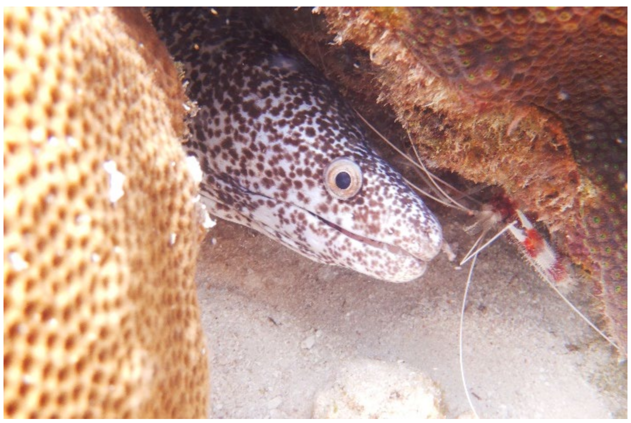
Long-term Monitoring of Selected Coral Reefs in Dry Tortugas National Park 2019-2020 Biennial Report



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This biennial report presents data collected in project years 2019 and 2020. Comprehensive analyses from project inception through 2020 are provided.

Cover Page Photographs: upper left: a spotted moray and banded peppermint shrimp between a greater starlet coral *Siderastrea siderea* and mountainous star coral *Montastraea cavernosa*; right: a vibrant green morph of boulder brain coral, *Colpophyllia natans*; lower left: grey snapper among the ESA-listed species elkhorn coral, *Acropora palmata*.

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Executive Summary

Coral reefs are a critically important natural resource in Dry Tortugas National Park (DRTO). Although DRTO reefs have been described as some of the most pristine on Florida's Coral Reef (FCR), they have undergone substantial declines during the last 40 years, including substantial losses of previously abundant *Acropora* species. For a time, it was believed the isolation of the Dry Tortugas would mitigate against the effects of land-based activities (e.g., pollution, sedimentation, deteriorating water quality) that promote environmentally stressful conditions to coral reefs. While in some instances its remoteness has insulated DRTO reefs against these disturbances, it has not stemmed the impact of regional stressors such as disease outbreaks or mass bleaching events.

The Fish and Wildlife Research Institute's (FWRI) Coral Reef Evaluation and Monitoring Project (CREMP) has been assessing the status and trends of benthic communities in the Tortugas region since 1999. Twelve reefs encompass the survey effort and sites were selected to evaluate changes of common and rare coral reef types, including stands of acroporid corals and pinnacle reef structures that are unique features restricted to the Tortugas region of FCR. As part of the cooperative agreement between DRTO and FWRI, comprehensive biennial reports are prepared to provide an update on coral resource condition within DRTO. This report includes data collected in all project years with an emphasis on the recent reporting period of 2019 and 2020. Both short- and long-term comparisons were completed for the percent cover of benthic taxa (corals, macroalgae, octocorals, and sponges) and the densities of corals and octocorals at all sites, and similar analyses were conducted for the three ESA-listed acroporid species (*Acropora cervicornis, A. palmata,* and *A. prolifera*), and *Orbicella* spp. at sites where they were most common. Short-term analyses compared the results averaged for the last biennial time period (2017-2018) against those of this one (2019-2020); long-term analyses compared the average for the first four years of monitoring at a site to the recent average calculated for 2017-2020. The two- and four-year means calculated for the short- and long-term timeframes, respectively, were performed to minimize interannual variability and reduce the effect of ephemeral events that could substantially alter percent cover or abundance values in a given year. The design of the analyses allowed for an interpretation of recent findings while also providing historical context. The results were delineated into three broader sections: (1) an appraisal of benthic community structure with percent cover and density serving as the metrics to evaluate any changes, (2) the status of the ESA-listed coral species, and (3) user pressure and the impact of the SCUBA diving activities on Research Natural Area (RNA) pinnacle reefs.

Changes in benthic community structure were determined by evaluating short- and long-term differences at 12 reefs for percent cover of corals, macroalgae, octocorals, and sponges and 11 reefs for coral and octocoral density. Short-term, between the 2017-2018 and 2019-2020 reporting periods, coral and macroalgae cover increased at three sites, sponge cover was greater at two sites, and octocoral cover was unchanged at all sites. There were no decreases in cover identified for corals or octocorals but macroalgae and sponge cover were both significantly lower at one site. Coral and octocoral density were both similar at 10 of the 11 sites short-term with only one site having a significant change for both taxa. With the exception of these few changes, benthic community structure during this reporting timeframe was similar to what was found in the 2017-2018 biennial report.

Because there were very few significant short-term differences in percent cover across the benthic taxa groups, many of the long-term comparisons for benthic community structure were consistent with what was reported in the 2017-2018 biennial report; however, there were a few notable changes. Starting with coral cover, five of the 12 sites have significantly lower coral cover now than during the first four years of monitoring. Previous biennial reports confirmed long-term declines in coral cover at four sites, Bird Key Reef, Black Coral Rock, White Shoal, and Little Africa, and herein a long-term decline was also substantiated for Loggerhead Patch. In contrast, three sites have demonstrated a significant increase in coral cover long-term, which increased from only one site in the previous biennial report. These include Palmata Patch, previously found to have an increase in coral cover, as well as Prolifera Patch and Mayer's Peak. For the other three benthic taxa groups (macroalgae, octocorals, and sponges), long-term changes have consisted of significant increases in cover. For macroalgae, nine of the 12 sites had significant increases in cover, including all sites for which the inception of monitoring pre-dates 2009. For octocorals, five sites have had a significant increase in cover, up from two sites in the previous report. Sponge cover was significantly greater at half (six) of the sites, only two of which were found to have significant increases in the previous report. Both coral and octocoral densities were significantly greater at six sites long-term while only one site demonstrated a significant decrease in density.

The status of ESA-listed corals was determined by evaluating short- and long-term differences in the percent cover of the acroporid species at their respective reefs and of *Orbicella* spp. across four reefs where it was abundant as well as pooled for the five RNA pinnacle reefs. Short-term, the cover of *A. prolifera* significantly increased between this and the previous biennial report while no changes were observed for *A. cervicornis* and *A. palmata*. *Orbicella* spp. cover was significantly lower at two sites short-term, while two sites were unchanged, and no differences were detected for the RNA pinnacle reefs. Long-term results for the acroporid species are similar to the previous report. *A. palmata* and *A. prolifera* cover have both significantly increased and approximately doubled at their respective sites. For *A. cervicornis*, cover was significantly lower at White Shoal than what was recorded between 1999-2002, and while no significant change in *A. cervicornis* cover was found at Loggerhead Patch, cover values were nearly zero. Long-term for *Orbicella* spp., cover has significantly decreased at four sites and for the average calculated for the RNA pinnacles. In the 2017-2018 report, there were no long-term changes detected in *Orbicella* spp. cover at Prolifera Patch and for the RNA pinnacle reefs, but that finding changed during this monitoring period. Dating back to the first four years of monitoring, more than 50% of the total *Orbicella* spp. cover has been lost at Bird Key Reef, and over one-third at Black Coral Rock and Little Africa. Although not as severe as the losses at those three sites, the reduction in *Orbicella* spp. cover at both Prolifera Patch and the RNA pinnacle reefs is ~25% with some of these changes occurring during the last two years. While *A. palmata* and *A. prolifera* have fared well since project inception, *A. cervicornis* and *Orbicella* spp. have not rebounded after losses during early years of monitoring (*A. cervicornis*) or are in a perpetual state of decline (*Orbicella* spp.).

Five pinnacle reefs inside of the RNA were used to investigate if concentrating SCUBA diving activities at sites designated with mooring buoys would result in harm or stress to the reef communities. Three pinnacle reefs received mooring buoys and serve as treatment sites, while two pinnacle reefs without mooring buoys act as reference sites. Differences between the treatment and reference sites were evaluated by comparing changes in percent cover and density of corals and octocorals. Data for the three treatment and two reference sites were pooled and for long-term analyses the first four years were standardized to 2009-2012 across treatment and reference sites. Short-term, between the 2017-2018 and 2019-2020 time periods, there were no significant differences in coral and octocoral cover and density. Long-term, between 2009-2012 and 2017-2020, there was a significant decline in coral cover at the treatment sites but no significant change at the reference sites. All other metrics including coral density, octocoral cover, and octocoral density all significantly increased long-term at both the treatment and reference sites. The decrease in coral cover at the treatment sites was mostly due to the loss of *Orbicella* spp., which, as outlined above, was a consistent finding across all sites analyzed for *Orbicella* spp. Because the loss of *Orbicella* spp. were widespread, the declines at the treatment sites were likely unrelated to SCUBA diving pressure and considering there were increases in overall coral density and octocoral cover and density, the results suggest that the current level of SCUBA diving activity has not had a deleterious effect on the benthic communities at the RNA pinnacles with mooring buoys.

From the resource management perspective, the continued decline in *Orbicella* spp. cover is of paramount concern. Massive corals within the *Orbicella* genus have been the most spatially abundant corals (e.g., the largest contributor to coral cover) at many sites in the Tortugas region and have comprised 50% or more of the total coral cover at many sites (e.g., Bird Key Reef, Black Coral Rock, and Little Africa). The declines in *Orbicella* spp. may not be preventable via park management actions because the declines in *Orbicella* spp. in DRTO are consistent with reports from other areas along Florida's Coral Reef (Ruzicka et al. 2013, Toth et al. 2014) and the broader Caribbean (Aronson and Precht 2006, Edmunds and Elahi 2007). Another pervasive issue has been persistently high macroalgal cover across the majority of sites. This has been described in detail in previous biennial reports (Ruzicka et al. 2018). Macroalgae was the greatest contributor to benthic cover at 11 of the 12 sites in 2019-2020. While initially believed that the rapid proliferation of macroalgae reported was associated with impressive upwelling captured by the CREMP temperature loggers in 2009, the high macroalgae values that started at that time have persisted through 2020. Upwelling along the Florida shelf is common but generally ephemeral, and if the bloom was fostered by upwelling it would be expected that over a decade after the bloom macroalgal cover would have begun to subside. The cause of the sustained increase in macroalgal cover was unlikely due to a change in herbivory pressure during the last twenty years, as herbivorous fishes are protected by DRTO regulations and the State of Florida Marine Life Rule, Chapter 68B-42 of the Florida Administrative Code. Although the grazing urchin *Diadema antillarum* has higher abundance in DRTO than elsewhere along FCR, overall *D. antillarum* density in DRTO is still likely lower than historical populations and may not be large enough to counterbalance the proliferation of fleshy macroalgae types like *Dictyota*. While increased macroalgal cover remains of principal concern, assessing its impact on other existing benthic taxa is difficult. At sites in which there have been substantial declines in coral cover (e.g., Black Coral Rock and Bird Key Reef) elevated macroalgae cover may be impeding coral recovery, however, at many sites coral cover or density has stayed similar spanning several biennial reports, and the cover of other benthic taxa, such as octocorals and sponges has been unchanged or even increased alongside the overabundance of macroalgae.

Although not present in DRTO during this biennial reporting period, the arrival of stony coral tissue loss disease (SCTLD) was confirmed by DRTO park management in May 2021. Because SCTLD is highly lethal to the most vulnerable species we anticipate major changes in coral cover and density in the 2021-2022 biennial report.

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Introduction

Situated at the western terminus of Florida's Coral Reef (FCR) approximately 70 miles west of Key West, the Dry Tortugas are a mosaic of coral reefs, sedimentary shoals, seagrass meadows, and small islands that lie at the convergence of the Gulf of Mexico, Caribbean Sea, and Atlantic Ocean (Jaap 1984, Jaap et al. 1994). Remotely located and separated from terrestrial impacts, this biologically diverse area is an important breeding ground for numerous seabirds and turtles and is known to be important in providing a larval supply for various fishes throughout the FCR (Dahlgren et al. 2001, Domeier 2004, Burton et al. 2005). The region is also home to more than 40 species of stony corals, numerous soft corals and sponges, and various other marine invertebrates. Coral reef structures in the Dry Tortugas, the focus of this report, are varied and include deep-water reef terraces, bank/barrier reefs, high relief patch or pinnacle reefs, and shallow monotypic stands of Acroporid corals (Franklin et al. 2003, Jaap et al. 2008).

The Dry Tortugas is an important area for numerous corals species, including several that are listed as threatened under the Endangered Species Act: *Acropora cervicornis*, *A. palmata, Orbicella faveolata, O. annularis,* and *O. franksi.* Historically, the Dry Tortugas was known for extensive populations of staghorn coral, *A. cervicornis* (Agassiz 1885, Davis 1982, Porter and Meier 1992). Declines in the population of *A. cervicornis* over the last century are well documented for the Dry Tortugas (Davis 1982) and have been attributed to a variety of stressors, including disease, cold-water events, harmful algal blooms, and hurricanes. *A. palmata* has followed a similar fate with the populations of both acroporid species in the Dry Tortugas estimated to have been reduced by >95% from early studies to the present (Roberts et al. 1982, Jaap and Sargent 1993, Precht and Miller 2007). Declines in the iconic *Orbicella* spp. have also occurred with once extensive populations experiencing slow but persistent losses due to chronic coral diseases and repetitive bleaching events throughout the Dry Tortugas and FCR as a whole (Bruckner 2006, Edmunds 2015). Loss of both *Orbicella* spp. and *A. palmata* is particularly concerning as both are known to be important framework building corals. Both *A. cervicornis* and *A. palmata* were listed as "threatened" under provisions of the U.S. Endangered Species Act in 2006. *Orbicella* spp. followed, acquiring the "threatened" listing in 2014.

Throughout the twentieth century numerous legislative actions were taken to promote the conservation of cultural and biological resources in the Dry Tortugas, culminating in the designation of the Dry Tortugas National Park (DRTO) in 1992. Since the establishment of the park further conservation efforts have been made with the designation of the Tortugas Ecological Reserves in 2001 and the Research Natural Area (RNA) in 2007. The Ecological Reserve, located to the northwest of Dry Tortugas National Park within the Florida Keys National Marine Sanctuary, prohibits all consumptive activities. The RNA, located within the park and making up nearly half of the park's geographic area, adds further protection for marine resources and prohibits resource extraction and anchoring and provides mooring balls at several sites that have been designated as dive or snorkel locations. Currently, DRTO covers approximately 100 square miles (25,900 hectares), with more than 99% of the park containing submerged resources.

The Fish and Wildlife Research Institute's (FWRI) Coral Reef Evaluation and Monitoring Project (CREMP) is a repeated measures monitoring program which provides information on coral reef status and temporal trends. CREMP first started long-term monitoring of benthic resources in the Dry Tortugas in 1999 with three sites that were originally selected because of their historical or ecological significance: Bird Key Reef, a bank reef that has been surveyed periodically since the early 1970s; White Shoal, a large patch reef once dominated by *A. cervicornis*; and Black Coral Rock, a deep pinnacle reef located outside the DRTO boundary inside the Tortugas Northern Ecological Reserve (TNER). In 2004, five additional monitoring sites were established to meet specific management objectives outlined in the DRTO management plan. Three sites were selected to monitor remaining stands of acroporid corals in DRTO (Loggerhead Patch, Palmata Patch, and Prolifera Patch) and two sites were established on well-known pinnacle reefs (Temptation Rock and Mayer's Peak). In 2009, three additional pinnacle reef sites (The Maze, Davis Rock, and Texas Rock) were added to the survey effort within the RNA to assess whether concentrating diving and snorkeling activities at sites designated with mooring buoys would lead to adverse effects on coral reef communities at these sites. Although most of the sites monitored by CREMP were selected to address specific research or management objectives, collectively, all study sites provide a general assessment of benthic habitat condition in DRTO.

This report summarizes CREMP data collected through 2020 and provides analyses of the temporal changes in benthic community cover and the densities of corals and octocorals over recent years (2017-2020) and over the period of monitoring (1999-2020). To better understand stressors affecting coral condition, as well as the general health of coral communities, summaries on disease prevalence and water temperature are also provided. Results are subdivided into three sections: (1) an assessment of coral, octocoral and other benthic fauna and flora (e.g., sponges and macroalgae) across DRTO, (2) the status and trends of the ESA-listed coral species, and (3) resource condition at the pinnacle reefs within the RNA.

Stony coral tissue loss disease (SCTLD) was not present in DRTO during this reporting period. SCTLD is a lethal condition which inflicts high rates of mortality across a large number of species (>20 documented;(Walton et al. 2018, Muller 2020). It was first documented in 2014 off Virginia Key (Miami) and has subsequently spread throughout all the FCR. The most recent data presented in this report was collected in August of 2020 at which time the leading boundary of SCTLD was in the Marquesas and progressing westward towards DRTO. SCTLD was reported in DRTO in May 2021 and its impacts will be addressed in the 2021-2022 biennial report.

Methods

Site Descriptions

The CREMP sampling effort encompasses a variety of coral reef habitats found in the Dry Tortugas; including high-relief pinnacle reefs that occur at various depths, a high-relief spur and groove reef, and several shallow mostly monotypic stands of ESA-listed acroporid species. Currently 12 sites are surveyed annually with surveys having commenced at various points in time (Figure 1, Table 1).

Table 1. Geospatial and descriptive information for the CREMP DRTO survey sites.

Site Name	Reef Type	Depth (m)	Location	Start Year	Rationale/Description
Bird Key Reef	Bank reef with spur and groove	15	24° 36.703 -82° 52.212	1999	Representative of typical spur and groove reef type on the outer edge of Florida Keys; historical periodic monitoring since 1975
Black Coral Rock	Pinnacle reef	24	24° 41.956 -83° 00.131	1999	Representative of a common reef community type within the TNER
Davis Rock	Pinnacle reef	10	24° 41.225 -82° 54.429	2009	Representative of a common DRTO reef community within RNA
Loggerhead Patch	*Acropora cervicornis* patch reef	2	24° 38.138 -82° 54.939	2005	Representative of *A. cervicornis* dominated coral community once common in DRTO
Little Africa	*Orbicella* spp. patch reef	<1	24° 38.148 -82° 55.230	2007	A shallow nearshore *Orbicella* spp. dominated community within RNA
Palmata Patch	*A. palmata* patch reef	3	24° 37.243 -82° 52.042	2004	One of two known extant DRTO *A. palmata* populations with the highest abundance
Prolifera Patch	*A. prolifera* patch reef	3	24° 37.239 -82° 52.180	2004	Largest known population of *A. prolifera* in Florida; only known population in DRTO
Mayer’s Peak	Pinnacle reef	10	24° 36.480 -82° 56.644	2004	Representative of a common DRTO reef community type within RNA.
The Maze	Pinnacle reef	14	24° 36.542 -82° 56.974	2009	Representative of a common DRTO reef community type within RNA.
Temptation Rock	Pinnacle reef	8	24° 38.587 -82° 55.844	2004	Representative of a common DRTO reef community type within RNA.
Texas Rock	Pinnacle reef	15	24° 40.832 -82° 53.115	2009	Representative of a common DRTO reef community type within RNA.
White Shoal	Sloping bank reef (w/o spur and groove)	7	24° 38.703 -82° 53.769	1999	Representative of *A. cervicornis* dominated coral community once common in DRTO

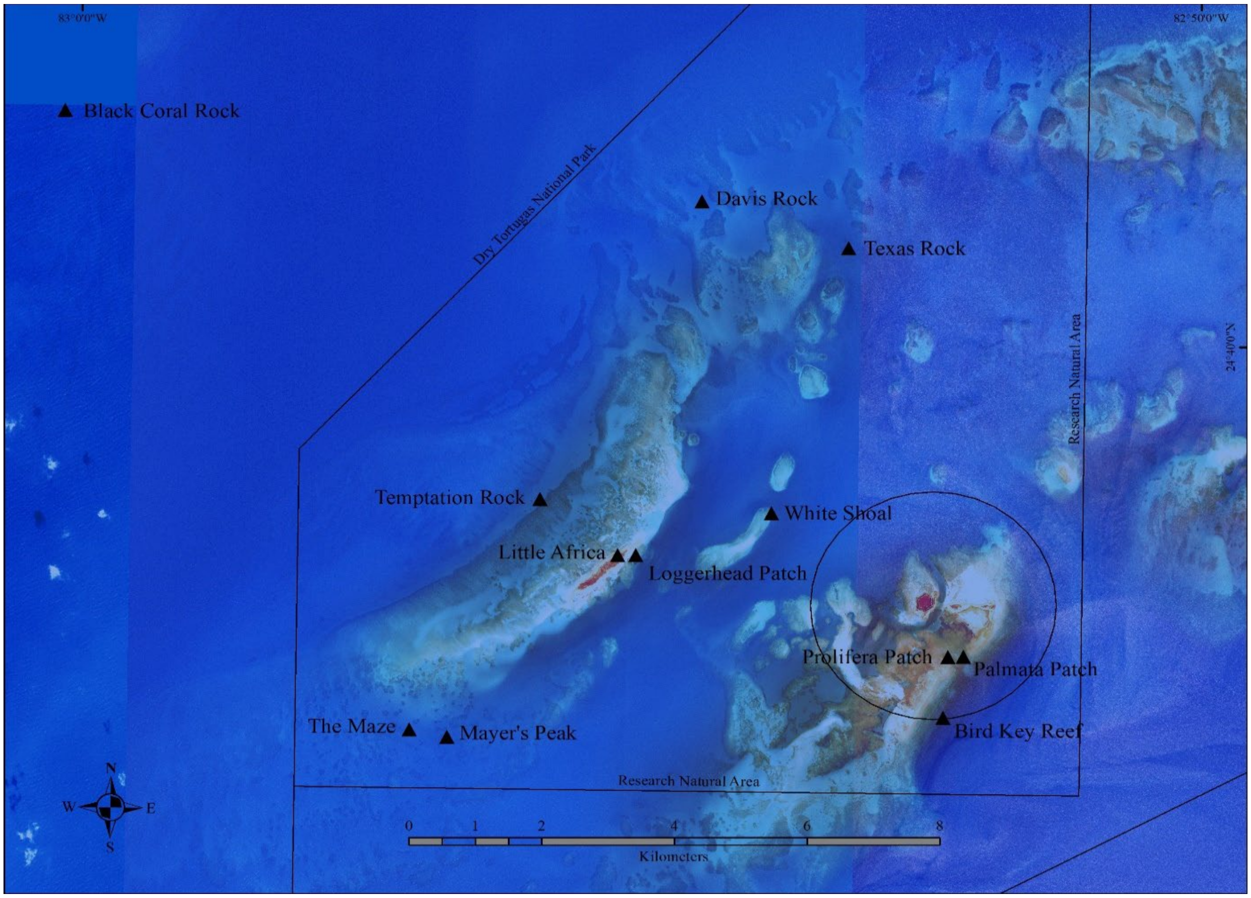

Figure 1. CREMP coral reef monitoring sites within Dry Tortugas National Park and the Research Natural Area.

Pinnacle reefs in the Dry Tortugas are located in the northern and western sections of DRTO and throughout the TNER. Pinnacle reefs provide high vertical relief and include diverse coral and octocoral assemblages. Five pinnacle reefs are surveyed by CREMP in DRTO. These pinnacle reefs crest at 10-15m depth with surrounding sand flats at ~20m depth. Monitoring surveys commenced in 2004 at two of these sites, Mayer's Peak and Temptation Rock. In 2009 three sites were added, all of which were designated for mooring buoy installation as part of the RNA science plan: The Maze, Davis Rock, and Texas Rock. Another pinnacle reef, Black Coral Rock, surveyed by CREMP since 1999, is located outside of DRTO boundaries in the TNER. Black Coral Rock crests at 24m depth with surrounding sand flats at 30m depth. Black Coral Rock is generally not grouped with the other pinnacle reefs because of the site's location in the TNER, greater depth, and longer period of surveys. Also, historic substrate coverage at Black Coral Rock contains a larger proportion of *Orbicella* spp. than other pinnacle reefs.

The ESA-listed coral species *Acropora cervicornis*, *A. palmata*, *A. prolifera* and *Orbicella* spp. are located throughout the park. Two sites, White Shoal and Loggerhead Patch, were selected because of historic stands of *A. cervicornis*. White Shoal is a large, submerged shoal between Loggerhead Key and Garden Key first surveyed as part of CREMP in 1999. Loggerhead Patch is located off the eastern edge of Loggerhead Key in less than 3m of water and was first surveyed in

2006. Two sites, Palmata Patch and Prolifera Patch, target stands of acroporid corals in the lagoon south of Garden Key. Both sites are ~1km from Fort Jefferson, < 3m depth and have been monitored since 2004. Little Africa is a mostly monotypic stand of *Orbicella* spp. located in < 2m depth, close to shore off the northwest side of Loggerhead Key. This site can be exposed at extreme low tides. CREMP surveys at Little Africa began in 2007. While these shallow patch reefs are largely composed of monotypic stands of their associated species, several large boulder corals (e.g., *Orbicella* spp., *Montastraea cavernosa*, and *Siderastrea* spp.), as well as numerous octocorals, are also present.

Bird Key Reef is a bank reef located south of the Garden Key lagoon, ~2km south of Fort Jefferson. Reef development here was offshore Bird Key, which disappeared in the impacts from the Labor Day Hurricane of 1935 (Dilley 1950). The reef forms a high-relief spur and groove pattern, more commonly seen near the Florida Keys, that quickly drops off to sand flats at ~22m depth. Surveys at Bird Key Reef are conducted along reef spurs at ~15m depth. Bird Key Reef has been surveyed as part of CREMP since 1999.

Survey Stations

Each repeated measures survey station is ~22m in length and demarcated by two permanently placed steel pins indicating the starting and ending boundaries. All pinnacle reef sites (Black Coral Rock, Mayer's Peak, Temptation Rock, The Maze, Texas Rock, and Davis Rock), Bird Key Reef, and White Shoal have four survey stations. Due to their smaller size, the shallow acroporid assemblages have a reduced number of stations: three stations at Prolifera Patch and two stations each at Palmata Patch and Loggerhead Patch. Due to the extreme shallow depth, different survey methods are used at Little Africa, and no permanent stations are present.

Historically, CREMP performed three major surveys at each station: a video survey to estimate benthic cover along three parallel transects, a bio-eroding sponge survey, and a coral species inventory survey that quantified coral species richness within the station boundaries (Figure 2). In 2011, survey methods were modified to provide a more robust assessment of the benthic community and to streamline survey efficiency. The video survey was replaced with still photographs. For all sites with four stations, image surveys were reduced from the three parallel transects to a single centered transect (Figure 3). Coral species inventories were replaced by coral and octocoral demographic surveys conducted on the first ten meters of the center transect at all stations. The bio-eroding sponge survey was discontinued. For more detailed information on discontinued survey methodology please refer to previous CREMP reports.

Image Transects

Prior to changing image survey methods two statistical analyses were conducted: 1) to ensure that images and data acquired through digital point and shoot cameras were consistent with images and datasets acquired using previous/other video technologies (Morrison et al. 2012), and 2) to confirm that long-term trends derived from only the center transect were consistent with the trends

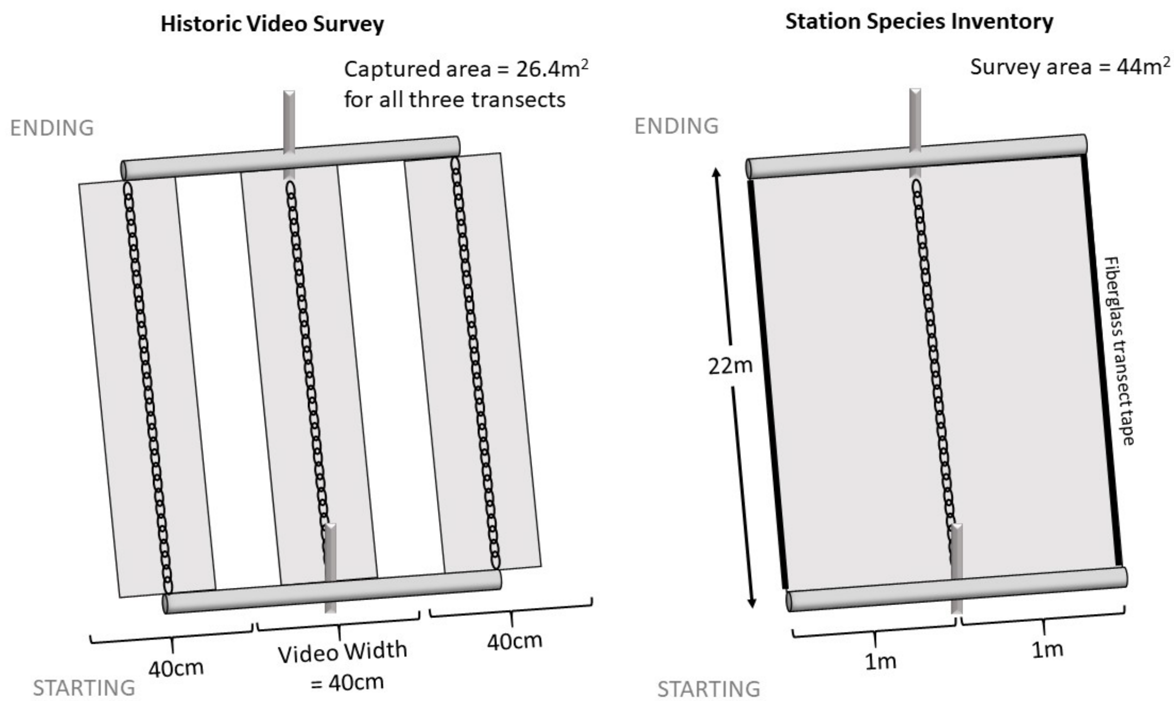

Figure 2. CREMP survey design prior to 2011. Three video transects and a timed coral station species inventory were conducted annually at each station. The center line of each transect was demarcated by a plastic chain laid upon the substrate. This sampling effort for image acquisition has been retained at Loggerhead Patch, Palmata Patch and Prolifera Patch because each of these sites has less than four stations (Figure 3). Station Species Inventories are no longer conducted.

observed from data acquired from all three parallel transects. These confirmed that still imagery did not result in different estimates when compared to video imagery and that trends for all the major benthic taxa (e.g., corals, octocorals, sponges and macroalgae) were similar at >84% of all stations whether all three or the single, centered transect was sampled. This allowed a reduction from three parallel transects to one at most stations. Three parallel image transects per station (Figure 2) are still performed are at Loggerhead Patch, Palmata Patch and Prolifera Patch - sites that have less than four stations, and which target a particular ESA-listed species where individual colonies can be difficult to distinguish in coral demographic surveys.

Station transects are prepared by securing a fiberglass tape between the two permanent marker stakes and then laying a plastic chain directly underneath the tape along the substrate (Figure 3). At stations where three parallel transects are used, a two-meter aluminum pole is placed atop each permanent stake. The three transects are laid in the same manner as above using the marker stake and either end of the aluminum poles as start and end points, such that the center of each transect is one meter apart (Figure 2). From 2011 to 2016 images were captured using a Canon PowerShot SD1100 IS and since 2017 using an Olympus TG-4. All images are captured at a distance of 40cm above the reef, resulting in images that are ~40cm wide, with each image transect containing approximately 60 images. An aluminum bar attached to the bottom of the camera housing aids in

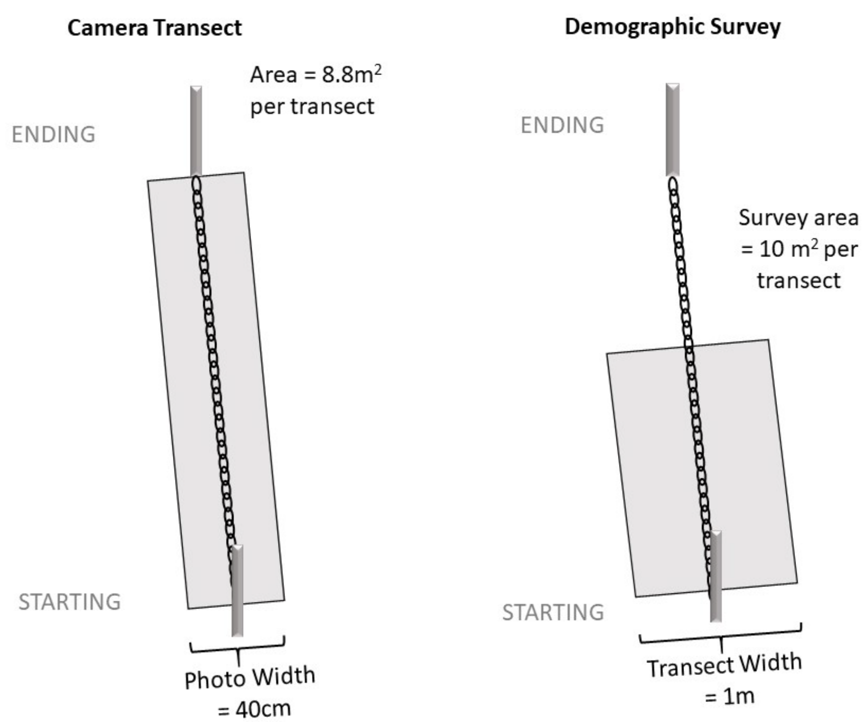

Figure 3. Current CREMP survey design. At all sites with four stations, still camera transects survey the center transects demarcated with a plastic chain and encompass 8.8m^2 of reef per station. Octocoral and coral demographic surveys are 1m x 10m belt transects and are performed at all sites.

maintaining a constant height above the substrate. To ensure minimal overlap between images, visual reference points on the substrate are used to proceed along a transect. Each photographic transect constitutes a sampling area of ~9 m^2. In the lab, images are formatted for PointCount '99 image analysis software (Dustan, 1998). Fifteen random points are overlaid on each image. Underneath each point, corals and other select benthic taxa are identified to species (all Scleractinia, plus *Gorgonia ventalina*, *Xestospongia muta,* and *Palythoa caribaeorum*), several macroalgal types to genera (*Dictyota* spp., *Halimeda* spp., and *Lobophora* spp.), and other flora and fauna at higher taxonomic levels (e.g., encrusting or branching octocoral, crustose coralline algae, zoanthid, sponge, and macroalgae). Identification of substrate includes a variety of reef surfaces; carbonate rock, unconsolidated sand or rubble, and areas colonized by small, filamentous turf algae. After all images are analyzed, the data are checked for quality assurance and compiled into a Microsoft Access database.

Coral Demographic Survey

The demographic survey protocol is similar to that used by the Atlantic and Gulf Rapid Reef Assessment Program (AGRRA) and the Florida Reef Resilience Program (FRRP) (Lang et al. 2010, Wagner and Willis 2010). At all stations divers conduct a single 1m x 10m belt transect beginning at the starting stake (Figure 3). Every coral species present is recorded and all colonies ≥4cm are measured to the nearest centimeter with a ruler affixed to a 0.5m PVC stick. The maximum diameter and height taken along the growth plane, presence of diseases and/or bleaching, and visual estimates of recent and old tissue mortality (and its cause if recent) are recorded for each colony. If a disease condition cannot be positively identified it is recorded as unknown and a series of diagnostic records describing the condition are recorded. Mortality is considered "recent" only if the corallite structure can be clearly distinguished and there is minimal overgrowth by algae or other fouling organisms. Otherwise, mortality is classified as "old" and causality not assigned. *Millepora alcicornis* is only recorded as present or absent. *Millepora complanata* is measured and assessed as described. Since 2018 all colonies <4cm are identified to the lowest possible taxonomic level and are counted but are not measured or assessed. Data are validated using established quality assurance/quality control protocols at the FWRI lab, which includes verification that data was correctly transcribed from field datasheets into a pre-formatted Microsoft Excel data entry template.

Octocoral Demographic Survey

Similar to the coral survey, divers conduct a 1m x 10m octocoral survey at each station at all sites (Figure 3). All octocoral colonies within the belt transect are counted, regardless of species. This provides a measurement of overall octocoral density. Five species of octocorals - *Antillogorgia americana* (formerly *Pseudopterogorgia americana*), *Antillogorgia bipinnata* (formerly *Pseudopterogorgia bipinnata*), *Eunicea flexuosa* (formerly *Plexaura flexuosa*), *Pseudoplexaura porosa*, and *Gorgonia ventalina* - are measured and assessed. A sixth species, *Eunicea calyculata*, was surveyed from 2011-2016 but is no longer included. These species were selected because they can be easily distinguished in the field and are relatively abundant in their preferred reef habitat. For each colony maximum height is measured to the nearest centimeter with a ruler affixed to a 0.5m PVC stick. A visual estimate of disease and bleaching is recorded for each species in addition to any condition leading to compromised health of the colony (e.g., predation, overgrowth). Data are validated using established quality assurance/quality control protocols back at the FWRI lab which includes verification that data was correctly transcribed from field datasheets into a pre-formatted Microsoft Excel data entry template.

Little Africa Survey

Little Africa is a shallow patch reef dominated by a large monotypic stand of the star corals (*Orbicella* spp.). Many of the colonies are in depths <1 meter which has prevented the installation of traditional CREMP stations. Instead, ten random transects delineated using a measuring tape, and orientated parallel to one another, are photographed with a still camera each survey year. Each transect is 10m long and made up of 20 consecutive abutting photographs. Still images were analyzed using Point Count '99, in the same manner as images captured from video transects at permanent stations. Coral and octocoral demographic surveys are not conducted at Little Africa.

Temperature

HOBO Water Temp Pro v2 loggers (model U22-001; Onset Corporation) were initially deployed at four locations (Bird Key Reef, Black Coral Rock, Mayer's Peak, and Temptation Rock) in September 2006. Additional loggers were added at Palmata Patch in 2008, Texas Rock in 2010, The Maze in 2013, White Shoal and Davis Rock in 2016, and Loggerhead Patch and Prolifera

Patch in 2017. Loggers are attached to the stainless-steel station marker pins at the reef substrate. Loggers record temperature hourly and are downloaded annually. Time series summaries for water temperature were done from 2009 thru 2020.

Descriptive & Statistical Analyses

Statistical analyses were conducted to examine: 1) temporal changes in the percent cover of four major benthic taxa (corals, octocorals, macroalgae, and sponges) at each site, 2) temporal changes in abundance of corals and octocorals, each summed for all species, at each site, 3) temporal changes in percent cover for four ESA-listed species at sites where they are most abundant, 4) temporal changes in the abundance of *Orbicella* spp. at sites where they are most abundant, and 5) temporal changes in the percent cover and abundance of corals and octocorals at pinnacles reefs within the RNA - this includes three pinnacle reefs with mooring buoys and two pinnacle reefs without mooring buoys. All temporal changes for both percent cover and abundance were examined at two timescales: 1) short-term, where the two most recent years (2019-2020) of data were pooled and compared to the previous two years (2017-2018) and 2) long-term, where the first four years of data collected at each site were pooled and compared to the most recent four years (2017-2020). Data were pooled across years in this way to minimize the effect of statistical outliers or ephemeral events that could substantially alter cover or abundance values in any given year. All statistical analyses were conducted using SAS Enterprise Guide® v8.3 (SAS Institute Inc.). All statistical inference was made at $\alpha = 0.05$.

Percent Cover

All percent cover data were analyzed using generalized linear mixed models (PROC GLIMMIX) with a binomial distribution and logit link function. For each station, untransformed data points identified as a given taxon were divided by the total points evaluated and were modeled using year groupings and sites as fixed effects. Two random intercept statements were included in each model to account for 1) the nesting of stations within sites and 2) the repeated measures of stations across years within each year grouping. For random effects accounting for nesting within sites the default option, variance components (VC), was used to define the covariance structure. For covariance associated with repeated measures, a first order auto-regressive function (ar(1)) was used for long-term analyses and compound symmetry (CS) was used for short-term analyses. For all analyses of individual species only the random statement for repeated measures was included. To examine difference within sites between time frames pair-wise post hoc comparisons were made; however, no post-hoc adjustment to p-values were included. These were omitted because of the small number of post hoc comparisons and because the adjustments were often too conservative for meaningful interpretation of the differences in results. The statistical outputs for each site and/or the sites that were pooled (e.g., RNA sites with moorings or *Orbicella* spp.) are provided in Appendix F.

Coral and Octocoral Demographics

All demographic data were analyzed using generalized linear mixed models (PROC GLIMMIX) with either a negative binomial or a Poisson distribution and log link function. For each taxa untransformed abundance data were modeled using year groupings and sites as fixed effects. For corals and octocorals random intercept statements were included in each model to account for the nesting of stations within sites and the repeated measures of stations across years within each year grouping. For covariance associated with nesting of stations within sites the default covariance structure, variance components (VC), was used. For covariance associated with repeated measures, a first order heterogenous auto-regressive function (arh(1)) was used. For analysis of *Orbicella* spp. both random statements were omitted. To examine differences within sites between time frames pair-wise post hoc comparisons were included; however, no post-hoc adjustment to p-values were made. These were omitted because they were often too conservative given analysis results. The statistical outputs for each site and/or the sites that were pooled (e.g., RNA sites with moorings or *Orbicella* spp.) are provided in Appendix G.

Results and Discussion

Corals

Percent Cover

For this report, two analyses were completed to compare short- and long-term changes in the percent cover of benthic taxa groups and density of corals and octocorals. Short-term changes in percent cover compared the pooled averages of the two-year period for this biennial report (2019-2020) against those in the previous report (2017-2018) while long-term differences compared a pooled mean for the first four years of monitoring (varies by site) against those calculated for the last four years (2017-2020). Short-term, three of 12 sites had significant increases in coral cover: Palmata Patch, Prolifera Patch, and Temptation Rock (Table 2), while no significant changes were detected across the other nine sites. Long-term, three of 12 sites had a significant increase in cover: Palmata Patch, Prolifera Patch, and Mayer's Peak, while five sites had a significant decrease: Bird Key Reef, Black Coral Rock, White Shoal, Loggerhead Patch, and Little Africa.

Table 2. Mean percent coral cover (% ± SE) for 12 sites. Long-term comparisons averaged for the first and last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial report. The first four-year period varies and is contingent upon commencement of monitoring at that site: Bird Key Reef, Black Coral Rock, and White Shoal = 1999-2002; Palmata Patch, Prolifera Patch, Mayer's Peak, Temptation Rock = 2004-2007; Loggerhead Patch = 2005-2008; Davis Rock, Texas Rock, The Maze = 2009-2012; Little Africa = 2007-2010. *Little Africa is surveyed differently than the other 11 sites (see Methods). Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

	Long-term	**Long-term**	**Short-term**	**Short-term**
Site	**First Four**	**2017-2020**	**2017-2018**	**2019-2020**
Bird Key Reef	17.8 ± 4.3	8.8 ± 2.4	8.8 ± 2.8	8.9 ± 2.8
Black Coral Rock	21.6 ± 5.0	13.5 ± 3.5	13.8 ± 4.1	13.2 ± 4.0
Davis Rock	9.4 ± 2.5	8.8 ± 2.4	8.9 ± 2.9	8.6 ± 2.8
Loggerhead Patch	2.4 ± 1.0	0.9 ± 0.4	1.0 ± 0.5	0.9 ± 0.5
Mayer's Peak	3.7 ± 1.1	5.4 ± 1.5	5.2 ± 1.7	5.5 ± 1.8
Palmata Patch	4.2 ± 1.8	8.5 ± 3.4	7.7 ± 3.7	9.2 ± 4.4
Prolifera Patch	13.7 ± 4.1	16.8 ± 4.8	15.2 ± 5.2	18.4 ± 6.1
Temptation Rock	3.3 ± 1.0	4.1 ± 1.2	3.6 ± 1.2	4.7 ± 1.6
Texas Rock	7.4 ± 2.0	6.3 ± 1.8	6.4 ± 2.1	6.2 ± 2.0
The Maze	12.1 ± 3.2	10.1 ± 2.8	10.1 ± 3.2	10.2 ± 3.2
White Shoal	7.0 ± 2.0	3.4 ± 1.0	3.4 ± 1.1	3.5 ± 1.2
Little Africa*	24.1 ± 1.6	14.8 ± 1.1	15.3 ± 0.6	14.2 ± 0.6

Palmata Patch and Prolifera Patch had positive changes in coral cover over both short and long-term (Table 2). The increase in cover at Palmata Patch was the most remarkable as overall cover at this site doubled between the long-term time intervals, increasing from 4.2 ± 1.8% (SE) in 2004-2007 to 8.5 ± 3.4% in 2017-2020. While much of the difference long-term can be attributed to the substantial increase in cover that occurred from 2007 to 2011 (Figure 4), significant increases have also occurred recently, following several years of reduced cover during the 2014/15 El Niño event. Coral cover at Prolifera Patch has followed a similar pattern. Short-term increases at Temptation Rock were significant but the 2019-2020 values were comparable to those reported prior to 2017-2018 and explain why there was no long-term difference detected (Appendix A). Mayer's Peak, the third site with a net gain in coral cover long-term, has been gradually increasing in cover through time since monitoring began in 2004.

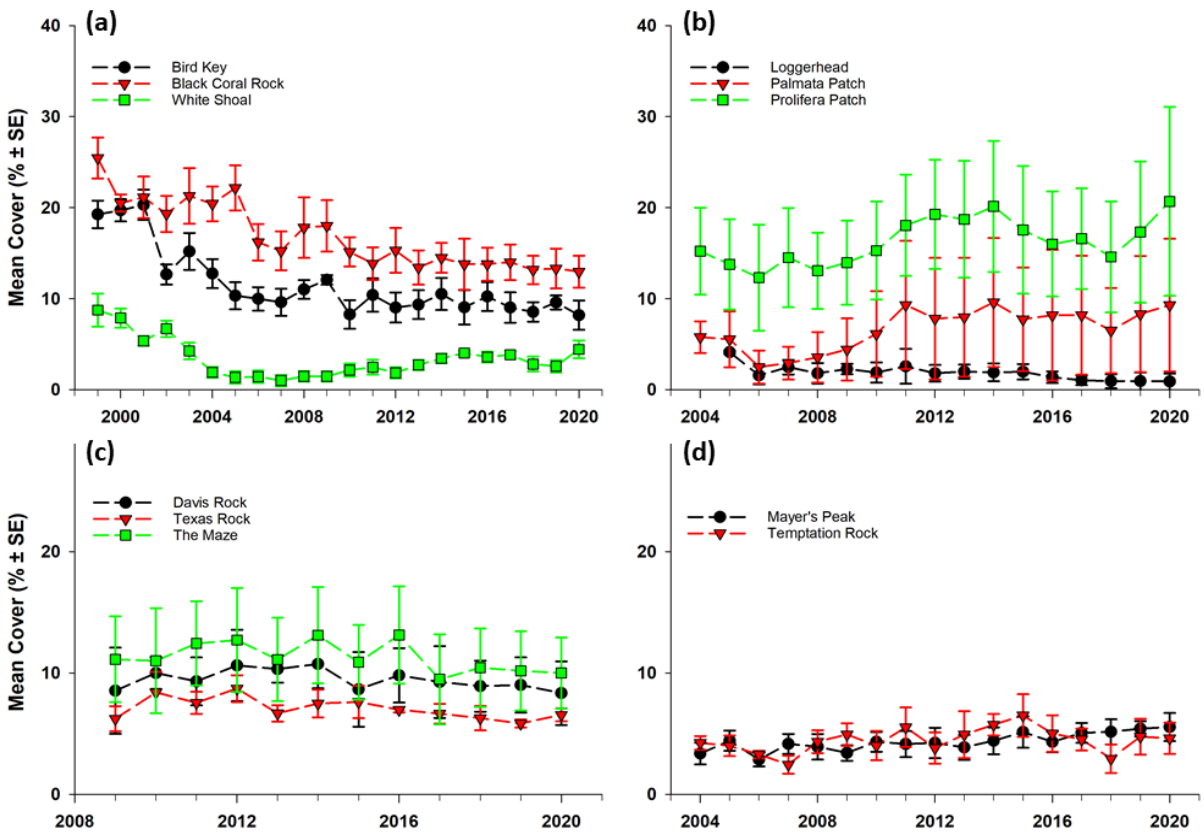

Figure 4. Total coral cover (% ± SE) by site. Graphs organized by timeline for monitoring. A) The three original sentinel sites, started in 1999. B) Three sites added to monitor various ESA species, started in 2004. C) Pinnacle reefs inside the RNA with mooring buoys, started in 2009. D) Pinnacle reefs inside the RNA without mooring buoys, started in 2004. Note: Y-axis scale differs between top and bottom graphs.

All three sites in which the initial time interval was 1999-2002 (Bird Key Reef, Black Coral Rock, and White Shoal) had significantly lower mean cover over the last four years of monitoring compared to the first four years. In addition, Loggerhead Patch and Little Africa both had significantly lower cover values averaged for the last four years of monitoring compared to the first four, 2005-2008 and 2007-2010, respectively (Table 2). Long-term, the greatest decrease in cover has occurred at Bird Key Reef, Black Coral Rock, and Little Africa. At all three, there has been an 8-9% decrease in absolute cover which equals nearly 40% of the initial cover at each of these sites. A large portion of this decline is attributed to *Orbicella* spp. which is the predominant coral at each location. Similarly, decreases in coral cover at White Shoal and Loggerhead Patch, though not as severe, can be attributed to the loss of *A. cervicornis*.

Most of the differences found in coral cover were associated with the changes in the predominant ESA species present at a given site (e.g., *Orbicella* spp. at Bird Key Reef and Black Coral Rock or *Acropora palmata* at Palmata Patch). A more detailed description of the changes in coral cover at most of these sites is included in the ESA-Listed Species Section below.

Demographics

Coral density (colonies/m^2) has been quantified as part of the coral demographic survey since 2011. Similar to percent coral cover, short- and long-term means were compared. Short-term analyses compared the pooled means for this biennial report (2019-2020) and the previous report (2017-2018), covering the same period as short-term analyses for percent cover. Long-term analyses compared pooled means calculated for 2011-2014, the first four years of demographic surveys, against 2017-2020. This covers 10 years of demographic surveys and does not align with long-term analyses for percent cover where the earliest time periods were 1999-2002 or 2004-2007 for most sites. Short-term, mean density was significantly different at only one site, Loggerhead Patch, which had a significant decline (Table 3). Long-term, six of 11 sites had a significant increase in density; one site, Loggerhead Patch, had a significant decline.

Coral density at Loggerhead Patch decreased significantly over both short- and long-term analyses. Currently this site is comprised mostly of non-living *A. cervicornis* rubble, which provides a less than optimal substrate that is opportunistically colonized by small, encrusting *Porites* spp. and *Agaricia agaricites* colonies. The unconsolidated rubble at Loggerhead Patch is prone to movement and displacement from storms and surge and these species have an ephemeral existence and/or at times are transient through the survey stations, potentially being recorded in one year but not the next. The unsuitable nature of this habitat has reduced coral abundance at Loggerhead to nearly zero. The percent coral cover at Loggerhead Patch remains at ~1.0%; however, this is mostly due to one large *Orbicella* spp. colony present in one of the survey stations.

Density significantly increased from 2011-2014 to 2017-2020 at Mayer's Peak, Temptation Rock, Davis Rock, and the Maze, leaving Texas Rock as the only pinnacle reef site without a significant change, though density did increase at this location (Table 3). This is consistent with results presented in the previous biennial report, which also showed a steady increase in colony density over the last decade. The greatest increase in density occurred at Mayer's Peak where mean coral density increased from 5.4 ± 0.9 colonies/m^2 (±SE) in 2011-2014 to 7.8 ± 1.2 colonies/m^2 in 2017-2020 (Table 3), whereas increases at the other pinnacle reefs were generally more moderate (<1 colony/m^2). The observed increases in density at the pinnacles are mostly attributed to several species: *Porites astreoides*, *Siderastrea siderea,* and, to a lesser extent, *Stephanocoenia intersepta* and *Agaricia agaricites* (Appendix D). Significant increases in coral density also occurred at Bird

Key Reef and White Shoal and can also be attributed to increases in one or more of these same species. White Shoal has also had an increase in the number of *A. cervicornis* colonies over recent years.

Table 3. Mean density (no. colonies/m^2 ± SE) of corals for 11 sites. Long-term comparisons averaged for the first and last four years of demographic data collection, and short-term comparison averaged for the two-year period for the current and previous biennial report. Demographic surveys are not performed at Little Africa. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$), respectively.

	Long-term	Long-term	Short-term	Short-term
Site	**First Four**	**2017-2020**	**2017-2018**	**2019-2020**
Bird Key Reef	5.2 ± 0.8	5.9 ± 0.9	6.2 ± 0.9	5.6 ± 0.8
Black Coral Rock	9.2 ± 1.4	9.3 ± 1.5	9.5 ± 1.3	9.0 ± 1.2
Davis Rock	4.6 ± 0.7	5.5 ± 0.9	5.4 ± 0.8	5.6 ± 0.8
Loggerhead Patch	1.2 ± 0.3	0.4 ± 0.1	0.7 ± 0.2	0.1 ± 0.0
Mayer's Peak	5.4 ± 0.9	7.8 ± 1.2	7.4 ± 1.0	8.2 ± 1.1
Palmata Patch	2.6 ± 0.6	2.4 ± 0.6	2.5 ± 0.5	2.8 ± 0.6
Prolifera Patch	0.9 ± 0.2	0.9 ± 0.2	0.8 ± 0.2	1.2 ± 0.2
Temptation Rock	3.2 ± 0.5	3.7 ± 0.6	3.8 ± 0.6	3.7 ± 0.5
Texas Rock	5.9 ± 0.9	6.6 ± 1.0	6.6 ± 0.9	6.7 ± 0.9
The Maze	3.9 ± 0.6	5.1 ± 0.8	5.3 ± 0.8	5.0 ± 0.7
White Shoal	3.4 ± 0.6	4.3 ± 0.7	4.6 ± 0.7	4.0 ± 0.6

It is both evident and important to recognize that increases in density over the last decade do not offset historical losses in percent cover. As we have observed, increases in density at most of these sites is primarily due to the recruitment of smaller, weedy species that may recruit to the substrate in high numbers but generally do not reach large sizes and do not contribute considerably to spatial coverage. Furthermore, this analysis does not account for partial mortality that can occur on coral colonies, particularly in large, spatially dominant species like *Orbicella* spp., which is the predominant species at several sites, including Bird Key Reef where density increased. Partial mortality is problematic; a colony can lose a large portion of living tissue but is still enumerated during the survey which will not result in a decrease in density. Additionally, partial mortality can often cause colonies to become fragmented, potentially leading to increases in density as the original colony becomes impossible to delineate with time, ultimately resulting in more albeit smaller colonies. Conversely, the growth patterns of several species, particularly the acroporids, *A. cervicornis*, *A. palmata*, and *A prolifera*, can often result in large thickets in which individual colonies can become difficult to enumerate resulting in high variability in annual estimates of colony density. Indeed, one station at Prolifera Patch is left out of density comparisons as this station is composed entirely of one large thicket of *A. prolifera* and colonies cannot be enumerated.

Bleaching and Temperature

Like disease prevalence, bleaching prevalence values were lower between 2011 and 2017 because surveys were conducted in June, prior to peak thermal stress. During those years, bleaching prevalence ranged from 0.6% to 5.1% with the highest prevalence recorded in 2017 (Table 4). These values could be considered background levels of bleaching in DRTO that is caused by stressors unrelated to seasonal highs in water temperature. In 2018 and 2019 bleaching prevalence was 6.8% and 5.9%, respectively, but in 2020 was only 2.0%, on par with normal background levels of bleaching. Thermal stress on corals can be measured by quantifying the number of days in which the mean daily sea temperature was above 30°C, with thermal stress becoming more intense as daily temperatures increase (Figure 5). Temperature loggers have been deployed at 11 CREMP sites since 2017 and at five sites since 2009.

Table 4. Bleaching prevalence (percentage of colonies with total or partial bleaching) pooled for all species for all monitoring sites. Prevalence values reported here may differ from previous reports but are consistent across the 10 years reported.

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
# of Colonies	1676	1923	1803	1744	1803	1933	2076	2107	2081	2032
Bleaching Prevalence (%)	0.7	0.8	0.9	1.0	2.6	2.0	5.1	6.8	5.9	2.0

It is noteworthy that although bleaching prevalence values were nearly three times higher in 2019 than in 2020, the number of days in which mean daily water temperatures were >30°C was highly comparable. In 2020, the average number of days across all 11 CREMP sites with daily mean sea temperatures above 30°C was 70 ± 9 (SD), which was only slightly below the number of days incurred in 2019 (76 ± 25 days per site). Contrast these results with 2018, where the mean number of days >30° was only 20 ± 16 days and bleaching prevalence was 6.8%.

Although thermal stress does not appear to align with bleaching estimates, sea temperatures are recorded by a data logger across the entire season, whereas bleaching estimates are made in situ during CREMP surveys. The differences across years can be attributed both to the timing of when elevated sea temperatures occur and to differences in the timing of surveys. For surveys occurring in August, if the onset of warmer temperatures doesn't start until mid or late August only the coral species that are the most sensitive to higher water temperatures will have bleached, resulting in lower bleaching estimates. However, if elevated sea temperatures begin in early July, more species will have been affected and the bleaching prevalence observed is likely to be higher. Surveys occurring in September are less likely to be affected by annual variations in the timing of increased sea temperatures as this is a peak bleaching month and all susceptible species would have the potential to be impacted.

Overall, since 2009, 2019 and 2020 appeared to be two of the five warmest years during the last 12 years. 2014 and 2015 were the warmest and coincided with a well-documented El Niño which resulted in mass bleaching elsewhere in Florida and the Caribbean (Eakin et al. 2019). This result is supported by the number of days in which the mean daily sea temperature was above 31°C (Figure 5) as well as the mean daily temperature averaged for the warmest months (July through

October; Appendix H). In 2015, each site incurred 25.8 ± 13 days above 31°C while the next highest number was 12 ± 8 days in 2014 and 2011 (Figure 5). The difference between the number of days over 30°C and 31°C is important to distinguish because mean daily water temperatures over 30°C were recorded for at least 60 days in seven out of twelve years, while temperatures over 31°C happen less frequently and may be a better indicator of severe thermal stress.

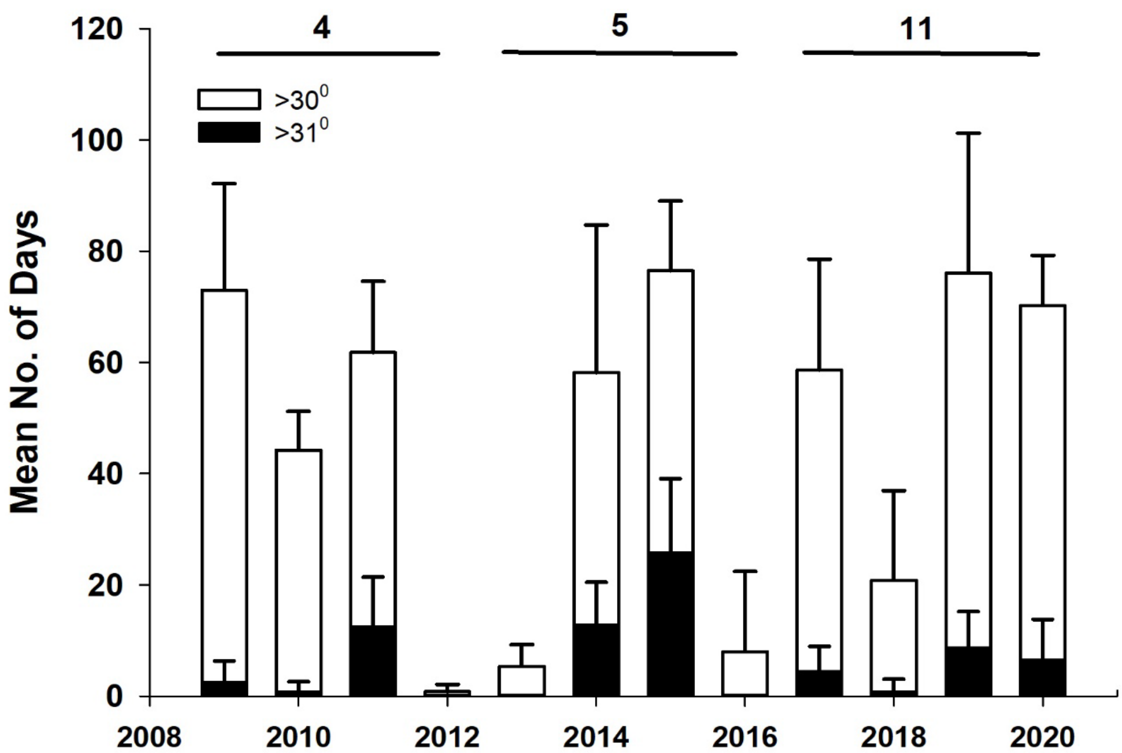

Figure 5. Average number of days (± SD) in which daily sea temperatures were above 30°C and 31°C between 2009-2020. Number of sites used to calculate the average for each year are listed above the bars.

The relationship between depth and water temperatures indicates that deeper reefs are afforded some protection against thermal stress. For example, our deepest site Black Coral Rock (24m depth) averages 21 ± 21 (SD) days annually with water temperatures >30°C. That is less than half the average number of days recorded at all other sites (Figure 6). The next lowest average was at Bird Key Reef (15m depth) which logs 44 ± 31 days annually. Temperature loggers at Black Coral Rock have never recorded a single day with the daily mean temperature <31°C (Appendix H).

In contrast, the shallow acroporid reefs are under the most thermal stress on an annual basis (Figure 6). Loggerhead Patch, Palmata Patch, Prolifera Patch, and White Shoal all endure at least 60 days annually with water temperatures >30°C. All four sites had more than 90 days above 30°C in 2019 and more than 70 days above 30°C in 2020 (Appendix H). Similarly, all four sites had at least nine days above 31°C in both 2019 and 2020.

Disease

Coral disease and bleaching are correlated with elevated sea surface temperatures with corals becoming stressed when sea temperatures exceed ~30°C for extended periods of time (Harvell et al. 1999, Jones et al. 2004, Bruno et al. 2007, Eakin et al. 2010, Hoegh-Guldberg and Bruno 2010).

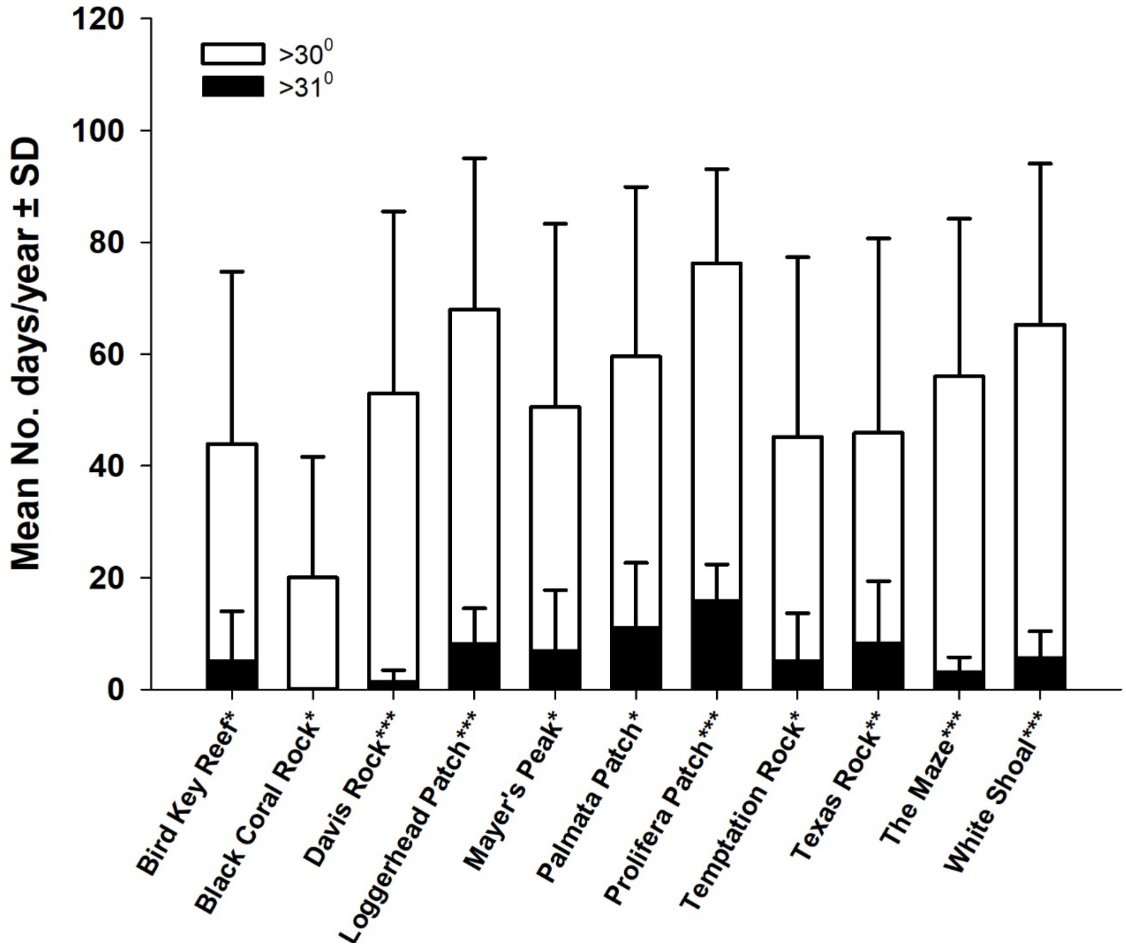

Figure 6. Average number of days (± SD) in which daily sea temperatures were above 30°C and 31°C at each site annually. The number of years used to calculate the average for each site are denoted by an asterisk: * = 2009-2020 (12 years); ** = 2013-2020 (8 years); *** = 2017-2020 (4 years).

In Florida, peak ocean temperatures occur during the late summer in the months of August and September (Kuffner et al. 2015, Manzello 2015); estimates of disease and bleaching will therefore be strongly dependent upon when annual surveys occur. Between 2011 and 2017 CREMP surveys were always completed in June, prior to peak thermal stress, whereas in 2018-2020 surveys were completed later in the summer - September in 2018 and August in 2019 and 2020 - to coincide with the timing of the Disturbance Response Monitoring Program also overseen by FWRI.

With the exception of 2011, coral disease prevalence has remained under 3% in all years (Table 5). This is consistent with normal ranges of disease prevalence documented elsewhere along the Florida Reef Tract by CREMP or other research efforts (Santavy et al. 2005, Weil and Cróquer

2009, Muller and van Woesik 2012). Even with the three most recent years of surveys occurring within the peak temperature months of August and September, disease prevalence was below normal background levels (0.5% in 2019 and 1.1% in 2020). The primary diseases included in this assessment were black band, white band, white pox, white plague, and dark spot syndrome. Other diseases that are less common but observed included yellow band, red band, rapid tissue loss, and ciliate conditions. The arrival of stony coral tissue loss disease (SCTLD) in the Dry Tortugas was confirmed in May 2021. Through August 2020, the most recent data included herein, SCTLD was not documented by CREMP.

Table 5. Coral disease prevalence (percentage of colonies with any disease condition present) pooled for all species for all monitoring sites. Prevalence values reported here may differ from previous reports but are consistent across the 10 years reported.

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
# of Colonies	1676	1923	1803	1744	1803	1933	2076	2107	2081	2032
Disease Prevalence (%)	3.9	1.6	1.8	2.3	1.9	1.1	0.6	2.0	0.5	1.1

Octocorals

Percent Cover

Short-term, between the 2017-2018 and 2019-2020 reporting periods, no significant changes in octocoral cover were detected across the 12 sites (Table 6). Long-term, from the first four years of monitoring at each site to the 2017-2020 interval, six of the 12 sites had a significant increase in octocoral cover: Davis Rock, Loggerhead Patch, Palmata Patch, The Maze, White Shoal, and Little Africa.

Of the three sites surveyed since 1999 (Bird Key Reef, Black Coral Rock, and White Shoal) only White Shoal had a significant increase in octocoral cover long-term. All three sites were consistent in indicating a pattern of decline during the earlier years of monitoring with each site reaching its lowest recorded values between 2004-2008 (Figure 7a). Following this low point, octocoral cover increased in most years at each site and has had a general positive trajectory. The gradual increase over the last 10 to 12 years at Bird Key Reef and Black Coral Rock (Figure 7a) has returned octocoral cover to levels observed during the first four years of monitoring at these sites (1999-2002). In contrast, octocoral cover at White Shoal has increased much faster and despite several years of considerable decreases that appear to be associated with major ecological events (e.g., 2014-2015 El Niño or Hurricane Irma; Figure 7a), octocoral cover at White Shoal nearly doubled from the initial four years to the most recent four years of monitoring (Table 6).

Table 6. Mean percent octocoral cover (% ± SE) for 12 sites. Long-term comparisons averaged for the first and last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial report. The first four-year period varies and is contingent upon commencement of monitoring at that site: Bird Key Reef, Black Coral Rock, and White Shoal = 1999-2002; Loggerhead Patch, Palmata Patch, Prolifera Patch, Mayer's Peak, Temptation Rock = 2004-2007; Davis Rock, Texas Rock, The Maze = 2009-2012; Little Africa = 2007-2010. Little Africa is surveyed differently than the other 11 sites (see Methods). Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

	Long-term	**Long-term**	**Short-term**	**Short-term**
Site	**First Four**	**2017-2020**	**2017-2018**	**2019-2020**
Bird Key Reef	18.8 ± 3.1	18.1 ± 3.0	16.4 ± 3.0	19.0 ± 3.3
Black Coral Rock	10.1 ± 1.9	9.2 ± 1.7	8.9 ± 1.8	8.9 ± 1.8
Davis Rock	0.6 ± 0.1	2.5 ± 0.5	2.2 ± 0.5	2.6 ± 0.6
Loggerhead Patch	0.8 ± 0.2	1.9 ± 0.5	2.5 ± 0.7	1.9 ± 0.6
Mayer's Peak	22.4 ± 3.5	27.4 ± 4.0	28.9 ± 4.4	24.5 ± 4.0
Palmata Patch	2.0 ± 0.5	13.2 ± 3.0	14.4 ± 3.5	12.1 ± 3.0
Prolifera Patch	4.8 ± 1.0	5.5 ± 1.2	5.3 ± 1.2	6.0 ± 1.4
Temptation Rock	14.7 ± 2.6	15.6 ± 2.7	16.6 ± 3.0	15.0 ± 2.8
Texas Rock	3.7 ± 0.7	3.1 ± 0.6	3.2 ± 0.7	3.3 ± 0.7
The Maze	7.0 ± 1.3	10.3 ± 1.9	9.8 ± 1.9	10.3 ± 2.0
White Shoal	8.5 ± 1.6	15.1 ± 2.6	16.3 ± 3.0	14.1 ± 2.6
Little Africa	5.2 ± 0.4	9.0 ± 0.7	9.8 ± 0.7	8.3 ± 0.6

Palmata Patch has had the greatest increase in octocoral cover. Octocoral cover was six times higher between the long-term reporting periods tested in this report (Table 6). Although not as severe as increases at White Shoal or Palmata Patch, Davis Rock, Loggerhead Patch, The Maze, and Little Africa all had at least a 1% gain in absolute octocoral cover between the long-term time intervals tested (years were variable among these sites).

Increases in octocoral cover following losses of hard corals have been reported from elsewhere along Florida's Coral Reef (Ruzicka et al. 2013). Three of the six sites that increased in octocoral cover over their associated long-term intervals also had a significant decrease in coral cover: Loggerhead Patch, White Shoal and Little Africa. Stony coral cover did decrease, albeit not significantly, at Davis Rock and at The Maze. While octocoral cover at Davis Rock and The Maze did significantly increase, these increases were less severe in magnitude than observed at other locations and as is noted below, Davis Rock was mostly due to increases in encrusting octocoral species. Both octocoral and coral cover increased long-term at Palmata Patch; however, this result is somewhat deceptive. Octocoral cover has drastically increased at one of the two stations, while coral cover at that station remained low, whereas at the other Palmata Patch station increases in octocoral cover have been far more moderate and coral cover has considerably increased. A more detailed description of the two stations at Palmata Patch is included in the ESA-Listed Species Section below.

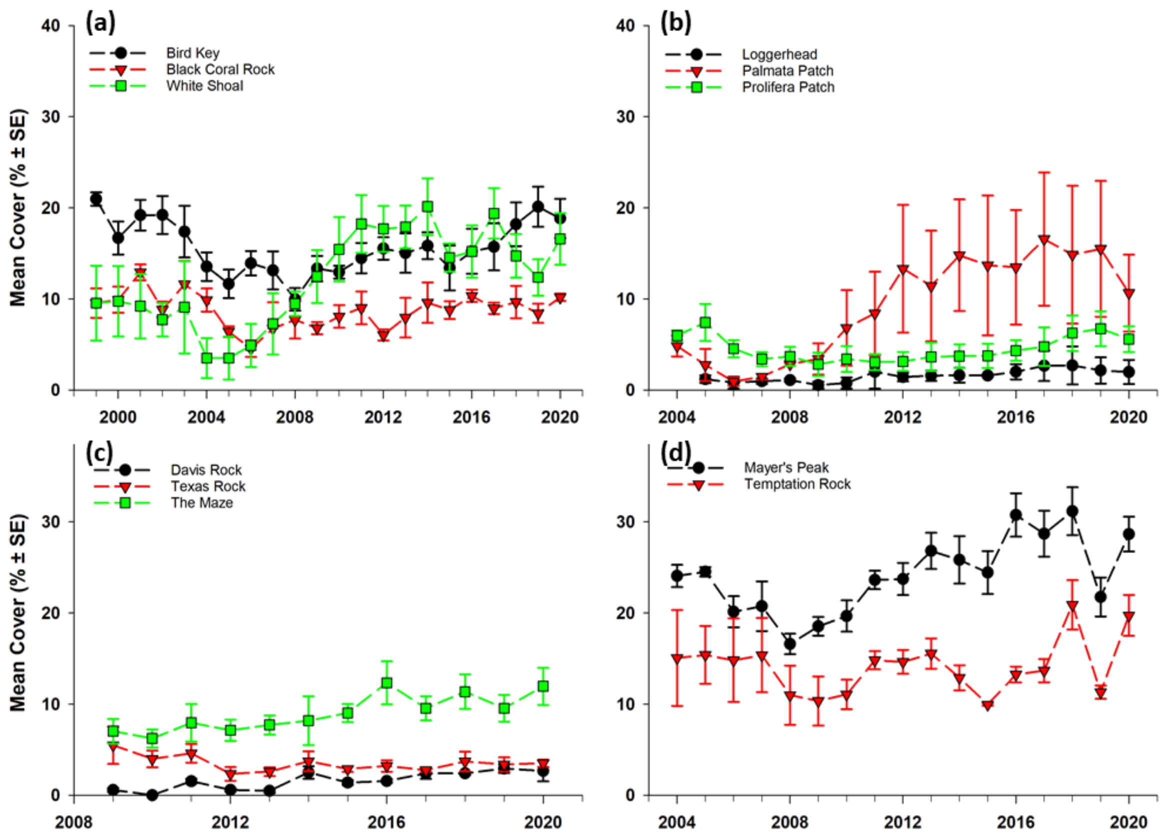

Figure 7. Total octocoral cover (% ± SE) by site.

Demographics

Octocoral density (colonies/m^2) has been measured as part of the octocoral demographic survey since 2011. Octocoral demographic surveys have been conducted over a ten-year period when octocoral cover has generally been increasing at many DRTO sites, and the results for density mostly mirror those reported for percent cover (Tables 6 and 7). Loggerhead Patch was the only site that exhibited a significant increase in density short-term. This occurred without a concomitant increase in cover over the same period (Table 6) and was mostly due to a high number of non-target species colonies counted in 2019 that were no longer present in 2020, likely due to octocoral recruits that did not survive. Long-term, a significant increase in density was observed at six of 11 sites: Bird Key Reef, Loggerhead Patch, Mayer's Peak, Palmata Patch, The Maze, and White Shoal (Table 7). One site, Black Coral Rock, decreased in density long-term.

The largest long-term increases (2011-2014 compared to 2017-2020) in octocoral density occurred at Bird Key Reef and Mayer's Peak. At Bird Key Reef, octocoral density increased by >8 colonies/m^2, from 12.5 ± 2.5 (SE) to 21.3 ± 4.3 colonies/m^2 between long-term time intervals (Table 7). This increase can be largely attributed to increases in *Antillogorgia bipinnata* (Appendix E). At Mayer's Peak, octocoral density increased by >6 colonies/m^2, rising from 20.3 ± 4.1 (SE) to 26.9 ± 5.4 colonies/m^2 between the long-term time intervals. The octocoral communities at Mayer's Peak are diverse and the increase in octocoral density can be attributed to an array of species increasing in abundance. Although significant changes in octocoral density occurred at five other locations, the increases were smaller in scale compared to Bird Key Reef and Mayer's Peak and do not necessarily correspond with changes in abundance of one or more of the five target species. At Black Coral Rock the primary species has been *Antillogorgia bipinnata* (Appendix E) throughout the decade of monitoring and decreases at this site are primarily due to decreases of this species. It is notable that significantly lower octocoral densities over the last four years (2017-2020) have occurred in association with relatively high percent cover values for cyanobacteria (see below).

Table 7. Mean density (no. colonies/m^2 ± SE) of octocorals for 11 sites. Long-term comparisons averaged for the first and last four years of demographic data collection, and short-term comparison averaged for the two-year period for the current and previous biennial report. Demographic surveys are not performed at Little Africa. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in density, respectively.

	Long-term	**Long-term**	**Short-term**	**Short-term**
Site	**2011-2014**	**2017-2020**	**2017-2018**	**2019-2020**
Bird Key Reef	12.5 ± 2.5	21.3 ± 4.3	20.5 ± 3.8	22.2 ± 4.2
Black Coral Rock	9.7 ± 2.0	7.4 ± 1.5	6.9 ± 1.3	7.7 ± 1.5
Davis Rock	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Loggerhead Patch	0.7 ± 0.2	1.8 ± 0.5	1.3 ± 0.4	2.5 ± 0.7
Mayer's Peak	20.3 ± 4.1	26.9 ± 5.4	26.8 ± 5.0	27.2 ± 5.1
Palmata Patch	2.4 ± 0.7	3.3 ± 1.0	3.2 ± 0.9	3.6 ± 1.0
Prolifera Patch	1.8 ± 0.4	2.0 ± 0.5	1.7 ± 0.4	2.2 ± 0.5
Temptation Rock	4.0 ± 0.8	3.8 ± 0.8	3.5 ± 0.7	4.2 ± 0.8
Texas Rock	0.5 ± 0.1	0.6 ± 0.1	0.5 ± 0.1	0.7 ± 0.2
The Maze	5.0 ± 1.0	6.2 ± 1.3	5.8 ± 1.1	6.6 ± 1.3
White Shoal	9.1 ± 1.8	13.2 ± 2.7	11.7 ± 2.2	14.3 ± 2.7

As with corals, changes in octocoral densities do not necessarily correlate with changes in octocoral cover; however, large changes in density have resulted in concomitant changes in cover at some sites. At Bird Key Reef, octocoral cover appears to have increased in association with increases in density over the last 10 years (Figure 7, Table 7). Although the same time intervals were not tested for percent cover and density, the increase of more than 8 colonies/m^2 has resulted in octocoral cover increasing by several percent. Conversely, at Black Coral Rock, while density has decreased by ~2 colonies/m^2, cover has been mostly consistent over the last decade. It is also worth highlighting that octocoral cover did significantly increase at Davis Rock while octocoral density remained unchanged at/near zero colonies/m^2 (Tables 6 and 7). However, at Davis Rock, upright, branching species of octocorals are only observed around the periphery of the pinnacle and the significant increase in cover is entirely due to the expansion of the two encrusting species, *Briareum asbestinum* and/or *Erythropodium caribaeorum*, that are not included in demographic surveys. These species are not identified separately during the image analysis, but both form thick encrusting mats that can overgrow the substrate and other benthic taxa.

Although the testing periods for long-term comparisons in octocoral density and octocoral percent cover are asynchronous, results from both surveys indicate a general expansion of octocoral communities at most sites over the course of monitoring. While octocoral canopy cover and density are generally affected by the same environmental perturbances as corals, octocoral communities appear to recruit and grow faster, and recover over much shorter time scales.

Macroalgae

Short-term, between the 2017-2018 and 2019-2020 reporting periods, three of the 12 sites had a significant increase in macroalgae cover: Mayer's Peak, The Maze, and Little Africa (Figure 8; Table 8). One site, Bird Key Reef, had a significant decrease in cover short-term, while no changes in cover were detected across the other seven sites. Long-term, all but three of the 12 sites had a significant increase in cover with Davis Rock, Texas Rock, and The Maze exhibiting no significant differences between the long-term testing periods.

Short-term increases at Mayer's Peak and The Maze were the largest with macroalgae cover more than doubling at Mayer's Peak and increasing by more than a third at The Maze. However, while these increases were relatively large, macroalgae cover at Mayer's Peak and The Maze was comparatively low in the 2017-2018 time period and the increases in 2019-2020 resulted in cover more similar to the other pinnacle reef locations. Significant increases at Little Africa were more moderate. At Bird Key Reef short-term decreases in macroalgae cover can be attributed to lower values recorded in 2019. Lower macroalgae values at Bird Key Reef in 2019 corresponded with high cover of cyanobacteria which can overgrow or become mixed within accumulations of macroalgae. Despite a lower value being present in 2019, macroalgae cover at Bird Key Reef still averaged nearly 30% during the 2019-2020 timeframe.

Table 8. Mean percent macroalgae cover (% ± SE) for 12 sites. Long-term comparisons averaged for the first and last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial report. The first four-year period varies and is contingent upon commencement of monitoring at that site: Bird Key Reef, Black Coral Rock, and White Shoal = 1999-2002; Loggerhead Patch, Palmata Patch, Prolifera Patch, Mayer's Peak, Temptation Rock = 2004-2007; Davis Rock, Texas Rock, The Maze = 2009-2012; Little Africa = 2007-2010. Little Africa is surveyed differently than the other 11 sites (see Methods). Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

	Long-term	Long-term	Short-term	Short-term
Site	**First Four**	**2017-2020**	**2017-2018**	**2019-2020**
Bird Key Reef	13.2 ± 3.4	36.5 ± 6.9	44.1 ± 5.7	29.7 ± 4.8
Black Coral Rock	8.0 ± 2.2	42.8 ± 7.3	41.1 ± 5.6	44.6 ± 5.7
Davis Rock	43.8 ± 7.3	49.2 ± 7.4	48.8 ± 5.8	49.4 ± 5.8
Loggerhead Patch	3.3 ± 1.1	19.2 ± 5.2	21.2 ± 4.7	17.4 ± 4.0
Mayer's Peak	1.9 ± 0.6	20.1 ± 4.8	13.7 ± 2.7	28.5 ± 4.7
Palmata Patch	1.9 ± 0.6	17.7 ± 4.9	16.0 ± 3.8	19.3 ± 4.4
Prolifera Patch	1.9 ± 0.6	11.0 ± 3.0	10.8 ± 2.4	11.3 ± 2.5
Temptation Rock	7.7 ± 2.1	34.7 ± 6.7	32.0 ± 5.0	37.2 ± 5.4
Texas Rock	32.2 ± 6.5	37.1 ± 6.9	35.3 ± 5.3	39.4 ± 5.5
The Maze	33.4 ± 6.6	33.7 ± 6.6	28.3 ± 4.7	39.1 ± 5.5
White Shoal	7.5 ± 2.1	25.7 ± 5.7	24.9 ± 4.3	26.6 ± 4.5
Little Africa	10.1 ± 1.9	24.5 ± 3.8	22.7 ± 0.8	26.5 ± 0.9

Since 2009 the contribution of macroalgae to the benthic assemblage in DRTO has been greater than any other taxa group. Long-term, all nine sites surveyed prior to 2009 had significantly higher macroalgae cover values in the most recent four-year interval (2017-2020) compared to their initial four years of surveys. This pattern may have also been upheld for Davis Rock, Texas Rock, and The Maze, but surveys at these sites did not start until 2009. At these sites, macroalgae cover exceeded 30% during both long-term time intervals examined. Over the 2017-2020 interval the cover of macroalgae exceeded 20% at six of the nine sites surveyed prior to 2009 with Loggerhead, Palmata Patch, and Prolifera Patch being the exceptions. In contrast, averaged for the first four years of monitoring, seven of the nine sites had macroalgae cover of 10% or less (Table 8). Aside from Little Africa, which is in a well-protected near-shore location, Loggerhead, Palmata Patch and Prolifera Patch are the shallowest sites monitored by the CREMP survey and macroalgae abundance may be limited by the instability of acroporid rubble at these sites.

Prior to 2010, the CREMP image analysis lumped all macroalgae and cyanobacteria into a single major taxa group identified as 'macroalgae' primarily because these different groups were difficult to distinguish in older CREMP imagery. Starting in 2010, to refine the CREMP analysis three macroalgae genera were individually recognized (*Dictyota* spp., *Lobophora* spp., and *Halimeda*

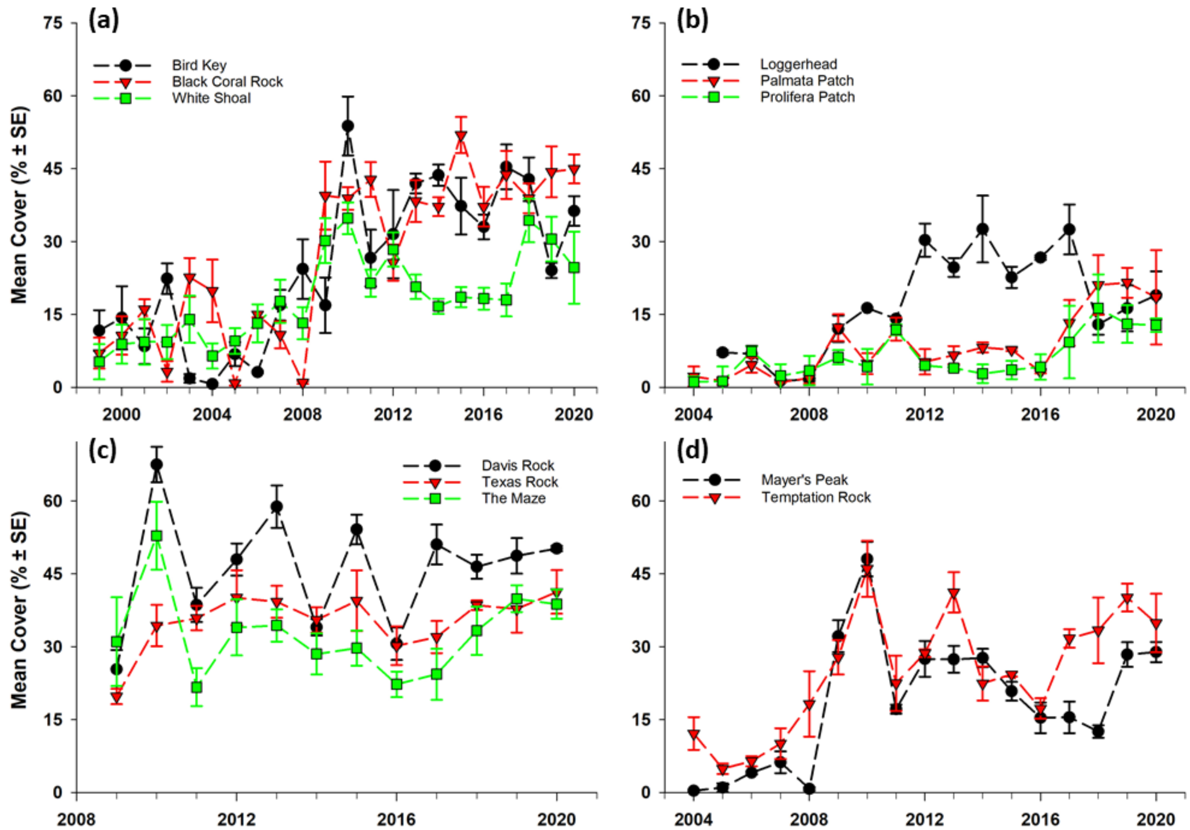

Figure 8. Total macroalgae cover (% ± SE) by site. A) The three original sentinel sites, started in 1999. B) Three sites that monitor Acroporid ESA species, started in 2004. C) Pinnacle reefs inside the RNA with mooring buoys, started in 2009. D) Pinnacle reefs inside the RNA without mooring buoys, started in 2004.

spp.) and cyanobacteria was given its own taxa grouping separate of macroalgae. Genera like *Dictyota* and *Lobophora* are fleshy alga and are viewed unfavorably because they proliferate quickly after disturbances, out-compete other benthic organisms for reef space or even inflict direct mortality (Kuffner et al. 2006, Paul et al. 2011), whereas calcareous algae like *Halimeda* spp. are considered as a positive contributor to reef integrity (Vroom et al. 2003). Cyanobacterial mats have been increasing on many Caribbean reefs and can foster negative feedback loops that lead to coral decline and contribute to long-term shifts from coral-dominated reefs to algae-dominated ones (Ford et al. 2018).

In 2019 and 2020 the mean absolute cover of *Dictyota* spp. (*N* = 11 sites, excluding Little Africa) was 15.0 ± 2.2% and 20.1 ± 2.7%, respectively (Appendix C). This represented 47.9% and 63.0% of the total macroalgae assemblage in each of those years. At nearly all sites, *Dictyota* has been the largest constituent of the total macroalgae cover since 2010 (Appendix C). Considering that total macroalgae cover was generally <10% during the first decade of monitoring (1999-2009), the increase in *Dictyota* is clearly substantial because *Dictyota* cover alone in 2019 and 2020 was greater than the total macroalgae cover of the earlier years. *Lobophora* has also been an important contributor to the macroalgae assemblage. Although not as widespread as *Dictyota* on shallow reefs, *Lobophora* can cover large portions of deeper reefs. *Lobophora* cover at Bird Key Reef and Black Coral Rock in many years has exceeded the cover of *Dictyota* (Appendix C). While *Dictyota* can form large blooms near the substrate, it is often loosely attached and can be cleared by the wave-energy associated with powerful storms. In contrast, *Lobophora* is well-attached to the substrate being nearly encrusting in nature and can have much longer residence on reef habitats.

Cyanobacteria serve as important nitrogen fixers on coral reefs and usually compose <1% of the benthos (Appendix A, unpublished CREMP data); however, higher coverage can lead to detrimental impacts on reefs and can be an indicator of sub-optimal water quality. Multiple factors may be supporting the increase in cyanobacteria including ocean acidification, rising seawater temperatures, higher sewage and nutrient input, and phosphorus enrichment (Ford et al. 2018). Although not compared statistically in this report, at many sites in DRTO the highest value ever attained for cyanobacteria was during the 2019 or 2020 sampling years. In some instances, the cover of cyanobacteria alone in either 2019 or 2020 was greater than the average macroalgae cover during the first four years of monitoring at that site. For example, at Bird Key Reef cyanobacteria cover was 25.3% and 6.4% in 2019 and 2020, respectively (Appendix A). During the first four-year time interval macroalgae cover averaged 13.2 ± 3.4% (SE) at this site. Likewise at Black Coral Rock, macroalgae averaged 8.0 ± 2.2% (SE) between 1999 and 2002 (Table 8). The last three years (2018-2020) cyanobacteria cover has exceeded 10% annually (Appendix A).

The proliferation and persistence of fleshy macroalgae like *Dictyota* and *Lobophora* as well as cyanobacteria is concerning. Furthermore, it is likely that values for both macroalgae genera and for cyanobacteria reported here are underestimated because they are often mixed with accumulations of various macroalgae and are counted as ‘other macroalgae’ in the CREMP image analysis when they cannot be readily distinguished.

Sponges

Short-term, between the 2017-2018 and 2019-2020 reporting periods, two sites had a significant increase in sponge cover (Palmata Patch and Little Africa), one site had a significant decrease in cover (Prolifera Patch) and the other nine sites had no significant changes in sponge cover (Figure 9; Table 9). Long-term, six of the 12 sites had a significant increase in cover and none of the sites had a significant decline (Table 9). At sites with increased in sponge cover, some nearly doubled between the reporting periods of the long-term analysis; however, the absolute values in cover are much smaller compared to those of corals, octocorals, and macroalgae. Averaged for 2019-2020, sponge cover ranged from a high of 6.8 ± 1.2% at Texas Rock to a low of 0.3 ± 0.1% at Prolifera Patch. Sponge cover was much higher on the pinnacle reefs than on the shallow acroporid reefs, and even though three of the acroporid reefs significantly increased in cover in the long-term analysis, total sponge cover at those sites were still less than 1%.

Table 9. Mean percent sponge cover (% ± SE) for 12 sites. Long-term comparisons averaged for the first and last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial report. The first four-year period varies and is contingent upon commencement of monitoring at that site: Bird Key Reef, Black Coral Rock, and White Shoal = 1999-2002; Loggerhead Patch, Palmata Patch, Prolifera Patch, Mayer's Peak, Temptation Rock = 2004-2007; Davis Rock, Texas Rock, The Maze = 2009-2012; Little Africa = 2007-2010. Little Africa is surveyed differently than the other 11 sites (see Methods). Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

	Long-term	**Long-term**	**Short-term**	**Short-term**
Site	**First Four**	**2017-2020**	**2017-2018**	**2019-2020**
Bird Key Reef	1.0 ± 0.2	1.1 ± 0.2	1.2 ± 0.3	1.0 ± 0.2
Black Coral Rock	3.8 ± 0.8	4.2 ± 0.8	3.9 ± 0.8	4.4 ± 0.8
Davis Rock	2.2 ± 0.4	3.7 ± 0.7	3.4 ± 0.7	4.0 ± 0.8
Loggerhead Patch	0.3 ± 0.1	0.7 ± 0.2	0.7 ± 0.2	0.7 ± 0.2
Mayer's Peak	2.4 ± 0.5	4.7 ± 0.9	4.8 ± 0.9	4.4 ± 0.9
Palmata Patch	0.1 ± 0.0	0.5 ± 0.1	0.4 ± 0.1	0.7 ± 0.2
Prolifera Patch	0.2 ± 0.1	0.4 ± 0.1	0.6 ± 0.1	0.3 ± 0.1
Temptation Rock	1.2 ± 0.3	2.5 ± 0.5	2.4 ± 0.5	2.6 ± 0.5
Texas Rock	4.6 ± 0.9	6.2 ± 1.2	5.9 ± 1.1	6.8 ± 1.2
The Maze	3.7 ± 0.7	4.8 ± 0.9	5.2 ± 1.0	4.4 ± 0.8
White Shoal	2.4 ± 0.5	2.8 ± 0.6	2.7 ± 0.5	3.2 ± 0.6
Little Africa	0.2 ± 0.1	0.4 ± 0.1	0.3 ± 0.1	0.6 ± 0.1

Endangered Species Act Listed Species

Acropora palmata

Palmata Patch is the only CREMP site where *Acropora palmata* is found in DRTO. Because the distribution of *A. palmata* colonies is relatively confined at this location, CREMP only established two monitoring stations to survey their condition. Short-term there was no significant difference in mean *A. palmata* cover between 2017-2018 and 2019-2020; however, values did increase from 6.3 ± 0.6% in 2017-2018 to 7.4 ± 0.7% (SE) in 2019-2020 (Figure 10a, Table 10). Long-term, *A. palmata* cover has significantly increased, with cover more than doubling from 3.0 ± 0.5% during the first four years of survey (2004-2007) to 6.8 ± 0.9% over 2017-2020 (Table 10).

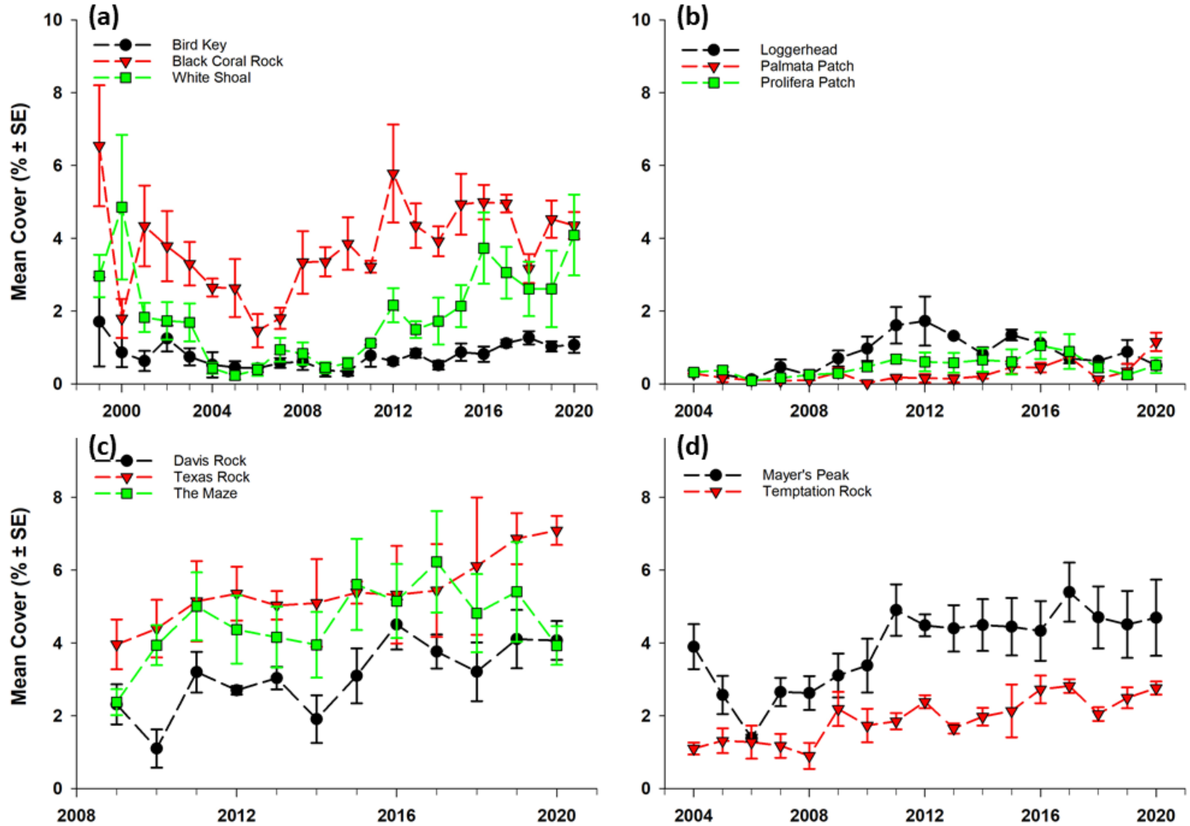

Figure 9. Total sponge cover (% ± SE) by site.

The initial four-year monitoring timeframe included the 2004 and 2005 hurricane seasons which destroyed many of the colonies (see previous reports; Figure 10a). During this time, the loss of *A. palmata* cover did not occur evenly across the two surveys stations. Between 2004 and 2006, *A. palmata* cover decreased from 3.6% to 0.5% at Station 1 and from 6.0% to 3.1% at Station 2. All colonies were lost at Station 1 except one (see following paragraph), which has severely limited the recovery of percent cover values within this station. As of 2020, *A. palmata* cover was only 0.4% within this station. In contrast, at Station 2, *A. palmata* cover was 14.8% in 2020, the highest value recorded for this survey station. All the increase in *A. palmata* cover at Palmata Patch has been driven by colonies within Station 2 over the last decade, with the overall slope trending in a positive direction, and only disrupted by the occasional year that a documented disturbance decreased cover (e.g., 2014/15 El Niño, Hurricane Irma).

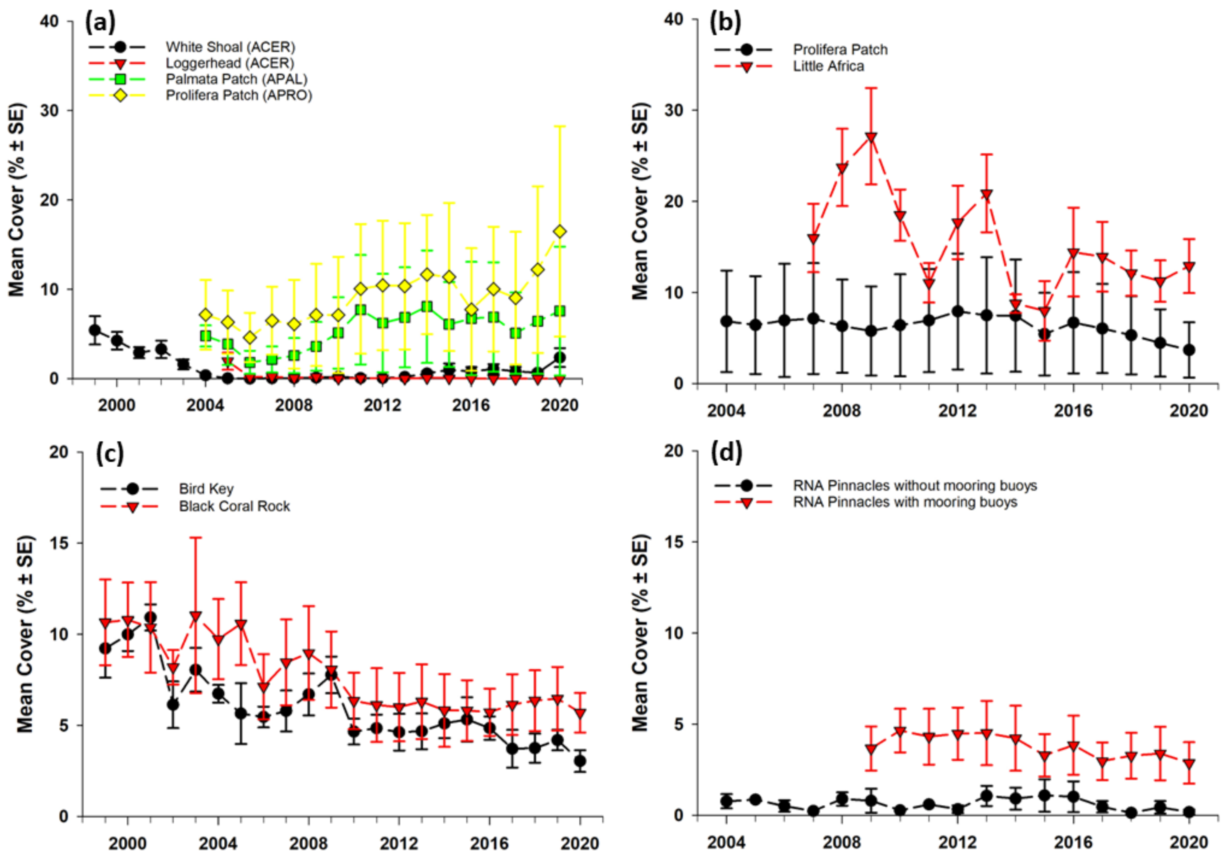

Figure 10. Coral cover (% ± SE) for four ESA corals. A) *Acropora cervicornis* (ACER) at White Shoal and Loggerhead Patch, *A. palmata* (APAL) at Palmata Patch, and *A. prolifera* (APRO) at Prolifera Patch. B) *Orbicella spp.* cover at Prolifera Patch and Little Africa. C) *Orbicella spp.* cover at Bird Key and Black Coral Rock. D) *Orbicella spp.* cover at RNA sites with or without mooring buoys. Note: Y-axis scale differs between graphs A) and B) and graphs C) and D).

While there has been some annual variability in the density of *A. palmata* colonies at Station 2, Station 1, as mentioned above, is composed of a single colony (equivalent to a density of 0.1 colonies/m^2) and has been throughout the 10 years of demographic surveys. Density at Station 2 has fluctuated, ranging from 17 colonies in 2015 to 28 colonies in 2020 (Table 11). The combination of density and substrate coverage suggests that the maintenance and growth of *A. palmata* at Palmata Patch is largely due to the regeneration and fragmentation of existing colonies. While CREMP performs an annual census, additional monitoring efforts carried out by FWC at this site fate-track *A. palmata* individuals. Their results corroborate that increases in cover are due to tissue regeneration on existing colonies because the density within their plots have remained similar or even slightly decreased over the last four years (Boisvert and Ruzicka 2022). While it is encouraging that cover and density of *A. palmata* is stable or expanding, without sexual recruitment the long-term prospects of further population expansion by *A. palmata* will be limited to fragmentation and tissue growth of the extant population.

Table 10. Mean percent coral cover (% ± SE) for the three Acroporid corals, *A. cervicornis, Acropora palmata,* and *A. prolifera,* at their respective sites. Long-term comparisons averaged for the first and last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial report. The first four-year period varies and is contingent upon commencement of monitoring at that site: Loggerhead Patch = 2005-2008; Palmata Patch and Prolifera Patch = 2004-2007; White Shoal = 1999-2002; The last four years represents 2017-2020. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

	Long-term	**Long-term**	**Short-term**	**Short-term**
Site	**First Four**	**2017-2020**	**2017-2018**	**2019-2020**
***Acropora palmata* (Prolifera Patch)**	3.0 ± 0.5	6.8 ± 0.9	6.3 ± 0.6	7.4 ± 0.7
***Acropora prolifera* (Prolifera Patch)**	5.7 ± 0.6	10.9 ± 1.1	8.7 ± 0.8	13.5 ± 1.1
***Acropora cervicornis* (White Shoal)**	3.8 ± 0.7	1.1 ± 0.2	0.9 ± 0.3	1.3 ± 0.4
***Acropora cervicornis* (Loggerhead Patch)**	0.3 ± 0.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

Since 2004, a rapid proliferation of octocorals has occurred at Palmata Patch. Octocoral cover and density have both significantly increased long-term at Palmata Patch (Table 6 and 7); particularly at the station with only a single *A. palmata* colony. Mean octocoral cover increased sixfold to 13.2% ± 3.0% (SE) between the long-term time intervals of 2004-2007 and 2017-2020. Although it doesn't span the same time period as percent cover, octocoral density has also increased during the last decade (Table 7). The transition to octocorals becoming the most abundant taxa or being the largest contributor to benthic cover on shallow reefs where acroporid corals were once dominant has also occurred in the Florida Keys (Ruzicka et al. 2013) and elsewhere in the Caribbean (Tsounis and Edmunds 2017). Even without significant increases in octocoral abundance the rapid growth of existing octocoral communities can create an expansive canopy that may prevent the settlement of *A. palmata* larvae and affords octocorals an advantage in spatial competition.

Table 11. Density (no. of colonies/m^2) of *A. palmata* at the two CREMP stations monitored at Palmata Patch.

Station	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
1	0.1	0.1	0.3	0.1	0.1	0.2	0.1	0.1	0.0	0.1
2	1.9	2.0	2.5	2.4	1.7	2.3	2.6	2.0	2.2	2.8

Acropora cervicornis

Acropora cervicornis is present throughout much of DRTO but occurs in low abundance at many reefs. Previous reports have described the declines of *A. cervicornis* in DRTO since the start of CREMP monitoring (Ruzicka et al. 2018). It is estimated that >95% of the population throughout DRTO has disappeared over the last 50 years as this species has been decimated by disease, hurricanes, and cold-water anomalies (Davis 1982, Roberts et al. 1982, Jaap and Sargent 1993, Porter and Porter 2002). CREMP monitors two legacy sites, White Shoal (surveyed since 1999) and Loggerhead Patch (surveyed since 2005), to evaluate the changes at these sites where there were once large stands of *A. cervicornis*.

Short-term, at White Shoal, there was no significant difference in mean *A. cervicornis* cover between the 2017-2018 and 2019-2020 intervals. Mean *A. cervicornis* cover was 0.9 ± 0.3% in 2017-2018 and 1.3 ± 0.4% (SE) in 2019-2020 (Figure 10a, Table 10). While there were no significant differences based on this analysis it is notable that *A. cervicornis* cover at White Shoal increased considerably from 2019 to 2020, with increases at all four survey stations and one station increasing in cover from 1.1% to 5.2%. Long-term, the four-year average calculated from 2017-2020, 1.1 ± 0.2%, is significantly less than the mean for 1999-2002, 3.8 ± 0.7%. At Loggerhead Patch, there has been no reestablishment of colonies after the decline at this site. *A. cervicornis* was recorded at is highest cover in 2005, the first year of surveys, when it represented 1.9% of the benthic cover. Loggerhead Patch was decimated during the 2005 hurricane season, and *A. cervicornis* cover rapidly declined thereafter and has not been present since 2015 (Appendix B). Because *A. cervicornis* cover at Loggerhead Patch plummeted to nearly near zero in 2006 and 2007, those two years lower the first four-year mean so substantially that no long-term difference was detected (Table 10).

The reduction of *A. cervicornis* at White Shoal and near absence of it at Loggerhead Patch has allowed other benthic taxa to become the prominent benthic features. The most concerning change is the proliferation of macroalgae, which has significantly increased at both sites long-term (Table 8). Fleshy macroalgae species are mostly responsible for the elevated levels observed since 2009. Although cover for *Dictyota* has varied considerably since 2010, in some years it has accounted for up to 86% of the total macroalgal cover at Loggerhead Patch and up to 52% of the total macroalgal cover at White Shoal (Appendix C). The sustained levels of greater macroalgal cover that has persisted the last decade has likely prevented the recovery of *A. cervicornis* at these sites. *Dictyota* spp. and several other fleshy macroalgae species are known inhibitors of coral recruitment that diminish the establishment of new sexually derived recruits and other toxic allelochemicals can inflict direct mortality on nearby fragments which reduces the expansion of extant colonies through asexual fragmentation (Kuffner et al. 2006, Morrow et al. 2017).

Similar to Palmata Patch, the emergence of octocorals at White Shoal may also be inhibiting *A. cervicornis* recovery. Octocoral cover at White Shoal has nearly doubled long-term from 8.5 ± 1.6% in 1999-2002 to 15.1 ± 2.6% in 2017-2020 (Table 6). The octocoral community appears well established at White Shoal and continues to expand with the density significantly increasing during the last decade mean octocoral density averaged 9.1 ± 1.8 colonies/m^2 in 2011-2014 but had risen to 13.2 ± 2.7 colonies/m^2 in 2017-2020 (Table 7).

Acropora prolifera

Prolifera Patch is believed to be the only site where *A. prolifera* is found in DRTO. Similar to the distribution of *A. palmata*, the presence of *A. prolifera* is confined to a small area and CREMP only established three monitoring stations. Prolifera Patch is likely composed of a single genet that is distributed as isolated colonies and small thickets throughout the site. Overall, the cover of *A. prolifera* has expanded and increased both short- and long-term. Short-term, the mean cover of *A. prolifera* increased from 8.7 ± 0.8% in 2017-2018 to 13.5 ± 1.1% in 2019-2020 (Figure 10, Table 10). Long-term, *A. prolifera* cover nearly doubled, increasing from 5.7 ± 0.6% in 2004-2007 to 10.9 ± 1.1% in 2017-2020 (Table 10).

Up until the most recent two-year period, *A. prolifera* cover had remained relatively similar between 2009 and 2018 (Figure 10a). Similar to the synopsis for Palmata Patch, the 2004 and 2005 hurricane seasons decimated much of the *A. prolifera* thickets, with cover between 2004-2007 only averaging 5.7 ± 0.6%. The increase in *A. prolifera* cover is notable because the site lies in close proximity to Palmata Patch and the expansion of the primary species at these two sites (*A. prolifera* and *A. palmata*) have either supported an overall increase in coral cover at the site or maintained the level observed at the start of surveys. Given that sexual recruitment of *Acropora* in Florida is rare (Williams et al. 2008, Miller et al. 2014) and that the genetic diversity is restricted to a single genotype, the increase in *A. prolifera* cover is only due to expansion of the existing thicket through asexual fragmentation. While the recent observations for *A. prolifera* are encouraging and do not parallel those for *A. cervicornis,* the population's lack of genetic diversity and the confined spatial distribution continues to place the species at risk.

Unlike the changes observed at the *A. cervicornis* sites, it does not appear that increased macroalgae cover has an adverse effect *A. prolifera* cover. Although there was a significant increase in macroalgae cover at Prolifera Patch long-term (Table 8), this site did have the lowest macroalgae cover of any site. Averaged for 2019-2020, macroalgae cover was 11.3 ± 2.5% (SE) at Prolifera Patch which was substantially less than at any other site. Similarly, there were no significant differences detected in octocoral cover and density both short- and long-term at Prolifera Patch. Palmata Patch, Loggerhead Patch and White Shoal all had significant increases in octocoral cover and density long-term (Tables 6 and 7). The differences in the changes of the other benthic taxa groups cover between Prolifera Patch and White Shoal and Loggerhead may partially explain why *A. prolifera* cover has recovered, and even expanded, while *A. cervicornis* cover has remained persistently low.

Orbicella spp.

For the CREMP image analyses, the *Orbicella* species are aggregated into a complex of three recognized species: *Orbicella annularis, O. faveolata*, and *O. franksi*. The three species are pooled into a single complex because it can be challenging to distinguish between them in Point Count imagery. The three species of *Orbicella* are individually recognized in the demographic surveys and the data are presented by species in the appendices. At sites where *Orbicella* populations are monotypic, the appropriate species is mentioned (e.g., *Orbicella* cover at Prolifera Patch is principally comprised of *O. annularis*). *Orbicella* spp. historically are one of the major reef-builders on Florida's coral reefs (Ginsburg and Shinn 1994, Toth et al. 2019). It has been the most spatially abundant coral (e.g., the largest contributor to coral cover) at Bird Key Reef, Black Coral Rock, and Little Africa (Appendix B) and is also common at Prolifera Patch and on the pinnacle reefs.

Short-term, between the 2017-2018 and 2019-2020 time periods, there were significant declines in mean *Orbicella* cover at Little Africa and Prolifera Patch but no short-term differences at Bird Key Reef, Black Coral Rock, and for the mean averaged for the five pinnacle reefs. Long-term, however, *Orbicella* cover has significantly declined at all sites and the pinnacle reefs (Figure 10b-d, Table 12). No significant differences in *Orbicella* density were found short-term or long-term across any of the sites or the pinnacle reefs (Table 13). The disconnect between the significant declines in percent cover and the lack of differences observed for density are due to several reasons. First, the starting points for the long-term comparisons in percent cover and density are over a decade apart. CREMP first began measuring percent cover in 1999 but did not initiate demographic surveys until 2011. Second, enumerating individual *Orbicella* colonies can be difficult when large monotypic stands are present because distinguishing these colonies as autonomous can be extremely challenging. Their plating or lobing growth forms and the large amount of partial mortality and fragmentation these corals typically undergo can lead to over- and underestimation of their abundance and increase the variance around the annual density measures. Lastly, only a small amount of living tissue needs to be observed for the colony to be recorded as alive; thus, while 99% of the live tissue may have been lost to mortality, the presence of the individual colony would still be reflected in the density calculation.

Examining changes at the site level, the long-term decline of *Orbicella* has been most apparent at Bird Key Reef. *Orbicella* cover has historically accounted for approximately 50% of the total coral cover at Bird Key Reef and the sloping forereef is comprised of a mixed assemblage of *O. faveolata* and *O. franksi*. During the first four-year timeframe (1999-2002), mean *Orbicella* cover was 8.9 ± 0.8% (Figure 10c, Table 12). During the last four years (2017-2020) mean *Orbicella* cover averaged 3.6 ± 0.3% representing a relative loss of 60% of the total *Orbicella* cover and a long-term contraction in absolute cover of nearly 7% between the two time periods at Bird Key Reef. *Orbicella* cover started to decline in 2002 (Figure 10c) with the most precipitous drop occurring between 2001 and 2002 when an outbreak from an undescribed disease was observed on *Orbicella* and *Colpophyllia natans* at Bird Key Reef. Other significant declines occurred for unknown causes between 2009 and 2010, and from the thermal stress endured during the 2014 & 2015 El Nino (Figure 10b-d).

Similar to Bird Key Reef, the *Orbicella* community at Black Coral Rock is a mixed assemblage of *O. faveolata* and *O. franksi*. *Orbicella* makes up roughly 45% of the coral cover at Black Coral Rock, and during the first four-years of monitoring (1999-2002), averaged 10.0 ± 0.4%, the second highest *Orbicella* cover of any CREMP sites in DRTO. Long-term, *Orbicella* cover has significantly declined by ~40% at Black Coral Rock and averaged 6.3 ± 0.3% between 2017-2020 (Table 12). Most of the loss in cover occurred between 1999 and 2010 (Figure 10c). Since 2010, *Orbicella* cover has remained stable. What caused the decline during the earlier years of monitoring is unknown but was likely a stressor unrelated to temperature. During the last 12 years, temperature loggers deployed at the site confirm that corals at Black Coral Rock rarely undergo heat stress that would lead to mortality associated with bleaching (Figure 6). This is also supported by the changes in *Orbicella* cover that occurred at Bird Key Reef and Black Coral Rock between 2014 and 2016, the time of the most recent mass bleaching event in Florida and the broader Caribbean (Eakin et al. 2019). *Orbicella* cover was unchanged at Black Coral Rock but decreased at Bird Key Reef during the same time period. At the onset of the heat stress in 2015, *Orbicella* cover was nearly identical at both sites.

Table 12. Mean percent coral cover (% ± SE) for *Orbicella* spp. at four sites and averaged for five pinnacle reefs (includes Davis Rock, Texas Rock, the Maze, Mayer's Peak, and Temptation Rock). Long-term comparisons averaged for the first and last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial report. The initial four-year period for the long-term comparison varies and is contingent upon commencement of monitoring at that site or at the pinnacle reefs: Bird Key Reef and Black Coral Rock = 1999-2002; Prolifera Patch = 2004-2007; Little Africa = 2007-2010; pinnacle reefs = 2009-2012. The last four years represents 2017-2020. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover.

	Long-term	Long-term	Short-term	Short-term
Site	**First Four**	**2017-2020**	**2017-2018**	**2019-2020**
Bird Key Reef	8.9 ± 0.8	3.6 ± 0.3	3.6 ± 0.2	3.5 ± 0.3
Black Coral Rock	10.0 ± 0.4	6.3 ± 0.3	6.5 ± 0.3	6.1 ± 0.3
Little Africa	21.1 ± 1.6	12.4 ± 1.1	12.8 ± 0.6	12.0 ± 0.6
Prolifera Patch	6.9 ± 0.5	5.0 ± 0.4	6.0 ± 0.3	4.2 ± 0.2
Pinnacle Reefs	2.6 ± 0.1	2.0 ± 0.1	2.0 ± 0.1	2.0 ± 0.1

The reef at Little Africa primarily consists of *Orbicella faveolata* and *O. annularis*. *Orbicella* comprises more than 80% of the total coral cover here. Both short-term and long-term declines in *Orbicella* were recorded at Little Africa (Table 12). Comparing the means averaged for the first and last four years of monitoring *Orbicella* cover has declined by ~41% at Little Africa. Between 2007-2010 mean *Orbicella* cover was 21.1 ± 1.6% (SE) but had declined to 12.4 ± 0.6% between 2017-2020. Using the values calculated for the two-year span in this biennial report *Orbicella* cover was only 12.0 ± 0.6%. While less substantial than the overall decline at Bird Key Reef, the timeframe is shortened by eight years and Little Africa is the only other site to indicate both a short- and long-term declines in *Orbicella* besides Prolifera Patch. Not all the factors that have contributed to the loss of *Orbicella* cover at Little Africa are known, but bleaching occurs frequently from thermal stress due to the shallow depth of the site. Although there is no temperature logger deployed at Little Africa the site likely has a comparable water temperature regime to other shallow sites like Loggerhead, Palmata, and/or Prolifera Patch which endure the highest number of days with seawater temperatures >30 or 31°C annually (Figure 6). In addition to undergoing elevated temperature stress on a more frequent basis, another commonality between the Bird Key Reef and Little Africa *Orbicella* communities is they are largely derived from monotypic stands of colonies which makes them vulnerable to epizootic outbreaks that can easily spread across the population.

At Prolifera Patch, *Orbicella* spp. colonies are concentrated along the southern side of the stations and primarily consist of large *O. annularis* heads greater than a meter in height or width. As stated, above, Prolifera Patch is the only other site besides Little Africa that indicated both a short- and long-term decline in *Orbicella* cover (Table 12). While not at the same level as Little Africa, there was a relative loss of ~28% of the *Orbicella* cover at Prolifera Patch during the long-term time periods of 2004-2007 and 2017-2020. In addition, the difference in cover averaged for this biennial report and the previous one also indicated a relative decline of ~30% over the last four years.

Although not nearly as spatially dominant or numerous as the sites described above, large *Orbicella* colonies are a common feature atop the pinnacle reefs. There are five pinnacle reefs assessed but three of them (The Maze, Davis Rock, and Texas Rock) were added to the survey in 2009. Therefore, the long-term comparison is between the time intervals of 2009-2012 and 2017-2020. A significant decrease in *Orbicella* cover was detected long-term, (Table 12) but cover was unchanged the last four years.

Coral demographic surveys have been completed at all sites that contain *Orbicella* since 2011, except Little Africa. No significant differences in *Orbicella* density were found for the short- or time intervals at Black Coral Rock, Prolifera Patch, and the pinnacle reefs (Table 13). *Orbicella* densities range from 0.2 ± 0.0 (SE) colonies/m^2 across the pinnacle reefs to 1.9 ± 0.2 colonies/m^2 at Black Coral Rock. As described earlier, the inconsistencies between coral cover and density are due to the difficulties in enumerating individual *Orbicella* colonies. Their plating or lobing growth form and the frequent occurrence of fragmentation makes assigning autonomy challenging and can lead to both an under and overestimation of abundance. Because only a small amount of living tissue needs to be observed for a colony to be alive, percent cover infers a more accurate evaluation on the condition of *Orbicella* when large monotypic stands are present. Because *Orbicella* colonies are massive corals and disproportionally contribute to coral cover, substantial declines in cover due to partial mortality can occur without decreases in density.

Table 13. Mean density (no. of colonies/m^2) ± SE *Orbicella* spp. at three sites and averaged for five pinnacle reefs (includes Davis Rock, Texas Rock, the Maze, Mayer's Peak, and Temptation Rock). Long-term comparisons averaged for the first and last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial report. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in density.

	Long-term	Long-term	Short-term	Short-term
Site	**2011-2014**	**2017-2020**	**2017-2018**	**2019-2020**
Bird Key Reef	1.5 ± 0.2	1.3 ± 0.1	1.4 ± 0.2	1.2 ± 0.2
Black Coral Rock	1.9 ± 0.2	1.8 ± 0.2	1.8 ± 0.2	1.7 ± 0.2
Prolifera Patch	0.7 ± 0.3	0.5 ± 0.2	0.4 ± 0.3	0.6 ± 0.3
Pinnacle Reefs	0.3 ± 0.0	0.3 ± 0.0	0.3 ± 0.0	0.2 ± 0.0

Pinnacle Reefs and User Pressure

Established in 2007, the Research Natural Area (RNA) of Dry Tortugas National Park is a 46-square-mile marine reserve designed to restore ecological integrity and capacity for self-renewal by minimizing human disturbance. The RNA is a no-take ecological preserve that allows for recreational diving, snorkeling, research, and education (Ziegler and Hunt 2012). Anchoring is not permitted within the RNA and SCUBA diving activities are only conducted through drift diving or securing the vessel to a reef designated with a mooring buoy. To determine if the use of mooring buoys would concentrate SCUBA diving activities to such an extent that it would result in detrimental effects or damage to benthic communities the CREMP program added three sites in 2009 that were designated for mooring buoy installation. This sub-study compares the changes in benthic communities at these mooring buoy sites to the changes at two similar sites where no mooring buoys are present and was intended to assist the park in establishing a diver "carrying capacity" so that RNA resource stewardship goals were upheld (Ziegler and Hunt 2012).

All five sites used in this assessment are pinnacle reefs located in the northern and western sections of the park. Mayer's Peak and Temptation Rock are the two sites without mooring buoys and serve as the refence sites for this analysis. They were first surveyed as part of CREMP in 2004. Davis Rock, The Maze, and Texas Rock were added in 2009, have mooring buoys and serve as the treatment sites. Survey methods conducted at all three sites are the same as for all CREMP sites. Statistical analyses also follow the same methods detailed above; however, for both long-term and short-term comparisons the data for reference sites and treatment sites were pooled and for long-term analyses the first four years are 2009-2012 for both reference and treatment site groups. To evaluate the differences between the reference sites and the treatment sites we compared changes in percent cover and density of corals and octocorals.

All mooring buoys were securely installed by 2013 and thus the first four-year period in the long-term analysis provides a baseline that predates mooring buoy installation. Several of the RNA mooring buoys have broken off during the study for extended periods of time. Due to the remote location of DRTO the time required for repair or replacement can be considerable, with affected sites having little or no SCUBA activity while moorings were absent. In addition, SCUBA diving effort has been difficult to quantify. The current vessel permit application used by DRTO does not distinguish between SCUBA diving and snorkeling activities. As is, they are currently lumped together in the permit application, and this precludes calculating a precise estimate of the SCUBA diving effort at the RNA sites. Based upon other studies, the most conservative estimates suggest that more than 5,000 to 6,000 divers per site per year are needed to surpass thresholds that would be detrimental to coral reef communities (Hawkins et al. 1999). Based upon our communication with DRTO park staff and members of the dive industry that operate within DRTO, the three treatments sites assessed here, at most, receive approximately 1,000 dives per year.

Short-term, between the 2017-2018 and 2019-2020 time periods, there were no significant differences in coral cover and density nor octocoral cover and density at the treatment or reference sites (Tables 14 and 15). Long-term, from 2009-2012 to 2017-2020, there was a significant decline in coral cover at the treatment sites but no significant change at the reference sites (Table 14). Coral density, however, significantly increased long-term at both treatment and reference sites (Table 15). Octocoral cover and density also significantly increased long-term at both treatment and reference sites (Tables 16 and 17).

Table 14. Mean percent coral cover (% ± SE) for three RNA sites with mooring buoys and two RNA sites without. Long-term comparisons were made between the average calculated for 2009-2012 and the last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial reports. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

	Long-term	**Long-term**	**Short-term**	**Short-term**
RNA Sites	**2009-2012**	**2017-2020**	**2017-2018**	**2019-2020**
With Moorings (3)	8.8 ± 1.2	7.6 ± 1.1	7.9 ± 1.0	7.7 ± 1.0
Without Moorings (2)	4.0 ± 0.6	4.4 ± 0.6	4.0 ± 0.6	4.7 ± 0.7

Table 15. Mean coral density (no of colonies/m^2 ± SE) for three RNA sites with mooring buoys and two RNA sites without. Long-term comparisons were made between the average calculated for 2011-2014 and the last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial reports. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

	Long-term	**Long-term**	**Short-term**	**Short-term**
RNA Sites	**2011-2014**	**2017-2020**	**2017-2018**	**2019-2020**
With Moorings (3)	4.7 ± 0.3	5.7 ± 0.3	5.7 ± 0.3	5.7 ± 0.3
Without Moorings (2)	4.1 ± 0.3	5.4 ± 0.4	5.3 ± 0.3	5.5 ± 0.3

Mean coral cover averaged across the three treatment sites was greater than at the two reference sites (Table 14). At the treatment sites coral cover declined 1.2% between the long-term periods analyzed, while at the reference sites there were no significant changes. The primary driver of the decreases in coral cover at the treatment sites was the loss of *Orbicella* spp., which has had relatively low cover values at the two reference locations throughout CREMP monitoring. Among the treatment sites The Maze had the highest *Orbicella* cover with values ranging from 4.5% in 2017 to 7.3% in 2014, whereas among the reference sites Temptation Rock had the highest *Orbicella* cover with values ranging 2.0% in 2015 to 0.1% in 2018 (Appendix B). Because *Orbicella* colonies are massive corals and disproportionally contribute to coral cover compared to coral density, substantial declines in cover due to partial mortality can occur without decreases in density. Long-term significant increases in coral density occurred at both treatment and reference sites (Table 15) suggesting that coral recruitment is occurring regardless of user differences and that newly settled corals are achieving 4cm in size and are included in the demographic counts. For both treatment and reference sites the increase in density is mostly due to smaller, weedy species as described above in the coral density section.

Although there was a large disparity in octocoral cover and density between the treatment and the reference sites, both groups had a significant increase in octocoral cover and density long-term (Tables 16 and 17). The two reference sites, Mayer's Peak and Temptation Rock, had the highest octocoral cover and density of any DRTO CREMP sites, with 24.5 ± 4.0% and 15.0 ± 2.8% cover, and 27.2 ± 5.1 and 4.2 ± 0.8 octocorals/m^2, respectively averaged for this biennial report (Tables 6 and 7). Octocoral cover or density has either increased or remained similar at both sites long-term. The same results were found for the three reference sites, Davis Rock, The Maze and Texas Rock, where the long-term analyses indicate that octocoral cover and density have either increased or remained the same.

Table 16. Mean percent octocoral cover (% ± SE) for three RNA sites with mooring buoys and two RNA sites without. Long-term comparisons were made between the average calculated for 2009-2012 and the last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial reports. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

	Long-term	**Long-term**	**Short-term**	**Short-term**
RNA Sites	**2009-2012**	**2017-2020**	**2017-2018**	**2019-2020**
With Moorings (3)	2.6 ± 0.2	4.5 ± 0.3	4.2 ± 0.4	4.6 ± 0.4
Without Moorings (2)	16.4 ± 1.3	21.1 ± 1.6	22.7 ± 2.4	19.4 ± 2.2

Table 17. Mean octocoral density (no of colonies/m^2 ± SE) for three RNA sites with mooring buoys and two RNA sites without. Long-term comparisons were made between the average calculated for 2011-2014 and the last four years of monitoring, and short-term comparison averaged for the two-year period for the current and previous biennial reports. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

	Long-term	**Long-term**	**Short-term**	**Short-term**
RNA Sites	**2011-2014**	**2017-2020**	**2017-2018**	**2019-2020**
With Moorings (3)	0.2 ± 0.0	0.5 ± 0.1	0.4 ± 0.1	0.6 ± 0.1
Without Moorings (2)	9.0 ± 0.9	10.2 ± 1.0	9.7 ± 1.1	10.6 ± 1.2

Whether at the treatment or reference sites, the permanency of the elevated macroalgal cover that has persisted over the last decade may be of greater concern than the amount of user pressure. As described in the macroalgae section, all CREMP sites increased in macroalgae cover over the long-term analyses except the three RNA sites with mooring buoys. However, surveys at the three treatment sites did not commence until after sharp increases in macroalgae had occurred throughout DRTO (Figure 8). At the two reference sites, Mayer's Peak and Temptation Rock, the amount of macroalgal cover observed during recent years, 2017-2020, was ten times and five times higher, respectively, than the first four years of monitoring, 2004-2007.

A significant decrease in coral cover over the long-term occurred at the treatment sites but not at the reference sites. No other significant changes were observed long-term for coral density, octocoral cover, or octocoral density, or for any of the short-term analyses. The decrease in coral cover at the treatment sites is mostly due to the loss of *Orbicella* which was a consistent finding across all CREMP sites. Furthermore, *Orbicella* values were relatively low at the start of monitoring at both reference locations. The results suggest the level of SCUBA diving activity that has occurred since the mooring buoys were established in 2013 have not had a deleterious effect on the benthic communities. This result does align with the belief that the user pressure during the evaluation period was much lower than those required to adversely reflect a coral reef community.

Conclusions

There were several changes to the status of the predominant benthic groups between this biennial report and the last one. Short-term changes in coral cover were positive, as three sites (Palmata Patch, Prolifera Patch, and Temptation Rock) had a significant increase in cover between the 2019-2020 and 2017-2018 reporting periods (Table 2). Coral density was similar at 10 of the 11 sites assessed (Little Africa excluded) with only Loggerhead Patch having a significant decline (Table 3). Octocoral cover was unchanged at all sites short-term, but octocoral density also declined at Loggerhead Patch, the only site with a change in octocoral density (Tables 6 and 7). Macroalgae cover was significantly higher at three sites (Mayer's Peak, The Maze, and Little Africa) during the 2019-2020 timeframe compared to the 2017-2018 one, but macroalgae cover did significantly decrease at one site, Bird Key Reef (Table 8). Lastly, sponge cover was significantly greater at two sites (Palmata Patch and Little Africa) and significantly lower at one site (Prolifera Patch). In all, the overall collective status of most benthic groups at DRTO CREMP sites was similar to what was reported in the 2017-2018 biennial report.

Many of the long-term changes to the benthic communities were consistent with what was described in the 2017-2018 biennial report; however, there were a few notable changes that deserve recognition. Loggerhead Patch was added to the list of sites that have had a long-term decline in coral cover. Four other sites were found to have a significant long-term decline (Bird Key Reef, Black Coral Rock, White Shoal, and Little Africa), which was consistent with long-term analyses in the previous report. At the three sites that have been surveyed since 1999 (Bird Key Reef, Black Coral Rock, White Shoal), all have lost more than a third of their coral cover (Table 18). In contrast, two sites (Prolifera Patch and Mayer's Peak) joined Palmata Patch as the only sites that have had significant gains in coral cover long-term. At Palmata Patch, coral cover continued to expand during this reporting period and mean coral cover here has doubled from the initial four years of monitoring, 2004-2007 (Tables 2 and 18).

For the other three benthic taxa groups (macroalgae, octocorals, and sponges), all long-term changes consisted of significant increases in cover. For macroalgae, nine of the 12 sites had significant increases in cover, with the sites added to the project in 2009 as the only ones not having an increase between their long-term timeframes. The change in macroalgae cover has been substantial, allowing it to become the dominant taxa group at each of those nine sites (Tables 8 and 18). Five sites had an increase in octocoral cover (Tables 6 and 18). Two of these sites, Palmata Patch and White Shoal, had a significant rise in octocoral cover identified in the previous report, but this was a new outcome for Davis Rock, Little Africa, and Loggerhead Patch. As described earlier in the report, the change in octocoral cover at Davis Rock is unique because the increase in cover is entirely due to the expansion of the encrusting species *Briareum asbestinum* and *Erythropodium caribaeorum*. For this report, sponge cover increased at six sites, four of which were change in status (Palmata Patch, Mayer's Peak, Temptation Rock, and Davis Rock) while two matched the results of the previous report, Loggerhead Patch and Prolifera Patch. While half of the sites demonstrated a significant increase in sponge cover, the overall contribution of sponge cover at many of these sites was still relatively small in comparison to the other benthic groups.

Table 18. Summary table of long-term changes in percent cover of the four primary benthic taxa groups between the first four years (varies by site) and last four years (2017-2020) of monitoring at 12 sites. The first four-year timeframes denoted by A = 1999-2002; B = 2004-2007; C = 2007-2010, D = 2009-2012. The first number is the absolute difference in percent cover between the first and last four-year intervals; the number in parentheses is the relative difference. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

Site	Coral	Macroalgae	Octocoral	Sponge
Bird Key Reef[A]	-9.0 (-56.5%)	23.3 (176.5%)	-0.7 (-3.7%)	0.1 (10.0%)
Black Coral Rock[A]	-8.1 (-37.5%)	34.8 (435.0%)	-0.9 (-8.9%)	0.4 (10.5%)
White Shoal[A]	-3.6 (-51.4%)	18.2 (72.0%)	6.6 (77.7%)	0.4 (16.7%)
Loggerhead Patch[B]	-1.5 (-62.5%)	15.9 (481.8%)	1.1 (137.5%)	0.4 (133.3%)
Palmata Patch[B]	4.3 (102.4%)	15.8 (831.6%)	11.2 (560.0%)	0.4 (400.0%)
Prolifera Patch[B]	3.1 (22.6%)	9.1 (478.9%)	0.7 (14.6%)	0.4 (100.0%)
Mayer's Peak[B]	1.7 (46.0%)	18.2 (957.9%)	5.0 (22.3%)	0.2 (95.83%)
Temptation Rock[B]	0.8 (-51%)	27.0 (350.7%)	0.9 (6.1%)	2.3 (108.3%)
Little Africa[C]	-9.3 (-38.6%)	14.4 (142.6%)	3.8 (73.1%)	0.2 (100.0%)
Davis Rock[D]	-0.6 (-6.4%)	5.4 (12.3%)	1.9 (316.7%)	1.5 (68.2%)
Texas Rock[D]	-1.1 (14.9%)	4.9 (15.2%)	-0.6 (16.2%)	1.6 (34.8%)
The Maze[D]	-2.0 (-16.5%)	0.3 (0.9%)	3.3 (47.1%)	1.1 (29.7%)

For the ESA-listed *Acropora* spp. the results of long-term analyses for *A. cervicornis, A. palmata,* and *A. prolifera* were similar to the results of the 2017-2018 biennial report. Between the long-term timeframes, *A. palmata,* and *A. prolifera* cover has approximately doubled at their respective sites (Table 19) and the absolute cover observed for both species in this report was slightly up from the previously reported values in the 2017-2018 biennial. For *A. cervicornis*, the results for both Loggerhead Patch and White Shoal were consistent with results provided in previous reports. Long-term declines in *A. cervicornis* cover were significant at both sites (Table 19) and *A. cervicornis* was still nearly absent from Loggerhead Patch. Although the 2019-2020 value for *A. cervicornis* cover at White Shoal was slightly greater than the 2017-2018 value, the long-term change still equaled a significant decline *A. cervicornis* cover at this site.

The results of long-term analysis for ESA-listed *Orbicella* spp. are concerning. Similar to the 2017-2018 report, significant declines in *Orbicella* cover were found at Bird Key Reef, Black Coral Rock and Little Africa, but there were also significant losses in cover detected for cover at Prolifera Patch and the mean averaged for the five RNA pinnacle reefs (Table 19). During the last 15 to 20 years more than 50% of the total *Orbicella* spp. cover has been lost at Bird Key Reef, and over one-third at Black Coral Rock and Little Africa. Although not on the same scale as the losses at those three sites, the reduction in *Orbicella* spp. at both Prolifera Patch and the RNA pinnacle reefs was ~25% and some of these changes have occurred during the last two years. The declines in *Orbicella* spp. in DRTO are consistent with reports from other areas along Florida's Coral Reef (Ruzicka et al. 2013, Toth et al. 2014) and broader Caribbean (Aronson and Precht 2006, Edmunds and Elahi 2007). Acute stressors including epizootic outbreaks, elevated seawater temperatures, and powerful hurricanes have at times rapidly reduced *Orbicella* spp. populations while recurring instances of partial mortality associated with more chronic conditions have cumulatively led to dramatic declines that warranted the ESA listing for *Orbicella* spp. Unfortunately, its status in DRTO appears no different than in other U.S. jurisdictions across Florida and the Caribbean and is of primary concern because of the relatively high contribution of *Orbicella* to coral cover on many reefs in DRTO.

Table 19. Summary table of long-term changes in percent cover of the four ESA-listed species present in DRTO between the first four years (varies by site) and last four years (2017-2020) of monitoring. The first four-year timeframes denoted by A = 1999-2002; B = 2004-2007; C = 2007-2010, D = 2009-2012. The first number is the absolute difference in percent cover between the first and last four-year intervals; the number in parentheses is the relative difference. Values highlighted in green or red represent a significant increase or decrease ($p < 0.05$) in cover, respectively.

Site	*A. cervicornis*	*A. palmata*	*A. prolifera*	*Orbicella* spp.
Bird Key Reef[A]	-	-	-	-5.3 (59.6%)
Black Coral Rock[A]	-	-	-	-3.7 (37.0%)
White Shoal[A]	-2.7 (-71.1%)	-	-	-
Loggerhead Patch[B]	-0.6 (-100.0%)	-	-	-
Palmata Patch[B]	-	3.8 (126.6%)	-	-
Prolifera Patch[B]	-	-	5.2 (91.2%)	-1.9 (-27.5%)
Little Africa[C]	-	-	-	-8.7 (-41.2%)
Pinnacle Reefs[D]	-	-	-	-0.6 (23.1%)

The increased and sustained levels of macroalgae on DRTO reefs is of great concern. Nine of the 12 sites had significantly higher macroalgae cover in the long-term analyses and eight of these nine sites had macroalgae cover more than double (Table 18). The findings presented here appear to be consistent with those reported from the Mesoamerican Reef region in which a pervasive increase in fleshy macroalgae cover has occurred during the last 15 years (Suchley et al. 2016), coincident with our results. In both cases, the rapid proliferation of fleshy macroalgae (e.g., *Dictyota*) were not preceded by acute losses in coral cover nor were such increases co-dependent with declines in herbivorous fish abundance. Conversely, the Mesoamerican reef study found an increase in herbivorous fish biomass during their study, and while herbivorous fish abundance was not quantified for this report, herbivorous fish species are fully protected in DRTO by Florida's Marine Life Rule so it is expected that their biomass has not declined during the last 20 years.

While a fundamental tenet of coral reef ecology has been that the transition from stony coral- to macroalgae-dominated reef communities in the Caribbean are often accelerated by the loss of herbivorous species (both *Diadema* and herbivorous fishes) following substantial losses in coral cover (Hughes et al. 2007, Bruno et al. 2009, Jackson et al. 2014), the sustained levels of macroalgal cover documented here and in the Mesoamerican study indicate there are additional factors beyond coral mass mortalities and the loss of herbivory that can drive the increased production of macroalgae. Region-wide changes to water quality stemming from increased nutrients and pollution, and rising seawater temperatures associated with climate change could be fostering macroalgae growth, independent of the historical losses to coral cover and herbivory, that exceed current grazing capacity by fishes and present day *Diadema* abundance. While increased macroalgal cover remains of principal concern, assessing its impact on other existing benthic taxa is difficult to quantify. At sites in which there have been substantial declines in coral cover (e.g., Black Coral Rock and Bird Key Reef), elevated macroalgae cover may be impeding coral recovery, however at many sites coral cover or density has stayed similar spanning several biennial reports, and the cover of other benthic taxa, such as octocorals and sponges has been unchanged or even increased alongside the overabundance of macroalgae.

Although not present in DRTO during this biennial reporting period, the arrival of stony coral tissue loss disease (SCTLD) was confirmed by DRTO park management in May 2021. Because SCTLD is highly lethal to the most vulnerable species we anticipate major changes in coral cover and density in the 2021-2022 biennial report. The 2019-2020 biennial report can serve as a baseline to evaluate the full impact of SCTLD in DRTO.

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Appendices

Appendix A: Percent cover of major taxonomic groups.

Bird Key Reef:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
1999		11.7%	21.0%	1.7%	0.0%	19.3%	46.4%	0.0%
2000		14.3%	16.7%	0.9%	0.0%	19.7%	48.4%	0.0%
2001		8.5%	19.2%	0.6%	0.0%	20.3%	51.4%	0.0%
2002		22.4%	19.2%	1.2%	0.0%	12.7%	44.5%	0.0%
2003		1.8%	17.4%	0.7%	0.0%	15.2%	64.9%	0.0%
2004		0.7%	13.5%	0.5%	0.0%	12.8%	72.5%	0.0%
2005		6.8%	11.6%	0.5%	0.0%	10.3%	70.8%	0.0%
2006		3.1%	13.9%	0.4%	0.0%	10.0%	72.5%	0.1%
2007		16.9%	13.1%	0.6%	0.0%	9.6%	59.8%	0.0%
2008		24.3%	9.9%	0.6%	0.0%	11.0%	54.0%	0.0%
2009		16.9%	13.3%	0.4%	0.0%	12.1%	57.4%	0.0%
2010	0.4%	53.8%	12.9%	0.3%	0.0%	8.3%	24.1%	0.0%
2011	8.1%	26.6%	14.5%	0.8%	0.0%	10.4%	39.4%	0.0%
2012	1.2%	31.5%	15.5%	0.6%	0.0%	9.0%	42.0%	0.0%
2013	4.3%	42.0%	15.0%	0.8%	0.0%	9.3%	27.9%	0.0%
2014	2.2%	43.7%	15.8%	0.5%	0.0%	10.5%	26.6%	0.0%
2015	6.7%	37.3%	13.4%	0.9%	0.0%	9.0%	31.8%	0.0%
2016	0.6%	33.0%	15.2%	0.8%	0.0%	10.2%	39.7%	0.0%
2017	2.5%	45.4%	15.7%	1.1%	0.0%	9.0%	25.6%	0.0%
2018	1.7%	42.8%	18.2%	1.3%	0.0%	8.5%	27.0%	0.0%
2019	25.3%	24.0%	20.1%	1.0%	0.0%	9.6%	19.5%	0.0%
2020	6.4%	36.3%	18.8%	1.1%	0.0%	8.2%	28.3%	0.0%

Appendix A: continued

Black Coral Rock:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
1999		7.0%	9.5%	6.5%	0.0%	25.5%	51.3%	0.1%
2000		10.6%	9.9%	1.8%	0.0%	20.5%	57.1%	0.0%
2001		16.0%	12.9%	4.3%	0.0%	21.1%	45.6%	0.0%
2002		3.3%	8.8%	3.8%	0.4%	19.3%	64.2%	0.1%
2003		22.6%	11.6%	3.3%	0.0%	21.3%	41.0%	0.2%
2004		19.8%	9.9%	2.6%	0.0%	20.4%	47.2%	0.0%
2005		0.9%	6.4%	2.6%	0.0%	22.2%	68.0%	0.0%
2006		15.0%	4.5%	1.5%	0.0%	16.2%	62.7%	0.1%
2007		10.8%	6.7%	1.8%	0.0%	15.3%	65.4%	0.0%
2008		1.0%	7.7%	3.3%	0.0%	17.8%	70.2%	0.0%
2009		39.5%	6.8%	3.4%	0.0%	18.0%	32.4%	0.0%
2010	5.3%	38.9%	8.1%	3.9%	0.0%	15.1%	28.5%	0.0%
2011	5.1%	42.8%	9.0%	3.2%	0.0%	13.8%	25.9%	0.0%
2012	7.0%	25.7%	6.0%	5.8%	0.0%	15.3%	39.3%	0.0%
2013	4.0%	38.3%	7.9%	4.3%	0.0%	13.4%	30.3%	0.0%
2014	8.7%	37.2%	9.6%	3.9%	0.0%	14.5%	25.1%	0.0%
2015	2.2%	51.9%	8.8%	4.9%	0.0%	13.8%	17.6%	0.0%
2016	3.5%	37.2%	10.3%	5.0%	0.0%	13.8%	29.6%	0.0%
2017	2.5%	43.7%	9.0%	5.0%	0.0%	14.0%	24.7%	0.0%
2018	10.0%	38.9%	9.7%	3.2%	0.0%	13.2%	24.2%	0.0%
2019	14.1%	44.4%	8.4%	4.5%	0.0%	13.3%	14.5%	0.0%
2020	10.0%	45.0%	10.2%	4.4%	0.0%	13.0%	16.9%	0.0%

Appendix A: continued

Davis Rock:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
2009		25.3%	0.6%	2.3%	0.0%	8.5%	59.7%	3.2%
2010	0.5%	67.5%	0.0%	1.1%	0.0%	10.0%	19.6%	1.2%
2011	8.0%	38.6%	1.5%	3.2%	0.0%	9.3%	36.2%	1.9%
2012	0.5%	48.0%	0.6%	2.7%	0.0%	10.6%	35.0%	1.8%
2013	0.2%	58.8%	0.5%	3.0%	0.0%	10.3%	24.2%	1.3%
2014	4.0%	34.0%	2.5%	1.9%	0.0%	10.7%	44.3%	1.8%
2015	0.6%	54.1%	1.4%	3.1%	0.0%	8.7%	30.2%	1.5%
2016	0.9%	30.6%	1.6%	4.5%	0.0%	9.8%	50.1%	1.7%
2017	1.5%	51.0%	2.4%	3.8%	0.0%	9.3%	29.6%	1.2%
2018	5.1%	46.5%	2.4%	3.2%	0.0%	8.9%	31.4%	1.2%
2019	4.1%	48.7%	2.9%	4.1%	0.0%	9.0%	29.2%	0.7%
2020	3.7%	50.2%	2.7%	4.1%	0.0%	8.3%	28.1%	1.2%

Loggerhead Patch:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
2005		7.1%	1.2%	0.3%	0.0%	4.1%	87.2%	0.0%
2006		6.9%	0.8%	0.1%	0.0%	1.6%	90.6%	0.0%
2007		1.3%	1.0%	0.5%	0.0%	2.5%	94.7%	0.0%
2008		1.6%	1.1%	0.2%	0.0%	1.8%	95.3%	0.0%
2009		12.0%	0.5%	0.7%	0.0%	2.3%	84.4%	0.0%
2010	0.0%	16.3%	0.8%	1.0%	0.0%	1.9%	79.9%	0.0%
2011	0.1%	14.1%	2.0%	1.6%	0.0%	2.6%	79.6%	0.0%
2012	0.0%	30.3%	1.4%	1.7%	0.0%	1.8%	64.4%	0.0%
2013	0.1%	24.6%	1.6%	1.3%	0.0%	2.0%	70.3%	0.0%
2014	0.1%	32.6%	1.6%	0.8%	0.0%	1.9%	62.5%	0.0%
2015	0.0%	22.6%	1.6%	1.3%	0.1%	2.0%	71.6%	0.0%
2016	0.0%	26.7%	2.0%	1.1%	0.6%	1.4%	68.1%	0.0%
2017	0.0%	32.5%	2.7%	0.7%	0.3%	1.0%	62.5%	0.0%
2018	0.0%	12.9%	2.7%	0.6%	0.6%	0.9%	82.1%	0.0%
2019	0.0%	16.3%	2.1%	0.9%	4.7%	0.9%	74.5%	0.0%
2020	0.0%	18.9%	2.0%	0.5%	1.2%	0.9%	76.2%	0.0%

Appendix A: continued

Mayer's Peak:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
2004		0.4%	24.1%	3.9%	0.0%	3.4%	62.4%	5.8%
2005		1.0%	24.5%	2.6%	0.0%	4.4%	62.8%	4.7%
2006		4.1%	20.1%	1.4%	0.0%	2.9%	66.5%	5.1%
2007		6.2%	20.7%	2.6%	0.0%	4.2%	62.9%	3.3%
2008		0.7%	16.6%	2.6%	0.0%	3.9%	72.1%	4.0%
2009		32.2%	18.5%	3.1%	0.0%	3.4%	38.9%	3.8%
2010	0.0%	48.1%	19.7%	3.4%	0.0%	4.3%	20.6%	3.8%
2011	0.6%	17.1%	23.6%	4.9%	0.0%	4.1%	45.1%	4.1%
2012	0.0%	27.5%	23.7%	4.5%	0.0%	4.2%	34.2%	5.2%
2013	0.2%	27.4%	26.8%	4.4%	0.0%	3.9%	33.6%	3.2%
2014	0.4%	27.7%	25.8%	4.5%	0.0%	4.4%	31.8%	4.3%
2015	0.8%	20.8%	24.4%	4.4%	0.0%	5.1%	40.0%	4.0%
2016	0.5%	15.4%	30.8%	4.3%	0.0%	4.3%	40.0%	4.2%
2017	1.2%	15.5%	28.7%	5.4%	0.0%	5.1%	39.3%	3.8%
2018	0.6%	12.6%	31.2%	4.7%	0.0%	5.1%	40.9%	4.5%
2019	13.1%	28.4%	21.8%	4.5%	0.0%	5.4%	20.9%	4.8%
2020	3.2%	28.9%	28.7%	4.7%	0.0%	5.5%	24.5%	4.2%

Appendix A: continued

Palmata Patch:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
2004		2.2%	4.8%	0.3%	0.0%	5.8%	86.6%	0.3%
2005		1.3%	2.7%	0.2%	0.0%	5.5%	89.9%	0.3%
2006		4.6%	0.9%	0.1%	0.0%	2.5%	91.7%	0.2%
2007		1.0%	1.5%	0.1%	0.0%	2.9%	94.4%	0.0%
2008		1.9%	2.8%	0.1%	0.0%	3.6%	91.2%	0.2%
2009		12.3%	3.4%	0.3%	0.0%	4.4%	79.1%	0.1%
2010	0.0%	4.9%	6.8%	0.0%	0.0%	6.1%	81.7%	0.2%
2011	0.1%	12.0%	8.4%	0.2%	0.0%	9.3%	69.8%	0.1%
2012	0.1%	5.2%	13.3%	0.2%	0.0%	7.8%	73.0%	0.2%
2013	0.1%	6.6%	11.4%	0.1%	0.0%	8.0%	73.4%	0.1%
2014	0.7%	8.2%	14.8%	0.2%	0.0%	9.6%	66.0%	0.1%
2015	1.7%	7.7%	13.7%	0.5%	0.0%	7.7%	67.9%	0.2%
2016	0.2%	3.1%	13.5%	0.4%	0.0%	8.2%	73.9%	0.2%
2017	0.8%	13.3%	16.6%	0.7%	0.0%	8.2%	59.4%	0.2%
2018	0.0%	21.1%	14.9%	0.1%	0.0%	6.5%	56.8%	0.2%
2019	0.1%	21.5%	15.5%	0.3%	0.0%	8.3%	53.8%	0.2%
2020	0.5%	18.5%	10.6%	1.2%	0.0%	9.3%	59.0%	0.1%

Appendix A: continued

Prolifera Patch:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
2004		1.1%	6.0%	0.3%	1.9%	15.2%	75.5%	0.0%
2005		1.2%	7.4%	0.4%	1.6%	13.8%	75.4%	0.1%
2006		7.4%	4.5%	0.1%	2.9%	12.3%	72.7%	0.1%
2007		2.3%	3.4%	0.2%	2.2%	14.5%	77.3%	0.0%
2008		3.4%	3.7%	0.2%	1.4%	13.1%	78.1%	0.0%
2009		6.2%	2.8%	0.3%	1.6%	14.0%	75.1%	0.0%
2010	0.0%	4.2%	3.4%	0.5%	2.9%	15.3%	73.6%	0.0%
2011	0.0%	11.9%	3.1%	0.7%	3.9%	18.1%	62.1%	0.0%
2012	0.0%	4.5%	3.1%	0.6%	3.6%	19.3%	68.5%	0.1%
2013	0.0%	4.0%	3.6%	0.6%	2.0%	18.7%	70.7%	0.1%
2014	0.2%	2.8%	3.7%	0.7%	2.5%	20.1%	69.6%	0.0%
2015	0.3%	3.6%	3.7%	0.6%	2.6%	17.5%	71.3%	0.0%
2016	0.3%	4.2%	4.3%	1.0%	3.9%	16.0%	69.9%	0.0%
2017	0.3%	9.3%	4.8%	0.9%	2.1%	16.6%	65.2%	0.0%
2018	0.0%	16.3%	6.2%	0.4%	1.6%	14.6%	60.3%	0.1%
2019	0.0%	13.0%	6.7%	0.2%	1.8%	17.3%	60.6%	0.1%
2020	0.1%	12.8%	5.6%	0.5%	1.7%	20.7%	58.3%	0.1%

Appendix A: continued

Temptation Rock:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
2004		12.1%	15.1%	1.1%	0.0%	4.2%	55.7%	11.7%
2005		4.9%	15.4%	1.3%	0.0%	4.0%	62.3%	12.1%
2006		6.4%	14.8%	1.3%	0.0%	3.3%	61.1%	13.1%
2007		10.1%	15.4%	1.2%	0.0%	2.4%	60.1%	10.9%
2008		18.2%	11.0%	0.9%	0.0%	4.3%	54.2%	11.4%
2009		27.8%	10.3%	2.2%	0.0%	4.9%	42.6%	12.1%
2010	0.1%	46.0%	11.1%	1.7%	0.0%	4.0%	27.1%	9.9%
2011	2.4%	22.5%	14.8%	1.8%	0.0%	5.5%	40.4%	12.1%
2012	0.4%	28.7%	14.6%	2.4%	0.0%	3.8%	39.3%	10.5%
2013	0.0%	41.2%	15.6%	1.6%	0.0%	4.9%	26.8%	9.3%
2014	0.3%	22.4%	12.9%	2.0%	0.0%	5.7%	45.1%	11.2%
2015	0.8%	24.3%	9.9%	2.1%	0.0%	6.5%	45.4%	10.7%
2016	0.1%	17.3%	13.2%	2.7%	0.0%	5.0%	51.8%	9.5%
2017	0.4%	31.7%	13.7%	2.8%	0.0%	4.5%	35.4%	10.4%
2018	1.7%	33.4%	20.9%	2.0%	0.0%	2.9%	28.4%	10.0%
2019	3.0%	40.1%	11.3%	2.5%	0.0%	4.7%	27.7%	10.4%
2020	1.9%	34.9%	19.7%	2.8%	0.0%	4.6%	25.1%	10.2%

Texas Rock:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
2009		19.8%	5.5%	4.0%	0.0%	6.2%	60.5%	3.1%
2010	0.4%	34.4%	4.0%	4.4%	0.0%	8.4%	45.9%	2.4%
2011	4.0%	35.9%	4.6%	5.1%	0.0%	7.5%	39.4%	2.3%
2012	0.7%	40.1%	2.3%	5.4%	0.0%	8.7%	38.4%	3.2%
2013	0.6%	39.3%	2.6%	5.0%	0.0%	6.7%	40.2%	2.9%
2014	0.7%	35.5%	3.7%	5.1%	0.0%	7.5%	42.7%	2.4%
2015	2.6%	39.5%	2.9%	5.4%	0.0%	7.6%	38.7%	1.7%
2016	3.1%	30.2%	3.2%	5.3%	0.0%	7.0%	46.3%	1.6%
2017	1.5%	32.0%	2.8%	5.4%	0.0%	6.6%	46.6%	1.5%
2018	4.4%	38.6%	3.7%	6.1%	0.0%	6.3%	35.9%	1.3%
2019	7.8%	37.8%	3.4%	6.9%	0.0%	5.8%	33.7%	1.4%
2020	6.5%	41.3%	3.5%	7.1%	0.0%	6.5%	30.9%	1.0%

Appendix A: continued

The Maze:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
2009		31.1%	7.0%	2.4%	0.0%	11.1%	45.2%	3.1%
2010	0.0%	52.9%	6.2%	3.9%	0.0%	11.0%	22.6%	3.0%
2011	0.5%	21.7%	7.9%	5.0%	0.0%	12.4%	48.4%	3.5%
2012	0.1%	34.0%	7.1%	4.4%	0.0%	12.7%	38.6%	2.7%
2013	0.2%	34.4%	7.7%	4.2%	0.0%	11.1%	39.8%	1.9%
2014	1.0%	28.5%	8.2%	3.9%	0.0%	13.1%	42.3%	2.3%
2015	0.4%	29.7%	9.0%	5.6%	0.0%	10.9%	40.7%	3.2%
2016	0.6%	22.3%	12.3%	5.2%	0.0%	13.1%	43.2%	2.7%
2017	1.1%	24.3%	9.5%	6.2%	0.0%	9.5%	46.1%	2.6%
2018	1.6%	33.3%	11.4%	4.8%	0.0%	10.4%	35.5%	2.0%
2019	10.4%	39.9%	9.5%	5.4%	0.0%	10.2%	21.8%	2.0%
2020	5.6%	38.8%	11.9%	3.9%	0.0%	10.0%	26.8%	1.8%

Appendix A: continued

White Shoal:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
1999		5.3%	9.5%	3.0%	0.0%	8.7%	73.5%	0.0%
2000		8.9%	9.7%	4.9%	0.0%	7.9%	68.7%	0.0%
2001		9.3%	9.2%	1.8%	0.0%	5.3%	74.2%	0.0%
2002		9.3%	7.7%	1.7%	0.0%	6.7%	74.6%	0.0%
2003		14.0%	9.1%	1.7%	0.0%	4.2%	71.0%	0.0%
2004		6.5%	3.5%	0.4%	0.0%	1.9%	87.7%	0.0%
2005		9.5%	3.5%	0.2%	0.0%	1.3%	85.4%	0.0%
2006		13.2%	4.9%	0.4%	0.0%	1.4%	80.2%	0.0%
2007		17.7%	7.3%	0.9%	0.0%	1.0%	73.1%	0.0%
2008		13.2%	9.5%	0.8%	0.0%	1.4%	74.9%	0.0%
2009		30.2%	12.5%	0.4%	0.0%	1.4%	55.3%	0.0%
2010	0.0%	34.8%	15.5%	0.6%	0.0%	2.1%	46.9%	0.0%
2011	6.7%	21.4%	18.2%	1.1%	0.0%	2.5%	49.8%	0.0%
2012	0.5%	28.4%	17.7%	2.2%	0.0%	1.8%	48.9%	0.0%
2013	0.0%	20.7%	17.9%	1.5%	0.0%	2.7%	57.1%	0.0%
2014	2.7%	16.7%	20.1%	1.7%	0.0%	3.4%	55.0%	0.0%
2015	2.1%	18.5%	14.5%	2.1%	0.0%	4.0%	58.2%	0.0%
2016	1.4%	18.2%	15.2%	3.7%	0.0%	3.6%	57.7%	0.0%
2017	1.1%	18.0%	19.4%	3.1%	0.0%	3.8%	53.5%	0.0%
2018	0.3%	34.4%	14.7%	2.6%	0.0%	2.8%	44.4%	0.0%
2019	6.5%	30.5%	12.4%	2.6%	0.0%	2.6%	45.4%	0.0%
2020	3.4%	24.6%	16.6%	4.1%	0.0%	4.4%	46.6%	0.0%

Appendix A: continued

Little Africa:

Year	Cyano-bacteria	Macroalgae	Octocoral	Porifera	Seagrass	Stony Coral	Substrate	Zoanthids
2007		4.0%	4.4%	0.4%	0.0%	18.8%	71.3%	0.9%
2008		15.1%	4.5%	0.0%	0.0%	26.4%	53.5%	0.5%
2009		10.4%	5.6%	0.3%	0.0%	29.7%	53.4%	0.3%
2010	2.7%	14.8%	7.0%	0.2%	0.0%	22.2%	51.9%	1.0%
2011	1.0%	21.9%	9.8%	0.3%	0.0%	13.5%	51.7%	1.5%
2012	0.1%	16.0%	4.2%	0.3%	0.0%	20.9%	54.8%	3.6%
2013	4.0%	18.6%	4.5%	0.6%	0.0%	23.7%	46.0%	1.7%
2014	0.1%	12.0%	8.5%	0.3%	0.0%	11.5%	65.0%	2.0%
2015	0.1%	18.3%	4.1%	0.5%	0.0%	10.5%	59.6%	6.6%
2016	0.0%	12.6%	7.0%	0.5%	0.1%	16.4%	59.8%	2.7%
2017	0.2%	21.5%	11.0%	0.3%	0.3%	16.0%	46.9%	2.8%
2018	1.7%	23.9%	8.3%	0.3%	0.0%	14.9%	47.2%	3.2%
2019	8.8%	25.3%	7.9%	0.4%	0.0%	13.2%	38.7%	4.7%
2020	2.8%	27.6%	8.7%	0.8%	0.1%	15.3%	43.1%	0.4%

Appendix B: Percent cover of coral species by site for each year. Species not listed have not been found at the given site through the course of monitoring. An asterisk (*) denotes a species complex. *Mycetophyllia lamarckiana* includes *M. danaana*. *Orbicella annularis* includes *O. faveolata* and *O. franksi*. *Porites porites* includes *P. furcata* and *P. divaricata*. *Madracis decactis* includes *M. pharensis* and *M. senaria*. *Agaricia agaricites* includes *A. humilus* and *A. tenuifolia*.

Bird Key Reef:

Species	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
*Agaricia agaricites**	0.0%	0.1%	0.0%	0.0%	0.3%	0.0%	0.2%	0.0%	0.0%	0.0%	0.1%
Acropora cervicornis	0.0%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Colpophyllia natans	2.1%	3.3%	3.1%	0.7%	0.4%	0.8%	0.3%	0.7%	0.6%	0.8%	0.4%
Diploria labyrinthiformis	0.7%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%
Meandrina meandrites	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Millepora alcicornis	0.7%	0.3%	0.5%	0.3%	0.8%	0.4%	0.4%	0.2%	0.2%	0.5%	0.6%
Montastraea cavernosa	2.2%	2.4%	2.1%	2.7%	1.7%	2.0%	0.8%	1.7%	0.8%	0.6%	1.5%
Mycetophyllia aliciae	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	0.0%	0.1%	0.2%
Mycetophyllia ferox	0.0%	0.2%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%
*Mycetophyllia lamarckiana**	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	9.2%	10.0%	10.9%	6.1%	8.1%	6.7%	5.6%	5.5%	5.8%	6.7%	7.8%
Porites astreoides	1.1%	0.9%	1.0%	1.4%	1.0%	0.9%	1.0%	0.2%	0.6%	0.5%	0.3%
*Porites porites**	0.3%	0.2%	0.1%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Pseudodiploria strigosa	0.2%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Scleractinia	0.3%	0.5%	0.3%	0.0%	0.3%	0.1%	0.2%	0.0%	0.0%	0.1%	0.0%
Siderastrea siderea	2.3%	1.3%	1.5%	0.8%	2.1%	1.3%	1.5%	1.3%	1.2%	1.5%	1.1%
Solenastrea bournoni	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stephanocoenia intersepta	0.1%	0.3%	0.3%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%

Appendix B: continued

Bird Key Reef (continued):

Species	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
*Agaricia agaricites**	0.0%	0.2%	0.1%	0.2%	0.0%	0.1%	0.2%	0.1%	0.1%	0.2%	0.1%
Acropora cervicornis	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Colpophyllia natans	0.4%	0.3%	0.4%	0.6%	0.4%	0.6%	0.8%	0.6%	0.3%	0.9%	0.6%
Diploria labyrinthiformis	0.1%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.2%	0.0%	0.1%	0.1%
Meandrina meandrites	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%
Millepora alcicornis	0.3%	0.4%	0.3%	0.5%	0.5%	0.3%	0.5%	0.5%	0.5%	0.5%	0.4%
Montastraea cavernosa	1.2%	1.8%	1.3%	1.1%	0.8%	0.8%	0.8%	0.9%	0.6%	0.9%	0.9%
Mycetophyllia aliciae	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Mycetophyllia ferox	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Mycetophyllia lamarckiana**	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	4.7%	4.8%	4.6%	4.7%	5.1%	5.3%	4.8%	3.7%	3.7%	4.2%	3.0%
Porites astreoides	0.2%	0.6%	0.4%	0.4%	0.6%	0.8%	0.9%	0.7%	0.7%	0.4%	0.7%
*Porites porites**	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.3%	0.3%
Pseudodiploria strigosa	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Scleractinia	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Siderastrea siderea	0.7%	1.6%	1.6%	1.6%	2.4%	1.0%	1.7%	2.0%	2.0%	1.9%	1.5%
Solenastrea bournoni	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Stephanocoenia intersepta	0.1%	0.3%	0.1%	0.0%	0.2%	0.1%	0.3%	0.0%	0.4%	0.0%	0.3%

Appendix B: continued

Black Coral Rock:

Species	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
*Agaricia agaricites**	0.1%	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Acropora cervicornis	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Agaricia lamarcki	0.1%	0.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Colpophyllia natans	2.7%	1.4%	1.9%	2.5%	1.3%	1.9%	2.1%	1.1%	0.9%	1.1%	1.5%
Dichocoenia stokesii	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Eusmilia fastigiata	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Helioseris cucullata	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Madracis decactis**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Meandrina meandrites	0.0%	0.1%	0.2%	0.0%	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%
Millepora alcicornis	1.1%	0.5%	0.5%	0.8%	0.7%	0.8%	0.8%	0.5%	0.6%	0.8%	0.9%
Montastraea cavernosa	7.7%	5.0%	5.7%	5.9%	6.1%	5.1%	6.4%	5.6%	3.8%	4.9%	4.8%
Mycetophyllia aliciae	0.3%	0.2%	0.3%	0.4%	0.2%	0.3%	0.1%	0.4%	0.2%	0.4%	0.4%
Mycetophyllia ferox	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%
*Mycetophyllia lamarckiana**	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%
*Orbicella annularis**	10.7%	10.8%	10.4%	8.2%	11.0%	9.7%	10.6%	7.1%	8.5%	9.0%	8.1%
Porites astreoides	0.5%	0.4%	0.8%	0.7%	0.2%	0.8%	0.7%	0.4%	0.5%	0.5%	0.9%
*Porites porites**	0.4%	0.4%	0.3%	0.1%	0.8%	0.4%	0.2%	0.1%	0.3%	0.1%	0.6%
Pseudodiploria strigosa	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%
Scleractinia	1.1%	0.7%	0.0%	0.3%	0.3%	0.0%	0.1%	0.3%	0.0%	0.2%	0.0%
Siderastrea siderea	0.4%	0.3%	0.7%	0.4%	0.1%	0.6%	0.4%	0.4%	0.3%	0.7%	0.5%
Solenastrea bournoni	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stephanocoenia intersepta	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%

Appendix B: continued

Black Coral Rock (continued):

Species	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
*Agaricia agaricites**	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Acropora cervicornis	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Agaricia lamarcki	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Colpophyllia natans	0.8%	1.5%	1.4%	1.0%	1.6%	1.4%	1.3%	1.3%	1.4%	1.2%	1.7%
Dichocoenia stokesii	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Eusmilia fastigiata	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Helioseris cucullata	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Madracis decactis**	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.3%	0.1%	0.0%	0.0%
Meandrina meandrites	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Millepora alcicornis	0.6%	0.5%	1.0%	0.7%	1.1%	0.8%	1.0%	0.9%	0.7%	0.7%	0.9%
Montastraea cavernosa	5.4%	4.5%	4.6%	3.9%	4.5%	4.1%	3.9%	3.4%	3.1%	3.5%	3.2%
Mycetophyllia aliciae	0.0%	0.0%	0.2%	0.2%	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%
Mycetophyllia ferox	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Mycetophyllia lamarckiana**	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	6.3%	6.1%	6.0%	6.3%	5.8%	5.8%	5.7%	6.1%	6.4%	6.5%	5.7%
Porites astreoides	0.5%	0.5%	0.6%	0.5%	0.3%	0.6%	0.4%	0.4%	0.4%	0.5%	0.5%
*Porites porites**	0.2%	0.0%	0.4%	0.1%	0.2%	0.3%	0.2%	0.2%	0.1%	0.2%	0.1%
Pseudodiploria strigosa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Scleractinia	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Siderastrea siderea	0.7%	0.4%	0.7%	0.4%	0.8%	0.4%	0.6%	0.8%	0.4%	0.6%	0.5%
Solenastrea bournoni	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stephanocoenia intersepta	0.1%	0.1%	0.2%	0.1%	0.0%	0.2%	0.5%	0.4%	0.3%	0.1%	0.2%

Appendix B: continued

Davis Rock:

Species	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
*Agaricia agaricites**	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Colpophyllia natans	1.8%	0.9%	0.3%	0.7%	0.4%	0.7%	0.6%	1.3%	0.9%	1.0%	1.3%	0.9%
Diploria labyrinthiformis	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Eusmilia fastigiata	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Meandrina meandrites	0.4%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Millepora alcicornis	0.7%	1.5%	1.5%	1.1%	0.9%	1.2%	0.7%	1.4%	1.3%	0.5%	1.2%	1.0%
Montastraea cavernosa	1.7%	1.6%	1.8%	2.4%	2.2%	2.4%	2.1%	1.5%	1.7%	1.5%	1.5%	1.9%
Mycetophyllia ferox	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Mycetophyllia lamarckiana**	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	3.4%	5.4%	4.5%	4.5%	5.7%	4.3%	3.2%	3.4%	3.4%	3.9%	3.1%	2.9%
Porites astreoides	0.1%	0.2%	0.2%	0.6%	0.4%	0.6%	0.4%	0.7%	0.7%	0.7%	0.7%	0.5%
*Porites porites**	0.1%	0.2%	0.3%	0.3%	0.2%	0.5%	0.4%	0.4%	0.4%	0.3%	0.3%	0.2%
Pseudodiploria clivosa	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.2%	0.2%	0.1%	0.0%	0.1%	0.1%
Pseudodiploria strigosa	0.0%	0.0%	0.1%	0.3%	0.1%	0.3%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%
Siderastrea siderea	0.2%	0.0%	0.2%	0.3%	0.2%	0.4%	0.5%	0.4%	0.4%	0.6%	0.4%	0.4%
Solenastrea bournoni	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stephanocoenia intersepta	0.1%	0.0%	0.1%	0.0%	0.0%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%

Appendix B: continued

Loggerhead Patch:

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
*Agaricia agaricites**	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Acropora cervicornis	1.9%	0.2%	0.2%	0.1%	0.2%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Millepora alcicornis	1.5%	0.7%	1.5%	1.0%	1.5%	1.2%	1.8%	0.8%	1.2%	1.1%	1.1%	0.7%	0.7%	0.9%	0.8%	0.8%
*Orbicella annularis**	0.4%	0.5%	0.4%	0.6%	0.4%	0.4%	0.6%	0.6%	0.5%	0.4%	0.4%	0.4%	0.1%	0.0%	0.1%	0.1%
Porites astreoides	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Porites porites**	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.2%	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%
Pseudodiploria clivosa	0.1%	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Pseudodiploria strigosa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%

Prolifera Patch:

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
*Agaricia agaricites**	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Acropora cervicornis	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	0.0%	0.1%	0.0%
Acropora palmata	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Acropora prolifera	7.1%	6.3%	4.6%	6.5%	6.1%	7.1%	7.1%	10.0%	10.4%	10.3%	11.6%	11.4%	7.7%	10.0%	9.0%	12.2%	16.5%
Colpophyllia natans	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Millepora alcicornis	0.3%	0.2%	0.2%	0.3%	0.3%	0.4%	0.4%	0.5%	0.4%	0.3%	0.3%	0.2%	0.2%	0.2%	0.1%	0.1%	0.2%
*Orbicella annularis**	6.8%	6.4%	6.9%	7.1%	6.3%	5.8%	6.4%	6.9%	7.9%	7.5%	7.4%	5.4%	6.7%	6.0%	5.3%	4.5%	3.7%
Porites astreoides	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.1%
Pseudodiploria clivosa	0.1%	0.3%	0.0%	0.2%	0.1%	0.2%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%	0.1%
Pseudodiploria strigosa	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Scleractinia	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Siderastrea siderea	0.5%	0.4%	0.5%	0.4%	0.2%	0.4%	0.4%	0.5%	0.4%	0.4%	0.5%	0.3%	0.3%	0.2%	0.1%	0.2%	0.1%

Appendix B: continued

Mayer's Peak:

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Acropora cervicornis	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.3%	0.1%	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Acropora prolifera	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Colpophyllia natans	0.5%	0.1%	0.3%	0.4%	0.2%	0.4%	0.4%	0.3%	0.4%	0.3%	0.5%	1.0%	0.4%	0.7%	0.8%	0.9%	0.3%
Dichocoenia stokesii	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Diploria labyrinthiformis	0.3%	0.2%	0.1%	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%
Eusmilia fastigiata	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Meandrina meandrites	0.5%	0.4%	0.4%	0.5%	0.3%	0.5%	0.4%	0.5%	0.4%	0.4%	0.7%	0.6%	0.7%	0.6%	0.6%	0.4%	0.4%
Millepora alcicornis	0.6%	1.3%	0.8%	0.8%	0.9%	0.7%	1.3%	1.1%	1.4%	1.1%	1.1%	1.3%	0.9%	0.9%	1.4%	1.4%	1.7%
Montastraea cavernosa	0.3%	0.6%	0.2%	0.7%	0.3%	0.2%	0.4%	0.4%	0.2%	0.4%	0.2%	0.2%	0.2%	0.3%	0.2%	0.3%	0.3%
Mycetophyllia ferox	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
*Mycetophyllia lamarckiana**	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	0.4%	0.9%	0.2%	0.3%	0.5%	0.1%	0.3%	0.6%	0.1%	0.5%	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%	0.0%
Porites astreoides	0.4%	0.3%	0.3%	0.4%	0.3%	0.5%	0.2%	0.2%	0.5%	0.2%	0.5%	0.4%	0.3%	0.6%	0.3%	0.3%	0.4%
*Porites porites**	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%
Pseudodiploria clivosa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Pseudodiploria strigosa	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.3%	0.1%	0.2%	0.0%	0.1%	0.2%	0.1%	0.2%	0.2%	0.2%	0.4%
Scleractinia	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Siderastrea siderea	0.2%	0.3%	0.3%	0.3%	0.5%	0.2%	0.4%	0.4%	0.3%	0.6%	0.6%	0.8%	0.9%	1.0%	1.0%	1.3%	1.5%
Stephanocoenia intersepta	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.2%	0.1%	0.1%	0.3%	0.3%	0.4%	0.4%	0.3%

Appendix B: continued

Palmata Patch:

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
*Agaricia agaricites**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Acropora cervicornis	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Acropora palmata	4.8%	3.9%	1.8%	2.1%	2.6%	3.6%	5.1%	7.7%	6.2%	6.8%	8.0%	6.1%	6.7%	6.9%	5.1%	6.4%	7.6%
Millepora alcicornis	0.2%	0.4%	0.1%	0.2%	0.3%	0.2%	0.2%	0.5%	0.4%	0.3%	0.7%	0.4%	0.4%	0.6%	0.5%	0.7%	0.7%
Montastraea cavernosa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	0.2%	0.4%	0.0%	0.1%	0.2%	0.1%	0.2%	0.2%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.3%	0.2%
Porites astreoides	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.2%	0.1%	0.1%	0.1%	0.2%
Pseudodiploria clivosa	0.1%	0.0%	0.2%	0.1%	0.1%	0.1%	0.0%	0.1%	0.2%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.2%
Pseudodiploria strigosa	0.0%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	0.0%	0.2%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%	0.0%	0.1%
Scleractinia	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Siderastrea radians	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Siderastrea siderea	0.2%	0.4%	0.3%	0.2%	0.2%	0.4%	0.4%	0.6%	0.2%	0.4%	0.4%	0.9%	0.5%	0.4%	0.4%	0.6%	0.3%

Appendix B: continued

Temptation Rock:

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Colpophyllia natans	0.1%	0.4%	0.7%	0.1%	0.4%	0.2%	0.5%	0.7%	0.4%	0.5%	0.6%	0.5%	0.4%	0.4%	0.2%	0.3%	0.6%
Diploria labyrinthiformis	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%
Eusmilia fastigiata	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Meandrina meandrites	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%
Millepora alcicornis	1.3%	1.5%	1.2%	1.5%	1.8%	2.0%	2.1%	2.3%	1.6%	1.6%	1.9%	2.3%	1.4%	1.5%	1.0%	1.6%	1.8%
Montastraea cavernosa	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.3%	0.0%
Mussa angulosa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mycetophyllia ferox	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Mycetophyllia lamarckiana**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Oculina diffusa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Oculina robusta	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	1.2%	0.8%	0.8%	0.2%	1.3%	1.5%	0.2%	0.6%	0.5%	1.6%	1.5%	2.0%	1.9%	0.8%	0.1%	0.8%	0.3%
Porites astreoides	0.0%	0.2%	0.1%	0.2%	0.2%	0.2%	0.2%	0.4%	0.2%	0.2%	0.4%	0.2%	0.4%	0.3%	0.2%	0.2%	0.4%
*Porites porites**	0.8%	0.3%	0.0%	0.1%	0.1%	0.3%	0.4%	0.2%	0.5%	0.2%	0.3%	0.3%	0.1%	0.0%	0.2%	0.2%	0.2%
Pseudodiploria clivosa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Pseudodiploria strigosa	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%
Siderastrea siderea	0.4%	0.6%	0.3%	0.2%	0.6%	0.5%	0.3%	0.8%	0.2%	0.4%	0.6%	0.5%	0.6%	1.2%	0.8%	1.0%	0.8%
Stephanocoenia intersepta	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%	0.2%	0.1%	0.3%

Appendix B: continued

Texas Rock:

Species	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Colpophyllia natans	0.3%	0.5%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.0%	0.2%
Dichocoenia stokesii	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%
*Madracis decactis**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%
Millepora alcicornis	0.8%	1.1%	0.9%	1.0%	1.4%	1.3%	1.0%	0.3%	0.6%	0.4%	0.7%	0.5%
Montastraea cavernosa	2.3%	2.8%	3.7%	3.3%	2.5%	3.6%	3.7%	3.6%	3.3%	3.1%	2.4%	3.3%
Mycetophyllia aliciae	0.1%	0.0%	0.1%	0.3%	0.1%	0.0%	0.1%	0.0%	0.0%	0.2%	0.1%	0.3%
*Orbicella annularis**	1.7%	2.3%	1.6%	2.0%	1.0%	1.1%	1.3%	1.3%	1.0%	0.9%	1.0%	0.9%
Porites astreoides	0.2%	0.5%	0.3%	0.5%	0.3%	0.2%	0.2%	0.4%	0.3%	0.4%	0.5%	0.2%
*Porites porites**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Pseudodiploria strigosa	0.1%	0.1%	0.2%	0.1%	0.2%	0.2%	0.1%	0.0%	0.1%	0.0%	0.1%	0.1%
Siderastrea siderea	0.3%	0.5%	0.4%	0.7%	0.5%	0.6%	0.6%	0.7%	0.7%	0.8%	0.6%	0.7%
Stephanocoenia intersepta	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.0%	0.2%	0.3%	0.2%	0.3%	0.1%

Appendix B: continued

The Maze:

Species	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
*Agaricia agaricites**	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%
Acropora cervicornis	0.2%	0.2%	0.2%	0.3%	0.2%	0.4%	0.3%	0.6%	0.0%	0.1%	0.1%	0.0%
Colpophyllia natans	0.4%	0.5%	0.2%	0.2%	0.6%	0.7%	0.3%	0.5%	0.3%	0.1%	0.2%	0.6%
Eusmilia fastigiata	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	0.1%
Meandrina meandrites	0.1%	0.3%	0.2%	0.3%	0.2%	0.1%	0.0%	0.2%	0.0%	0.3%	0.1%	0.2%
Millepora alcicornis	1.4%	1.4%	1.7%	2.2%	0.9%	2.2%	1.8%	1.5%	1.0%	1.3%	0.7%	1.2%
Millepora complanata	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Montastraea cavernosa	1.2%	1.1%	1.3%	1.0%	1.2%	0.8%	1.4%	1.5%	1.6%	1.3%	1.6%	1.3%
Mycetophyllia aliciae	0.3%	0.3%	0.1%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Mycetophyllia ferox	0.0%	0.0%	0.1%	0.0%	0.1%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	5.9%	6.3%	6.8%	7.0%	6.8%	7.3%	5.4%	6.9%	4.5%	5.1%	6.1%	4.8%
Porites astreoides	0.5%	0.4%	0.4%	0.4%	0.2%	0.3%	0.4%	0.4%	0.5%	0.5%	0.3%	0.5%
Pseudodiploria strigosa	0.1%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Scleractinia	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Siderastrea siderea	0.8%	0.3%	0.9%	0.6%	0.6%	0.7%	0.7%	1.0%	1.0%	1.1%	0.8%	0.8%
Stephanocoenia intersepta	0.0%	0.1%	0.4%	0.4%	0.1%	0.1%	0.3%	0.4%	0.3%	0.3%	0.2%	0.4%

Appendix B: continued

White Shoal:

Species	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
*Agaricia agaricites**	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%
Acropora cervicornis	5.4%	4.2%	2.9%	3.3%	1.6%	0.4%	0.0%	0.0%	0.0%	0.0%	0.1%
Colpophyllia natans	0.2%	0.6%	0.5%	0.6%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%
Diploria labyrinthiformis	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Eusmilia fastigiata	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%
Meandrina meandrites	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Millepora alcicornis	1.3%	0.8%	0.5%	1.2%	0.6%	0.4%	0.5%	0.8%	0.3%	0.4%	0.6%
Montastraea cavernosa	0.3%	0.1%	0.2%	0.2%	0.1%	0.3%	0.1%	0.0%	0.1%	0.0%	0.1%
Oculina diffusa	0.1%	0.0%	0.0%	0.1%	0.2%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%
Oculina robusta	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	0.1%	0.5%	0.4%	0.5%	0.6%	0.2%	0.3%	0.2%	0.1%	0.0%	0.0%
Porites astreoides	0.2%	0.3%	0.0%	0.1%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Porites porites**	0.3%	0.3%	0.1%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%
Pseudodiploria clivosa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pseudodiploria strigosa	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Scleractinia	0.3%	0.6%	0.1%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Siderastrea siderea	0.5%	0.0%	0.4%	0.2%	0.4%	0.3%	0.1%	0.2%	0.2%	0.3%	0.3%
Stephanocoenia intersepta	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%

Appendix B: continued

White Shoal (continued):

Species	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
*Agaricia agaricites**	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%
Acropora cervicornis	0.2%	0.1%	0.1%	0.2%	0.6%	1.0%	0.8%	1.1%	0.8%	0.7%	2.3%
Colpophyllia natans	0.1%	0.2%	0.2%	0.1%	0.4%	0.5%	0.2%	0.1%	0.0%	0.0%	0.1%
Diploria labyrinthiformis	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Eusmilia fastigiata	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Meandrina meandrites	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
Millepora alcicornis	0.7%	1.0%	0.6%	0.9%	1.0%	0.7%	1.1%	0.9%	0.6%	0.8%	0.5%
Montastraea cavernosa	0.3%	0.1%	0.1%	0.1%	0.2%	0.1%	0.2%	0.1%	0.1%	0.1%	0.3%
Oculina diffusa	0.1%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%
Oculina robusta	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	0.1%	0.2%	0.1%	0.1%	0.2%	0.3%	0.3%	0.5%	0.3%	0.2%	0.6%
Porites astreoides	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%
*Porites porites**	0.3%	0.3%	0.3%	0.5%	0.6%	0.7%	0.2%	0.4%	0.3%	0.3%	0.2%
Pseudodiploria clivosa	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Pseudodiploria strigosa	0.0%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%
Scleractinia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Siderastrea siderea	0.3%	0.1%	0.3%	0.2%	0.2%	0.2%	0.3%	0.2%	0.4%	0.2%	0.1%
Stephanocoenia intersepta	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%

Appendix B: continued

Little Africa:

Species	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
*Agaricia agaricites**	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Colpophyllia natans	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Diploria labyrinthiformis	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Favia fragum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Millepora alcicornis	0.3%	0.5%	0.4%	0.9%	0.3%	0.3%	0.4%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%
Montastraea cavernosa	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.1%
Mycetophyllia ferox	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
*Orbicella annularis**	16.0%	23.7%	27.1%	18.5%	11.0%	17.7%	20.9%	8.8%	8.0%	14.4%	13.9%	12.1%	11.2%	12.9%
Porites astreoides	1.5%	0.8%	0.7%	1.6%	0.9%	0.9%	0.9%	1.0%	1.3%	0.8%	0.7%	1.2%	0.8%	1.0%
*Porites porites**	0.1%	0.4%	0.2%	0.1%	0.7%	0.6%	0.5%	0.5%	0.3%	0.9%	0.2%	0.1%	0.2%	0.5%
Pseudodiploria clivosa	0.0%	0.0%	0.1%	0.2%	0.3%	0.3%	0.1%	0.1%	0.1%	0.0%	0.0%	0.2%	0.1%	0.3%
Pseudodiploria strigosa	0.5%	0.1%	0.9%	0.0%	0.0%	0.7%	0.1%	0.4%	0.5%	0.0%	0.0%	0.2%	0.0%	0.3%
Scleractinia	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Siderastrea siderea	0.1%	0.7%	0.1%	0.9%	0.1%	0.2%	0.5%	0.3%	0.0%	0.0%	0.8%	0.9%	0.7%	0.1%
Stephanocoenia intersepta	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%

Appendix C: Percent cover of macroalgae genera averaged for all sites, averaged for the RNA Pinnacle Reefs, and at each site for all years that macroalgae genera were included in percent cover estimates. The annual mean includes data from 11 sites. The RNA Pinnacles includes data from 5 sites.

Sites	Year	*Dictyota* spp.	*Halimeda* spp.	*Lobophora* spp.	Other Macroalgae
Annual Mean	2010	21.8 ± 6.0%	0.5 ± 0.2%	3.5 ± 2.1%	10.8 ± 2.7%
Annual Mean	2011	7.4 ± 1.1%	1.0 ± 0.3%	2.7 ± 1.2%	13.0 ± 1.9%
Annual Mean	2012	7.8 ± 1.7%	0.7 ± 0.3%	2.0 ± 1.1%	17.1 ± 2.6%
Annual Mean	2013	15.7 ± 3.4%	0.5 ± 0.2%	4.0 ± 2.1%	10.4 ± 1.7%
Annual Mean	2014	12.0 ± 2.5%	0.4 ± 0.1%	3.8 ± 1.9%	10.1 ± 1.3%
Annual Mean	2015	13.4 ± 3.4%	0.5 ± 0.2%	5.4 ± 2.9%	9.0 ± 1.5%
Annual Mean	2016	8.6 ± 1.9%	0.6 ± 0.3%	5.3 ± 2.4%	7.2 ± 1.5%
Annual Mean	2017	15.7 ± 3.3%	0.4 ± 0.2%	5.1 ± 2.0%	7.7 ± 1.0%
Annual Mean	2018	16.9 ± 2.1%	0.3 ± 0.1%	1.9 ± 1.1%	11.0 ± 2.1%
Annual Mean	2019	15.0 ± 2.2%	0.5 ± 0.2%	0.8 ± 0.5%	15.0 ± 2.0%
Annual Mean	2020	20.1 ± 2.7%	0.6 ± 0.2%	1.7 ± 0.8%	9.5 ± 1.5%
RNA Pinnacles	2010	38.7 ± 7.4%	0.5 ± 0.4%	0.7 ± 0.3%	9.9 ± 3.4%
RNA Pinnacles	2011	7.7 ± 0.8%	1.3 ± 0.7%	1.8 ± 0.7%	16.3 ± 2.7%
RNA Pinnacles	2012	12.3 ± 2.1%	0.4 ± 0.2%	0.9 ± 0.3%	22.0 ± 2.3%
RNA Pinnacles	2013	25.1 ± 3.5%	0.6 ± 0.3%	2.4 ± 0.7%	12.1 ± 1.9%
RNA Pinnacles	2014	17.3 ± 2.3%	0.2 ± 0.1%	1.9 ± 0.9%	10.2 ± 1.0%
RNA Pinnacles	2015	20.7 ± 5.7%	0.1 ± 0.1%	2.3 ± 0.8%	10.5 ± 2.1%
RNA Pinnacles	2016	10.5 ± 2.4%	0.1 ± 0.0%	3.4 ± 1.4%	9.1 ± 2.3%
RNA Pinnacles	2017	18.8 ± 4.9%	0.0 ± 0.0%	4.3 ± 0.7%	7.8 ± 1.1%
RNA Pinnacles	2018	18.7 ± 3.8%	0.0 ± 0.0%	0.6 ± 0.4%	13.5 ± 3.3%
RNA Pinnacles	2019	19.7 ± 3.2%	0.0 ± 0.0%	0.5 ± 0.2%	18.8 ± 1.7%
RNA Pinnacles	2020	25.8 ± 3.5%	0.1 ± 0.1%	0.9 ± 0.4%	12.0 ± 1.9%
Bird Key Reef	2010	20.2%	0.0%	18.3%	15.3%
Bird Key Reef	2011	7.3%	0.0%	11.3%	8.0%
Bird Key Reef	2012	2.2%	0.0%	5.8%	23.6%
Bird Key Reef	2013	13.3%	0.1%	8.1%	20.5%
Bird Key Reef	2014	8.9%	0.3%	17.3%	17.2%
Bird Key Reef	2015	9.6%	0.6%	18.0%	9.1%
Bird Key Reef	2016	5.1%	0.6%	21.6%	5.8%
Bird Key Reef	2017	15.9%	0.1%	21.5%	7.9%
Bird Key Reef	2018	23.3%	0.2%	11.9%	7.4%
Bird Key Reef	2019	11.2%	0.3%	0.9%	11.7%
Bird Key Reef	2020	26.0%	0.5%	5.8%	4.0%

Appendix C: continued

Sites	Year	*Dictyota* spp.	*Halimeda* spp.	*Lobophora* spp.	Other Macroalgae
Black Coral Rock	2010	8.1%	0.0%	16.3%	14.4%
Black Coral Rock	2011	16.5%	1.5%	9.2%	15.6%
Black Coral Rock	2012	5.3%	0.1%	11.6%	8.7%
Black Coral Rock	2013	3.9%	0.1%	24.0%	10.3%
Black Coral Rock	2014	6.9%	0.0%	15.0%	15.3%
Black Coral Rock	2015	16.2%	0.0%	29.2%	6.5%
Black Coral Rock	2016	5.5%	0.0%	19.7%	12.0%
Black Coral Rock	2017	24.2%	0.0%	12.8%	6.8%
Black Coral Rock	2018	16.3%	0.2%	5.7%	16.7%
Black Coral Rock	2019	20.1%	0.0%	5.9%	18.4%
Black Coral Rock	2020	21.9%	0.0%	8.0%	15.1%
Davis Rock	2010	59.1%	0.3%	0.2%	7.9%
Davis Rock	2011	8.8%	3.0%	4.4%	22.5%
Davis Rock	2012	17.1%	0.6%	2.0%	28.3%
Davis Rock	2013	36.0%	1.4%	2.8%	18.7%
Davis Rock	2014	14.6%	0.6%	5.2%	13.7%
Davis Rock	2015	42.6%	0.3%	3.3%	7.9%
Davis Rock	2016	6.3%	0.1%	7.6%	16.6%
Davis Rock	2017	35.1%	0.1%	6.5%	9.4%
Davis Rock	2018	30.1%	0.0%	2.2%	14.2%
Davis Rock	2019	30.7%	0.1%	1.2%	16.7%
Davis Rock	2020	37.6%	0.0%	1.3%	11.3%
Loggerhead Patch	2010	9.7%	1.4%	0.0%	5.2%
Loggerhead Patch	2011	4.1%	1.2%	0.0%	8.9%
Loggerhead Patch	2012	5.0%	3.1%	0.0%	22.2%
Loggerhead Patch	2013	18.1%	0.5%	0.0%	6.0%
Loggerhead Patch	2014	23.0%	1.3%	0.0%	8.3%
Loggerhead Patch	2015	4.2%	2.5%	0.0%	15.9%
Loggerhead Patch	2016	20.2%	3.6%	0.0%	2.9%
Loggerhead Patch	2017	28.0%	1.3%	0.0%	3.2%
Loggerhead Patch	2018	5.9%	1.0%	0.0%	6.0%
Loggerhead Patch	2019	5.8%	2.3%	0.0%	8.2%
Loggerhead Patch	2020	8.6%	1.2%	0.0%	9.0%

Appendix C: continued

Sites	Year	*Dictyota* spp.	*Halimeda* spp.	*Lobophora* spp.	Other Macroalgae
Mayer's Peak	2010	46.5%	0.0%	0.4%	1.2%
Mayer's Peak	2011	4.7%	0.0%	0.4%	12.1%
Mayer's Peak	2012	8.7%	0.0%	0.1%	18.7%
Mayer's Peak	2013	15.3%	0.0%	1.0%	11.1%
Mayer's Peak	2014	18.3%	0.0%	0.1%	9.4%
Mayer's Peak	2015	13.4%	0.0%	0.2%	7.3%
Mayer's Peak	2016	12.3%	0.0%	0.2%	2.9%
Mayer's Peak	2017	5.9%	0.0%	2.9%	6.7%
Mayer's Peak	2018	8.6%	0.0%	0.0%	3.9%
Mayer's Peak	2019	13.7%	0.0%	0.2%	14.5%
Mayer's Peak	2020	21.1%	0.0%	0.0%	7.8%
Palmata Patch	2010	3.0%	0.2%	0.0%	1.7%
Palmata Patch	2011	2.8%	0.2%	0.0%	8.9%
Palmata Patch	2012	0.5%	0.3%	0.0%	4.5%
Palmata Patch	2013	2.2%	0.5%	0.0%	3.9%
Palmata Patch	2014	2.5%	0.5%	0.0%	5.2%
Palmata Patch	2015	3.7%	0.4%	0.0%	3.6%
Palmata Patch	2016	2.4%	0.2%	0.0%	0.6%
Palmata Patch	2017	6.5%	0.2%	0.0%	6.6%
Palmata Patch	2018	17.8%	0.1%	0.0%	3.1%
Palmata Patch	2019	12.2%	0.2%	0.0%	9.1%
Palmata Patch	2020	14.6%	0.3%	0.0%	3.7%
Prolifera Patch	2010	0.7%	0.1%	0.0%	3.5%
Prolifera Patch	2011	8.4%	0.8%	0.0%	2.7%
Prolifera Patch	2012	1.4%	1.2%	0.0%	1.9%
Prolifera Patch	2013	1.5%	0.4%	0.0%	2.0%
Prolifera Patch	2014	0.5%	0.3%	0.0%	2.0%
Prolifera Patch	2015	1.5%	0.5%	0.0%	1.6%
Prolifera Patch	2016	1.1%	0.6%	0.0%	2.4%
Prolifera Patch	2017	2.7%	0.7%	0.0%	5.9%
Prolifera Patch	2018	13.3%	0.7%	0.0%	2.3%
Prolifera Patch	2019	9.2%	1.5%	0.0%	2.3%
Prolifera Patch	2020	8.1%	1.4%	0.0%	3.3%

Appendix C: continued

Sites	Year	*Dictyota* spp.	*Halimeda* spp.	*Lobophora* spp.	Other Macroalgae
Temptation Rock	2010	38.3%	2.0%	0.6%	5.1%
Temptation Rock	2011	8.2%	2.8%	0.8%	10.7%
Temptation Rock	2012	6.4%	1.2%	1.0%	20.1%
Temptation Rock	2013	28.2%	1.4%	1.2%	10.5%
Temptation Rock	2014	10.3%	0.1%	1.1%	11.0%
Temptation Rock	2015	10.3%	0.0%	3.9%	10.1%
Temptation Rock	2016	4.1%	0.0%	5.7%	7.5%
Temptation Rock	2017	22.8%	0.0%	4.3%	4.6%
Temptation Rock	2018	14.0%	0.0%	0.5%	18.9%
Temptation Rock	2019	22.4%	0.0%	0.2%	17.5%
Temptation Rock	2020	19.2%	0.0%	2.2%	13.5%
Texas Rock	2010	14.2%	0.0%	0.3%	19.9%
Texas Rock	2011	9.6%	1.0%	2.3%	23.0%
Texas Rock	2012	12.7%	0.2%	0.7%	26.5%
Texas Rock	2013	20.8%	0.3%	5.0%	13.1%
Texas Rock	2014	24.1%	0.5%	2.1%	8.8%
Texas Rock	2015	17.0%	0.2%	3.5%	18.7%
Texas Rock	2016	17.0%	0.1%	1.7%	11.4%
Texas Rock	2017	16.1%	0.1%	5.1%	10.7%
Texas Rock	2018	16.5%	0.0%	0.4%	21.7%
Texas Rock	2019	16.8%	0.0%	0.4%	20.6%
Texas Rock	2020	21.5%	0.3%	0.9%	18.6%
The Maze	2010	35.5%	0.0%	1.9%	15.4%
The Maze	2011	7.4%	0.0%	1.2%	13.0%
The Maze	2012	16.5%	0.0%	0.8%	16.7%
The Maze	2013	25.3%	0.0%	2.0%	7.1%
The Maze	2014	19.3%	0.0%	1.1%	8.1%
The Maze	2015	20.4%	0.0%	0.7%	8.6%
The Maze	2016	13.0%	0.1%	2.0%	7.2%
The Maze	2017	14.1%	0.0%	2.5%	7.8%
The Maze	2018	24.6%	0.0%	0.1%	8.7%
The Maze	2019	14.6%	0.0%	0.7%	24.6%
The Maze	2020	29.7%	0.0%	0.1%	8.9%

Appendix C: continued

Sites	Year	*Dictyota* spp.	*Halimeda* spp.	*Lobophora* spp.	Other Macroalgae
White Shoal	2010	4.5%	1.0%	0.0%	29.3%
White Shoal	2011	3.5%	0.5%	0.0%	17.4%
White Shoal	2012	9.9%	1.5%	0.0%	17.0%
White Shoal	2013	8.0%	1.4%	0.0%	11.3%
White Shoal	2014	3.5%	1.0%	0.0%	12.1%
White Shoal	2015	8.2%	0.7%	0.1%	9.5%
White Shoal	2016	7.3%	1.0%	0.0%	9.9%
White Shoal	2017	1.8%	1.3%	0.0%	14.9%
White Shoal	2018	15.0%	1.0%	0.0%	18.4%
White Shoal	2019	8.2%	1.5%	0.0%	20.9%
White Shoal	2020	13.0%	2.3%	0.0%	9.3%
Little Africa	2010	2.3%	8.4%	0.0%	4.2%
Little Africa	2011	3.2%	4.0%	0.0%	14.7%
Little Africa	2012	0.4%	7.1%	0.0%	8.5%
Little Africa	2013	1.5%	6.1%	0.0%	11.0%
Little Africa	2014	0.2%	4.7%	0.0%	7.1%
Little Africa	2015	0.5%	10.0%	0.0%	7.7%
Little Africa	2016	0.8%	6.5%	0.0%	5.2%
Little Africa	2017	2.2%	9.1%	0.0%	10.2%
Little Africa	2018	2.2%	8.1%	0.0%	13.6%
Little Africa	2019	2.2%	8.2%	0.0%	14.9%
Little Africa	2020	12.6%	8.5%	0.0%	6.5%

Appendix D: Density of stony coral species by site. Only individual colonies ≥ 4cm in max diameter were included. *Orbicella faveolata* and *O. franksi* were counted as *O. annularis* in 2011 and 2012.

Bird Key Reef:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.23	0.18	0.30	0.10	0.33	0.15	0.10	0.13	0.13	0.18
Agaricia fragilis	0.38	0.28	0.05	0.23	0.00	0.05	0.13	0.18	0.08	0.13
Agaricia humilis	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agaricia lamarcki	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Colpophyllia natans	0.23	0.23	0.20	0.20	0.18	0.18	0.13	0.20	0.15	0.15
Dichocoenia stokesii	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0.00
Diploria labyrinthiformis	0.00	0.03	0.03	0.03	0.03	0.00	0.03	0.03	0.00	0.00
Eusmilia fastigiata	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Helioseris cucullata	0.03	0.03	0.00	0.03	0.03	0.03	0.05	0.05	0.03	0.05
Madracis decactis	0.15	0.15	0.05	0.18	0.05	0.18	0.15	0.18	0.15	0.15
Montastraea cavernosa	0.70	0.73	0.73	0.55	0.63	0.68	0.50	0.73	0.43	0.48
Mussa angulosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mycetophyllia aliciae	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.03	0.05	0.08
Orbicella annularis	1.53	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella faveolata			1.68	0.53	0.65	0.58	0.18	0.30	0.18	0.58
Orbicella franksi			0.20	0.55	0.55	0.53	0.98	1.25	1.13	0.53
Porites astreoides	0.45	0.50	0.40	0.40	0.60	0.40	0.53	0.63	0.60	0.70
Porites porites	0.20	0.18	0.23	0.18	0.20	0.20	0.28	0.30	0.48	0.38
Scolymia cubensis	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Siderastrea radians	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Siderastrea siderea	1.25	1.55	1.28	1.18	1.25	1.50	1.88	2.73	1.95	1.95
Stephanocoenia intersepta	0.53	0.38	0.30	0.23	0.23	0.28	0.40	0.63	0.40	0.55
Total	5.75	6.93	5.50	4.45	4.78	4.83	5.38	7.35	5.73	5.88

Appendix D: continued

Black Coral Rock:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.18	0.13	0.10	0.13	0.18	0.18	0.10	0.13	0.23	0.13
Agaricia fragilis	0.08	0.30	0.15	0.10	0.08	0.20	0.28	0.25	0.15	0.20
Agaricia lamarcki	0.05	0.13	0.05	0.20	0.03	0.08	0.18	0.15	0.08	0.10
Colpophyllia natans	0.33	0.35	0.30	0.25	0.25	0.23	0.18	0.18	0.18	0.18
Dichocoenia stokesii	0.05	0.08	0.05	0.08	0.05	0.08	0.05	0.05	0.05	0.05
Eusmilia fastigiata	0.05	0.03	0.05	0.03	0.00	0.03	0.03	0.03	0.03	0.03
Helioseris cucullata	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.03	0.05	0.03
Isophyllia sinuosa	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
Madracis aurentenra	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madracis decactis	0.73	1.50	0.98	1.48	1.05	1.35	1.60	0.90	1.13	0.63
Madracis pharensis	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madracis scenaria	0.05	0.10	0.00	0.08	0.08	0.10	0.15	0.20	0.15	0.45
Meandrina meandrites	0.00	0.03	0.03	0.03	0.00	0.03	0.00	0.03	0.00	0.00
Montastraea cavernosa	2.20	2.20	2.00	1.90	1.78	1.78	1.80	1.98	1.75	1.83
Mussa angulosa	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Mycetophyllia aliciae	0.03	0.05	0.05	0.08	0.08	0.05	0.05	0.05	0.05	0.03
Mycetophyllia danaana	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mycetophyllia ferox	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Mycetophyllia lamarckiana	0.08	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0.03	0.05
Orbicella annularis	1.78	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella faveolata			0.53	0.65	1.05	0.65	0.25	0.10	0.23	0.40
Orbicella franksi			1.63	1.15	0.73	1.08	1.68	1.63	1.45	1.33
Porites astreoides	1.08	0.98	0.95	0.90	0.98	0.93	1.05	0.93	0.93	1.03
Porites porites	0.20	0.15	0.15	0.15	0.08	0.13	0.28	0.23	0.20	0.20
Scolymia cubensis	0.03	0.03	0.00	0.03	0.00	0.03	0.03	0.08	0.00	0.03
Scolymia lacera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Siderastrea siderea	1.13	1.50	1.40	1.35	1.40	1.35	1.85	1.45	1.63	1.45
Stephanocoenia intersepta	0.28	0.58	0.53	0.65	0.55	0.75	0.68	0.68	0.88	0.88
Total	8.33	10.18	9.25	9.28	8.43	9.00	10.23	9.03	9.15	9.03

Appendix D: continued

Davis Rock:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.08	0.13	0.10	0.08	0.05	0.08	0.05	0.08	0.05	0.08
Agaricia fragilis	0.08	0.03	0.03	0.05	0.00	0.00	0.00	0.03	0.08	0.03
Colpophyllia natans	0.05	0.03	0.05	0.05	0.05	0.03	0.03	0.05	0.05	0.03
Eusmilia fastigiata	0.03	0.05	0.05	0.03	0.00	0.03	0.03	0.00	0.08	0.05
Helioseris cucullata	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00
Madracis aurentenra	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madracis decactis	0.18	0.23	0.00	0.20	0.15	0.08	0.15	0.13	0.20	0.05
Madracis scenaria	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Meandrina meandrites	0.05	0.08	0.05	0.08	0.05	0.03	0.03	0.03	0.00	0.00
Montastraea cavernosa	0.45	0.40	0.40	0.35	0.28	0.40	0.33	0.33	0.35	0.33
Mycetophyllia ferox	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oculina diffusa	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Orbicella annularis	0.40	0.28	0.00	0.00	0.03	0.05	0.00	0.00	0.00	0.00
Orbicella faveolata			0.23	0.30	0.20	0.30	0.33	0.33	0.28	0.20
Orbicella franksi			0.03	0.05	0.08	0.00	0.10	0.03	0.03	0.13
Porites astreoides	1.30	1.70	1.68	1.93	1.58	2.03	2.20	2.35	2.28	2.28
Porites porites	0.35	0.50	0.60	0.63	0.30	0.53	0.35	0.33	0.40	0.50
Pseudodiploria clivosa	0.03	0.03	0.03	0.03	0.03	0.03	0.08	0.03	0.03	0.03
Pseudodiploria strigosa	0.13	0.13	0.13	0.10	0.05	0.10	0.03	0.08	0.08	0.10
Scolymia cubensis	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Siderastrea radians	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.03
Siderastrea siderea	0.58	0.83	0.75	0.93	0.93	1.15	1.25	1.45	1.45	1.35
Stephanocoenia intersepta	0.40	0.43	0.28	0.45	0.38	0.40	0.43	0.43	0.45	0.45
Total	4.10	4.85	4.48	5.25	4.18	5.23	5.35	5.65	5.78	5.63

Appendix D: continued

Loggerhead Patch:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.40	0.25	0.30	0.10	0.20	0.00	0.05	0.00	0.00	0.00
Acropora cervicornis	0.30	0.25	0.35	0.10	0.10	0.20	0.10	0.00	0.00	0.00
Manicina areolata	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella annularis	0.05	0.05	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Orbicella faveolata			0.00	0.05	0.05	0.05	0.00	0.00	0.00	0.00
Porites astreoides	0.20	0.15	0.15	0.05	0.15	0.05	0.10	0.05	0.00	0.05
Porites porites	0.15	0.30	0.25	0.25	0.65	0.90	0.65	0.05	0.00	0.00
Pseudodiploria clivosa	0.15	0.15	0.10	0.30	0.20	0.10	0.10	0.05	0.00	0.00
Pseudodiploria strigosa	0.15	0.20	0.15	0.00	0.15	0.15	0.10	0.05	0.05	0.05
Total	1.40	1.35	1.40	0.85	1.50	1.45	1.15	0.20	0.05	0.10

Mayer's Peak:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.15	0.13	0.15	0.08	0.13	0.10	0.08	0.13	0.20	0.33
Acropora cervicornis	0.03	0.08	0.08	0.05	0.08	0.00	0.00	0.00	0.00	0.00
Agaricia fragilis	0.00	0.08	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.00
Colpophyllia natans	0.03	0.08	0.05	0.05	0.13	0.05	0.05	0.03	0.05	0.10
Dichocoenia stokesii	0.13	0.13	0.15	0.08	0.13	0.10	0.13	0.10	0.10	0.08
Eusmilia fastigiata	0.03	0.05	0.03	0.05	0.05	0.05	0.05	0.03	0.03	0.03
Madracis decactis	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.03	0.03	0.03
Manicina areolata	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meandrina meandrites	0.03	0.03	0.05	0.05	0.05	0.03	0.03	0.05	0.05	0.05
Montastraea cavernosa	0.53	0.55	0.50	0.35	0.48	0.50	0.55	0.58	0.50	0.63
Mycetophyllia lamarckiana	0.05	0.05	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella annularis	0.18	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella faveolata			0.13	0.13	0.10	0.13	0.13	0.08	0.10	0.10
Orbicella franksi			0.05	0.05	0.05	0.03	0.05	0.08	0.08	0.03
Porites astreoides	0.75	1.03	1.05	1.18	1.33	1.58	1.78	1.40	1.75	1.80
Porites porites	0.15	0.13	0.20	0.13	0.10	0.08	0.08	0.10	0.15	0.03
Pseudodiploria clivosa	0.00	0.00	0.00	0.03	0.00	0.05	0.00	0.00	0.00	0.00
Pseudodiploria strigosa	0.15	0.15	0.15	0.15	0.13	0.13	0.18	0.20	0.18	0.18
Siderastrea siderea	1.85	2.15	2.40	2.38	3.08	3.23	3.65	3.33	4.03	3.73
Stephanocoenia intersepta	0.80	0.75	0.88	0.80	0.98	1.08	1.18	1.05	1.23	1.15
Total	4.85	5.55	5.95	5.58	6.78	7.10	7.93	7.15	8.45	8.23

Appendix D: continued

Palmata Patch:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.65	1.30	0.65	1.70	0.30	0.20	0.65	0.60	0.65	0.60
Acropora cervicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.15
Acropora palmata	1.00	1.05	1.40	1.25	0.90	1.25	1.35	1.05	1.10	1.45
Diploria labyrinthiformis	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Montastraea cavernosa	0.05	0.05	0.10	0.05	0.05	0.00	0.00	0.00	0.00	0.05
Orbicella annularis	0.00	0.05	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00
Orbicella faveolata			0.05	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Porites astreoides	0.10	0.35	0.40	0.40	0.40	0.40	0.50	0.25	0.45	0.45
Porites porites	0.05	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.10	0.05
Pseudodiploria clivosa	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.00	0.00	0.00
Pseudodiploria strigosa	0.00	0.05	0.00	0.00	0.00	0.05	0.15	0.15	0.15	0.15
Siderastrea radians	0.10	0.15	0.10	0.15	0.15	0.10	0.10	0.10	0.15	0.10
Siderastrea siderea	0.05	0.20	0.30	0.05	0.10	0.20	0.15	0.10	0.05	0.25
Total	2.00	3.20	3.05	3.70	2.00	2.30	2.95	2.25	2.70	3.25

Prolifera Patch: * = thicket; colonies not enumerated

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.17	0.13	0.17	0.13	0.17	0.13	0.10	0.43	0.57	0.40
Acropora cervicornis	0.00	0.00	0.00	0.03	0.00	0.10	0.00	0.00	0.00	0.00
Acropora prolifera	*	*	*	*	*	*	*	*	*	*
Orbicella annularis	0.77	0.63	0.57	0.67	0.53	0.60	0.37	0.47	0.17	0.00
Orbicella faveolata			0.00	0.00	0.03	0.00	0.00	0.00	0.47	0.50
Porites astreoides	0.10	0.03	0.07	0.20	0.23	0.13	0.17	0.13	0.17	0.13
Pseudodiploria clivosa	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.07	0.00	0.03
Pseudodiploria strigosa	0.03	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.03
Siderastrea siderea	0.03	0.03	0.03	0.03	0.03	0.07	0.03	0.07	0.07	0.07
Total	1.13	0.90	1.37	2.17	1.40	1.73	0.80	1.37	2.27	3.50

Appendix D: continued

Temptation Rock:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.03	0.03	0.03	0.05	0.05	0.00	0.00	0.05	0.00	0.05
Agaricia fragilis	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Colpophyllia natans	0.13	0.18	0.15	0.15	0.15	0.18	0.10	0.10	0.10	0.08
Dichocoenia stokesii	0.03	0.03	0.00	0.03	0.03	0.00	0.03	0.00	0.00	0.00
Diploria labyrinthiformis	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eusmilia fastigiata	0.03	0.03	0.03	0.03	0.03	0.00	0.00	0.03	0.03	0.05
Madracis decactis	0.00	0.03	0.00	0.00	0.05	0.05	0.05	0.00	0.00	0.03
Manicina areolata	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Meandrina meandrites	0.05	0.03	0.05	0.03	0.00	0.00	0.00	0.03	0.00	0.03
Montastraea cavernosa	0.13	0.23	0.10	0.15	0.15	0.18	0.13	0.15	0.15	0.05
Mussa angulosa	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mycetophyllia aliciae	0.03	0.03	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Mycetophyllia lamarckiana	0.03	0.00	0.05	0.05	0.05	0.03	0.05	0.00	0.05	0.03
Oculina diffusa	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Oculina robusta	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella annularis	0.23	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella faveolata			0.20	0.20	0.23	0.28	0.13	0.08	0.10	0.15
Orbicella franksi			0.00	0.03	0.00	0.00	0.10	0.05	0.05	0.00
Porites astreoides	0.55	0.75	0.90	0.73	0.80	1.00	1.05	0.95	0.95	0.98
Porites porites	0.43	0.50	0.40	0.35	0.43	0.18	0.33	0.30	0.25	0.38
Pseudodiploria clivosa	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Pseudodiploria strigosa	0.15	0.15	0.15	0.10	0.13	0.15	0.13	0.18	0.15	0.13
Scolymia cubensis	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.03
Siderastrea radians	0.05	0.08	0.10	0.05	0.08	0.05	0.03	0.03	0.03	0.03
Siderastrea siderea	0.63	0.85	0.68	0.75	1.35	1.20	1.58	1.18	1.43	1.35
Solenastrea bournoni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Stephanocoenia intersepta	0.33	0.38	0.38	0.38	0.40	0.38	0.48	0.40	0.38	0.40
Total	2.93	3.63	3.28	3.13	3.95	3.68	4.18	3.55	3.70	3.78

Appendix D: continued

Texas Rock:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.03	0.05	0.05	0.03	0.08	0.05	0.00	0.03	0.03	0.03
Agaricia fragilis	0.00	0.03	0.03	0.08	0.03	0.03	0.03	0.05	0.05	0.05
Agaricia lamarcki	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Colpophyllia natans	0.13	0.13	0.08	0.18	0.08	0.05	0.13	0.13	0.13	0.15
Dichocoenia stokesii	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diploria labyrinthiformis	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.05	0.05
Eusmilia fastigiata	0.10	0.08	0.10	0.05	0.05	0.03	0.03	0.03	0.05	0.00
Helioseris cucullata	0.03	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Madracis aurentenra	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madracis decactis	0.55	0.70	0.38	0.38	0.75	0.38	0.55	0.43	0.63	0.50
Madracis scenaria	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.03	0.00	0.03
Meandrina meandrites	0.10	0.13	0.08	0.10	0.15	0.15	0.10	0.10	0.08	0.10
Montastraea cavernosa	1.45	1.58	1.83	1.53	1.75	1.63	1.40	1.63	1.38	1.45
Mussa angulosa	0.03	0.08	0.08	0.03	0.05	0.05	0.05	0.03	0.05	0.08
Mycetophyllia aliciae	0.05	0.05	0.05	0.05	0.08	0.05	0.08	0.08	0.05	0.05
Mycetophyllia lamarckiana	0.03	0.03	0.03	0.00	0.03	0.03	0.00	0.00	0.03	0.03
Oculina diffusa	0.05	0.00	0.03	0.00	0.03	0.03	0.00	0.00	0.00	0.00
Oculina robusta	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella annularis	0.55	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella faveolata			0.28	0.40	0.38	0.58	0.25	0.18	0.23	0.18
Orbicella franksi			0.20	0.10	0.15	0.05	0.18	0.38	0.18	0.28
Porites astreoides	0.73	0.88	0.75	0.53	0.88	0.88	0.95	0.90	1.00	0.85
Porites porites	0.13	0.18	0.20	0.10	0.23	0.15	0.18	0.10	0.23	0.28
Pseudodiploria clivosa	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiploria strigosa	0.05	0.03	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.03
Scolymia lacera	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Siderastrea siderea	1.05	1.48	1.38	1.28	1.43	1.75	1.83	2.08	2.18	2.03
Solenastrea bournoni	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.00
Stephanocoenia intersepta	0.45	0.53	0.58	0.45	0.50	0.48	0.58	0.63	0.45	0.63
Total	5.60	6.65	6.48	5.33	6.68	6.45	6.48	6.83	6.80	6.75

Appendix D: continued

The Maze:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.08	0.10	0.05	0.10	0.13	0.10	0.05	0.10	0.15	0.13
Acropora cervicornis	0.03	0.03	0.03	0.03	0.05	0.05	0.08	0.13	0.05	0.03
Agaricia fragilis	0.20	0.18	0.13	0.13	0.00	0.03	0.05	0.08	0.05	0.00
Agaricia lamarcki	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Colpophyllia natans	0.08	0.08	0.08	0.05	0.05	0.05	0.00	0.05	0.08	0.03
Eusmilia fastigiata	0.03	0.05	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.08
Madracis aurentenra	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madracis decactis	0.10	0.15	0.03	0.10	0.15	0.05	0.20	0.20	0.15	0.08
Madracis scenaria	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.03	0.00
Meandrina meandrites	0.10	0.08	0.10	0.05	0.05	0.05	0.08	0.08	0.08	0.08
Montastraea cavernosa	0.68	0.58	0.55	0.53	0.55	0.60	0.60	0.58	0.55	0.45
Mussa angulosa	0.03	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Mycetophyllia aliciae	0.03	0.03	0.03	0.03	0.08	0.05	0.05	0.05	0.05	0.05
Mycetophyllia ferox	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00
Mycetophyllia lamarckiana	0.03	0.03	0.00	0.00	0.00	0.05	0.03	0.03	0.03	0.03
Orbicella annularis	0.28	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella faveolata			0.15	0.08	0.10	0.18	0.10	0.13	0.08	0.05
Orbicella franksi			0.08	0.13	0.10	0.08	0.13	0.08	0.13	0.10
Porites astreoides	0.28	0.40	0.48	0.53	0.48	0.65	0.55	0.78	0.70	0.85
Porites porites	0.00	0.05	0.03	0.03	0.03	0.08	0.10	0.05	0.10	0.03
Pseudodiploria clivosa	0.00	0.03	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00
Pseudodiploria strigosa	0.13	0.13	0.10	0.05	0.05	0.13	0.13	0.13	0.08	0.10
Scolymia cubensis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Scolymia lacera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Siderastrea radians	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.00	0.00
Siderastrea siderea	1.05	1.28	1.05	1.23	1.30	1.78	2.08	1.98	2.03	1.83
Stephanocoenia intersepta	0.70	0.80	0.93	0.78	0.83	0.95	0.98	0.95	1.03	0.85
Total	3.80	4.35	3.93	3.93	4.05	5.00	5.25	5.45	5.40	4.75

Appendix D: continued

White Shoal:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agaricia agaricites	0.43	0.23	0.23	0.25	0.38	0.35	0.73	1.40	0.78	0.78
Acropora cervicornis	0.33	0.28	0.28	0.28	0.30	0.38	0.23	0.88	0.55	0.65
Colpophyllia natans	0.03	0.00	0.05	0.03	0.05	0.00	0.00	0.00	0.00	0.03
Dichocoenia stokesii	0.03	0.03	0.03	0.03	0.00	0.03	0.03	0.00	0.00	0.00
Eusmilia fastigiata	0.28	0.20	0.13	0.05	0.10	0.15	0.20	0.13	0.15	0.10
Manicina areolata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Meandrina meandrites	0.08	0.08	0.10	0.13	0.08	0.15	0.13	0.08	0.05	0.08
Montastraea cavernosa	0.13	0.05	0.05	0.08	0.05	0.03	0.03	0.00	0.03	0.03
Oculina diffusa	0.15	0.20	0.18	0.18	0.18	0.25	0.18	0.13	0.13	0.10
Oculina robusta	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orbicella annularis	0.03	0.03	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00
Orbicella faveolata			0.03	0.03	0.03	0.00	0.00	0.03	0.03	0.03
Porites astreoides	0.33	0.45	0.35	0.40	0.73	0.68	0.58	0.63	0.63	0.48
Porites porites	1.90	2.13	1.60	1.75	1.43	1.78	1.83	1.75	1.58	1.28
Pseudodiploria clivosa	0.08	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Pseudodiploria strigosa	0.03	0.05	0.05	0.05	0.05	0.08	0.08	0.05	0.05	0.05
Siderastrea radians	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Siderastrea siderea	0.18	0.25	0.28	0.30	0.33	0.48	0.43	0.43	0.50	0.53
Stephanocoenia intersepta	0.05	0.05	0.03	0.00	0.03	0.05	0.13	0.10	0.10	0.13
Total	4.00	4.03	3.35	3.55	3.73	4.40	4.58	5.58	4.58	4.23

Appendix E: Density of targeted octocoral species and total octocorals at each site.

Bird Key Reef:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.2
Antillogorgia americana	0.0	0.1	0.4	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Antillogorgia bipinnata		11.2	11.4	16.3	15.8	19.5	20.8	18.5	23.7	20.8
Total Octocoral Density	10.3	12.3	13.5	17.0	15.7	20.8	23.9	20.5	25.1	22.7

Black Coral Rock:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina		0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1
Antillogorgia americana		0.8	0.9	1.0	1.4	1.2	1.2	0.8	0.9	1.1
Antillogorgia bipinnata		9.0	8.3	5.2	4.1	4.3	4.2	5.3	5.4	6.2
Eunicea flexuosa		0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Octocoral Density		10.3	10.8	8.1	7.0	6.8	6.7	7.5	7.1	8.6

Davis Rock:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Octocoral Density	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0

* No target species recorded

Loggerhead Patch:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina		0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.2	0.1
Antillogorgia americana		0.3	0.2	0.2	0.2	0.4	0.1	0.1	0.2	0.0
Eunicea flexuosa		0.3	0.2	0.5	0.1	0.1	0.3	0.1	0.2	0.2
Pseudoplexaura porosa		0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Total Octocoral Density		0.6	0.6	0.9	0.8	1.3	1.5	1.1	4.0	1.0

Mayer's Peak:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina	2.3	2.8	0.9	1.0	1.7	1.6	1.8	1.8	1.5	1.4
Antillogorgia americana	2.2	2.7	2.8	2.7	3.6	3.4	3.0	3.2	3.1	2.7
Antillogorgia bipinnata		1.9	0.1	0.5	1.4	0.7	0.7	1.3	3.1	0.5
Eunicea flexuosa	3.7	5.1	5.3	4.3	4.1	4.0	4.3	4.2	4.7	3.6
Pseudoplexaura porosa	0.8	0.6	0.9	0.8	0.8	0.6	0.5	0.5	0.8	0.2
Total Octocoral Density	18.1	20.0	22.2	22.3	24.6	24.8	26.3	28.1	30.4	24.3

Appendix E: continued

Palmata Patch:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina		0.4	0.6	0.3	0.2	0.4	0.6	0.7	1.0	0.9
Antillogorgia americana		1.4	1.8	1.5	1.5	1.5	1.6	1.9	1.5	1.8
Eunicea flexuosa		0.0	0.1	0.1	0.0	0.2	0.0	0.2	0.1	0.3
Pseudoplexaura porosa		0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.3	0.2
Total Octocoral Density		3.0	3.9	2.9	2.8	3.0	3.5	4.6	4.5	4.4

Prolifera Patch:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina		0.5	0.4	0.5	0.6	0.5	0.4	0.6	0.6	0.8
Antillogorgia americana		0.1	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Eunicea flexuosa		0.6	0.6	0.6	0.7	0.5	0.3	0.2	0.4	0.6
Pseudoplexaura porosa		0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.2
Total Octocoral Density		1.9	2.0	2.0	2.5	1.9	1.6	2.2	2.4	2.5

Temptation Rock:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina	1.1	1.3	1.0	0.7	0.6	0.5	0.5	0.5	0.6	0.6
Antillogorgia americana	1.8	1.7	2.0	2.2	1.9	2.0	2.1	2.0	2.2	2.2
Eunicea flexuosa	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Pseudoplexaura porosa	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Octocoral Density	4.3	4.0	4.8	3.7	3.8	3.4	3.7	3.8	4.3	4.5

Texas Rock:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.2	0.3
Antillogorgia americana	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eunicea flexuosa	0.1	0.1	0.1	0.2	0.1	0.0	0.1	0.0	0.2	0.1
Total Octocoral Density	0.7	0.6	0.6	0.7	0.4	0.4	0.4	0.7	0.9	0.7

Appendix E: continued

The Maze:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina	1.0	1.0	0.4	0.2	0.3	0.4	0.4	0.4	0.4	0.7
Antillogorgia americana	0.8	1.0	0.7	1.0	1.1	1.2	1.2	1.1	1.1	1.2
Antillogorgia bipinnata		0.9	0.8	1.2	1.1	1.1	0.1	1.0	2.0	1.0
Eunicea flexuosa	0.6	1.1	0.8	1.1	0.7	0.7	0.7	0.7	0.7	0.7
Pseudoplexaura porosa	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Total Octocoral Density	6.1	5.0	4.8	5.3	5.7	5.6	6.4	6.1	7.0	7.2

White Shoal:

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gorgonia ventalina	0.2	0.3	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.5
Antillogorgia americana	1.3	0.9	0.7	1.2	1.1	1.2	1.3	1.8	1.7	2.1
Eunicea flexuosa	0.2	0.6	0.9	0.7	0.6	0.6	0.7	0.7	1.2	0.9
Pseudoplexaura porosa	0.2	0.5	0.6	0.2	0.0	0.3	0.1	0.3	0.3	0.1
Total Octocoral Density	6.7	9.0	10.4	10.8	10.0	11.0	12.0	11.7	14.3	15.0

Appendix F: Statistical outputs (p-values) of the mixed model regression for short- and long-term comparisons by site or the RNA pinnacle reefs for percent cover of major benthic taxa and ESA corals. NA indicates an analysis was not conducted. Significant values are in bold: α = 0.05. No post-hoc adjustments were applied.

Site	Time Interval Comparison	Stony Coral	Octo-coral	Macro-algae	Sponge	ORBI	APAL	APRO	ACER
Bird Key Reef	1999-2003 v 2017-2020	**<.0001**	0.7831	**0.0002**	0.8182	**<.0001**	NA	NA	NA
Bird Key Reef	2017-2018 v 2019-2020	0.9221	0.2696	**0.0097**	0.5584	0.7969	NA	NA	NA
Black Coral Rock	1999-2003 v 2017-2020	**<.0001**	0.5329	**<.0001**	0.6622	**<.0001**	NA	NA	NA
Black Coral Rock	2017-2018 v 2019-2020	0.5006	0.9892	0.5428	0.5753	0.3864	NA	NA	NA
Davis Rock	2009-2012 v 2017-2020	0.5832	**<.0001**	0.5411	**0.0129**	NA	NA	NA	NA
Davis Rock	2017-2018 v 2019-2020	0.6230	0.3272	0.9192	0.3915	NA	NA	NA	NA
Loggerhead Patch	2005-2008 v 2017-2020	**<.0001**	**<.0001**	**<.0001**	**0.0004**	NA	NA	NA	NA
Loggerhead Patch	2017-2018 v 2019-2020	0.5484	0.1582	0.2982	0.9906	NA	NA	NA	NA
Mayer's Peak	2004-2007 v 2017-2020	**0.0058**	0.1049	**<.0001**	**0.0014**	NA	NA	NA	NA
Mayer's Peak	2017-2018 v 2019-2020	0.5184	0.1573	**0.0002**	0.6367	NA	NA	NA	NA
Palmata Patch	2004-2007 v 2017-2020	**<.0001**	**<.0001**	**<.0001**	**<.0001**	NA	**0.0043**	NA	NA
Palmata Patch	2017-2018 v 2019-2020	**0.0101**	0.2071	0.3496	**0.0217**	NA	0.2983	NA	NA
Prolifera Patch	2004-2007 v 2017-2020	**0.0474**	0.3878	**<.0001**	**0.0020**	**0.0061**	NA	**0.0005**	NA
Prolifera Patch	2017-2018 v 2019-2020	**0.0005**	0.4298	0.8302	**0.0229**	**0.0013**	NA	**0.0062**	NA
Temptation Rock	2004-2007 v 2017-2020	0.0944	0.6756	**<.0001**	**0.001**	NA	NA	NA	NA
Temptation Rock	2017-2018 v 2019-2020	**0.0124**	0.4608	0.3378	0.6799	NA	NA	NA	NA
Texas Rock	2009-2012 v 2017-2020	0.2067	0.2658	0.5443	0.1307	NA	NA	NA	NA
Texas Rock	2017-2018 v 2019-2020	0.6430	0.7482	0.4549	0.4364	NA	NA	NA	NA

Appendix F: continued

Site	Time Interval Comparison	Stony Coral	Octo-coral	Macro-algae	Sponge	ORBI	APAL	APRO	ACER
The Maze	2009-2012 v 2017-2020	0.1140	**0.0119**	0.9705	0.1768	NA	NA	NA	NA
The Maze	2017-2018 v 2019-2020	0.8839	0.7198	**0.0429**	0.3279	NA	NA	NA	NA
White Shoal	1999-2003 v 2017-2020	**<.0001**	**0.0001**	**<.0001**	0.4776	NA	NA	NA	**<.0001**
White Shoal	2017-2018 v 2019-2020	0.7148	0.3044	0.7014	0.394	NA	NA	NA	0.543
Little Africa	2007-2010 v 2017-2020	**<.0001**	**<.0001**	**0.0005**	0.1003	**<.0001**	NA	NA	NA
Little Africa	2017-2018 v 2019-2020	0.1964	0.1176	**0.0035**	**0.024**	0.3687	NA	NA	NA
RNA pinnacles w/ mooring	2009-2012 v 2017-2020	**<.0001**	NA	NA	NA	NA	NA	NA	NA
RNA pinnacles w/ mooring	2017-2018 v 2019-2020	0.5138	NA	NA	NA	NA	NA	NA	NA
RNA pinnacles w/o mooring	2009-2012 v 2017-2020	0.1976	NA	NA	NA	NA	NA	NA	NA
RNA pinnacles w/o mooring	2017-2018 v 2019-2020	0.0617	NA	NA	NA	NA	NA	NA	NA
All RNA Pinnacles	2009-2012 v 2017-2020	NA	NA	NA	NA	**<.0001**	NA	NA	NA
All RNA Pinnacles	2017-2018 v 2019-2020	NA	NA	NA	NA	0.9818	NA	NA	NA

Appendix G: Statistical outputs (p-values) of the mixed model regression for short- and long-term comparisons of coral, octocoral, and *Orbicella* spp. densities by site or the RNA pinnacle reefs. Significant values in bold: α = 0.05. No post-hoc adjustments were applied.

Site	Time Interval Comparison	Coral	Octocoral	*Orbicella* spp.
Bird Key Reef	2011-2014 v 2017-2020	**0.0481**	**<.0001**	0.2798
Bird Key Reef	2017-2018 v 2019-2020	0.1768	0.3613	0.5828
Black Coral Rock	2011-2014 v 2017-2020	0.8326	**0.0091**	0.4477
Black Coral Rock	2017-2018 v 2019-2020	0.3098	0.2999	0.6866
Davis Rock	2011-2014 v 2017-2020	**0.0035**	0.0717	NA
Davis Rock	2017-2018 v 2019-2020	0.6129	0.7105	NA
Loggerhead Patch	2011-2014 v 2017-2020	**<.0001**	**<.0001**	NA
Loggerhead Patch	2017-2018 v 2019-2020	**0.0005**	**0.0025**	NA
Mayer's Peak	2011-2014 v 2017-2020	**<.0001**	**0.0023**	NA
Mayer's Peak	2017-2018 v 2019-2020	0.0982	0.8701	NA
Palmata Patch	2011-2014 v 2017-2020	0.4912	**0.0478**	NA
Palmata Patch	2017-2018 v 2019-2020	0.3246	0.5123	NA
Prolifera Patch	2011-2014 v 2017-2020	0.4716	0.5547	0.6417
Prolifera Patch	2017-2018 v 2019-2020	0.0522	0.1118	0.7329
Temptation Rock	2011-2014 v 2017-2020	**0.0235**	0.7391	NA
Temptation Rock	2017-2018 v 2019-2020	0.6966	0.1578	NA
Texas Rock	2011-2014 v 2017-2020	0.0562	0.8091	NA
Texas Rock	2017-2018 v 2019-2020	0.7747	0.0523	NA
The Maze	2011-2014 v 2017-2020	**<.0001**	**0.0294**	NA
The Maze	2017-2018 v 2019-2020	0.4697	0.1973	NA

Appendix G: continued

Site	Time Interval Comparison	Stony Coral	Octocoral	*Orbicella* spp.
White Shoal	2011-2014 v 2017-2020	**0.0004**	**<.0001**	NA
White Shoal	2017-2018 v 2019-2020	0.0641	0.0528	NA
RNA Pinnacle Reefs	2011-2014 v 2017-2020	NA	NA	0.2859
RNA Pinnacle Reefs	2017-2018 v 2019-2020	NA	NA	0.3544

Appendix H: Average daily temperature (° Celsius) for each month of peak heating (July – October) for all sites with all available data. Months where the average daily temperature was at or above the bleaching temperature of 30° are in bold.

Site	Month	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Bird Key Reef	Jul	**30.1**	29.6	29.7	28.3	29.3	28.6	28.6	**30.4**	**30.4**	29.5	**30.2**	29.9	**30.8**	29.8
Bird Key Reef	Aug	**30.4**	**30.3**	**30.3**	**30.5**	**30.8**	29.4	29.7	**31.0**	**31.0**	29.6	**30.2**	28.8	**30.7**	**30.5**
Bird Key Reef	Sep	29.9	28.8	**30.3**	29.9	**30.2**	28.8	29.5	29.9	**30.5**	29.2	30.0	29.5	29.7	**30.5**
Bird Key Reef	Oct	28.7	27.8	29.4	27.7	27.9	27.7	28.8	28.9	28.7	28.3	28.5	28.0	28.9	29.3
Black Coral Rock	Jul	29.0	29.4	27.8	24.8	28.0	26.0	27.3	29.2	29.2	26.3	29.6	26.9	29.5	28.4
Black Coral Rock	Aug	29.3	29.6	29.3	30.0	**30.0**	27.3	29.3	29.2	**30.2**	26.0	29.3	24.1	29.7	**30.0**
Black Coral Rock	Sep	29.9	28.7	**30.0**	29.9	**30.1**	27.4	29.2	29.6	**30.4**	26.5	29.4	28.1	29.6	**30.3**
Black Coral Rock	Oct	28.7	28.0	29.5	27.9	28.2	27.4	28.5	28.9	28.7	28.0	28.4	26.3	28.9	29.2
Davis Rock	Jul										28.4	**30.3**	29.8	**30.4**	29.6
Davis Rock	Aug										28.9	**30.3**	28.5	**30.6**	**30.4**
Davis Rock	Sep										28.1	30.0	29.1	29.7	**30.5**
Davis Rock	Oct										28.2	28.4	27.6	28.7	29.2
Loggerhead Patch	Jul											**30.5**	**30.3**	**30.5**	**30.2**
Loggerhead Patch	Aug											**30.4**	29.5	**30.9**	**30.7**
Loggerhead Patch	Sep											**30.1**	29.5	29.9	**30.5**
Loggerhead Patch	Oct											28.4	28.1	29.0	29.2
Mayer's Peak	Jul	**30.2**	29.5	29.6	28.7	29.3	28.3	28.7	**30.5**	**30.4**	28.6	**30.4**	**30.2**	**30.4**	**30.1**
Mayer's Peak	Aug	**30.4**	**30.3**	**30.4**	**30.5**	**31.0**	29.1	29.8	**31.0**	**31.1**	29.5	**30.4**	29.3	**30.7**	**30.5**
Mayer's Peak	Sep	29.9	28.8	**30.5**	29.9	**30.3**	28.5	29.6	**30.0**	**30.6**	28.7	**30.1**	29.4	29.8	**30.4**
Mayer's Peak	Oct	28.6	27.8	29.5	27.8	27.9	27.7	28.7	29.0	28.7	28.2	28.5	27.9	29.0	29.2
Palmata Patch	Jul			**30.1**	29.2	29.6	28.8	28.9	**30.6**	**30.6**	29.4	**30.5**	**30.4**	**30.6**	**30.2**
Palmata Patch	Aug			**30.5**	**30.7**	**31.1**	29.5	29.9	**30.9**	**31.2**	29.9	**30.5**	29.8	**30.9**	**30.7**
Palmata Patch	Sep			**30.6**	**30.0**	**30.4**	28.9	29.6	29.8	**30.6**	29.3	**30.1**	29.6	29.8	**30.5**
Palmata Patch	Oct		27.4	29.5	27.6	27.9	27.7	28.8	28.8	28.7	28.3	28.5	28.1	29.0	29.2

Appendix H: continued

Site	Month	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Prolifera Patch	July											**30.6**	**30.5**	**30.6**	**30.2**
Prolifera Patch	Aug											**30.6**	29.9	**30.9**	**30.8**
Prolifera Patch	Sep											**30.2**	29.8	29.8	**30.6**
Prolifera Patch	Oct											28.6	28.1	29.0	29.3
Temptation Rock	July	**30.1**	29.6	29.4	26.9	29.1	27.3	28.7	**30.4**	**30.2**	27.6	**30.3**	29.7	**30.4**	29.8
Temptation Rock	Aug	**30.3**	**30.3**	**30.2**	**30.5**	**30.9**	28.4	29.8	**30.8**	**31.0**	28.0	**30.2**	26.8	**30.7**	**30.4**
Temptation Rock	Sep	29.8	28.8	**30.5**	29.9	**30.2**	28.1	29.5	29.8	**30.5**	27.8	30.0	28.9	29.8	**30.4**
Temptation Rock	Oct	28.5	27.7	29.4	27.5	27.8	27.5	28.6	28.8	28.6	28.0	28.3	27.0	28.8	29.1
Texas Rock	July				27.8		28.1	28.6	**30.5**	**30.2**	28.5	**30.2**	29.9	**30.3**	29.9
Texas Rock	Aug				**30.5**		28.8	29.7	**30.9**	**31.1**	29.0	**30.3**	28.6	**30.7**	**30.5**
Texas Rock	Sep				30.0		28.5	29.4	29.9	**30.5**	28.2	29.9	29.2	29.9	**30.5**
Texas Rock	Oct				27.6		27.6	28.6	28.9	28.7	28.2	28.4	27.7	28.9	29.2
The Maze	July							28.8			28.4	**30.3**	**30.1**	**30.4**	29.9
The Maze	Aug							29.8			29.3	**30.3**	28.7	**30.7**	**30.5**
The Maze	Sep							29.6			28.6	**30.0**	29.2	29.7	**30.5**
The Maze	Oct							28.7			28.2	28.4	27.8	28.9	29.2
White Shoal	July										29.0	**30.4**	**30.2**	**30.5**	**30.0**
White Shoal	Aug										29.6	**30.4**	29.4	**30.8**	**30.6**
White Shoal	Sep										28.7	**30.1**	29.5	29.8	**30.5**
White Shoal	Oct										28.2	28.5	28.1	28.9	29.2