Florida Fish And Wildlife Conservation Commission
Fish And Wildlife Research Institute
Coral Reef Evaluation & Monitoring Project

2005 Executive Summary
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INTRODUCTION

The Florida Keys Coral Reef Evaluation and Monitoring Project (CREMP) was initiated in 1994 to provide data on the status of coral reef resources of the Florida Keys National Marine Sanctuary (FKNMS) and document changes in status over time. In 1995, forty sites were identified throughout the FKNMS and permanent survey stations were installed. Data collection began in 1996 and continued annually through 2005. Stations were installed at three additional sites in the Dry Tortugas in 1999. In 2001, surveys of abundance and cover of bioeroding sponges (clionid) which aggressively encrust and invade stony coral colonies were initiated in the FKNMS and Dry Tortugas. Annual monitoring was initiated in response to concerns that clionids were implicated in coral decline. In 2002, additional sampling techniques were incorporated into the project which included detailed surveys of stony coral abundance and an expanded stony coral disease survey. Only the bioeroding sponge survey results are summarized herein. This report presents results for the FKNMS sanctuary-wide and by region. The regions are defined as Upper Keys, Middle Keys, and Lower Keys. The data for the Dry Tortugas sites are presented separately from those for the FKNMS (Figure 1).

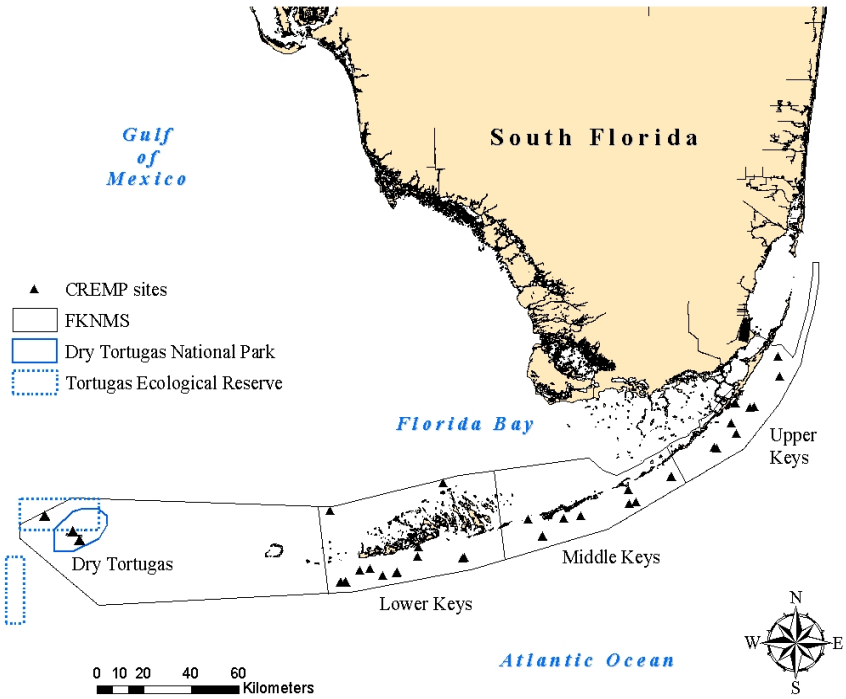


Figure 1. Coral Reef Evaluation and Monitoring Project site locations and region boundaries.

Stony coral cover is presented for all stony coral combined and for the five most common species. It is important to determine if changes in coral abundance are due to a general decline in all species or whether it is the result of a large decline in one or two species. Although the focus of CREMP is on stony corals, reef habitat is composed of many other ecologically important functional groups. Changes in the abundance of these different functional groups may indicate a shift in community type. Therefore, CREMP also monitors macroalgae, octocorals (sea fans, sea whips), and sponges. When a complex habitat such as a coral reef begins to deteriorate, those species that are more sensitive to changes will disappear, resulting in a decline in species richness. CREMP inventories the number of different stony coral species at each station and data is analyzed and presented by region. Since 1996, CREMP has also recorded the incidence of disease (by pathogen where possible) in stony corals and the abundance of the long-spined sea urchin *Diadema antillarum.* These urchins are herbivores and they help to keep corals free of algal overgrowth. The ecological importance of the long-spined sea urchin is well documented; however, urchin populations suffered a Caribbean-wide mortality event in 1983-84 and their recovery has been slow.

In 2005, a severe bleaching event was observed in response to sustained elevated water temperatures. Data was collected to document the event in the Middle Keys, but was not collected in the other regions because of hurricane activity.

METHODS

Station Layout

Each station is marked with two stainless steel reference stakes. Two steel poles, three plastic chains and three measuring tapes define the transects (Figure 2).

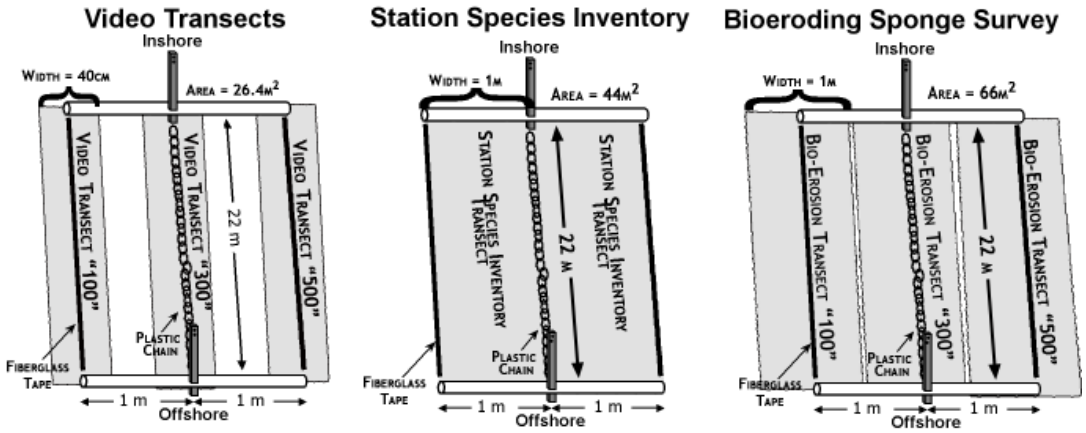


Figure 2. Station layout within a CREMP site.

Station Species Inventory

A pair of observers records the presence of every stony coral species in each station (2x22m) (Figure 2) during a 15-minute search period (Figure 3). The divers initially conduct independent surveys, then check and verify each other's data as a quality control assurance. Incidence of condition/disease, bleaching, and presence of long-spined sea urchin (Diadema) are also recorded. Stony coral species richness is calculated for each station and sanctuary-wide.

Figure 3. Divers conducting Station Species Inventory.

Video Transects

Video is filmed along each of the 22m transects (Figure 2 and 4). Consecutive frames are extracted from the video transects and analyzed using custom software. Percent cover of stony corals, other functional groups, and substrate are summarized.

Figure 4. Diver filming video transects.

Bioeroding Sponge (Clionid) Survey

The sponge survey area is defined by three 1m wide belt transects within existing CREMP stations (Figure 2). The location, species, and size of bioeroding sponge species (*Cliona delitrix*, *C. lampa* and *C.caribbaea*) are recorded as well as the coral species affected (Figure 5). The total area of clionid sponges per square meter of substrate is calculated for each station.

Figure 5. Diver performing a Bioeroding Sponge Survey.

FKNMS RESULTS

Stony Coral Species Richness

Between 1996 and 2005, the total number (maximum of 43) of species recorded throughout the FKNMS has not changed significantly. However , the mean number of species found per station has declined. For a total of 105 stations, species richness decreased in 77%, increased in 18%, and remained unchanged in 5% of the stations. This trend is also observed in each region (Figure 6). Data did not show significant changes in stony coral species richness between 2004 and 2005.

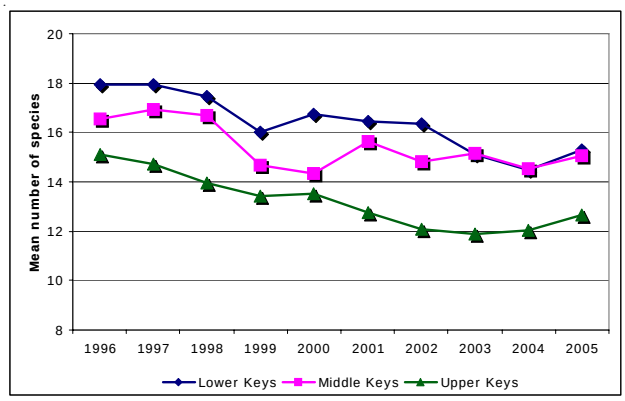


Figure 6. Temporal change in mean number of stony coral species per station by region.

Stony Coral Disease/Condition

Diseases were recorded as present or absent for each species during the Station Species Inventory and the type of disease/condition was noted. Data were recorded for three categories: black band, white diseases (i.e. white plague, white band and white pox), and "other" diseases (including dark spot, yellow band and idiopathic diseases) (Figure 7). Incidence of black band disease peaked in 1998 but now occurs at a low level. The most prevalent categories were white disease and the "other" diseases. The latter category is a "catch all" for a suite of emerging and little known pathogens which occurred at almost 80% of the survey stations in 2005.

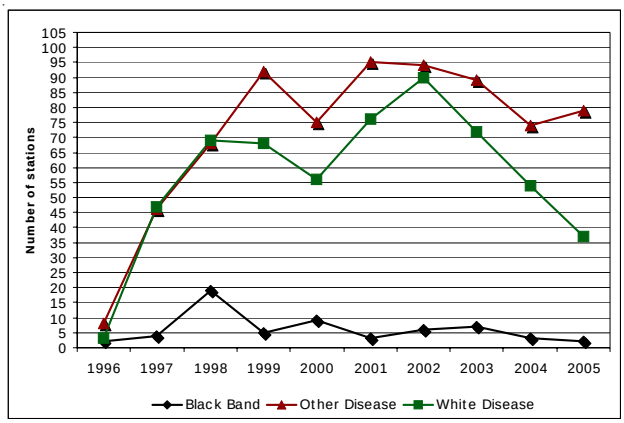


Figure 7. Number of stations with stony coral disease/ condition.

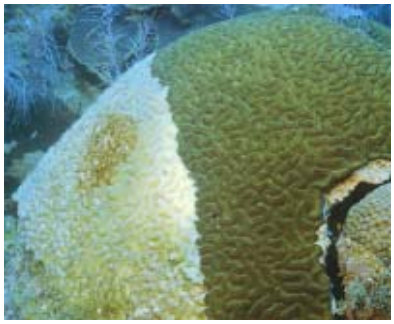


Figure 8. Image of coral disease in the FKNMS.

Long-Spined Sea Urchin (*Diadema*) Distribution

The long-spined sea urchin (*Diadema antillarum*) has been reported at a maximum of 13 stations for two (2002 and 2005) of the ten years sampled. However, all CREMP data shows an increase in *Diadema* distribution mid-way in the project. For the first five years of monitoring, *Diadema* were reported at an average of only 5.8 stations. From 2001 to 2005, the average number of stations (11.2) where *Diadema* were observed had nearly doubled. By region, from 2001 to 2005, Lower Key's sites had the most stations (maximum 6) with *Diadema*. For the same five years, *Diadema* was recorded more often at offshore shallow stations (average 5.6). Unfortunately, for CREMP stations, *Diadema* occurrence is still far less than one urchin per square meter sanctuary-wide. Overall, CREMP data show more frequent observations of *Diadema* in FKNMS since the survey began in 1996 (Figure 10).

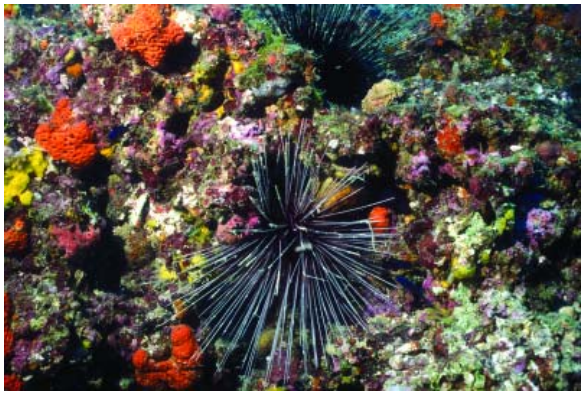


Figure 9. Image of the long-spined sea urchin, *Diadema antillarum*.

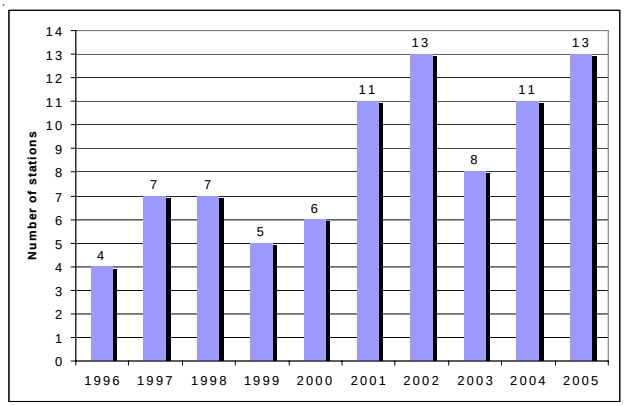


Figure 10. Stations with *Diadema*.

Stony Coral Cover

sanctuary-wide

Between 1996 and 2005, mean stony coral cover in the FKNMS declined from 11.9% to 6.7% Sanctuary-wide (Figure 11), which represents a loss of 43.7% of the initial coral cover. The greatest percent loss occurred between 1998 and 1999. Percent stony coral cover remained relatively stable between 1999 and 2003. Although stony coral cover declined slightly between 2003 and 2004, no significant changes in stony coral cover occurred during the past two years (2004-2005).

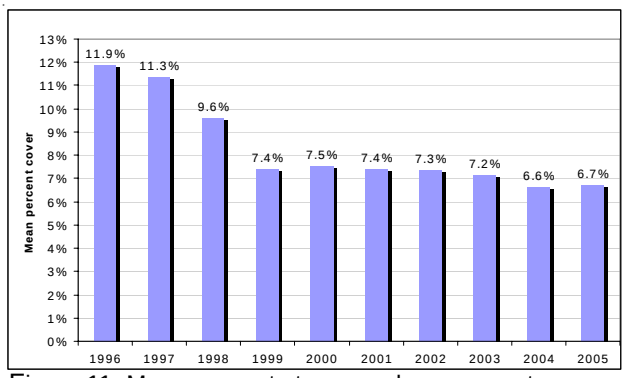


Figure 11. Mean percent stony coral cover sanctuary-wide.

By Region

The Upper and Lower Key's regions showed greatest loss in mean stony coral cover since the beginning of the sampling period (Figure 12). Since 1999, mean percent coral cover has been relatively stable in the Upper and Middle Keys; however, stony coral cover continued to slightly (9.3% to 8%) decline in the Lower Keys. There was no statistical difference in stony coral cover between 2004 and 2005 for any of the regions.

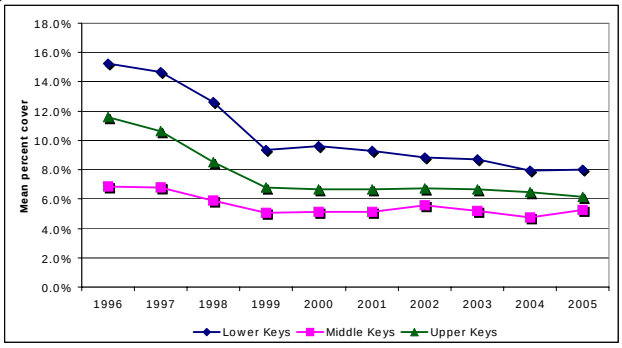


Figure 12. Mean percent stony coral cover for Upper, Middle and Lower Keys stations.

By Species

Underlying trends in stony coral cover can be obtained by analyzing the changes in the most common species. The five most common species in the FKNMS have been *Montastraea annularis* (species complex), *Montastraea cavernosa, Siderastrea siderea, Porites astreoides* and *Colpophyllia natans.* All except *P. asteoides* commonly attain large size and contribute significantly to the reef framework. The data shows that the loss of 37% (4.1% to 2.6%) of the live *M. annularis* (boulder star coral) cover is likely driving the general decline of stony coral cover in FKNMS. Percent cover of the four remaining common species has not changed significantly since 1996. (Figure 13)

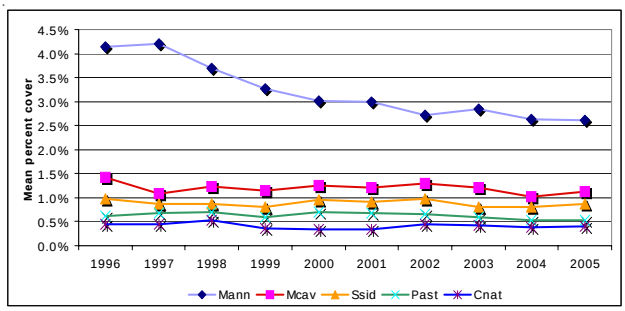


Figure 13. Sanctuary-wide mean percent stony coral cover per station for the five most common species (*Montastraea annularis*, *Montastraea cavernosa, Siderastrea siderea, Porites astreoides* and *Colpophyllia natans)*.

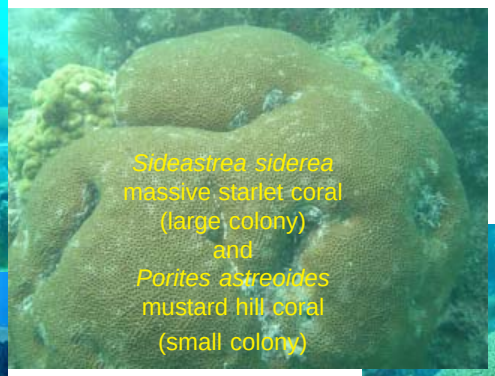
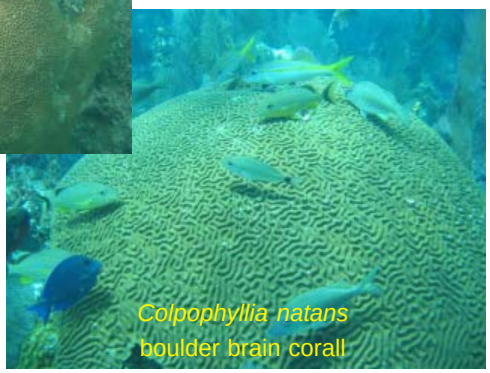


Figure 10. Images of the five most common corals in the FKNMS with common and scientific names.



Functional Group Cover

Major functional groups defined in this study are stony corals, octocorals, sponges and macroalgae. Data show that mean percent stony coral cover stabilized at about 7% and the percent cover of octocorals increased to about 13%. Mean sponge cover has not significantly changed since 1996 (Figure 14).

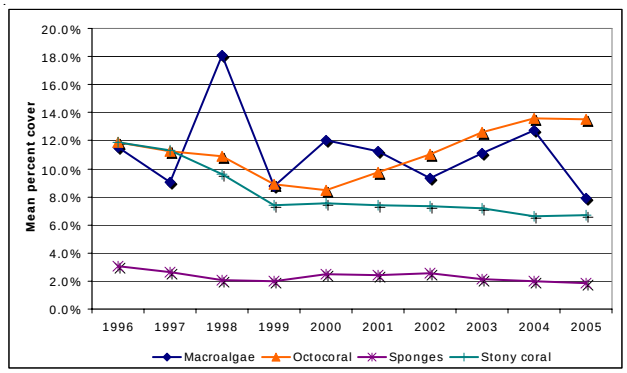


Figure 14. Sanctuary-wide mean percent cover of major functional groups.

Bioeroding Sponge (Clionid) Cover

Three of the four species (*Cliona delitrix, C. lampa, and C. caribbaea)* of clionid sponges which occur in FKNMS were monitored during the survey. Sanctuary-wide means of clionid cover are presented in figure 15. In 2001, clionid sponge cover was 7cm/m^2. Clionid sponge cover decreased sharply in 2002, but has increased steadily over the past three years. Apart from hardbottom habitat, the clionid sponge populations have remained relatively stable at offshore reefs since the beginning of monitoring. Patch reefs had consistently higher sponge cover than shallow and deep reefs (Figure 17).

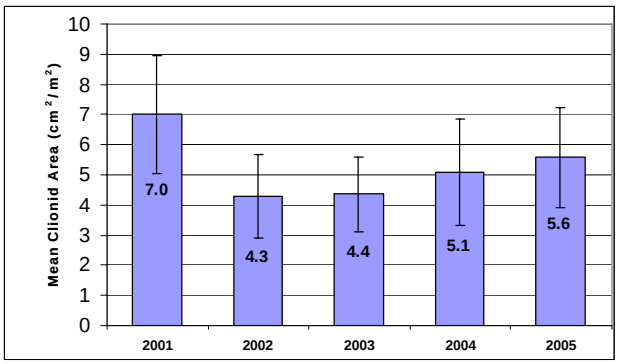


Figure 15. Temporal changes in area cover of clionid sponges throughout the FKNMS.

Figure 16. Image of a clionid sponge invading and overgrowing a stony coral species

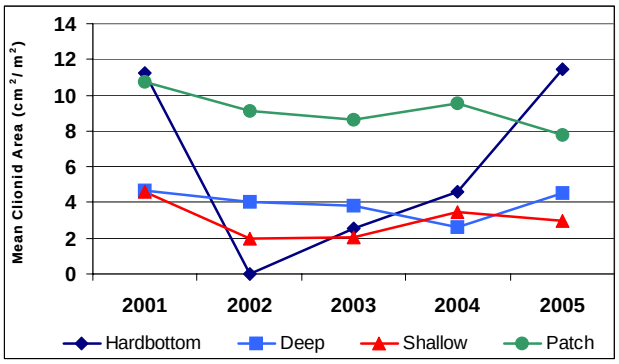


Figure 17. Temporal changes in area cover of clionid sponges in different habitats.

TORTUGAS RESULTS

Stony Coral Species Richness

Maximum number of stony coral species for Tortugas CREMP sites was 33; however, mean stony coral species richness by station is higher in Tortugas than in the FKNMS. A mean of 21.5 species per station was recorded in 1999. By 2005, the mean had declined to 17.5 species per station (Figure 18).

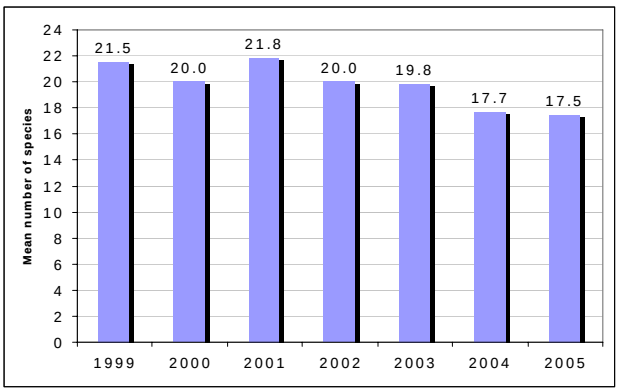


Figure 18. Temporal change in mean number of stony coral species by station.

Stony Coral Disease/Condition

Between 1999 and 2003, at least one disease was present in 80-100% of the 12 stations sampled (Figure 19) . White disease was recorded in all 12 stations in 2003, 7 stations in 2004 and was not recorded at any stations in 2005. Reports of “other” disease also declined between 2003 and 2005. Black band was only recorded at 2 stations in 2000.

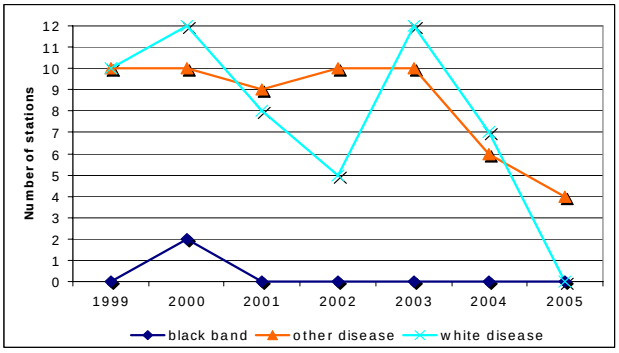


Figure 19. Number of stations showing presence of three primary disease.

Long-Spined Sea Urchin (*Diadema*) Distribution

Diadema distibution among Dry Tortugas CREMP stations has declined sharply over the seven years sampled (Figure 20). It was reported from only 1/3 of the stations in 1999, none of the stations in 2000 and reported in only one or two stations the remaining years.

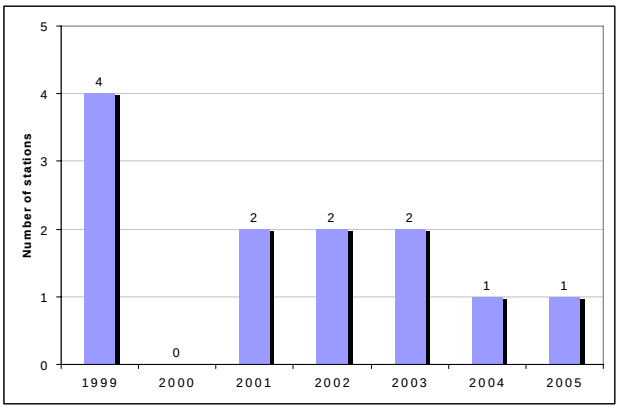


Figure 20. Number of stations with *Diadema*.

Stony Coral Cover

Mean percent stony coral cover for the twelve Dry Tortugas stations decreased from ~19% in 1996 to 11.4% in 2005 (Figure 21). The greatest decrease in mean stony coral cover occurred between 2001 (17.4%) and 2002 (14.1%).

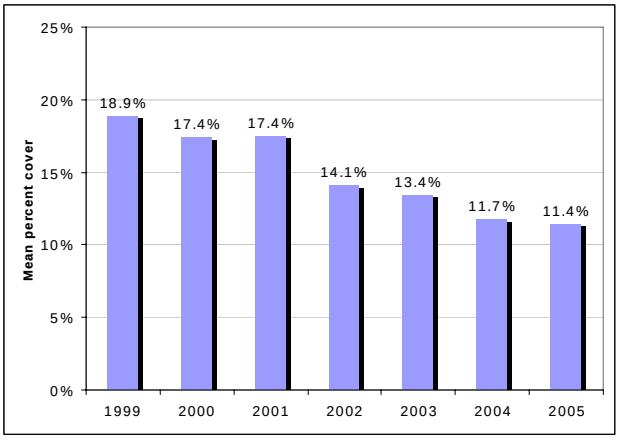


Figure 21. Temporal change in mean stony coral cover.

By Habitat

The deep reef habitats supported the highest mean coral cover (Figure 22). Mean percent coral cover has generally declined steadily at the Dry Tortugas for both the deep and patch reef CREMP sites over the seven years sampled.

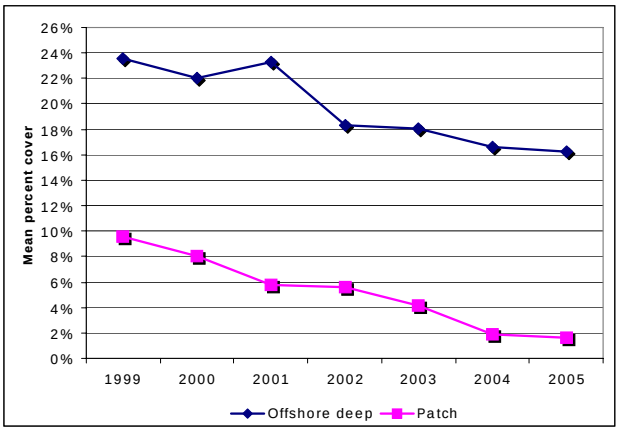


Figure 22. Temporal change in mean stony coral cover by habitat.

By Species

The five most common species in Dry Tortugas have been *Montastraea annularis* (species complex), *Montastraea cavernosa, Colpophyllia natans, Acropora cervicornis and Siderastrea siderea.* All but A. *cervicornis* were also most common in FKNMS, attain large size and contribute mass to reef framework. Losses in mean stony coral cover between 2001 and 2002 were likely driven by the decline of the boulder star coral *Montastraea annularis.* The boulder brain coral (*C. natans*) and staghorn coral (*A. cervicornis*) notably declined between 1999 and 2005. Mean stony coral cover continued to decline through 2005 (Figure 21 and 24).

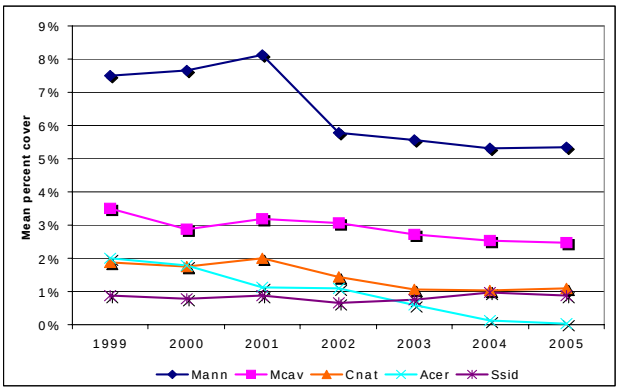


Figure 23. Mean stony coral cover of the five most common species.

Functional Group Cover

Mean cover for octocorals fluctuated at slightly more than 12% between 1999 and 2003 but has declined over the last two years to 8%. Mean sponge cover has declined slightly but consistently. Mean macroalgae cover peaked in 2003 but has also declined over the last two years (Figure 24).

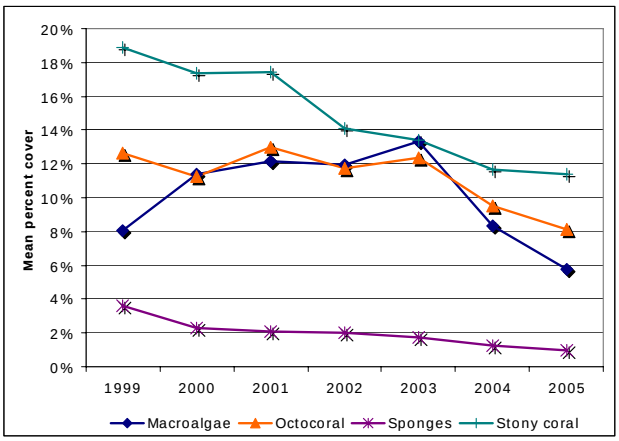


Figure 24. Mean percent cover of major functional groups.

Bioeroding Sponge (Clionid) Cover

Mean clionid cover decreased from 12.3 cm^2/m^2 in 2001 to 5.9 cm^2/m^2 in 2003. However, since 2003 mean clionid cover increased to 9.9cm^2/m^2 in 2005 (Figure 25).

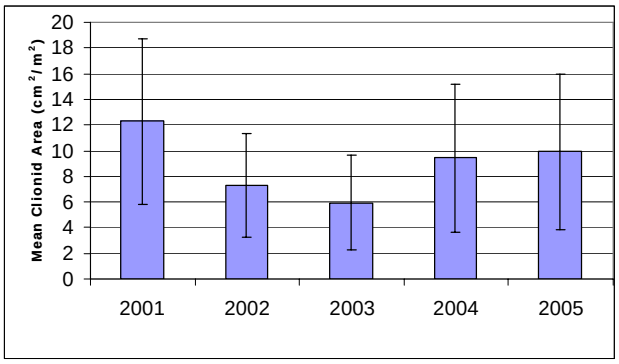


Figure 25. Temporal changes in mean cover of clionid sponges by station.

DISCUSSION

The Station Species Inventory data indicate that the stony coral species richness sanctuary-wide has been relatively stable over the ten years monitored with a maximum of 43 species recorded in 1996 and a minimum of 39 species recorded in 2002. However, the mean number of stony coral species recorded per station has decreased over time. Regionally, the mean number of stony coral species decreased slightly between 1996 and 2005. In ecosystems with relatively few species, the appearance of one or two rare species (that may or may not persist) will have a disproportionate effect on the data than in an ecosystem with high species richness. The ultimate objective should be to facilitate a return to historic values, rather than accept a stable but decreased baseline.

In spite of a decrease in incidence of white disease over the past four years, incidence of “other” disease has remained high (80 out of 105 stations) throughout FKNMS. Coral diseases are notoriously challenging to study; pathogens are often difficult to identify and different causative agents can produce similar disease symptoms. In general, disease incidence has fluctuated over time, possibly due to the decrease in some pathogens as others emerged. High and persistent disease incidence in FKNMS is cause for concern, particularly since data on mortality and recovery is not being collected during the Station Species Inventory. However, mortality and recovery of selected diseased stony corals are being monitored in more detail in a subset of the CREMP monitoring stations in the FKNMS and Dry Tortugas

Diadema was decimated by a well-documented Caribbean-wide mortality event in 1984. Sea urchins are broadcast spawning species that release eggs and sperm into the water column to fertilize. It is possible that the urchin population was reduced to such an extent that reproductive viability was compromised. These urchins feed on macroalgae that can overgrow stony corals and their loss is thought to have had a significant impact on coral reef health. CREMP inventory of the long-spined sea urchin, *Diadema antillarum*, showed a slight increase in distribution in FKNMS since the CREMP began monitoring.

The mean stony coral cover in the FKNMS declined sharply between 1996 and 1999; however, for the past seven years mean stony coral cover has been approximately 7% sanctuary-wide. The decline was also apparent by region, although some differences in region-specific percent stony coral cover were evident. When the data were presented by species, the observed loss in mean stony coral cover sanctuary-wide was likely driven by the decline of *Montastraea annularis* species complex, which forms very large colonies (>2m diameter) throughout the Sanctuary. The complete or partial mortality of a single boulder star coral colony represents a large decrease in coral cover and ultimately habitat structure. Further research into the cause of the observed decline is required to consider recommendations to preserve this important species.

Functional group cover shows the prevalence of other important habitat components such as octocorals, sponges, and macroalgae. Mean octocoral cover has increased significantly and consistently after a general decline from 1996 to 2000. The level of sponge cover has not changed appreciably since the inception of the project. Mean macroalgae cover has changed cyclically with a minimum of approximately 8%. Changes in the percent cover of major functional groups provides valuable community information, but can also raise a “red flag” for further investigation into the factors driving the changes in coral habitat.

Research has shown that sponges feed on ultraplankton (bacteria, cyanobacteria, etc) and there is anecdotal evidence that when bacterial load increases, sponge populations also increase. Clionid sponges are common bioeroders of stony corals world-wide, but despite their global distribution very little is known about their biology or ecology. Clionid populations may be influenced by differences in water quality or sponge recruitment dynamics. CREMP patch reef sites have consistently higher clionid sponge cover than the shallow and deep reef sites. Substrate limitation is not driving this distribution since there is sufficient substrate available in all habitat types. Sanctuary-wide data was strongly influenced by the large decline in clionid sponges observed in hardbottom habitats in 2002. Causes for the observed distribution are currently unclear; however, clionid sponges do not appear to have caused significant decline in coral cover in the Sanctuary since the beginning of the clionid survey in 2001.

Since the inception of monitoring in the Dry Tortugas in 1999, a combination of disease, hurricanes and potentially some unknown stressors have caused a decline in both coral cover and species richness at CREMP sites. This occurred with stony corals and other major functional groups. The mean stony coral cover loss appears to have been primarily driven by cover losses in *M. annularis* species complex. High levels of mortality from white diseases of boulder brain coral (*C. natans*) and staghorn coral (*A. cervicornis*) have also contributed to the overall decline. The incidence of white disease decreased from 100% of stations affected in 2003, to no stations affected in 2005. Mean stony coral cover and species richness had no significant change between 2004 and 2005. Hopefully conditions have stabilized with decline of the disease pathogens and corals at the Dry Tortugas can begin the recovery process.

EVENT RESPONSE – SUMMER 2005 BLEACHING EVENT

Three sites in the Middle Keys region were surveyed between August 24th and September 16th 2005, to determine the level of stony coral bleaching in response to sustained elevated temperatures during August (Figure 27). These were patch reefs at Dustan Rocks (stations 2 and 4) and W. Turtle Shoal (stations 3 and 4) and a single shallow reef station at Looe Key.

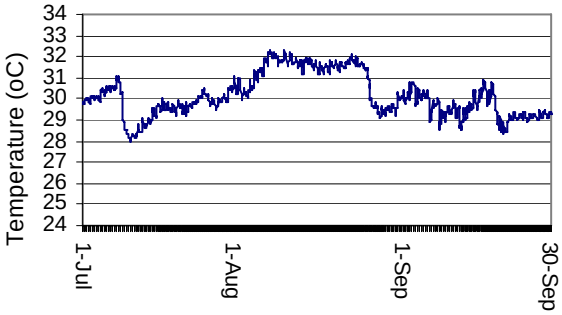


Figure 26. Hourly water temperature at West Turtle Shoal Patch Reef between 1st July and 30th September 2005 showing elevated temperature (>30°C) during August particularly.

Percent cover of unbleached (healthy), partially bleached, and totally bleached stony coral was calculated from video surveys. For each colony, bleaching was defined as partially bleached: tissue lighter in appearance than the surrounding tissue; and totally bleached: completely white and completely devoid of visible algae (Figure 27). This distinction was made because the degree of bleaching stress may affect colony recovery, and therefore the long-term impact on the stony coral community. Data show that bleaching severity varied greatly by site (Figure 28). The number of affected colonies (bleached and partially bleached) was higher at the patch reefs than the shallow reef. The primary species affected also varied between the different reef types. At Looe Key shallow reef, *the boulder star coral (M. annularis*) was affected more than other species. At the patch reefs, *great star coral (M. cavernosa), mustard hill coral (P. astreoides)* and *massive starlet coral (S. siderea)* were the most impacted. In summary, only half of the stony coral species at the shallow site showed signs of bleaching whereas 85-100% of the species on the patch reef sites were affected.

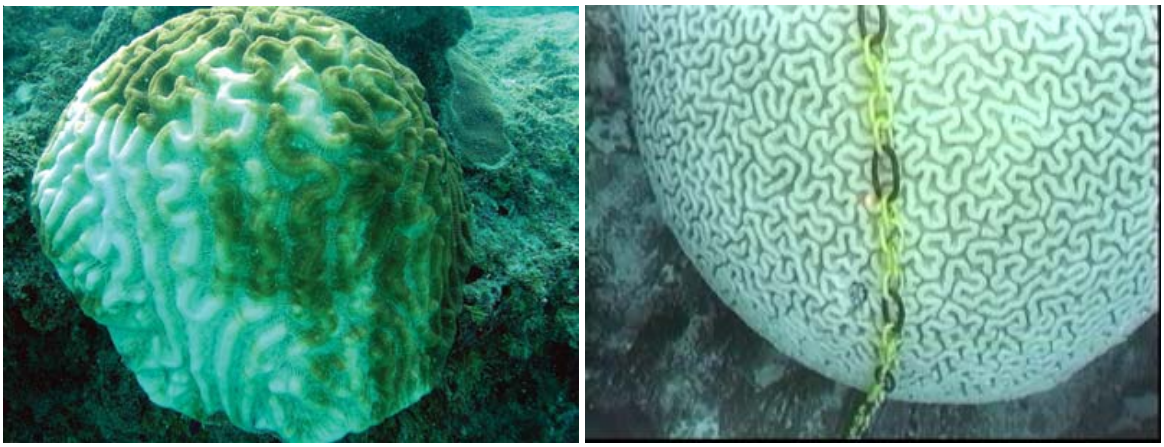


Figure 27. Partially bleached and totally bleached brain coral colonies.

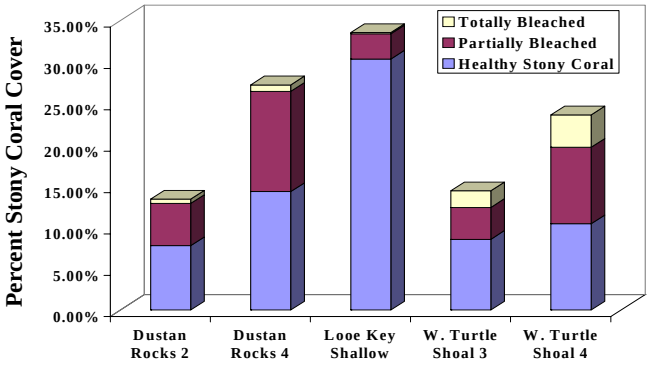


Figure 28. Percentage of unbleached (healthy), partially bleached and totally bleached stony coral cover at each site.

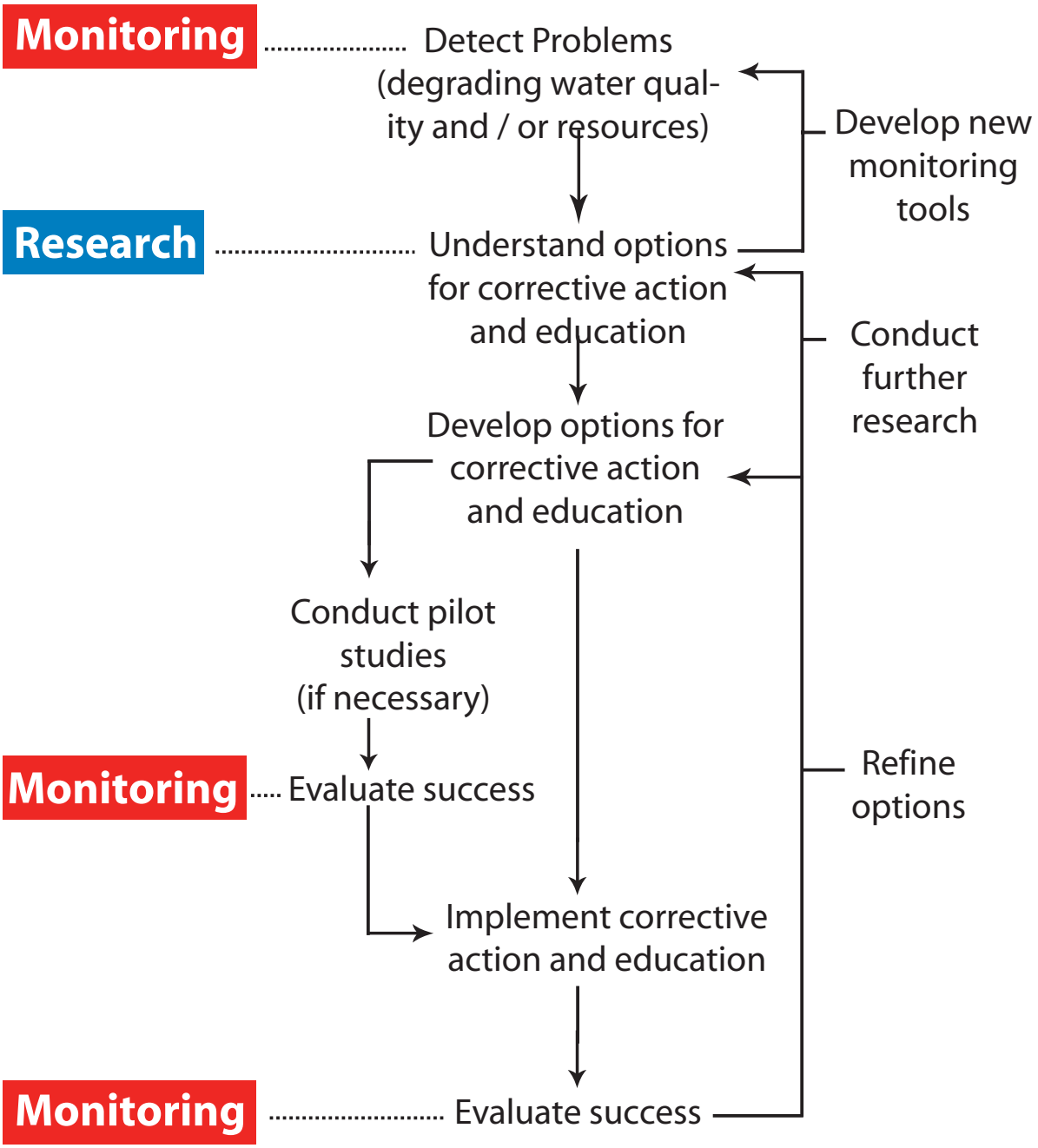


Figure 29. Roles of monitoring and research in the Water Quality Protection Program. Monitoring is critical in multiple stages of the process.