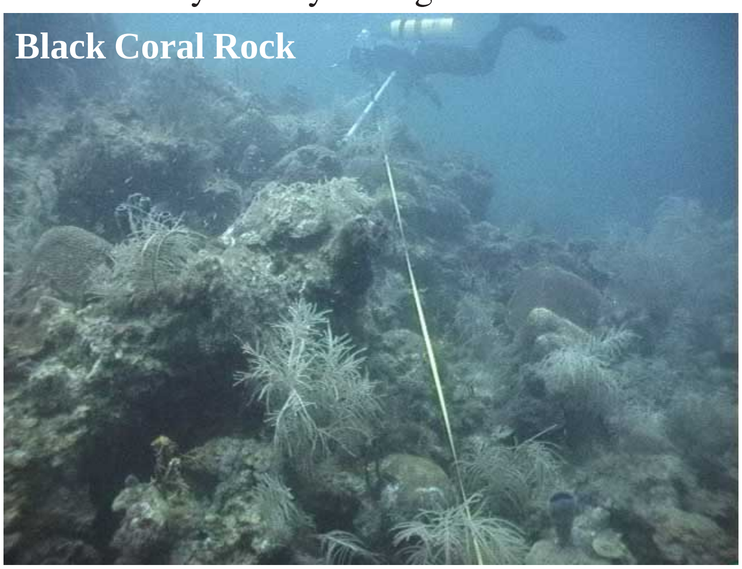
EPA / FKNMS Coral Reef Monitoring Project
Updated Executive Summary 1996-2000
Steering Committee Meeting August 1, 2001

Northern Keys to Dry Tortugas 193 miles



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INTRODUCTION

The Florida Keys coastal ecosystem exhibits the typical Caribbean pattern: mangroves at the coastal interface and a mosaic of sedimentary, seagrass, hardbottom, and coral reef habitats off the coast. The majority of coral reefs are located on the ocean side of the Keys. Hardbottom habitat exists on the ocean side and in Florida Bay as well. Coral reefs are least abundant of the benthic habitat types, estimated to comprise approximately one percent of the seafloor within the Florida Keys National Marine Sanctuary (FKNMS). The northern latitude and flooding of Florida Bay 4000 years before present, represent an unfavorable habitat setting. Frequent hurricanes, bleaching episodes, and intensive anthropogenic activities in the Florida Keys coastal area are additional negative factors affecting the coral reef ecosystem.

The Florida Keys National Marine Sanctuary and Protection Act (HR5909) designated over 2,800 square nautical miles of coastal waters as the Florida Keys National Marine Sanctuary. In cooperation with NOAA, the US Environmental Protection Agency and the State of Florida implemented a Water Quality Protection Program to monitor seagrass habitats, coral reefs and hardbottom communities, and water quality.

The Coral Reef Monitoring Project (CRMP) sampling strategy and methods were developed in conjunction with EPA, FKNMS, Continental Shelf Associates and the Principal Investigators in 1994. The major criteria for coral reef monitoring included Sanctuary-wide spatial coverage, repeated sampling, and statistically valid findings to document status and trends of the coral communities. Results are useful to the public, the research community, and assist managers in understanding, protecting, and restoring the living marine resources of the FKNMS.

METHODS

Sampling site locations were chosen using stratified random (US EPA E-map) procedures. Forty reef sites located within 5 of the 9 EPA Water Quality Segments were selected in the Florida Keys National Marine Sanctuary during 1994; permanent station markers were installed in 1995. Sampling was initiated in 1996 and 160 stations among 40 sites were sampled through 2000. Three additional sites were installed and sampled in the Dry Tortugas beginning in 1999 (Figure 1). The project's 43 sampling sites include 7 hardbottom, 11 patch, 12 offshore shallow, and 13 offshore deep reef sites.

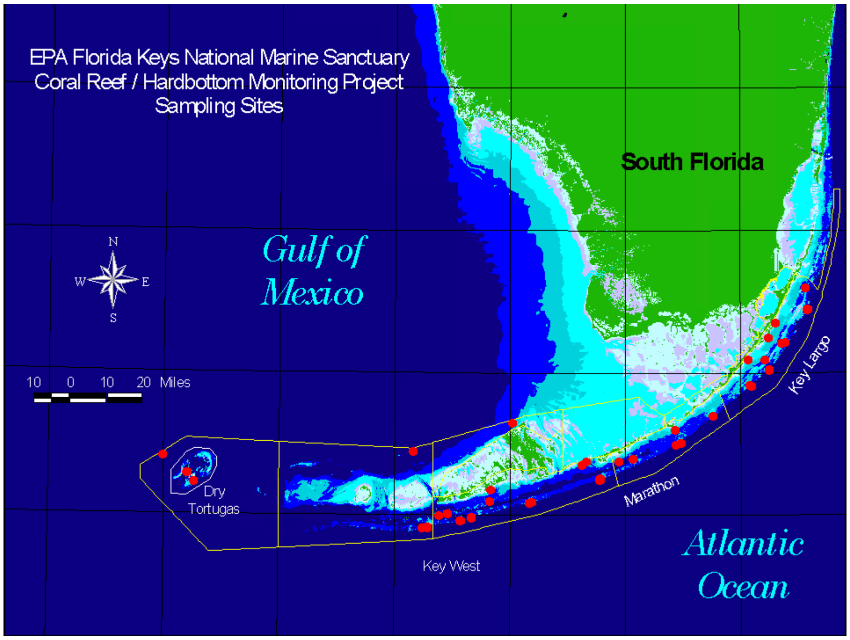
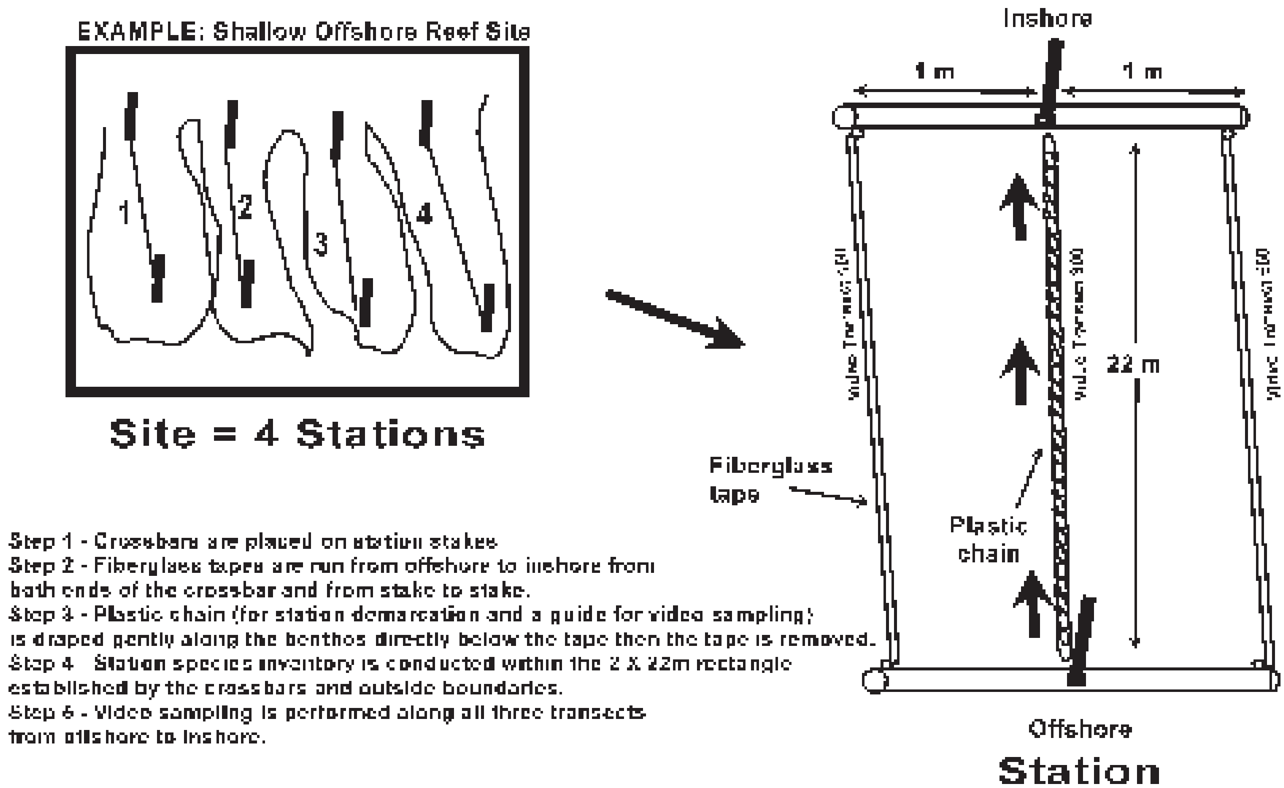


Figure 1.

Field sampling consists of station species inventories and video transects conducted at 4 stations at each site as illustrated in Figure 2.

Figure 2. Site Set-up



<u>Station Species Inventory (SSI)</u>

Counts of stony coral species (Milleporina and Scleractinia) present in each station provide data on stony coral species richness (S). Two observers conduct simultaneous timed (15min) inventories within the roughly 22 x 2 m stations and enter the data on underwater data sheets. Each observer records all stony coral taxa and fire corals and enumerates long-spined urchins (<u>Diadema</u> <u>antillarum</u>) within the station boundaries. After recording the data, observers compare (5min) data underwater and confirm species recorded by only one observer. Taxonomic differences are addressed. Data sheets are verified aboard the vessel and forwarded to FMRI for data entry and processing. This method facilitates data collection with broad spatial coverage at optimal expenditure of time and labor.

<u>Diseases/Conditions</u>

During the timed species count, if any species within a station exhibits specific signs of either bleaching or disease (black band, white complex and other), the appropriate code letter is entered for the species on the data sheet.

Videography

All sampling through 1999 was conducted with a Sony CCD-VX3 with full automatic settings and artificial lights (two 50 watt) at 40 cm above the benthos. Beginning in 2000, the project upgraded to digital video filming all sites with a SONY TRV 900. A convergent laser light system indicates distance from the reef surface for filming. The videographer films a clapperboard prior to beginning each transect. A complete record of date and location of each film segment is recorded. Filming is conducted at a constant swim speed of about 4 m/minute yielding approximately 9,000 video frames per transect. Images for all transects are framegrabbed, written to and archived on CD-ROM.

Image Analyses

Camera settings are optimized for quality of individual frames. Although approximately 9000 frames of video are collected for each transect, only 120 frames of imagery are digitized for analysis. CRMP video analysis uses only captured still imagery. Percent cover analysis is predicated on selecting video frames that abut, with minimal overlap between images. At the filming distance of 40cm above the reef surface, the field of view is 40cm wide. About 60 abutting frames are required to capture a 20 meter transect in 40 cm segments. Therefore, of the original 120 digitized images, each trained analyst selects a subset of about 60 abutting frames. Image analysis is conducted using a custom software application PointCount for coral reefs. When the analyst opens each image, the software inserts ten random points over the image. Selected benthic taxa (stony coral, octocoral, zoanthid, sponge, seagrass and macroalgae) and substrate are identified under each point. The software has a "point and click" feature that feeds the identification data into a backend spreadsheet. After all images are analyzed, the data is converted to an ASCII file for Quality Assurance and entry into the master ACCESS data set.

Statistical Analyses

In addition to the descriptive methods of organizing and summarizing the data, hypothesis testing was performed to analyze the percent cover, species richness, and disease/condition data. The decision to reject or not to reject the null hypothesis that there is no significant difference in the data for certain years is based on the minimum detectable difference for different significance levels and powers. Six combinations for significance level (α) and power ($1-\beta$) were considered: $\alpha = 0.05$, $1-\beta = 0.75$; $\alpha = 0.10$, $1-\beta = 0.75$; $\alpha = 0.20$, $1-\beta = 0.75$; $\alpha = 0.05$, $1-\beta = 0.80$; $\alpha = 0.10$, $1-\beta = 0.80$; and $\alpha = 0.20$, $1-\beta = 0.80$. When the one-sided alternative is tested, the above values for alpha must be divided by two. The output consists of the minimum detectable difference for a certain pair (α, $1-\beta$), which can be used to construct a $(1-\alpha)$ % confidence interval and provides a measure of the test accuracy.

Video Data

To ensure at least 90% similarity between point assessments of the observers, the Bray-Curtis dissimilarity measure was performed. Each species was assigned a coefficient of dissimilarity based on the interobserver data files. In addition to the three principal investigators, the point assessments of three additional observers were included. The list of species in a station was reviewed, and if necessary, the rare (below 5% contribution) species were combined into a category "other" until the sum of the coefficients of the species present became less than 10%. Hypotheses for difference between species proportions on a the station level were tested:

- within stony coral, i.e., a particular species vs. total stony coral
- total stony coral vs. total coral coverage.

The conditions for normality were met and hypothesis testing was completed between two proportions for all pair-wise comparisons between the years: 1996 vs. 1997, 1997 vs. 1998, and 1996 vs. 1998. The output is the minimum detectable difference between the two proportions for three significance levels (0.05, 0.10, and 0.20) and two power levels (0.75 and 0.80).

Tests were run for: $H_0 : p_1 = p_2$ vs. $H_1 : p_1 \neq p_2$ If either one of the one-sided alternatives is of interest $H_1 : p_1 > p_2$ $H_1 : p_1 < p_2$ then the above significance level must be divided by two. To perform the above hypothesis testing, an S-PLUS code is written**.**

Results presented herein are for the significance level of 0.20 (0.10 for a one-sided alternative) and power of 0.75. Three colors signify change as follows: yellow - no significant change; green - significant increase; and red - significant decrease. The results for increase or decrease of one particular stony coral species are conditional on the total stony corals. For instance, if the total stony coral decreases then the contribution of one species within stony coral could increase even if the presence of this species is not changed.

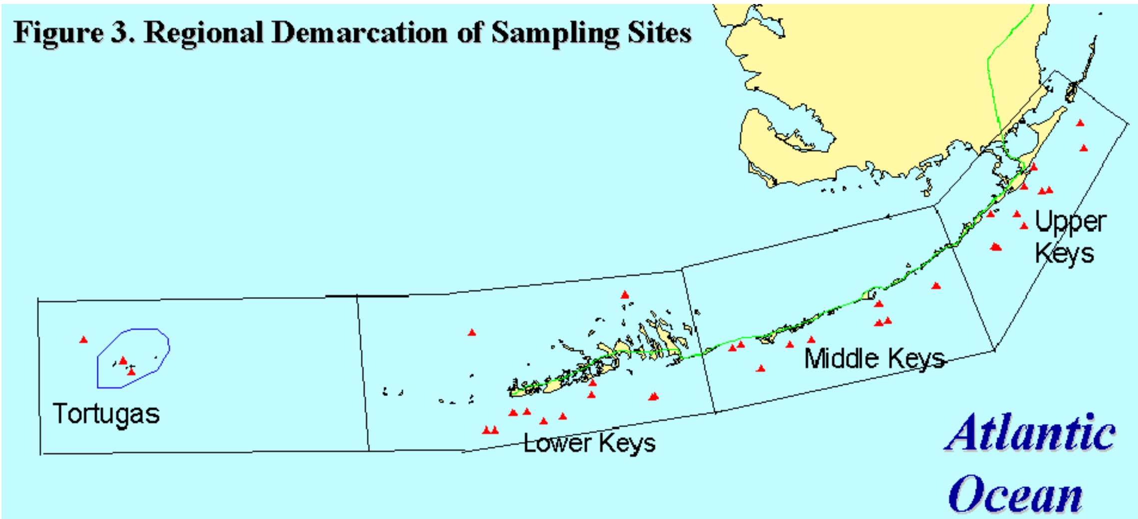
Species Inventory and Disease / Condition Data

To study the species richness, the hypothesis of whether there is difference in the proportion of the number of stations where each species is present was tested. Results are sanctuary-wide. Species richness is highly influenced by presence/absence of the relatively rare species. In this sense, results are complementary to those from the coral cover hypothesis testing.

Pair-wise tests were run for total stony coral and for individual species with adequate data,
to determine whether there was significant change in number of stations with presence of a certain disease/condition from 1996 to 2000.

RESULTS

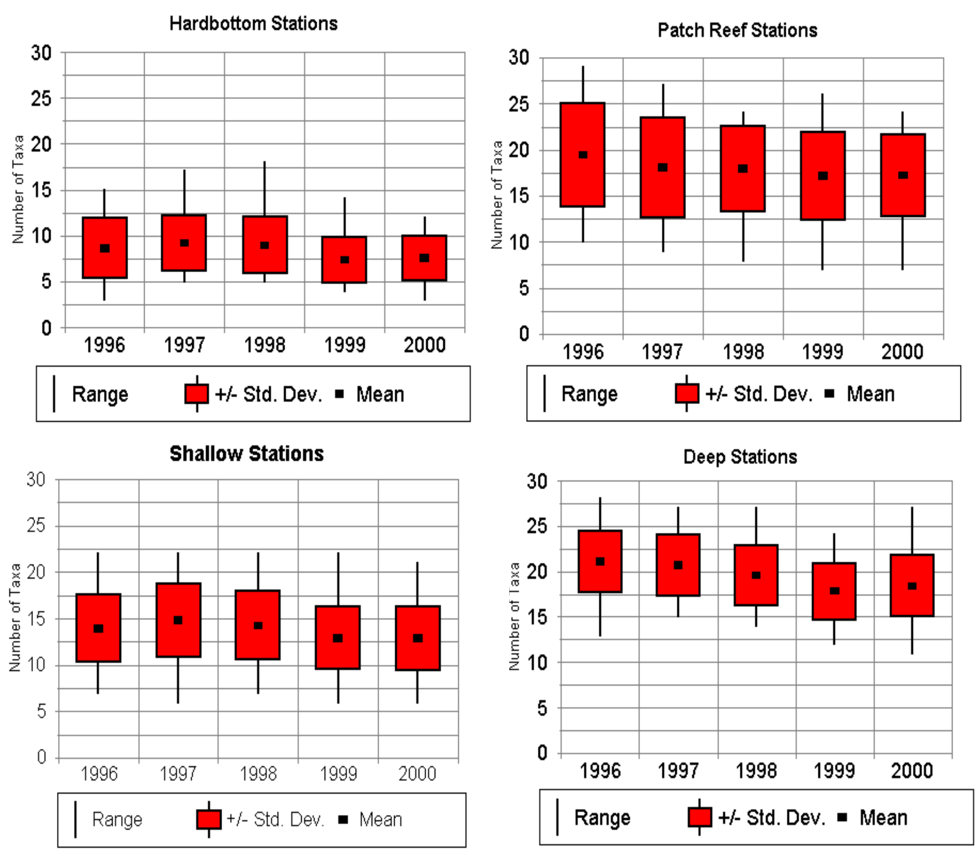
Results are reported by regions defined as follows: Upper Keys (north Key Largo to Conch Reef), Middle Keys (Alligator Reef to Molasses Keys), Lower Keys (Looe Key to Smith Shoal), and Tortugas (Dry Tortugas to Tortugas Banks) (Figure 3).



Stony Coral Species Richness

The offshore deep and patch reef stations had the greatest numbers of stony coral taxa. The least number of stony coral were observed at hardbottom stations. (Figure 4).

Figure 4. Species Richness by Habitat Type, 160 stations, 1996-2000



Between 1996 and 2000, in the upper keys, there was a loss of stony coral species at 32 of 52 stations (61.5%); 11 stations gained species, and at nine stations, presence of stony coral species was unchanged (Figure 5).

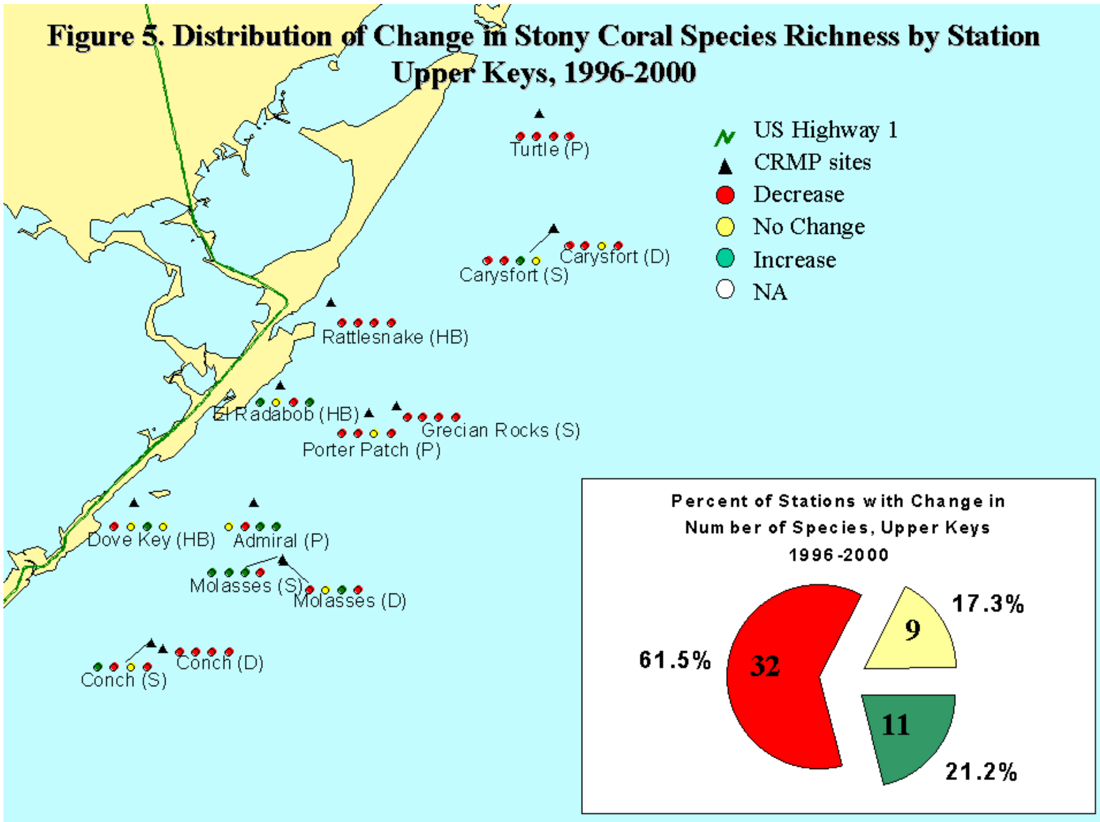


Figure 5. Distribution of Change in Stony Coral Species Richness by Station Upper Keys, 1996-2000

In the middle keys, 32 of 44 stations (72.7%) lost stony coral species; six stations gained species, and six stations were unchanged (Figure 6).

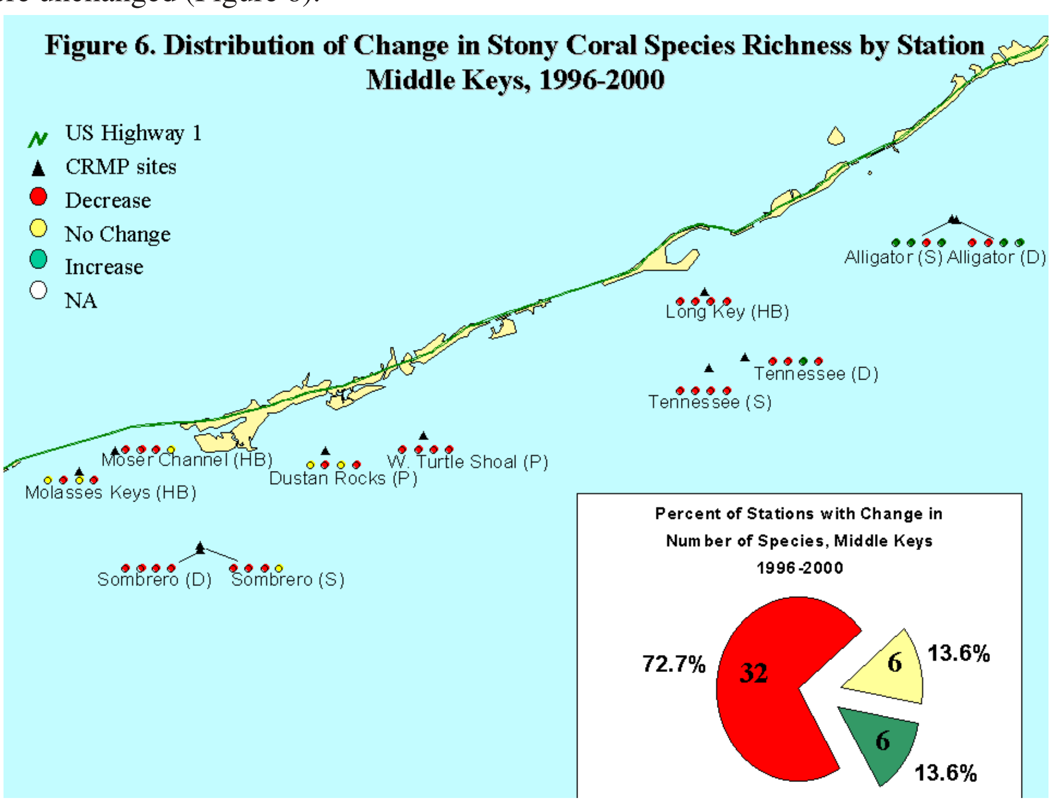


Figure 6. Distribution of Change in Stony Coral Species Richness by Station Middle Keys, 1996-2000

In the lower keys, 43 of 64 stations (67.2%) lost stony coral species; 15 stations gained species, and 6 stations were unchanged (Figure 7).

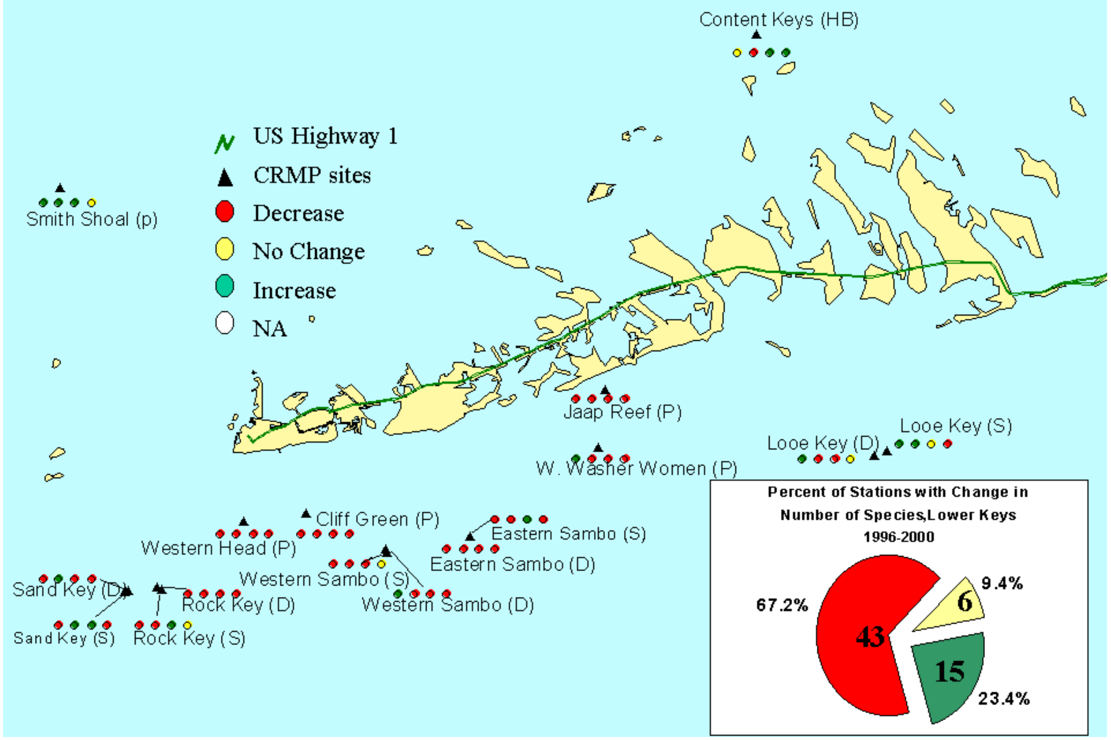


Figure 7. Distribution of Change in Stony Coral Species Richness by Station Lower Keys, 1996-2000

Between 1996 and 2000, Smith Shoal Station 2 had the maximum of five stony coral species gained. Greatest losses in stony coral species richness were at Carysfort Deep Station 4, Cliff Green Station 2, and Conch Deep Station 1, each lost nine species. By habitat type, 16 of 28 (57.1%) hardbottom stations had stony coral species losses; five hardbottom stations gained, and seven stations were unchanged. Twenty-nine (72.5%) of 40 patch reef stations had stony coral species losses; six stations gained, and five stations were unchanged. For shallow reef stations, 28 of 48 (58.3%) showed stony coral species losses; 14 stations gained, and six were unchanged. Thirty-four of 44 (77.3%) deep reef stations had stony coral species losses; seven stations gained, and three stations were unchanged (Table 1).

Table 1. Number of Stations with Change in Number of Stony Coral Species, by Habitat Type, 1996-2000

Habitat Type	Hardbottom			Patch			Shallow			Deep		
Status	Lost	Gained	No Change	Lost	Gained	No Change	Lost	Gained	No Change	Lost	Gained	No Change
Lower Keys	1	2	1	15	4	1	11	6	3	16	3	1
Middle Keys	9	0	3	6	0	2	8	3	1	9	3	0
Upper Keys	6	3	3	8	2	2	9	5	2	9	1	2
Total	16	5	7	29	6	5	28	14	6	34	7	3
Percent	57.1%	17.9%	25.0%	72.5%	15.0%	12.5%	58.3%	29.2%	12.5%	77.3%	15.9%	6.8%

Between 1999 and 2000, in the upper keys, 20 stations (38.5%) had an increase in stony coral species present, 16 stations (30.8%) showed a decrease and 16 stations were unchanged (Figure 8).

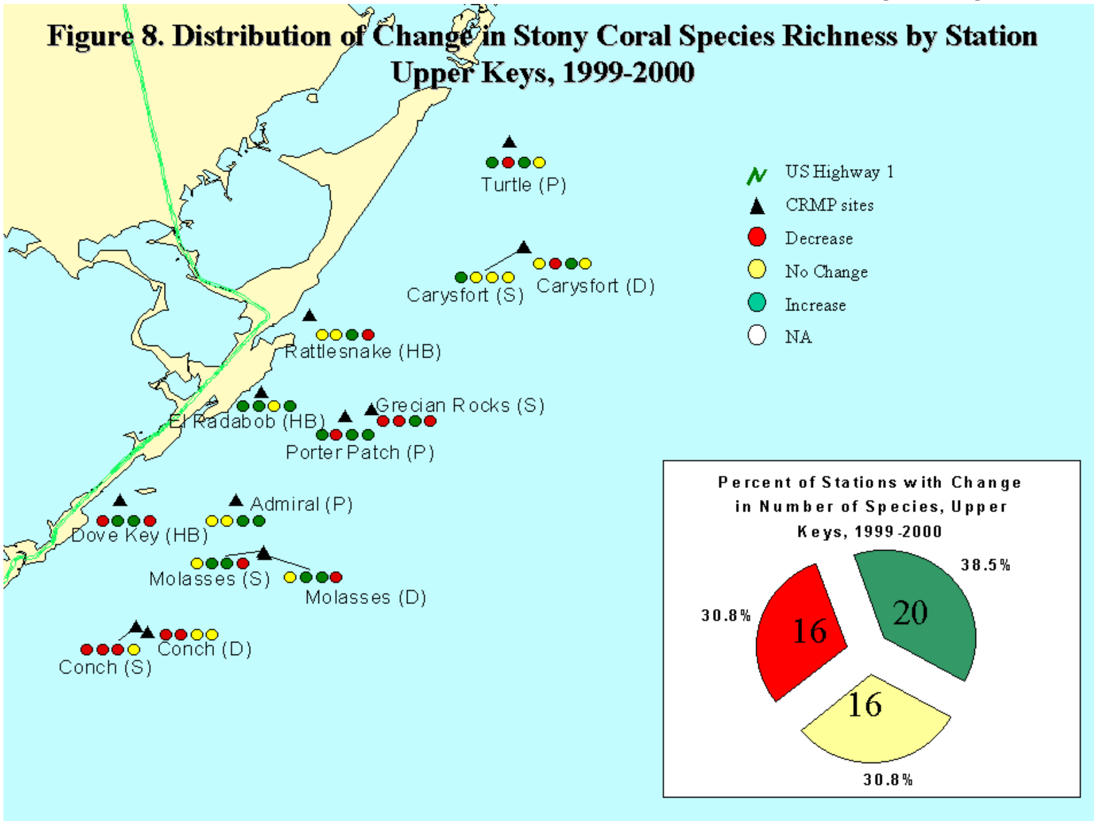


Figure 8. Distribution of Change in Stony Coral Species Richness by Station Upper Keys, 1999-2000

In the middle keys, 19 stations (43.2%) lost stony coral species, 17 stations (38.6%) gained and 8 stations (18.2%) were unchanged (Figure 9).

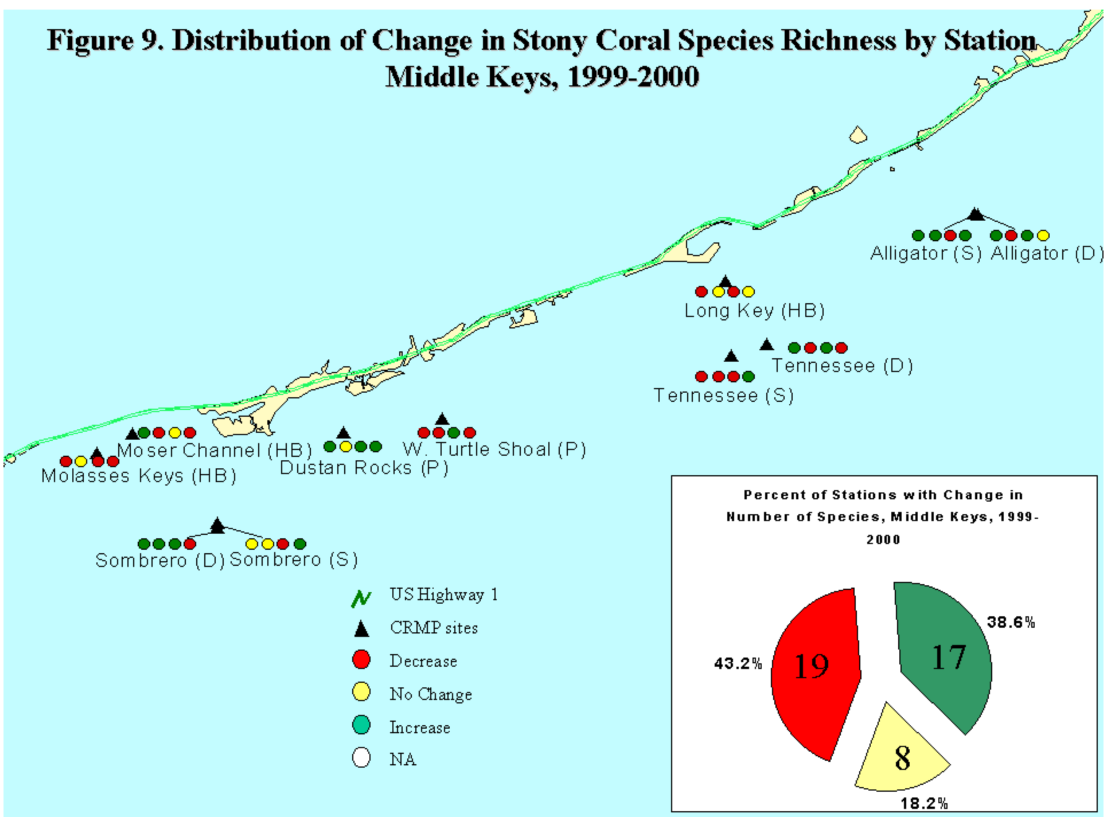
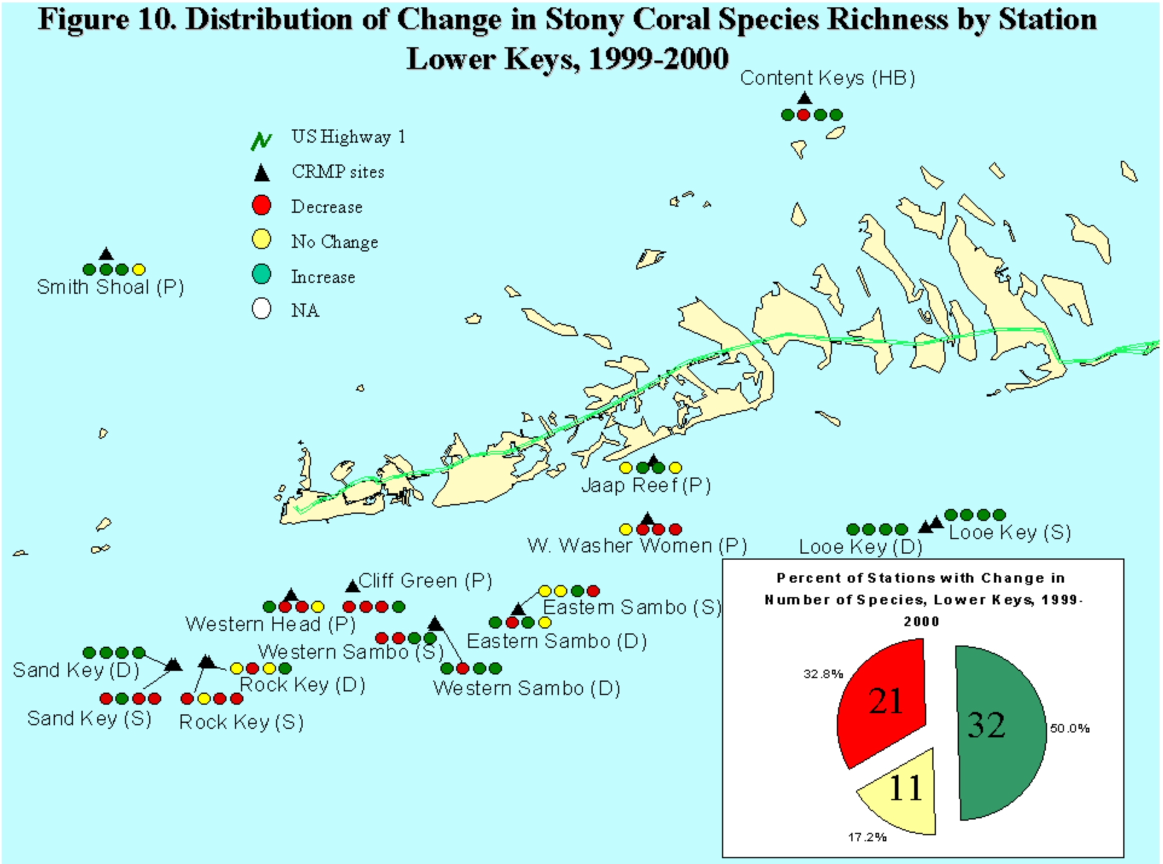
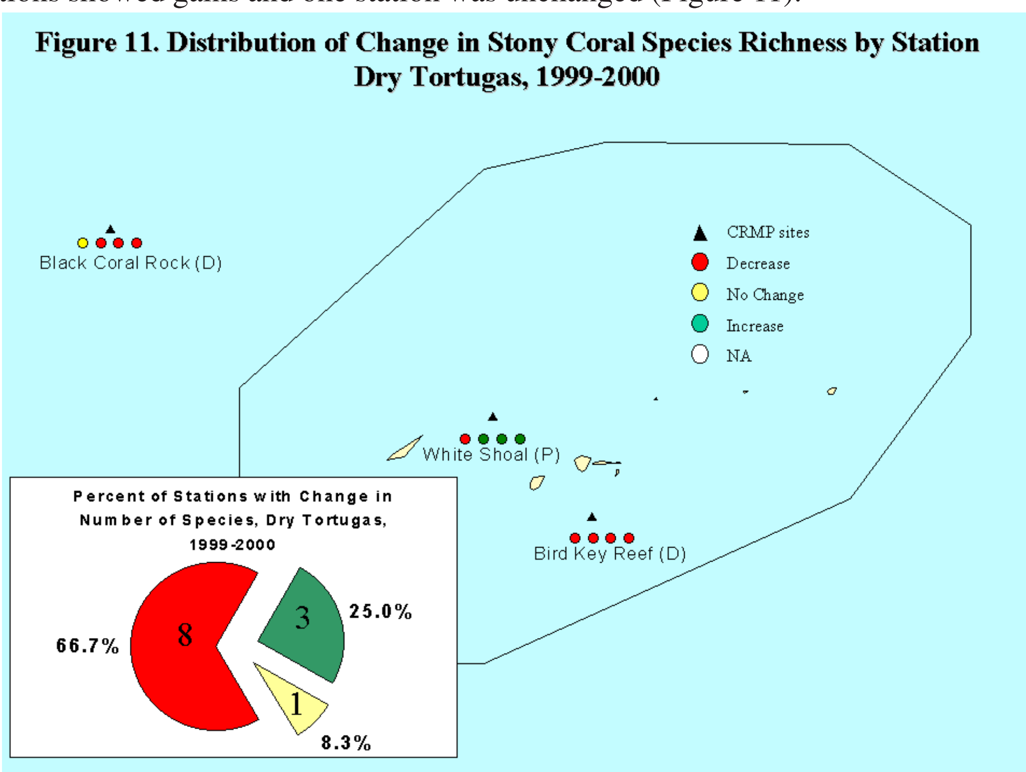


Figure 9. Distribution of Change in Stony Coral Species Richness by Station Middle Keys, 1999-2000

In the lower keys, 32 stations (50.0%) showed an increase in the number of species present, 21 stations (32.8%) had a decrease and 11 stations (17.2%) were unchanged (Figure 10).



In the Dry Tortugas, 8 stations (66.7%) showed a decrease in the number of stony coral species identified, 3 stations showed gains and one station was unchanged (Figure 11).



Sanctuary-wide from 1996 to 2000, stony coral species richness declined at 107 stations, 32 stations had a gain in species richness and species richness was unchanged at 21 stations. Although the overall trend for all 5 years was a decline in species richness, for 1999 to 2000 about half as many stations lost species (56 vs 107 stations) and more than twice as many stations (69 vs 32 stations) gained species. For the 160 original stations between 1999 and 2000, 69 stations showed an increase in number of stony coral species present, 56 stations decreased and 35 stations stayed the same. For patch reef stations, 18 stations showed an increase in stony coral species present, 13 stations decreased and 9 stations stayed the same. At shallow reef stations stony coral species richness declined at 21 stations, increased at 17 stations and was unchanged at 10 stations. For deep reef stations, an increase in stony coral species richness was documented at 24 stations, while 11 stations declined and the remaining 9 stations were unchanged. Eleven hardbottom stations had a loss in stony coral species richness versus 10 stations that showed an increase and 7 stations that were unchanged.

Stony Coral Species Richness Analyses

For successive years sampling between 1996, 1997 and 1998, there was no significant change in the presence of the majority of stony coral species sampled Sanctuary-wide. Between 1998 and 1999, significant losses were recorded for four stony coral species (*Millepora alcicornis, Mycetophyllia danaana, Mycetophyllia ferox, and Porites porites)* and significant gains were recorded for *Oculina diffusa and Scolymia lacera.* Again, between 1999 and 2000, for the the majority of stony coral species, there was no significant change in their presence Sanctuary-wide. However, when the first and last years data was compared, eight stony coral species (*Acropora cervicornis, Leptoseris cucullata, Millepora alcicornis and Millepora complanata, Mycetophyllia danaana, ferox and lamarckiana and Porites porites*) had experienced a significant loss. Only *Agaricia fragilis* showed a significant gain over the time span sampled (Table 2).

Table 2. Significant Change in Stony Coral Species Presence, Sanctuary-wide, 1996-2000

Species	96-97	97-98	98-99	99-00	96-00
Acropora cervicornis	0	0	0	0	L
Acropora palmata	0	0	0	0	0
Agaricia agaricites complex	0	0	0	0	0
Agaricia fragilis	G	0	0	0	G
Agaricia lamarcki	0	0	0	0	0
Astrangia poculata					
Astrangia solitaria					
Cladacora arbuscula	0	0	0	0	0
Colpophyllia natans	0	0	0	0	0
Dendrogyra cylindrus					
Dichocoenia stokesii	0	0	0	0	0
Diploria clivosa	0	0	0	0	0
Diploria labyrinthiformis	0	0	0	0	0
Diploria strigosa	0	0	0	0	0
Eusmilia fastigiata	0	0	0	0	0
Favia fragum	0	0	0	0	0
Isophyllastrea rigida					
Isophyllia sinuosa					
Leptoseris cucullata	0	0	0	0	L
Madracis decactis	0	0	0	0	0
Madracis mirabilis	0	0	0	0	0
Madracis pharensis					
Manicina areolata	0	0	0	0	0
Meandrina meandrites	0	0	0	0	0
Millepora alcicornis	0	L	L	0	L
Millepora complanata	0	0	0	0	L
Montastraea annularis complex	0	0	0	0	0
Montastraea cavernosa	0	0	0	0	0
Mussa angulosa	0	0	0	0	0
Mycetophyllia aliciae	0	0	0	0	0
Mycetophyllia danaana	0	0	L	0	L
Mycetophyllia ferox	0	0	L	0	L
Mycetophyllia lamarckiana	0	0	0	0	L
Oculina diffusa	0	0	G	0	0
Oculina robusta					
Phyllangia americana	0	0	0	0	0
Porites astreoides	0	0	0	0	0
Porites branneri					
Porites porites	0	0	L	0	L
Scolymia cubensis	0	0	0	0	0
Scolymia lacera	0	0	G	L	0
Siderastrea radians	0	0	0	0	0
Siderastrea siderea	0	0	0	0	0
Solenastrea bournoni	0	0	0	0	0
Solenastrea hyades					
Stephanocoenia michelinii					
		G	= Significant Increase		
		L	= Significant Decrease		
		0	= No Significant Change		

Coral Condition

In general, scleractinian corals in CRMP stations Sanctuary-wide, experienced a significant increase in disease infections from 1996 to 2000 (Table 3). Significance for reported disease conditions are presented in Table 3 for all 160 stations over time.

Table 3. Significance of change in disease conditions recorded at stations between 1996-2000 $\alpha = 0.10$ and $1-\beta = 0.75$.

Time Frame	1996-1997	1997-1998	1998-1999	1999-2000	1996-2000
Black Band	Significant Increase	Significant Increase	Significant Decrease	No Significant Change	No Significant Change
White Complex	Significant Increase	Significant Increase	No Significant Change	No Significant Change	Significant Increase
Other Diseases	Significant Increase	Significant Increase	Significant Increase	No Significant Change	Significant Increase

All disease conditions exhibited increasing frequency of coral infection from 1996-1997 and 1997-1998. There was significant decrease in Black Band disease in 1998-1999. From 1999–2000 there was no significant change in disease infections. Over the 5 years, there was a significant increase in White Complex disease, and other diseases significantly increased. Overall, there were increases in the number of stations containing diseased coral, the number species with disease, and the different types of diseases that were observed.

Stony Coral Cover

Sanctuary-wide, a general trend of decline in stony coral cover is presented in Figure 12. The decline in mean percent coral cover from 1997 to 1998 and from 1998 to 1999 was significant with a p-value of 0.03 or less for the Wilcoxon rank-sum test. The change observed from 1996 to 1997 and from 1999 to 2000 was determined to be insignificant.

Figure 12. Mean Percent Stony Coral Cover Sanctuay Wide, 160 Stations, 1996-2000

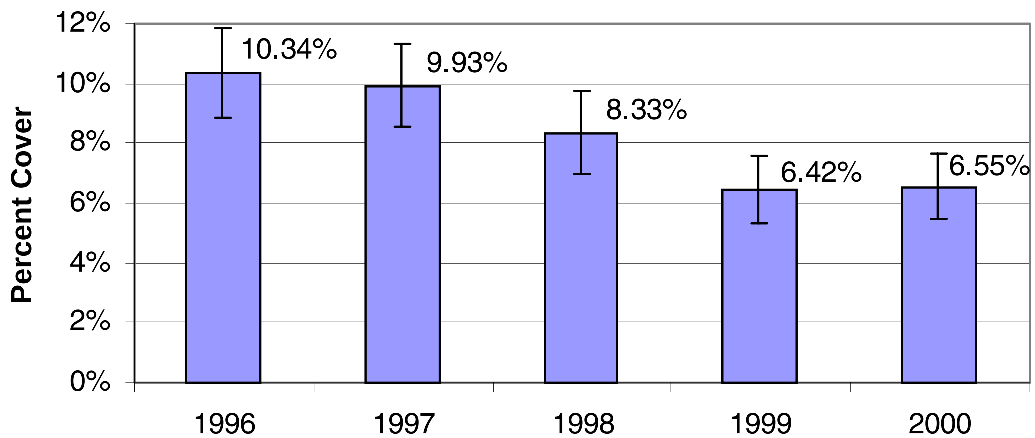
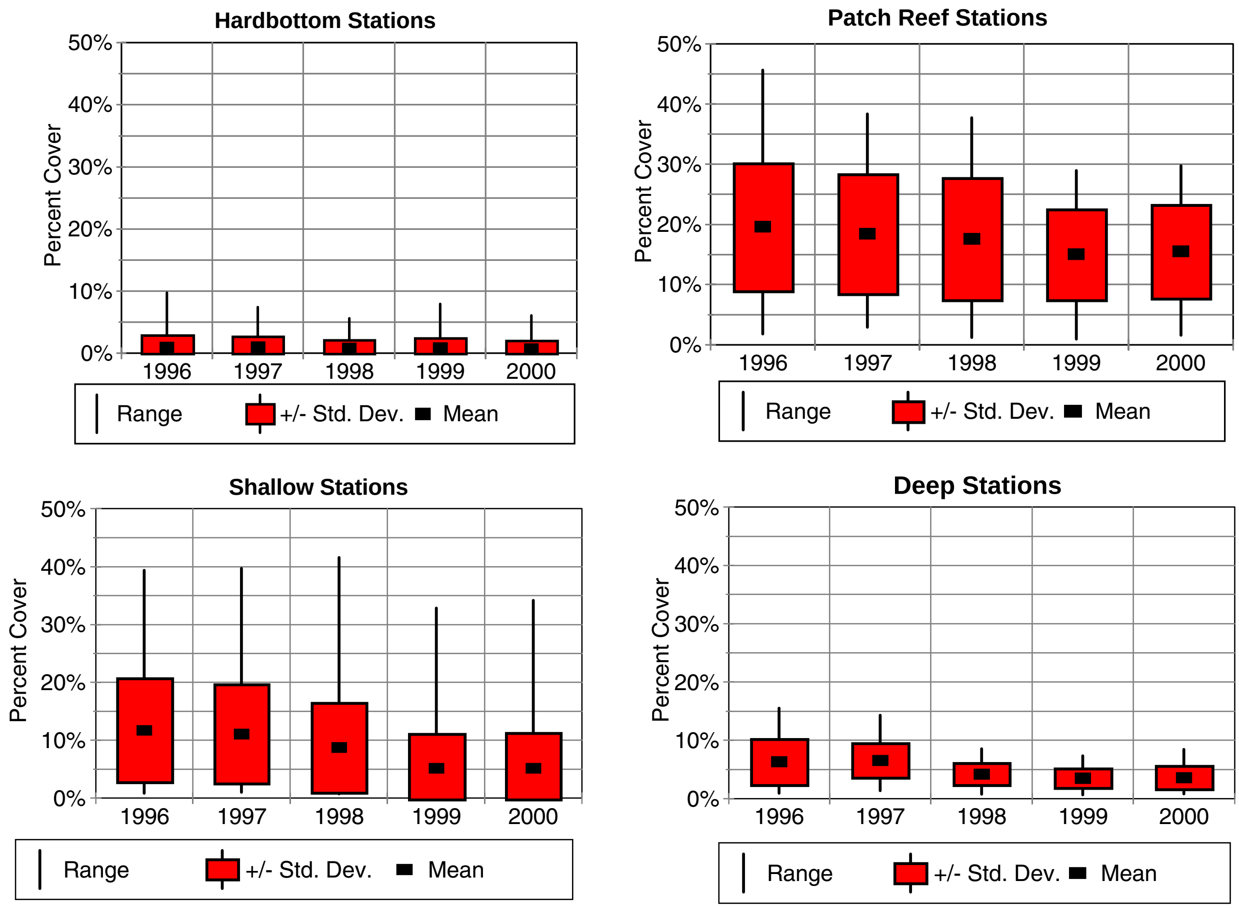


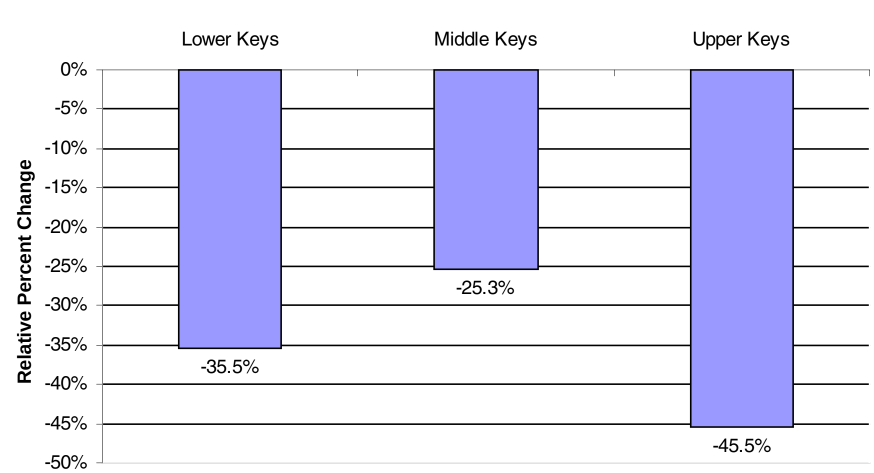
Figure 13. Mean Percent Stony Coral Cover by Habitat Type, 160 Stations, 1996-2000.



For 1996 through 2000, stony coral cover by habitat type and year is provided in Figure 13. Greatest mean percent stony coral cover was consistently observed at patch reef stations.

Regionally, there was a greater relative change in mean stony coral cover in the upper keys (Figure 14). Additionally, a greater percent of upper keys stations showed significant loss of coral cover compared with lower and middle keys stations.

Figure 14. Relative Change in Percent Stony Coral Cover by Region, 1996-2000



Mean percent stony coral cover declined every year from 1996 to 1999 Sanctuary-wide. A slight increase in mean percent stony coral cover was documented from 1999 to 2000 (Figure 15). The lower and middle keys mean percent stony coral cover mimics the Sanctuary-wide trend; however, coral cover in the upper keys continued to decline.

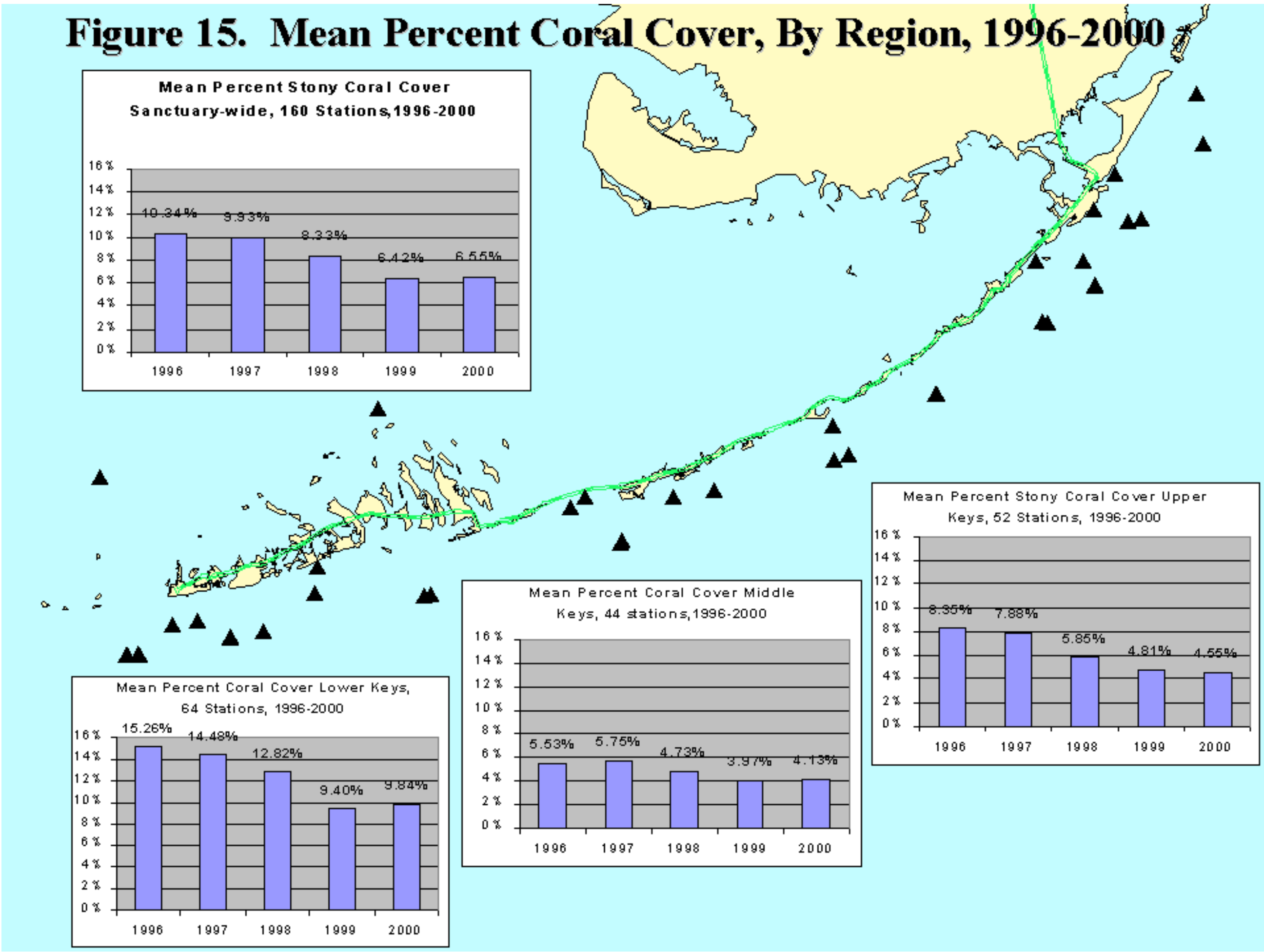
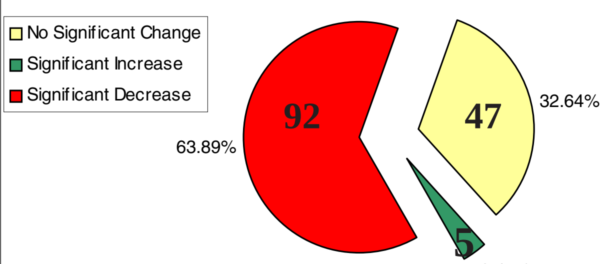


Figure 15. Mean Percent Coral Cover, By Region, 1996-2000

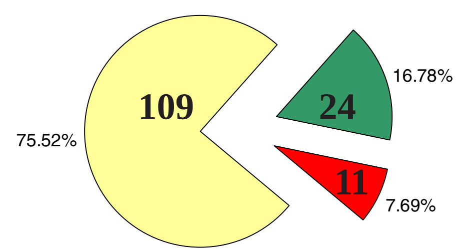
From 1996 through 2000, 144 stations had sufficient data for analysis. Of the 144 stations analyzed, coral cover significantly decreased at 92 stations (63.9%), showed no significant change at 47 stations (32.6%), and gained significantly at only 5 stations (3.5%) (Figure 16a). From 1999 to 2000, the overall trend of declining stony coral cover appears to have halted. Stony coral cover was statistically unchanged at 109 stations (75.2%), but significantly increased at 24 stations (16.8%), and decreased significantly at only 11 stations (7.7%) (Figure 16b).

Figure 16a. Percent of Stations with Significant Change in Stony Coral Cover Sanctuary-Wide, 1996-2000

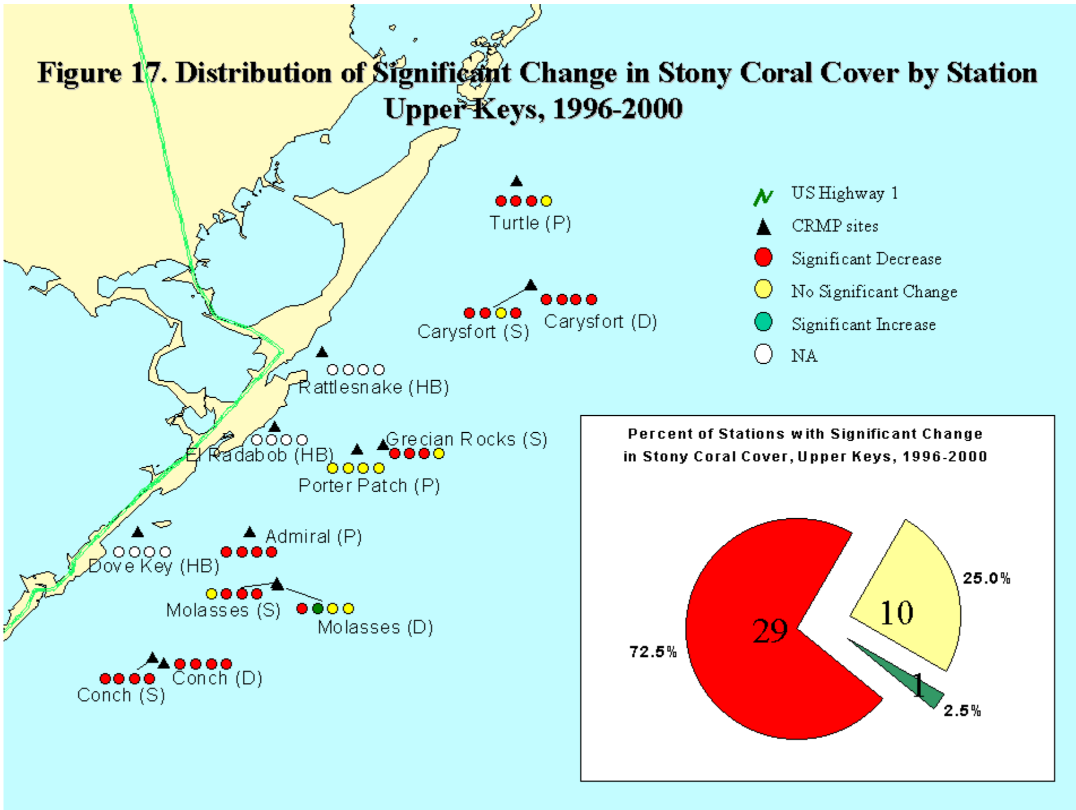


$\alpha = 0.10$ (one-sided alternative) $1\text{-}\beta = 0.75$

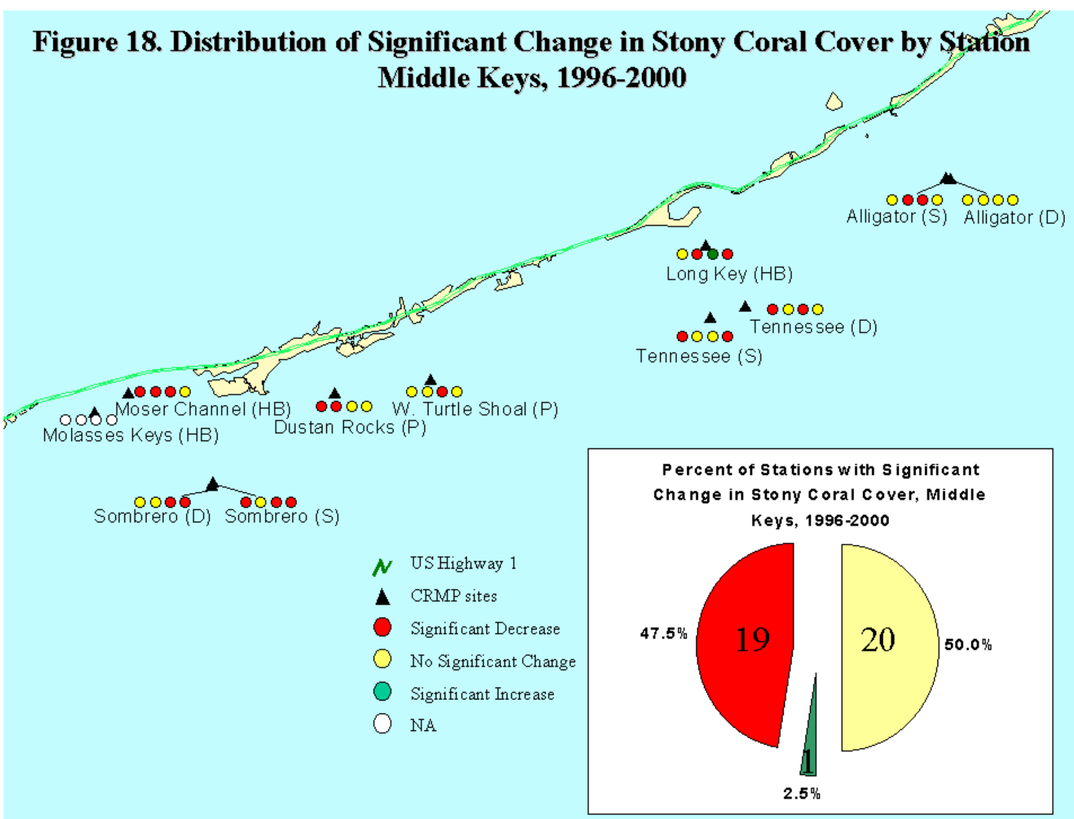
Figure 16b. Percent of Stations with Significant Change in Stony Coral Cover Sanctuary-Wide, 1999-2000



In the upper Keys, 29 stations (72.5%) experienced significant loss of coral cover, 10 (25.0%) had no significant change and only one station experienced a significant gain in coral cover (Figure 17).



In the middle Keys, 19 stations (47.5%) experienced significant coral cover losses, 20 stations (50.0%) had no significant change and only one station gained significant coral cover (Figure 18).



In the lower Keys, 44 stations (68.8%) lost a significant amount of coral cover, 17 stations (26.6%) had no significant change and 3 stations (4.7%) showed a significant gain in coral cover (Figure 19).

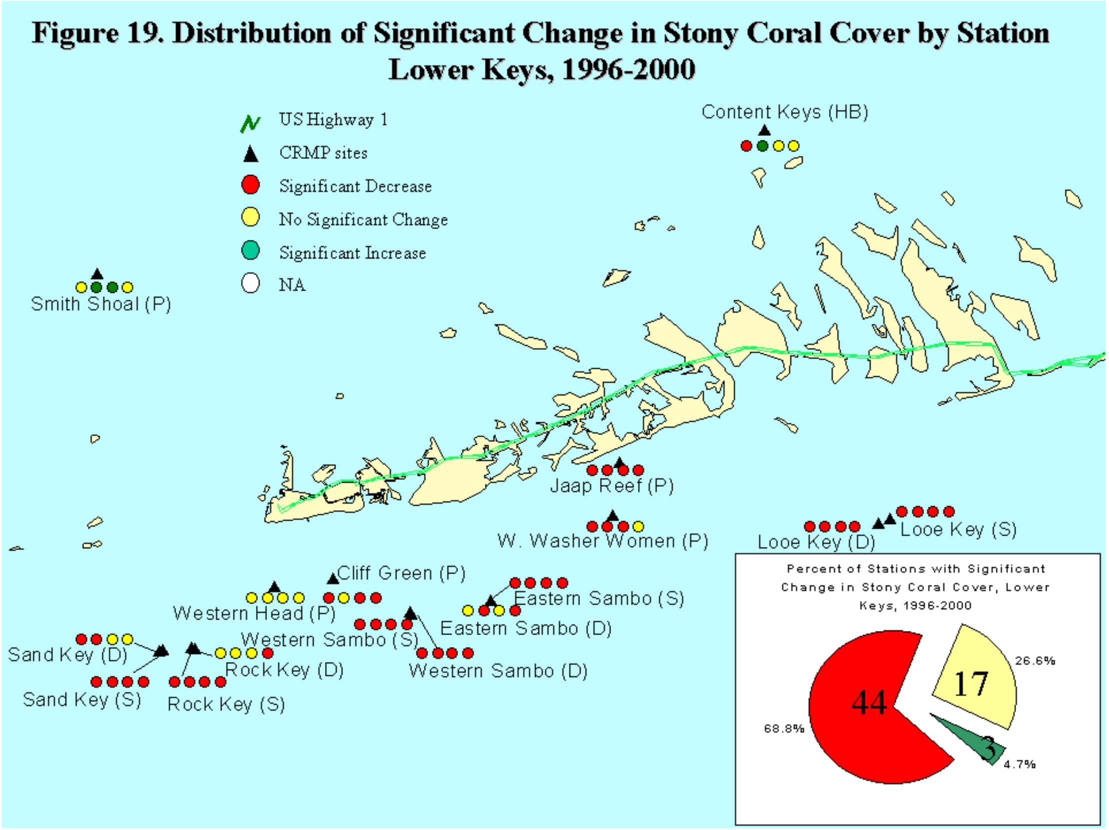


Figure 19. Distribution of Significant Change in Stony Coral Cover by Station Lower Keys, 1996-2000

In the upper keys, coral cover was statistically unchanged at 27 stations (67.5%), 7 stations (17.5%) experienced a significant increase and 6 stations (15.0%) had a significant decrease (Figure 20).

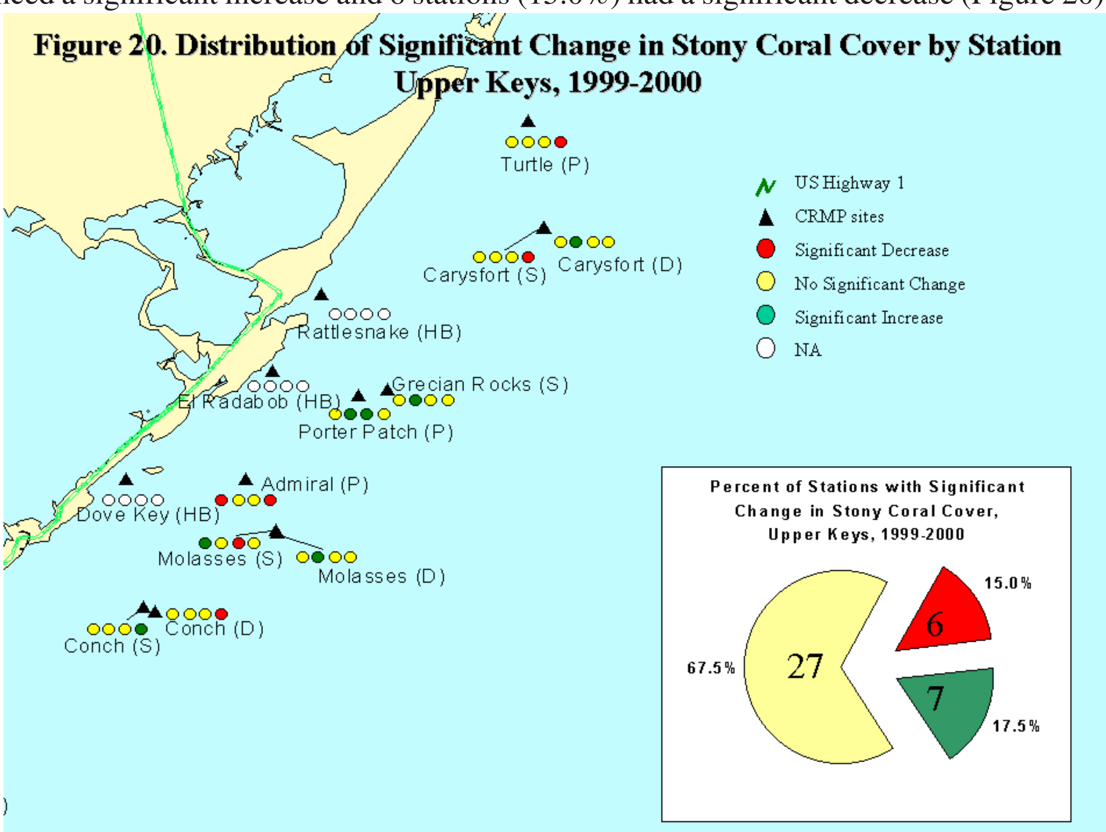
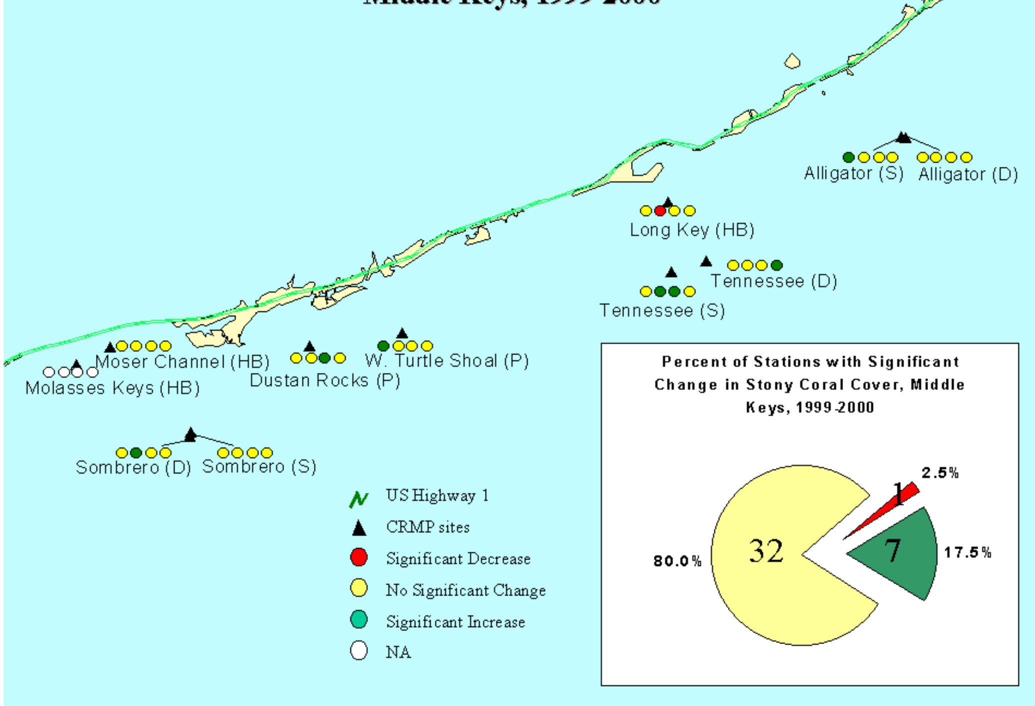


Figure 20. Distribution of Significant Change in Stony Coral Cover by Station Upper Keys, 1999-2000

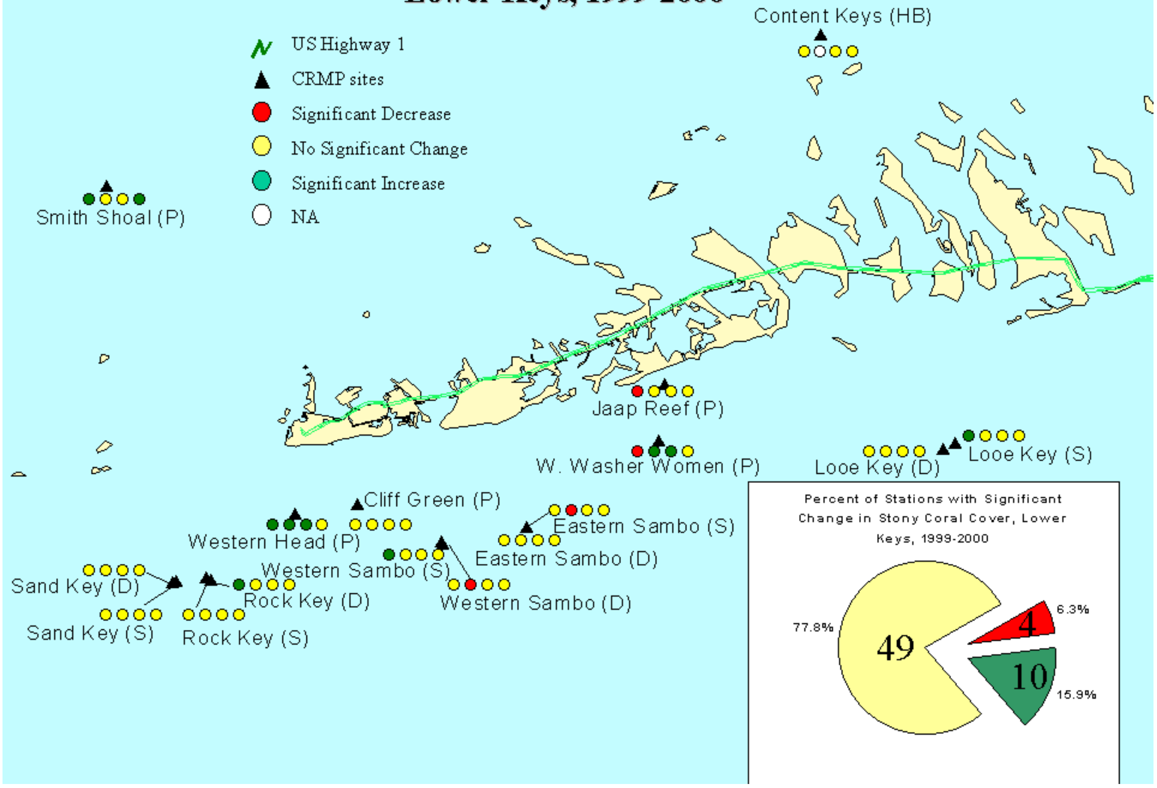
In the middle keys, 32 stations (80.0%) showed no change in coral cover, 7 stations (17.5%) had a significant increase and only one station had a significant decrease (Figure 21).

Figure 21. Distribution of Significant Change in Stony Coral Cover by Station Middle Keys, 1999-2000



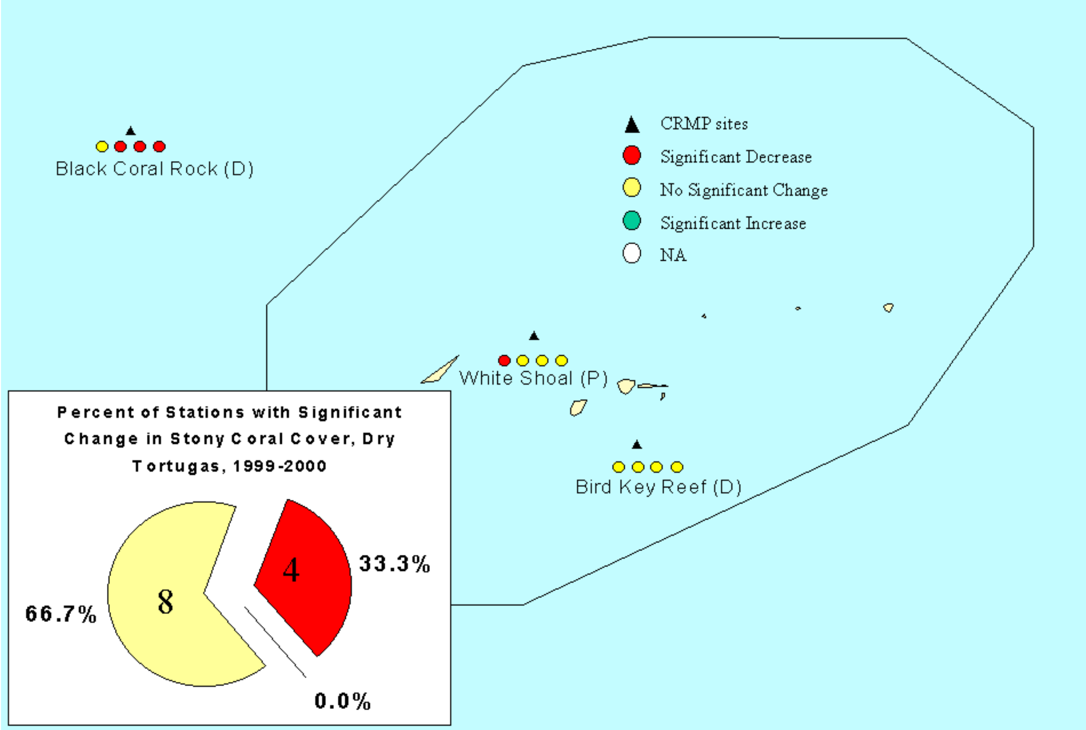
In the lower keys (Figure 22), analysis revealed no significant change in coral cover at 49 stations (77.8%), significant increase at 10 stations (15.9%) and significant decrease at 4 stations(6.3%).

Figure 22. Distribution of Significant Change in Stony Coral Cover by Station Lower Keys, 1999-2000



In the Dry Tortugas, for 1999-2000, 8 stations (66.7%) had no significant change in stony coral cover and 4 stations (33.3%) had a significant loss (Figure 23).

Figure 23. Distribution of Significant Change in Stony Coral Cover by Station Dry Tortugas, 1999-2000



By habitat type, for 1996-2000, 20 patch reef stations (50.0%) lost significant cover, for 18 stations (45.0%) cover was statistically unchanged and 2 stations (5.0%) had a significant gain in coral cover. For offshore shallow sites, 40 stations (83.3%) had significant loss of coral cover, 8 stations (16.7%) had no significant change in cover and no station exhibited a significant gain. In the offshore deep habitat, 26 stations (59.1%) lost significant coral cover, 17 stations (38.6%) had no significant change in cover and only one gained significant cover (Table 4). For the hardbottom habitat stations with very sparse coral cover, hypothesis testing was applicable in only 12 of 28 stations. Overall, there were significant losses in coral cover for 71.7% of offshore reef stations, both shallow and deep.

Table 4. Number of stations with statistically significant change in coral cover by habitat type, 1996-2000. (alpha =0.1, 1-beta = 0.75)

Habitat Type	Hardbottom			Patch			Shallow			Deep		
Status	Lost	Gained	No Change	Lost	Gained	No Change	Lost	Gained	No Change	Lost	Gained	No Change
Lower Keys	1	1	2	10	2	8	20	0	0	13	0	7
Middle Keys	5	1	2	3	0	5	7	0	5	4	0	8
Upper Keys	0	0	0	7	0	5	13	0	3	9	1	2
Total	6	2	4	20	2	18	40	0	8	26	1	17
Percent	50.0%	16.7%	33.3%	50.0%	5.0%	45.0%	83.3%	0.0%	16.7%	59.1%	2.3%	38.6%

Functional Group Cover

Percent cover data for functional groups were analyzed for the geographic regions 1996 to 2000. Functional groups included: stony corals, octocorals, zoanthids, sponges, macroalgae, seagrass, and substrate (rock, rubble and sediments). Zoanthid and seagrass perent cover values are too low to represent graphically. In all three geographic regions, stony coral, sponge and octocoral cover decreased (Figures 24, 25, 26) wheras macroalgae (Figures 24, 25, 26) and substrate cover (Figure 27) increased. Macroalgae percent cover exhibits higher variability than all other functional groups.

Percent cover of functional groups has been analyzed by habitat type from 1996 to 2000. Generally, functional group cover trends mimic those observed at the regional level. Macroalgae percent cover increased dramatically at deep stations but declined slightly in the other three habitat types. Sponge percent cover decline was greater in deep and shallow stations than in patch and hardbottom stations. Zoanthid cover decreased sharply at deep and hardbottom stations, but increased slightly at shallow and patch stations.

Percent Stony Coral Cover Species Analyses

An understanding of the overall trend in stony coral cover can be gained through further analysis of change in percent cover of the most common species. In Figure 28, the six species with the greatest percent coral cover in 1996 were *Montastraea annularis* (3.39%), *M. cavernosa* (1.36%), *Acropora palmata* (0.90%), *Siderastrea siderea* (0.87%), *Millepora complanata* (0.80%) and *Porites astreoides* (0.55%). *M. annularis* represents approximately 33% of the coral cover at CRMP stations Sanctuary-wide. The relative percent cover of *M. annularis* and *M. cavernosa* increased (Figure 29) although their mean cover decreased (*M. annularis* 3.39% in 1996 to 2.41% in 2000 and *M. cavernosa* 1.36% in 1996 to 1.22% in 2000).

Figure 24. Mean Percent Cover of Functional Groups, Upper Keys, 1996-2000

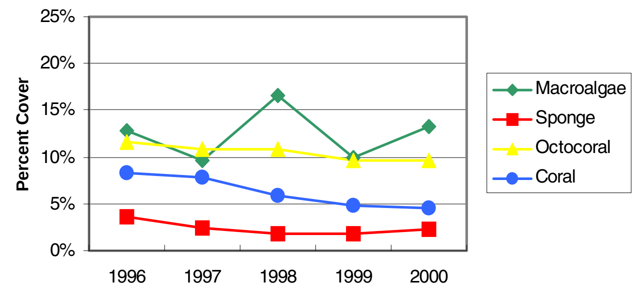


Figure 25. Mean Percent Cover of Functional Groups, Middle Keys, 1996-2000

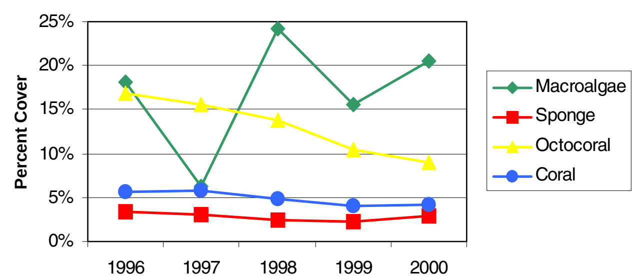


Figure 26. Mean Percent Cover of Functional Groups, Lower Keys, 1996-2000

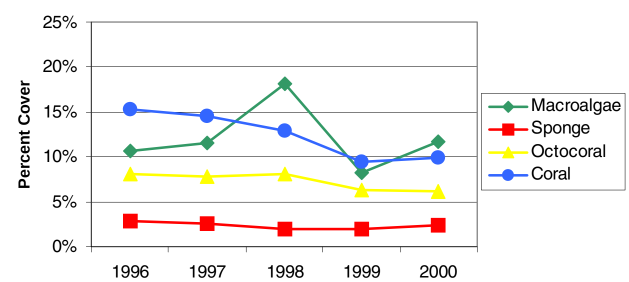
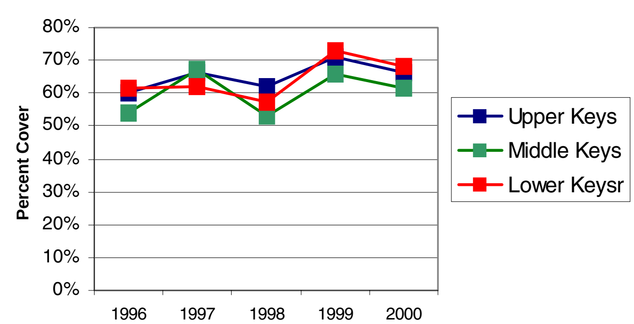


Figure 27. Mean Percent Cover of Substrate, Sanctuary Wide, 1996-2000



The most striking changes were decline in coral cover for *Acropora palmata*, *A. cervicornis*, and *Millepora complanata*. At shallow stations, the mean percent cover of *A. palmata* dropped from 3.01% (1996) to 0.35% (2000). Sanctuary-wide, percent cover of *A. cervicornis* dropped from 0.20% (1996) to a barely detectable 0.006% (2000). *M. complanata* declined from a mean percent cover of 2.65% (1996) to 0.12% (2000) for all shallow stations. *Siderastrea siderea* and *Porites astreoides* showed slight increases in mean as well as relative coral cover (Figures 28, 29). The three other species shown in Figure 28, *Agaricia agaricites*, *Colpophyllia natans* and *M. alcicornis*, all experienced slight declines in cover.

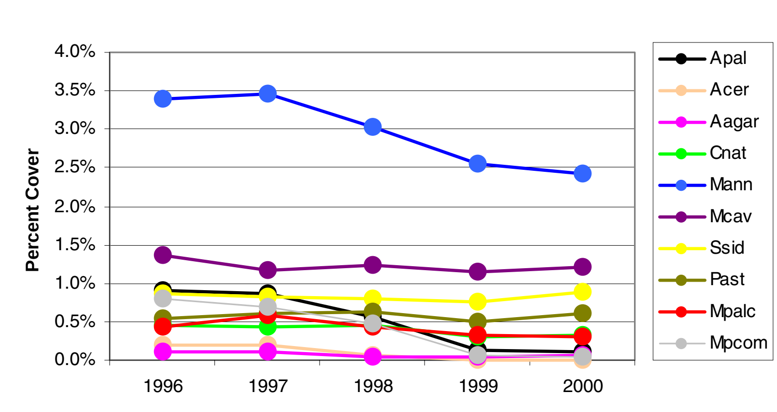


Figure 28. Mean Coral Cover Sanctuary Wide by Species 1996-2000

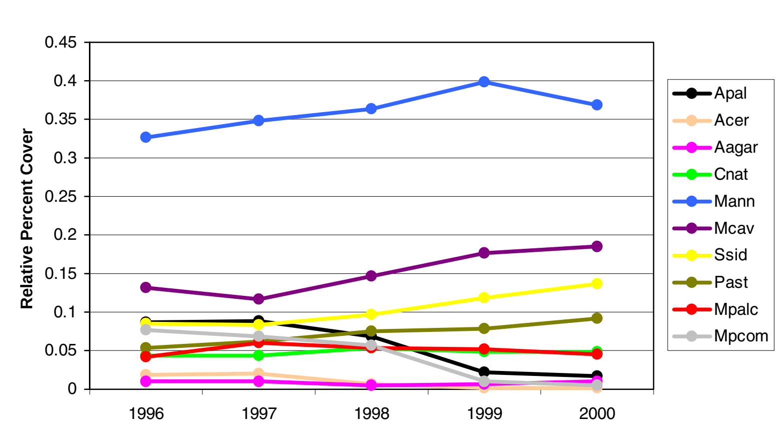


Figure 29. Relative Coral Cover Sanctuary Wide by Species, 1996-2000

SUMMARY

Data for each successive sampling year is being compared with prior years' data to obtain a broader understanding of the dynamics of the FKNMS coral reef system. As the coral reef monitoring is integrated with the seagrass and water quality programs, the results can be used to focus research on determining causality (Figure 30) and to fine tune and evaluate management decisions. These data provide the first opportunity to address these questions at the spatial scales (Sanctuary-wide) required to detect large-scale patterns and discriminate between hypotheses.

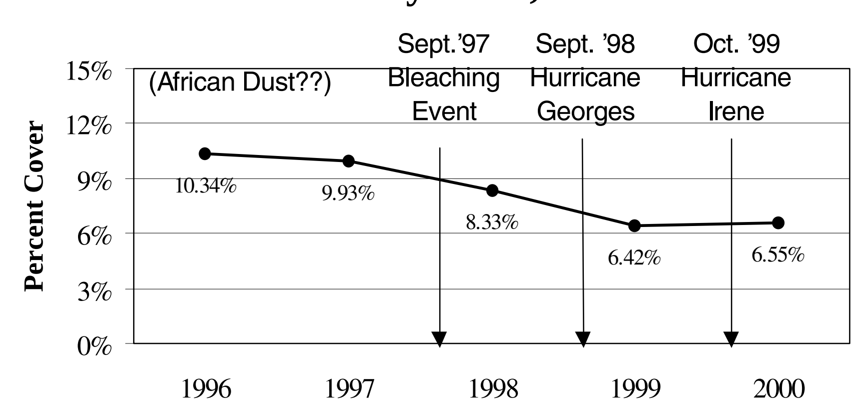


Figure 30. Mean Percent Stony Coral Cover Sanctuary-Wide, 1996-2000

CONCLUSIONS FOR FIVE YEARS SUCCESSIVE MONITORING (ALL STATIONS EXCEPT TORTUGAS)

- From 1996 to 2000, 67 % of stations lost species, 20% gained species and 13% were unchanged.
- From 1999 to 2000, 43% of stations gained species, 35% lost and 22% did not change.
- From 1996-2000, stony coral cover significantly decreased in 63.9% of stations, was unchanged at 32.6% and showed a significant gain at 3.5% of stations .
- By region, the upper keys experienced the greatest decline with significant loss in coral cover.at 72.5% of stations; followed by the lower keys with loss at 68.8% and the middle keys with a loss at 47.5% of stations.
- From 1999 to 2000, stony coral cover at 75.5% of stations showed no change, 16.8% of stations showed a significant increase and 7.7% of stations had a significant decrease.
- From 1996-2000, mean percent stony coral cover decreased by 36.6% Sanctuary-side.
- Diseases have increased in the number of stations where they occur, the number of species that are infected, and a slight number of new disease-phenomena were observed.

Enhanced CRMP for 2001

At the meeting of the Technical Advisory Committee (TAC) in December, 2000, the project was praised for it's monitoring efforts to date. Suggestions for resolving certain coral population dynamics questions led the CRMP to re-evaluate sampling efforts. Since it was statistically determined that the total number of stations sampled could be reduced, and allow the project to cover the same broad geographic area with less sampling effort, the CRMP incorporated the following for 2001:

- Census of stony coral recruits by species
- Census of bioeroding sponges

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http://www.floridamarine.org

Modes of larval transport. Long Key hardbottom.