

**US EPA Water Quality Protection Program For
The Florida Keys National Marine Sanctuary**

**Coral Reef Monitoring Project
Analysis of trends 1996-1999
Executive Summary**

Principal Investigators

**Phillip Dustan¹
James W. Porter²
Walter C. Jaap³**

EPA Florida Keys Coordinator

Fred McManus⁴

**Jennifer Wheaton, Project Manager³
Matt Patterson, Data Manager³**

¹ Department of Biology, University of Charleston, SC
² Institute of Ecology, University of Georgia
³ Florida Fish and Wildlife Conservation Commission
⁴ US EPA, Region IV

Introduction

The Coral/Hardbottom Monitoring Project (CRMP) is monitoring the status and trends of coral and hardbottom communities throughout the Florida Keys National Marine Sanctuary. Biodiversity, coral condition and cover are censused annually at 43 permanently marked sites comprised of shallow and deep outer reefs, patch reefs, and hardbottom communities. These sites range from the northern Florida Keys to the Dry Tortugas.

Study site locations were chosen using a random stratified technique based on EPA E-MAP survey procedures. Each site consists of four stations (approximately 22 x 2 meters each) within which coral biodiversity and condition are censused by two divers using a Station Species Inventory (SSI) protocol. The cover of major benthic organisms with emphasis on scleractinian corals is measured using random point count analysis of video images of each of three transects within each station. This experimental design thus provides statistically robust paired-comparisons over time of coral species richness, condition and cover at the station level throughout the Florida Keys.

Project History

Site installation of 160 stations at 40 sites distributed from Key Largo to Key West occurred in 1995. Three additional sites were installed in the Dry Tortugas during the summer of 1999. All extant stations were sampled in 1996, 1997, 1998, and 1999.

The SSI data has been tabulated and examined for all years. The raw video imagery for 1996, 1997, 1998, and part of 1999 has been converted to digital imagery and distributed to CRMP labs for point counting analysis. Compilation of point count data from 1996 and 1997 has been completed. All of the 1998 imagery has now been point counted and data for 9 of 40 sites have been subjected to statistical analysis for this presentation. An analysis of the full data set from all 40 sites will be presented at the March 30th Water Quality Protection Program Steering Committee Meeting in Marathon, FL. Processing and distribution of the 1999 video imagery is nearly 50 percent complete and point counting has begun.

Findings

Scleractinian Biodiversity

Twenty-nine of forty sites (73%) exhibited losses in scleractinian coral taxa between 1996 and 1999. Five sites showed no change and 6 stations showed net gains in species between 1996 and 1999. The maximum number of species lost was 7 (29 species to 22) and the maximum gained was 3 (15 species to 18). Between 1996 and 1998, the heaviest losses were on offshore reefs in the Upper and Lower Keys. By 1999, significant species losses were recorded on inshore patch reefs as well as offshore deep and shallow reefs, with one patch reef losing 7 of 35 species. The inshore hardbottom sites, which are sparsely populated by corals, show the least change in species and lowest incidences of disease.

All areas of the Keys exhibited loss in coral diversity although it was more pronounced in the Middle Keys. Water Quality Segments 5, 3 and 2 (Lower Keys) had net loss at 14 of 20 sites. Water Quality Segment 9 (Upper Keys) had 8 of 13 sites with net loss, and Water Quality Segment 7 (Middle Keys) had 7 of 7 sites with net loss.

Coral Condition

Coral disease in the Florida Keys became more widespread from 1996 to 1998. Since 1996, the CRMP has documented increases in the number of stations containing diseased coral (Table 1.), the number species with disease (Table 2.), and the numbers of diseases (Table 3.). The greatest concentrations of diseases occurred on stations in the Upper and Lower Keys while less were found in the Middle Keys.

Scleractinian Coral Cover:

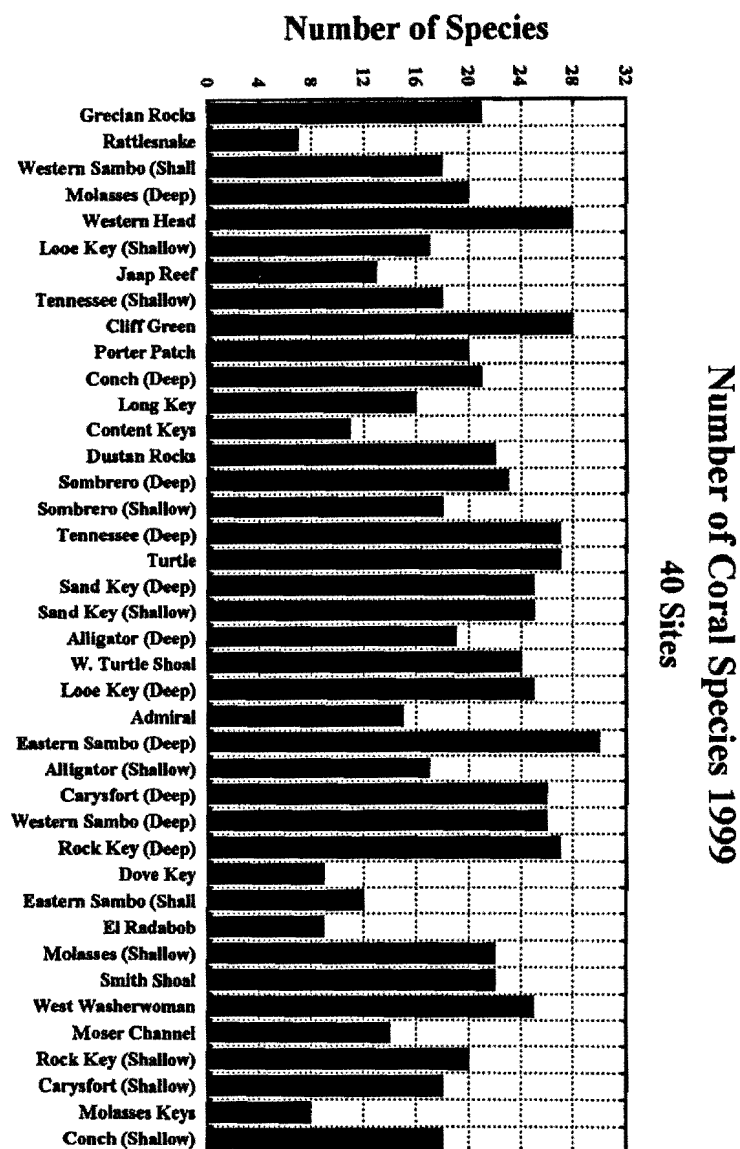
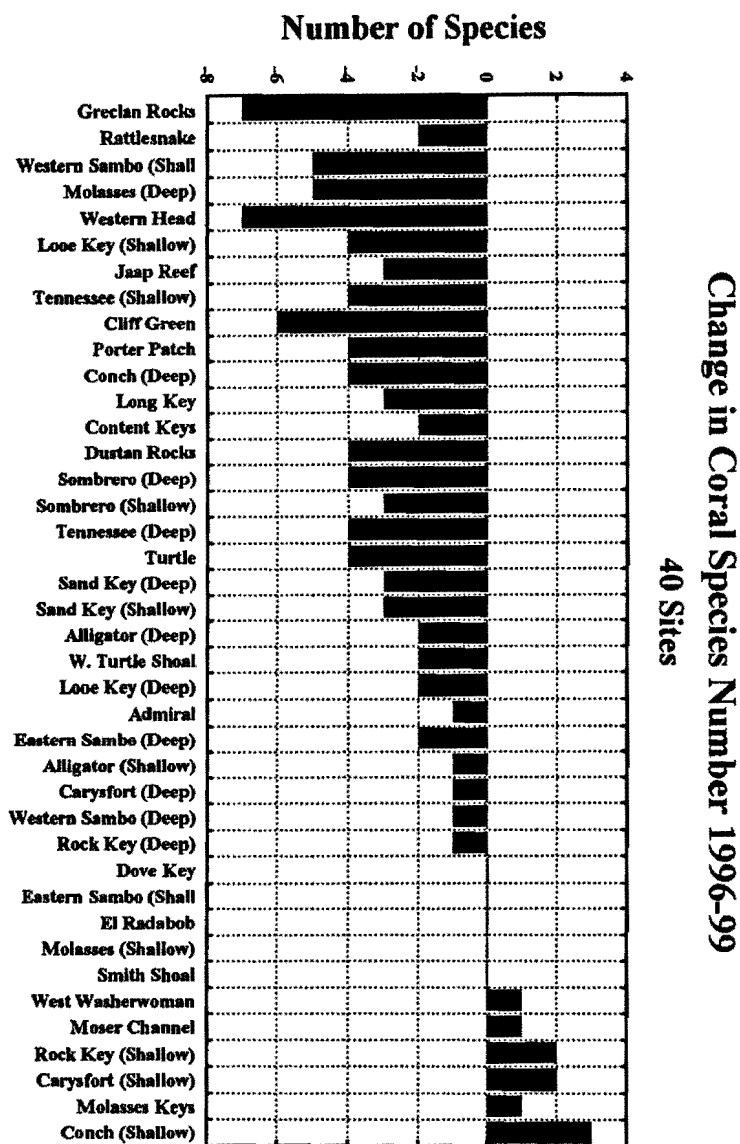
Point count analysis of underwater video images from all 40 sites reveals that between 1996 and 1997 the mean percent living scleractinian coral cover changed from 9.16% to 8.66%, a mean loss of 0.5% (Wilcoxin Matched Pairs Test $p=0.019$). Point count analysis of the subset of nine sites for which all analyses are complete from 1996 through 1998 revealed a decrease in overall coral coverage between 1996 and 1997 (Wilcoxin Matched Pairs Test $p=0.066$).

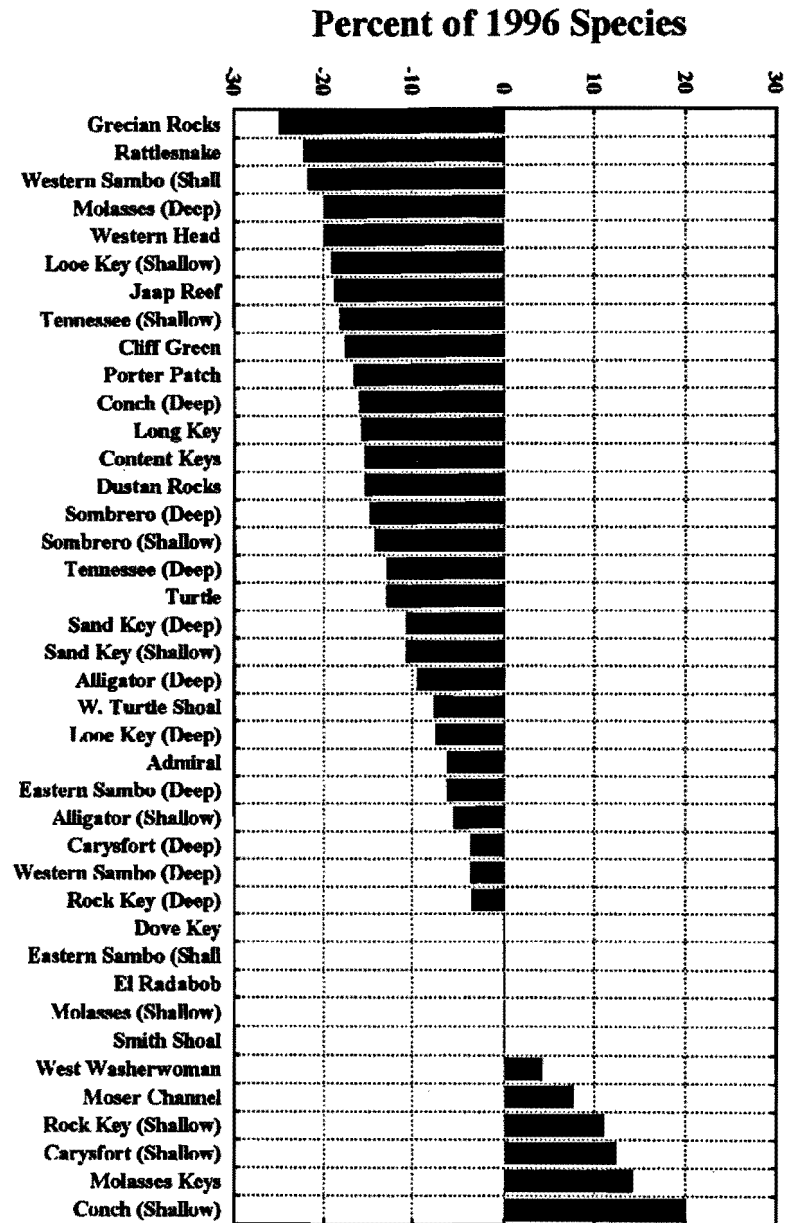
Scleractinian coral cover declined at 7 of the 9 sites (28 of 36 stations). The mean loss per station was 18.33% (std = 21.9, $n=9$, Wilcoxin Matched Pairs Test, $p=0.021$ based on mean percent cover at each site, and Repeated Measures Analysis of Variance, $p<0.0001$ on arc sine transformation of the data). At these nine sites there was an estimated total cover of 136.7m² of living coral in 1996, 131.5m² in 1997, and 114.4m² in 1998. This constitutes an overall loss of 16.4% of living coral at these nine sites.

Conclusions

The CRMP has identified significant losses in species richness and coral cover between 1996 and 1998. It is expected that the 1999 sampling, which occurred after Hurricane Georges, will demonstrate further losses. It is important, however, to point out that these hurricane losses only exacerbate the downward trend in coral coverage, they are not the cause of it. Continued monitoring and directed studies are needed to further elucidate the causes of decreased coral vitality and loss of biomass.

- Since 1996, CRMP Sites have experienced a loss of coral diversity; more sites lost coral species than remained unchanged or gained species.
- Since 1996, there has been an epidemic of coral diseases as evidenced by increases in spatial and habitat distribution of diseases, more types of diseases, and more coral species infected.
- Between 1996 and 1998, the majority of sites that have been monitored and analyzed to date have lost coral cover.





Percent Change in Species Number 1996-99
40 Sites

Table 1. The number of EPA Coral Reef Monitoring Stations in the Florida Keys with coral disease (WH- white diseases, BB- black band disease, OD- other diseases, and TD- total diseases). The percent of affected stations is shown in parentheses. The percent increase for 1996-1998 is listed at the bottom.

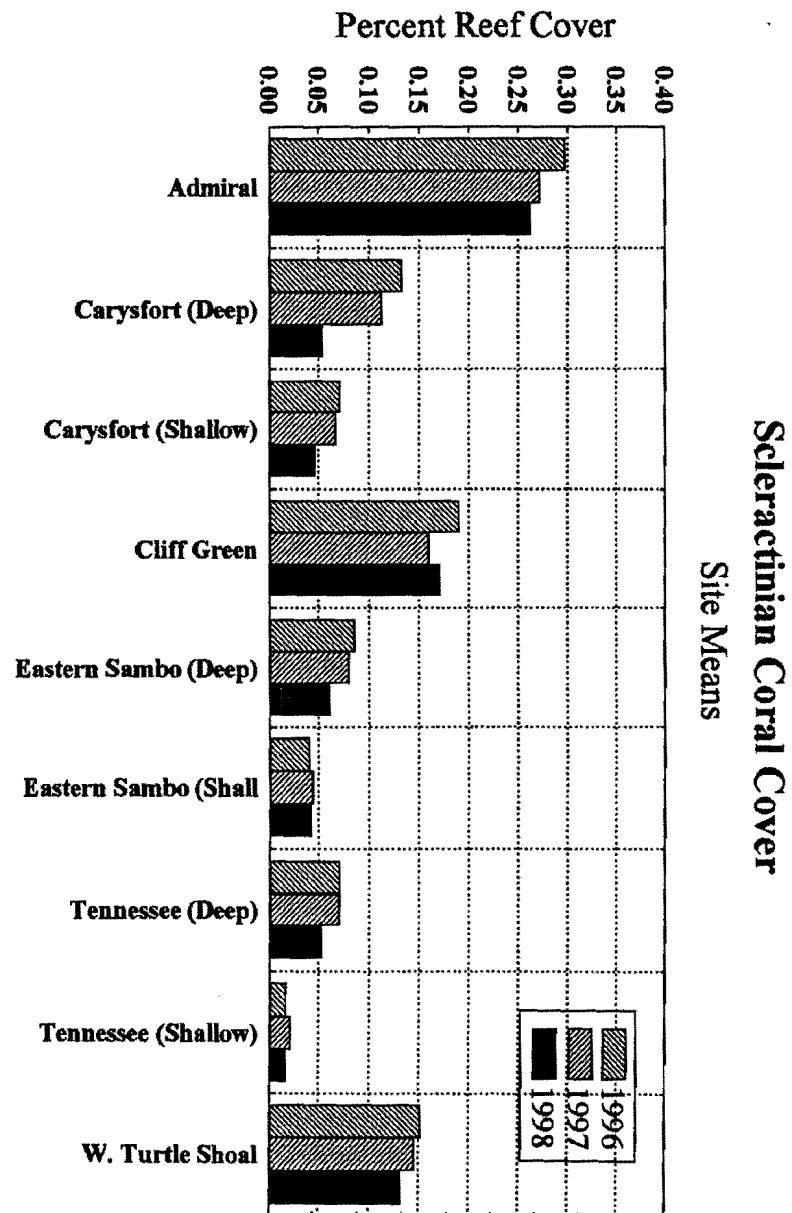
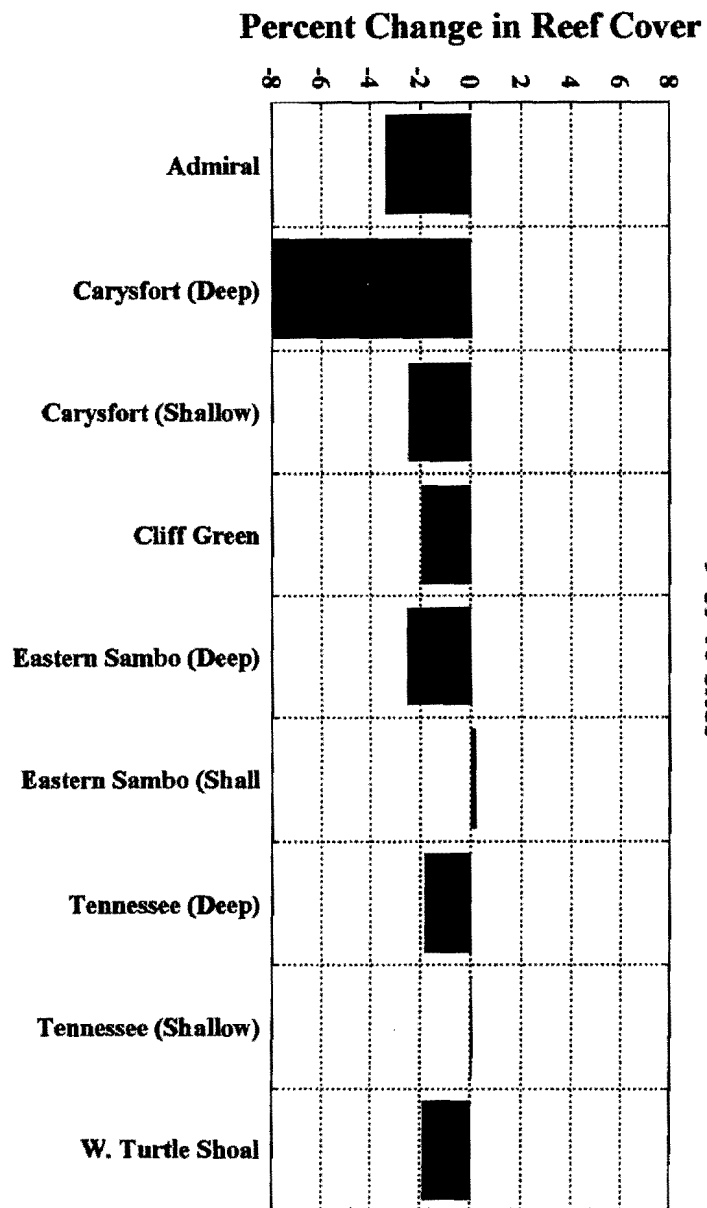
Year	Disease Condition			
	WH	BB	OD	TD
1996	7 (4%)	7 (4%)	16 (10%)	26 (16%)
1997	61 (38%)	11 (7%)	66 (41%)	95 (59%)
1998	97 (61%)	28 (18%)	92 (58%)	131 (82%)
Increase ('96-'97)	771%	57%	312%	265%
Increase ('97-'98)	59%	155%	39%	38%
Increase ('96-'98)	1,286%	300%	475%	404%

Table 2. The number of EPA Coral Reef Monitoring Stations in the Florida Keys with coral disease (WH- white diseases, BB- black band disease, OD- other diseases, and TD- total diseases) and their percent increase for 1996-1998. The percent of affected stations (shown in parentheses) is based on an S value of 41 species.

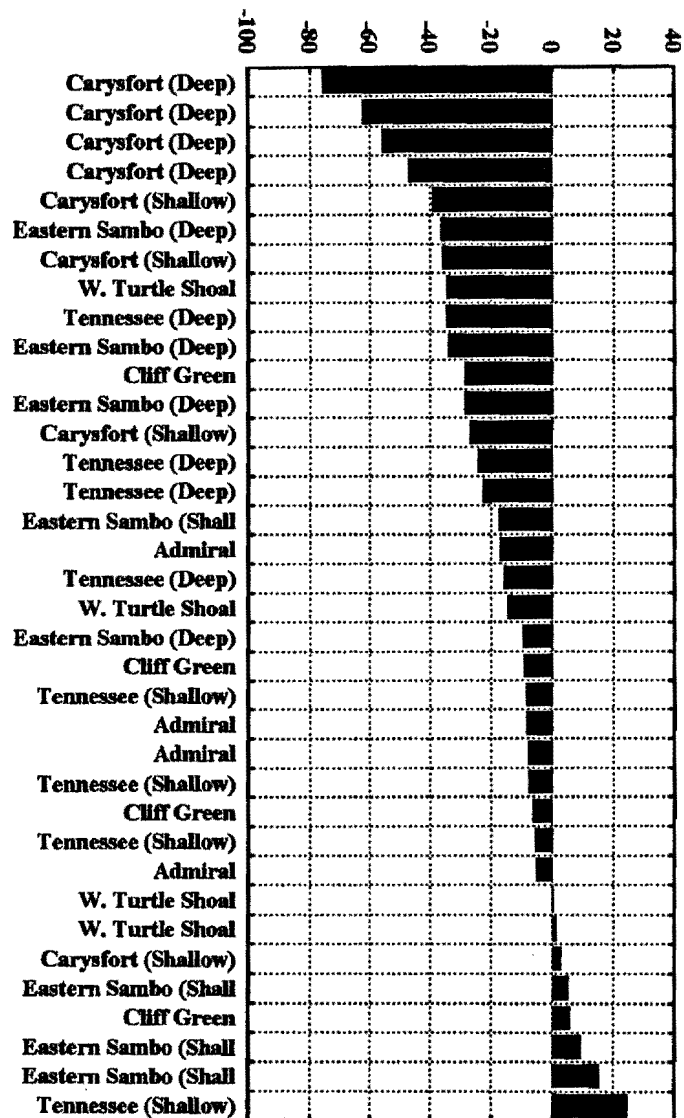
Year	Disease Condition			
	WH	BB	OD	TD
1996	3 (7%)	2 (5%)	16 (20%)	11 (27%)
1997	22 (54%)	4 (10%)	22 (54%)	28 (68%)
1998	28 (68%)	7 (18%)	28 (68%)	35 (85%)
Increase ('96-'97)	633%	100%	175%	155%
Increase ('97-'98)	27%	75%	27%	25%
Increase ('96-'98)	833%	250%	250%	218%

Table 3. The proportion of EPA Coral Reef Monitoring Stations in the Florida Keys affected by coral diseases (WH- white diseases, BB- black band disease, OD- other diseases, and TD- total diseases) between 1996 and 1998. The *F* statistic and means are calculated using a SAS best-fit model (Littell et. al., 1996) (upper and lower 95% confidence limits are shown in parentheses, N=40 sites). All disease increases are highly significant. An extra dispersion scale value (λ) is shown for each disease condition.

Year	Proportion of Stations in the Florida Keys with Disease			
	Disease Condition			
	WH	BB	OD	TD
1996	0.02 (0.01-0.06)	0.03 (0.01-0.07)	0.09 (0.05-0.17)	0.14 (0.08-0.23)
1997	0.34 (0.21-0.50)	0.05 (0.02-0.10)	0.41 (0.30-0.53)	0.60 (0.47-0.72)
1998	0.65 (0.49-0.78)	0.14 (0.08-0.23)	0.58 (0.46-0.69)	0.84 (0.74-0.91)
<i>F</i>	33.8	9.28	21.10	42.33
<i>df</i>	2, 78	2, 78	2, 78	2, 78
<i>p</i>	0.0001	0.0002	0.0001	0.0001
Extra Dispersion Scale				
λ	1.34	0.96	1.64	1.47
<i>p</i>	<0.01	n.s.	<0.01	<0.01

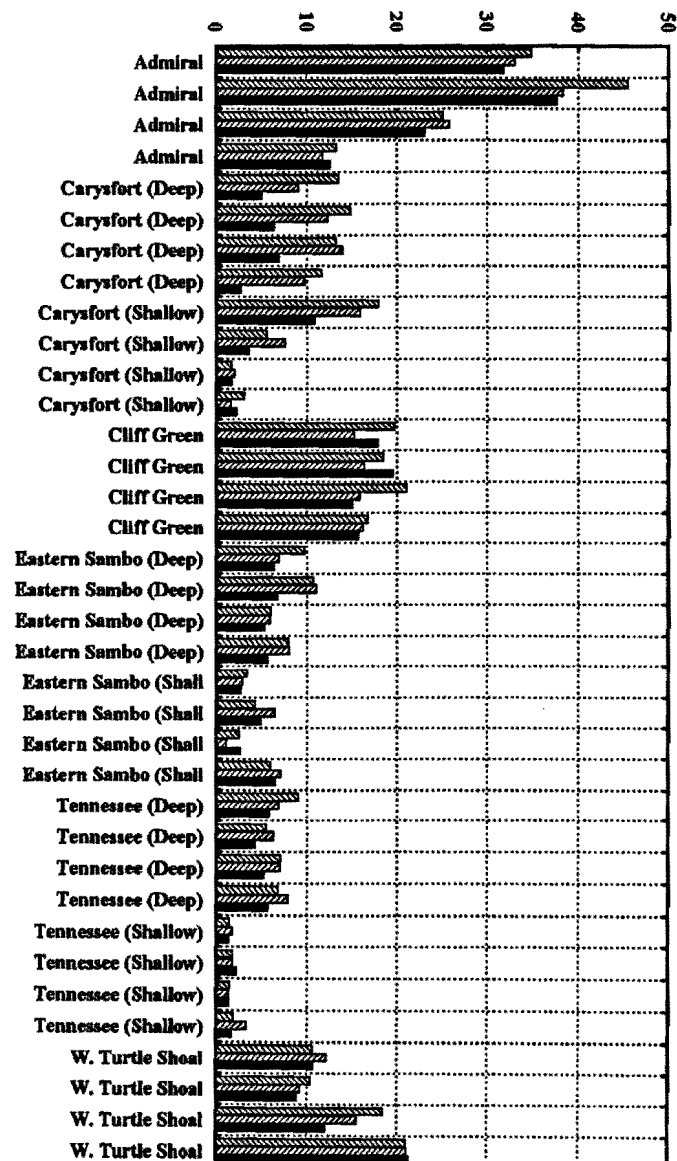


Percent Coral Cover Change
(1996-98/1996) * 100



Normalized Change in Scleractinian Coral Cover 1996-98
Stations at 9 of 40 Sites

Percent Reef Cover



Scleractinian Coral Cover 1996-98
36 Stations at 9 Sites

Contacts

Phillip Dustan
Department of Biology
University of Charleston
58 Coming Street
Charleston, SC 29412
Ph: 843-953-4908
Email: pdustan@zeus.cofc.edu

Walter C. Jaap
Florida Fish and Wildlife Conservation
Commission
100 Eighth Avenue, SE
St. Petersburg, FL 33701
Ph: 727-826-8626
Email: jaap_w@epic7.dep.state.fl.us

James W. Porter
Institute of Ecology
717 Biological Sciences Bldg.
University of Georgia
Cedar Street
Athens, GA 30602-2602
Ph: 706-542-3410
Email: jporter@arches.uga.edu

Fred McManus
US Environmental Protection Agency
Region IV
345 Courtland St., NE
Atlanta, GA 30365
Ph: 404-562-9385
Email: mcmanus.fred@epa.gov

CRMP Team Members

University of Charleston: Michael Brill, Vladimir Kosmynin, James Leard, Jamie O'Brien

University of Georgia: Doug Marcinek, Katie Patterson

Florida Fish and Wildlife Conservation Commission: Lonnie Anderson, John Dotten, Dave Eaken, Matt Lybolt, Matt Patterson, Tom Trice, Jennifer Wheaton

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