reconnaissance surveys had been completed there. To determine the potential spread of SCTLD into the Marquesas, the DRM program organized a research cruise targeting areas of known hardbottom and reef habitat. The 2019 DRM season marked the first year that the Marquesas subregion had been included in the effort since 2007, when only six sites were surveyed.

During the 2019 DRM season (between August and October), 82 surveys were completed in southeast Florida, 124 in the Florida Keys, 31 in the Marquesas, and 48 in the Dry Tortugas. No surveys were completed north of the Palm Beach subregion. As in 2018, surveys were not conducted in the Martin County subregion due to adverse weather and poor water quality resulting from releases from Lake Okeechobee. Therefore, the results of this report do not reflect conditions experienced in the Martin County subregion during the 2019 DRM season.

Survey partners for the 2019 season included Biscayne National Park, Broward County, Dry Tortugas National Park, Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission (FWC), John Pennkamp Coral Reef State Park, Keys Marine Laboratory, Miami-Dade County, Mote Marine Laboratory, National Oceanic and Atmospheric Administration (NOAA), Nova Southeastern University, Palm Beach Zoo, Rosenstiel School of Marine and Atmospheric Science, and The Nature Conservancy.

This summary report describes the prevalence of coral bleaching, paling, and disease in 2019 as assessed through belt transect surveys. Prevalence values were calculated by pooling all corals by sites and by zones within a subregion. Reef zones were classified by cross-shelf position, distance from shore, and depth, while subregions were stratified latitudinally. In addition to the belt transect surveys, if time allowed, a Roving Diver Survey (RDS) was conducted at each site to better detect the occurrence of SCTLD across the FRT. RDS were implemented to increase the survey area at a reef. Case definitions and other information on SCTLD are compiled by the Florida Keys National Marine Sanctuary and can be found at <https://floridakeys.noaa.gov/coral-disease/>.

METHODOLOGY

Belt Transects

The DRM program surveys coral populations using a probabilistic sampling design based on how corals are distributed spatially within and across different subregions and zones of the FRT. For the 2019 DRM season, 323 potential survey sites were allocated across 39 discrete reef zones in 12 subregions.

Sites were randomly selected, and surveys consisted of two replicate 1x10 m belt transects that were haphazardly placed within a 100x100 m sample area. At all sites, the indicators recorded for all stony corals >4 cm were size (max diameter and height) and condition, as determined by the presence of bleaching, paling (i.e., the precursor to bleaching), disease, and percent mortality. Percent mortality was assigned as either old mortality, recent mortality due to disease, or recent mortality due to other factors (biotic or abiotic). If disease was the cause of recent mortality, surveyors described the tissue loss pattern and rate of spread, and identified the condition using a three-letter coral disease identification code. The identification code for SCTLD was added to the DRM data entry system in 2019 as 'STL' (Stony Tissue Loss).

From the surveyed population, prevalence values of bleaching alone, bleaching and paling combined, and disease were calculated by pooling coral data by site and by zone within each subregion. Prevalence values represent the percent of corals affected within a site or zone population. Prevalence values were compared across zones and subregions to identify spatial differences in the severity of coral bleaching and paling as well as identify spatial patterns of coral diseases.

Roving Diver Survey

Once two belt transects had been completed at a site, divers completed one or two separate RDS if time allowed. The diver(s) conducting the RDS swam outside of the belt transect area and tallied corals >10 cm in diameter in one of three categories: healthy, diseased, or 100% recently dead from disease. Only corals experiencing active tissue loss from disease or 100% tissue loss from disease were recorded during the RDS survey. Corals with conditions such as Dark Spot Syndrome or that had discolored tissue were not recorded as diseased. Due to the wide range of symptoms exhibited by corals with SCTLD, surveyors were not asked to distinguish between the different types of diseases during the RDS. Thus, any corals with active tissue loss from disease were recorded.

The RDS survey was limited to seven target coral species known to be highly susceptible to SCTLD: *Colpophyllia natans*, *Dichocoenia stokesii*, *Diploria labyrinthiformis*, *Meandrina meandrites*, *Montastraea cavernosa*, *Orbicella faveolata*, and *Pseudodiploria strigosa*. While survey time was recorded for each RDS, the size of the area surveyed, and the duration of the survey varied across sites.

Similar to the belt transect data, prevalence values of disease from the roving diver surveys was calculated by pooling coral data by site within each subregion. Disease prevalence values represent the percent of the surveyed population at a site that were experiencing active tissue loss from disease.

2019 DRM RESULTS

Belt Transect Results

A total of 285 sites were completed across 11 subregions for the 2019 DRM season. Six sites were completed in North Palm Beach, nine in South Palm Beach, two in Deerfield, 65 in Broward-Miami, 15 in Biscayne, 27 in the Upper Keys, 10 in the Mid-Upper Keys Transition, 18 in the Middle Keys, 54 in the Lower Keys, 31 in the Marquesas, and 48 in the Dry Tortugas.

The prevalence of colonies exhibiting signs of bleaching and paling was pooled by sites (**Table 1** and **2**) and by zones (**Figure 1** and **2**) within each subregion. Prevalence values were broken into three categories: mild (0-20%), moderate (21-50%), and severe (>50%). When looking at bleached and partially bleached colonies only (i.e., excluding pale colonies), mild bleaching occurred at 249 of the 285 sites surveyed (**Table 1**). Moderate bleaching occurred at 33 sites, including 11 sites in the Broward-Miami subregion and 11 in the Dry Tortugas subregion. Only three sites were recorded with severe bleaching: one each in North Palm Beach, South Palm Beach, and Broward-Miami. All three severely bleached sites, however, had less than five coral colonies recorded along the belt transects. When prevalence data was pooled by zone within the subregions, all subregion-zones were recorded with mild bleaching prevalence (0-20%; **Figure 1**).

Table 1. Total number of sites within each subregion recorded with mild, moderate or severe bleaching prevalence of coral colonies.

Subregion	Total Sites	Total Corals	# of Sites with Bleaching Prevalence		
			Mild 0-20%	Moderate 21-50%	Severe >50%
North Palm Beach	6	45	5		1
South Palm Beach	9	100	6	2	1
Deerfield	2	49	2		
Broward-Miami	65	1262	53	11	1
Biscayne	15	784	12	3	
Upper Keys	27	1476	27		
Mid-Upper Keys Transition	10	552	10		
Middle Keys	18	968	18		
Lower Keys	54	4510	48	6	
Marquesas	31	3666	31		
Dry Tortugas National Park	48	4232	37	11	
Total	285	17644	249	33	3

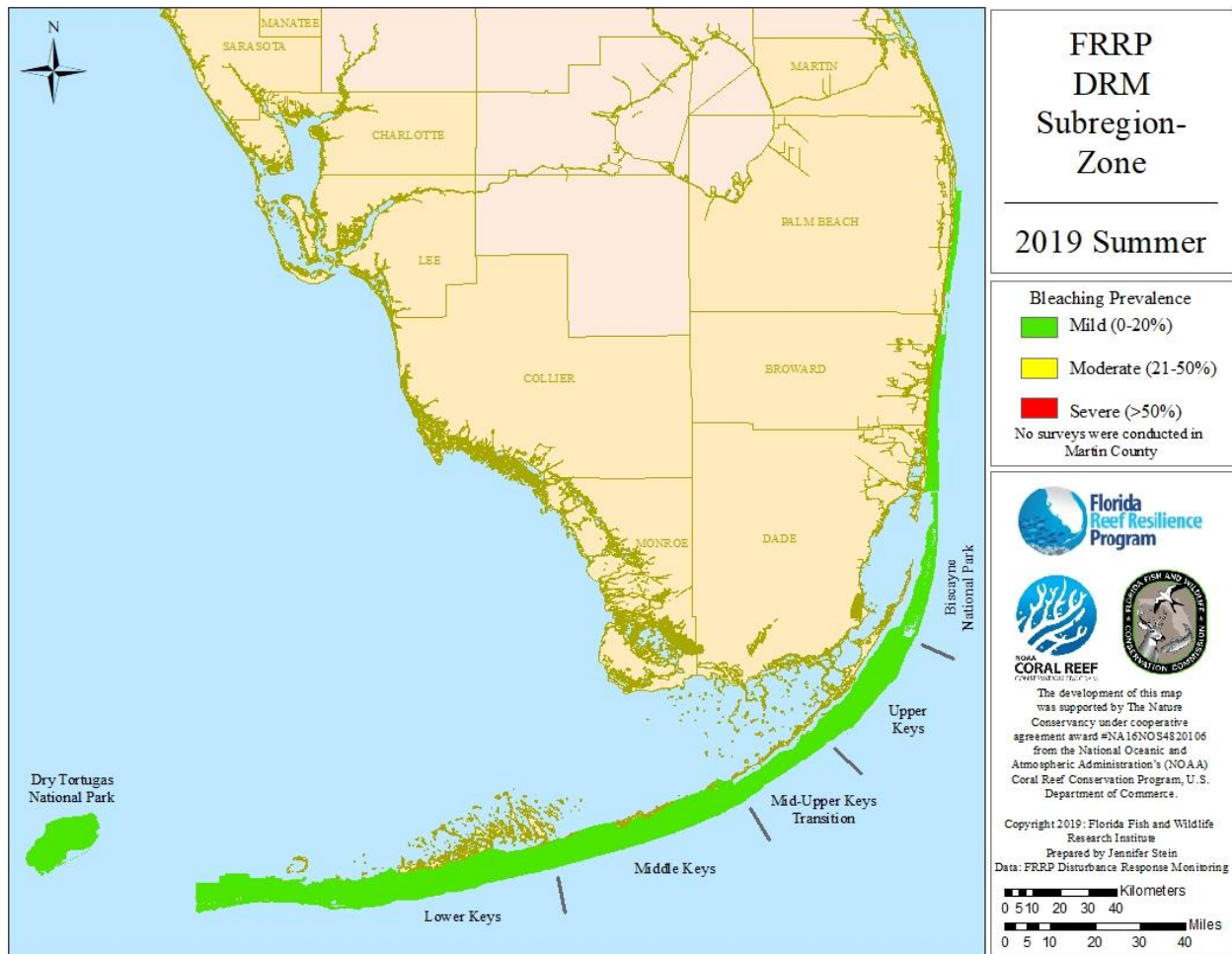


Figure 1. Bleaching prevalence of surveyed coral colonies by subregion-zone.

When paling was included within the bleaching analysis, prevalence values increased to moderate (21-50%) and severe (>50%) in over half the sites surveyed in 2019 (**Table 2**). Sites with moderate bleaching and paling occurred in at least one zone of all surveyed subregions except for Deerfield. The Marquesas, Dry Tortugas, and Broward-Miami subregions had the highest number of sites with moderate bleaching and paling. The Dry Tortugas also had 22 sites with severe bleaching and paling. Pooled by subregion-zone, 16 of the 31 subregion-zones were recorded with moderate bleaching and paling (**Figure 2**). While the outer reef of South Palm Beach had severe paling at 73%, this high percentage was likely the result of the low density of corals in that area (11 colonies total within the subregion-zone surveys). All reef zones in the Middle Keys subregion were recorded with less than 20% bleaching and paling (**Figure 2**).

Paling (a precursor to bleaching where coral color is lighter than normal) is included within the prevalence analysis 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 divers across the wide range of DRM surveyors interpret variations in coral color in the field.

Paling of coral tissue is most commonly attributed to thermal stress but can also be the result of the initial phases of SCTLD. Discoloration of tissue and paling from disease can often be difficult to distinguish in the field and can occur simultaneously if the corals are thermally stressed and SCTLD is just becoming active on the reef. Therefore, a cautious interpretation of the results is advised again for regions or zones with high bleaching prevalence (when paling is included in the analysis) and where SCTLD was highly active.

Table 2. Total number of sites within each subregion recorded with mild, moderate or severe bleaching (BL) and paling (P) prevalence.

Subregion	Total Sites	Total Corals	# of Sites with BL & P Prevalence		
			Mild 0-20%	Moderate 21-50%	Severe >50%
North Palm Beach	6	45	3	2	1
South Palm Beach	9	100	1	5	3
Deerfield	2	49	2		
Broward-Miami	65	1262	33	25	7
Biscayne	15	784	7	7	1
Upper Keys	27	1476	11	16	
Mid-Upper Keys Transition	10	552	4	5	1
Middle Keys	18	968	13	5	
Lower Keys	54	4510	32	13	9
Marquesas	31	3666	4	27	
Dry Tortugas National Park	48	4232	1	25	22
Grand Total	285	17644	111	130	44

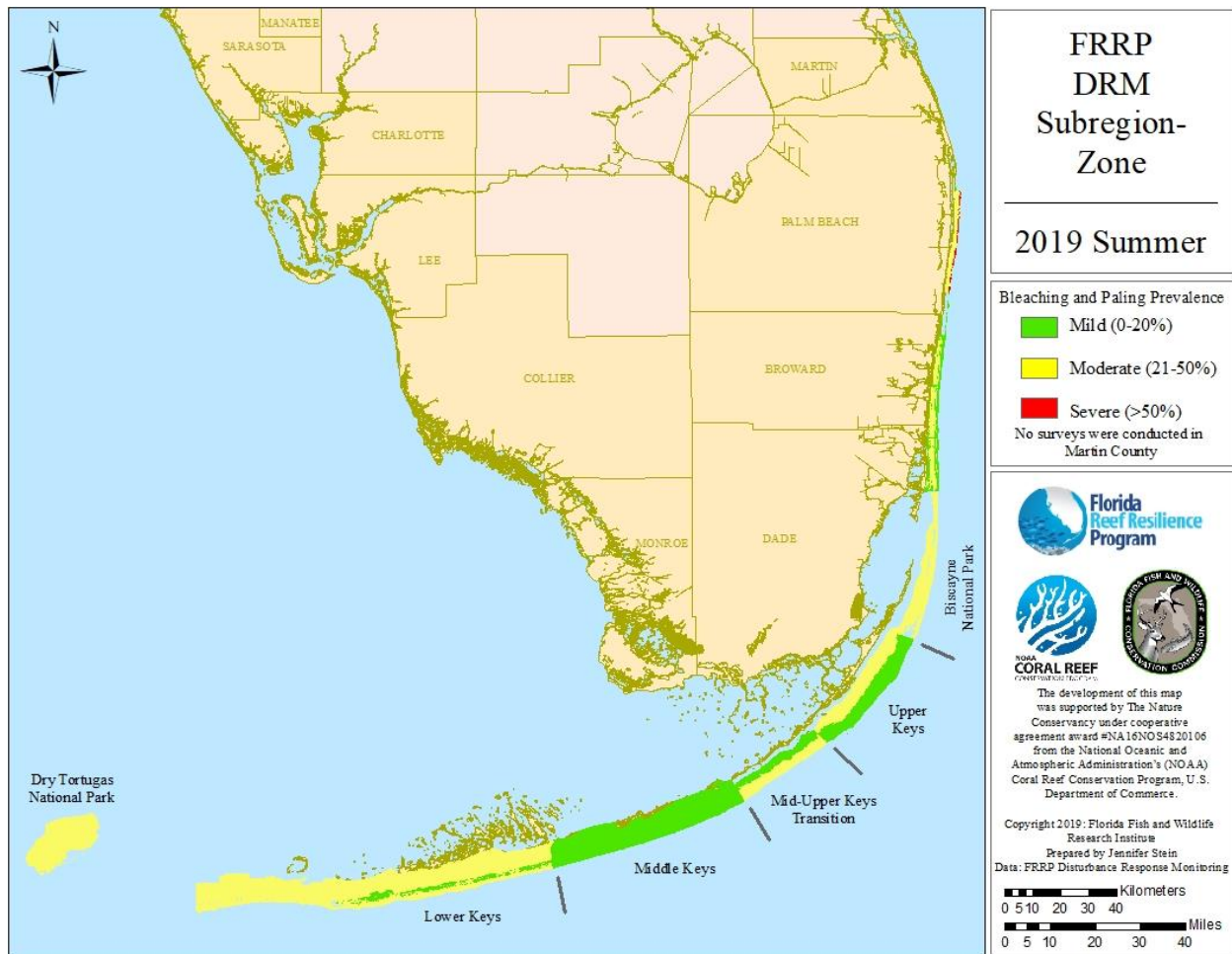


Figure 2. Bleaching and paling prevalence of surveyed coral colonies by subregion-zone.

The prevalence of disease was pooled by sites (**Table 3**) and by zones (**Figure 3**) within each subregion. Prevalence values were broken into three categories: low (0-5%), medium (6-10%), and high (>10%). All disease prevalence values were calculated from diseases with tissue loss and do not include Dark Spot Syndrome or Discoloration conditions. Across the 285 sites surveyed in 2019, 13 sites were recorded with medium disease prevalence and seven sites with high disease prevalence (**Table 3**). The Broward-Miami subregion had the highest number of sites with medium and high disease prevalence. Pooled by subregion-zone, the Deerfield inshore reef was the only subregion-zone to experience high (>10%) disease prevalence (**Figure 3**). Two sites were surveyed in the Deerfield subregion with only one on the inshore reef. Sixteen corals were recorded at the Deerfield inshore reef site, four of which were diseased. All four observations of disease were identified as ‘Unknown’ and occurred on the species *Solenastrea bournoni*. All other subregion-zones were recorded with low disease prevalence (<5%).

Table 3. Total number of sites within each subregion recorded with low, medium or high disease prevalence.

Subregion	Total Sites	Total Corals	# of Sites with Disease Prevalence		
			Low 0-5%	Medium 6-10%	High >10%
North Palm Beach	6	45	5	1	
South Palm Beach	9	100	8	1	
Deerfield	2	49	1		1
Broward-Miami	65	1262	57	5	3
Biscayne	15	784	15		
Upper Keys	27	1476	25	2	
Mid-Upper Keys Transition	10	552	9		1
Middle Keys	18	968	18		
Lower Keys	54	4510	49	4	1
Marquesas	31	3666	31		
Dry Tortugas National Park	48	4232	47		1
Grand Total	285	17644	265	13	7

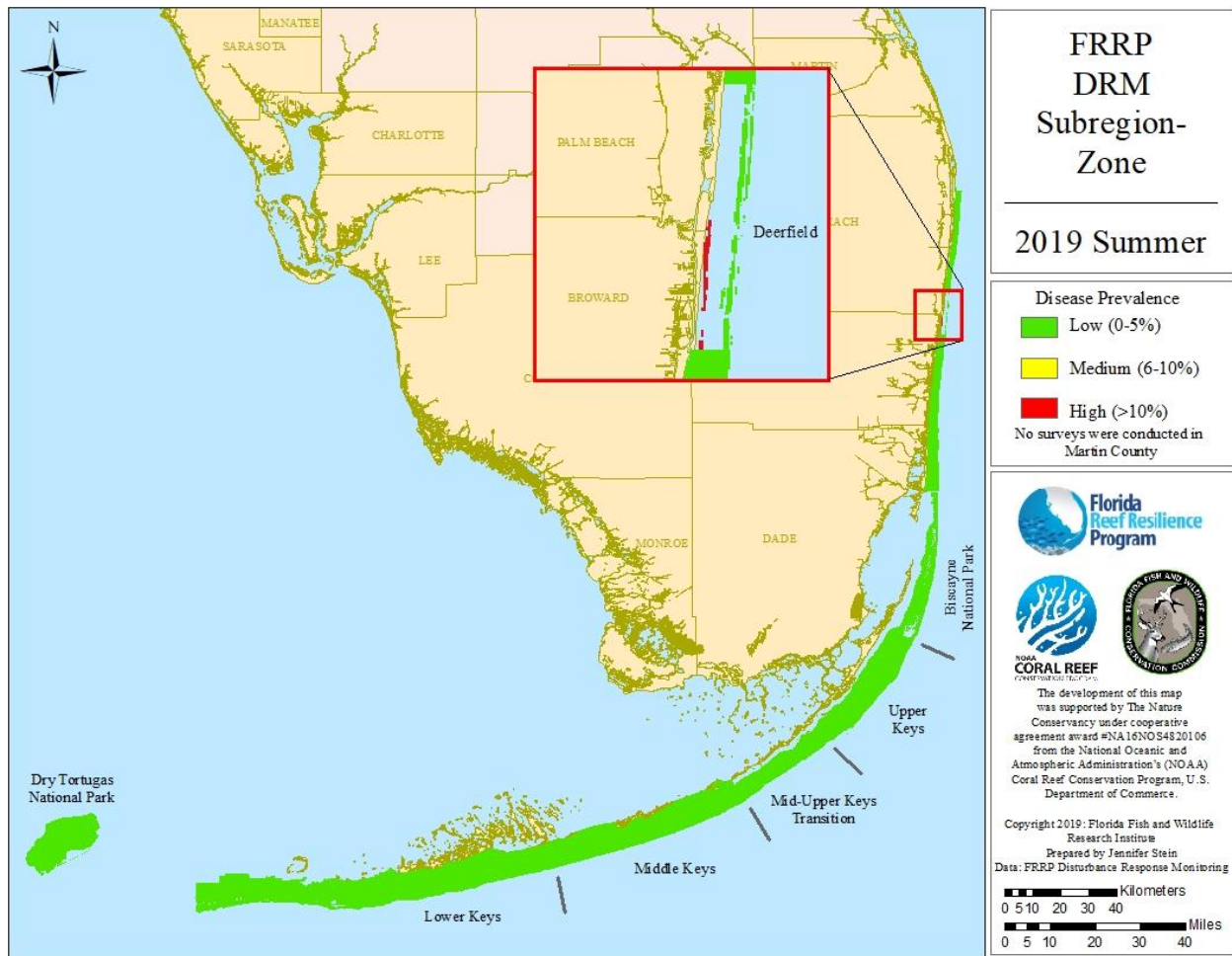


Figure 3. Disease prevalence of surveyed coral colonies by subregion-zone. A larger scale inset map of the Deerfield subregion was added to exemplify the high (>10%) prevalence of disease in that subregion.

Across all sites surveyed in 2019, a total of 82 corals were recorded with SCTLD within the belt transects. Seventy-three of those corals were in the Lower Keys subregion with 18 occurrences on *Siderastrea siderea*, 12 on *M. cavernosa*, 10 on *C. natans*, 10 on *O. faveolata*, and five on *P. strigosa*. All other species recorded with SCTLD in the Lower Keys had less than five occurrences. Due to the high density of corals in the Lower Keys, however, disease prevalence values were low at both the site and zone level.

Roving Diver Survey Results

In 2018, the DRM program implemented a Roving Diver Survey (RDS) to be completed if divers had bottom time after completing two belt transects at a site. The purpose of the RDS was to determine the presence of SCTLD on a scale greater than the 20m² area surveyed in the belt transects at each site. Due to the wide range of symptoms exhibited by corals with SCTLD, surveyors were not asked to distinguish between the different types of diseases during the RDS. Instead, surveyors tallied corals with any type of disease that resulted in active tissue loss and corals that appeared healthy. The RDS data was used to identify the leading edge of SCTLD as it

progressed westward, where corals with SCTLD lesions were most frequent (i.e. the location of the “epidemic zone”) and how persistent SCTLD was in the “endemic zone” or regions in which outbreak levels of SCTLD had concluded.

Across the Florida Reef Tract, 263 RDS were conducted during the 2019 season with a total of 8,550 corals tallied. Across all RDS surveys, a total of 783 corals were observed with active tissue loss from disease, with 680 of those corals observed in the Lower Keys subregion (**Table 4**). Among the seven coral species targeted during the surveys, *C. natans* had the highest occurrence of disease resulting in tissue loss. In the Lower Keys subregion alone, 316 diseased *C. natans* colonies were tallied. The Broward-Miami subregion had a total of 44 diseased colonies tallied, with over half recorded in the nearshore reef zones (inshore and inner reef; **Table 4**). Thirty-two of the 44 diseased colonies recorded in the Broward-Miami subregion were *M. cavernosa*.

Prevalence values of diseased corals tallied during the RDS were calculated for each site and then categorized into low (0-5%), medium (6-10%), and high (>10%; **Figure 4**). High disease prevalence was recorded at RDS sites within the Deerfield, Broward-Miami, Biscayne, Upper Keys, Middle Keys, and Lower Keys subregions. The greatest number of sites with high disease prevalence calculated from the RDS was in the Lower Keys. No diseased corals were recorded during the RDS in South Palm Beach, potentially due to the low density of target coral species in that area. All other subregions were recorded with less than 20 total diseased colonies tallied during the RDS (**Table 4**). Without a standardized survey area or survey time for the RDS, prevalence values should be interpreted with caution. Results from the RDS can vary based on survey time, visibility, current, and diver-bias in survey pattern.

Table 4. Total number of colonies tallied during RDS and total percent diseased colonies of the target species. Total coral tallies are pooled across subregions and subregion-zones.

Subregions	Roving Diver Survey Total Coral Tallies														% of diseased colonies among the target species
	<i>Colpophyllia natans</i>		<i>Dichocoenia stokesii</i>		<i>Diploria labyrinthiformis</i>		<i>Meandrina meandrites</i>		<i>Montastraea cavernosa</i>		<i>Orbicella faveolata</i>		<i>Pseudodiploria strigosa</i>		
	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	
North Palm Beach															--
South Palm Beach	1		2		1		1		14		2	4			0%
Deerfield					1				10	3					35%
Broward-Miami	3	1	28	1	5		18		493	32	40	5	27	5	7%
Biscayne	2		4		2				60	1	58	2	7		2%
Upper Keys	8		47		40	1	7		83	1	100	6	16		3%
Mid-Upper Keys Transition	15		11		8				41		53	1	3		1%
Middle Keys	36	2	16	2	9		3		196	6	75	6	42	3	5%
Lower Keys	256	316	101	26	70	11	33	12	718	93	305	135	118	87	30%
Marquesas	170	2	98	1	34		150		1350	1	154	2	258	1	0%
Tortugas--Dry Tortugas NP	326	2	69		67	1	168		1043	5	470	6	221		1%
Grand Total	817	323	376	30	237	13	380	12	4008	142	1257	167	692	96	9%

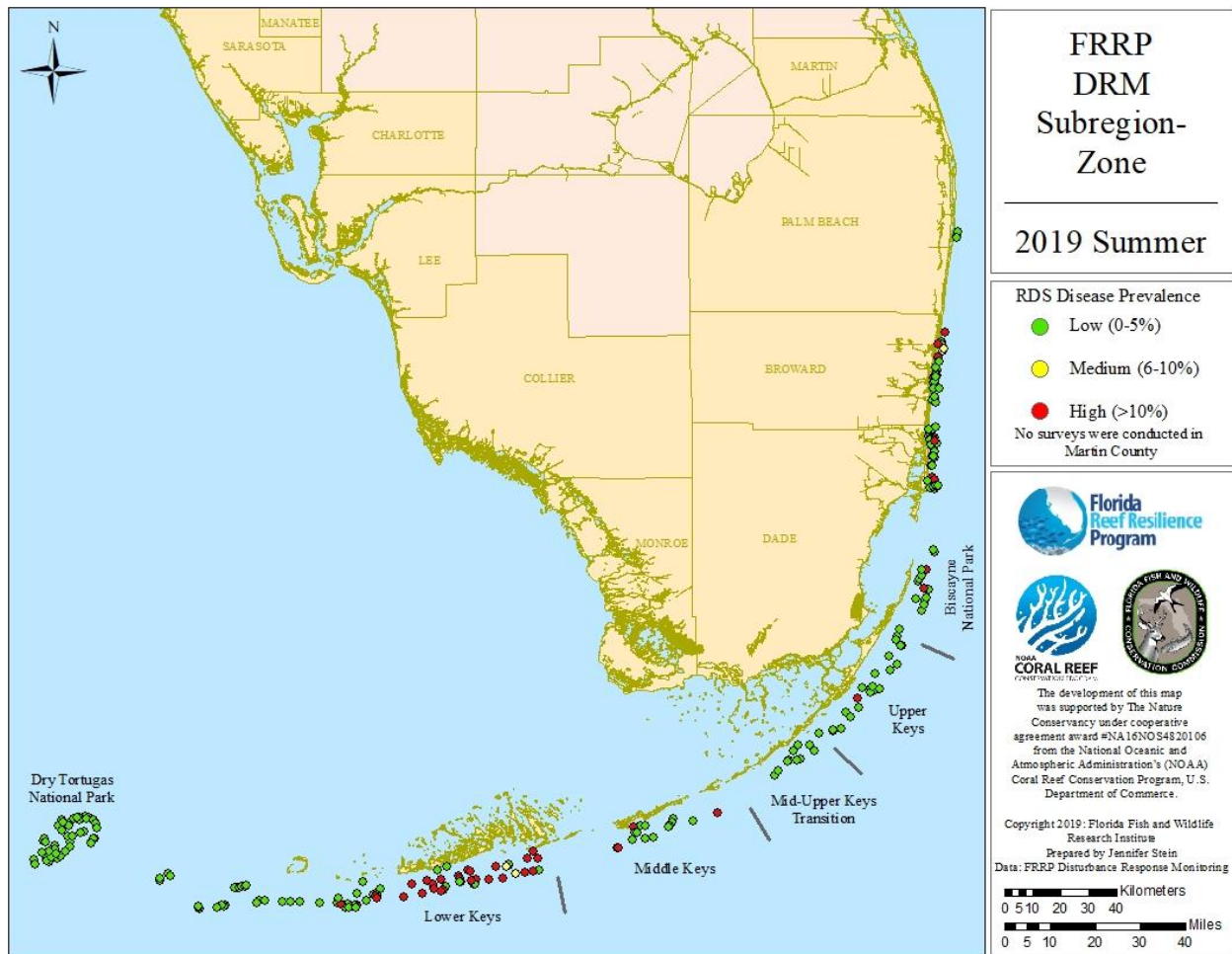


Figure 4. Disease prevalence at sites where RDS were completed. Roving Diver Surveys were limited to seven target coral species (*C. natans*, *D. stokesii*, *D. labyrinthiformis*, *M. meandrites*, *M. cavernosa*, *O. faveolata*, and *P. strigosa*).

SUMMARY

Overall, the results indicate that 2019 was a mild bleaching year when prevalence values were combined for all subregion-zones (**Figure 1**). When corals recorded with paling are included, bleaching values were moderate (21-50%) in over half of the subregion-zones surveyed (**Figure 2**). Severe paling was observed on the outer reef of South Palm Beach when pooled across the four sites surveyed. However, none of these sites had more than five total corals. All pale colonies recorded on the South Palm Beach outer reef were either *Stephanocoenia intersepta* or *S. siderea*. When compared to last year, bleaching prevalence was slightly lower in 2019 than in 2018; however, when the values are inclusive of paling, 2019 bleaching prevalence values are very similar to those in 2018 (**Table 5**).

Table 5. Number of subregion-zones recorded with mild, moderate, or severe bleaching prevalence, and combined bleaching and paling prevalence, for each DRM summer survey event. *2017 does not include data from the IRMA rapid response effort.

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			16	4		20
2007	27	1	1	16	12	1	29
2008	21			17	4		21
2009	23	2		9	16		25
2010	22			15	7		22
2011	20	5		7	16	2	25
2012	23	1		21	3		24
2013	23			16	7		23
2014	7	13	8	2	9	17	28
2015	14	14	1	4	14	11	29
2016	28			13	14	1	28
2017*	12			6	6		12
2018	24	2		9	14	3	26
2019	31			14	16	1	31

Overall disease prevalence (calculated from the belt transects) was low in 2019, except at the Deerfield inshore reef (**Figure 3**), where ‘Unknown’ coral disease (i.e., a disease not positively identifiable as SCTLD or another disease) affected four *S. bournoni* colonies. *S. bournoni* is known to be affected by SCTLD and is considered an intermediately susceptible species by the Florida Keys National Marine Sanctuary. In intermediately susceptible species lesions can develop several months to years after the highly susceptible species perish (<https://floridakeys.noaa.gov/coral-disease/>).

From the belt transect results, SCTLD was recorded within four of the 11 subregions surveyed in 2019 (Broward-Miami, Upper Keys, Middle Keys, and Lower Keys). Almost 90% of those corals were recorded in the Lower Keys subregion with the majority comprised of *S. siderea*, *M. cavernosa*, *C. natans*, and *O. faveolata* (**Figure 5**). Of those species, *C. natans* is considered highly susceptible to SCTLD, while the others are considered intermediately susceptible. Overall prevalence values of SCTLD, when pooled by subregion-zone, was less than 3% in every subregion-zone. When analyzed by site, one site on the Lower Keys forereef was recorded with high SCTLD prevalence (11%) and one site on the Broward-Miami inner reef was recorded with medium SCTLD prevalence (6%). All other sites surveyed in 2019 had less than 5% SCTLD prevalence along the belt transects.



Figure 5. Images of coral disease in the Lower Keys subregion. Top left: *C. natans*; top right: *M. cavernosa* (photo credit: Lonny Anderson, NOAA); bottom left: *O. faveolata*; bottom right: *S. siderea* (photo credit: Cory Walters, MOTE Marine Lab).

Although the overall prevalence of diseased corals was low in the Lower Keys (likely due to a higher density of corals in that subregion, many of which do not contract SCTLD), the region had the highest number of diseased corals recorded along the belt transects, totaling 104 colonies (**Table 3**). The RDS supported this finding in the Lower Keys, where 31 of 54 sites surveyed were recorded with high (>10%) disease prevalence and two sites with medium (6-10%) disease prevalence (**Figure 4**).

The purpose of the RDS was to expand the survey area at a site beyond the 20m² surveyed in the belt transects, to better assess the presence of SCTLD. The larger survey area aided in documenting the presence of tissue loss lesions on rare coral species affected by SCTLD. In addition, depending upon the coral community composition at the site the prevalence of SCTLD can be low during both the early onset of the disease or in later stages in the endemic zone if SCTLD has already killed the highly susceptible species. The RDS provided a technique that could be used to identify the arrival of SCTLD at a site and aid in tracking its western advancement along the FRT. As stated above, RDS prevalence values should be interpreted with caution since they were not standardized for survey area and time.

At the conclusion of the 2019 DRM season on October 29th, the results indicated that the leading edge of SCTL D was advancing towards the Marquesas subregion. Five sites within the Lower Keys subregion that are west of Key West were recorded with SCTL D. This put SCTL D at the eastern most boundary of the Marquesas subregion during the month of October, when surveys were completed.

For more information about FRRP and its DRM effort see the website <http://ocean.floridamarine.org/FRRP/>. For more information about the Summer 2019 DRM results contact Jennifer Stein at Jennifer.Stein@MyFWC.com or at (305) 676-3252.