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

Executive Summary 2012

Overview

- The Coral Reef Evaluation and Monitoring Project (CREMP) completed its 16th year of annual surveys in the Florida Keys in 2011.
- Recent modifications to survey design now employ two primary methods for evaluating the status and trends of the benthic communities in the Florida Keys: (1) demographic surveys to quantify stony coral, octocoral, and *Xestospongia muta* density, size class distribution, and condition and (2) video transects to quantify the percent cover of major benthic taxa (e.g., stony corals, macroalgae, and sponges) All surveys are performed at 22m x 2m sampling stations within each site (Figure 1). Four stations are surveyed at all sites except at the new patch reefs (installed in 2009) where only two stations are sampled.
- In 2011, 40 sites were sampled in the Keys-wide. This included 12 shallow forereefs, 11 deep forereefs, 15 patch reefs, and 2 backcountry patch reefs located in Florida Bay, north of the Lower Keys. Collectively, 148 stations were surveyed.
- Statistical differences in octocoral, macroalgal, sponge, and stony coral percent cover between 2010 and 2011 were compared with a two-way mixed model ANOVA with year and location as factors. Sites were pooled for region*habitat (e.g. Middle Keys patch reefs) and habitat analyses.
- This summary highlights the differences in percent cover between 2010 and 2011. Additionally, it describes the temporal changes in benthic assemblages on Florida Keys reefs 11 years after the 1997/1998 El Niño which has been accepted for publication in *Marine Ecology Progress Series*.

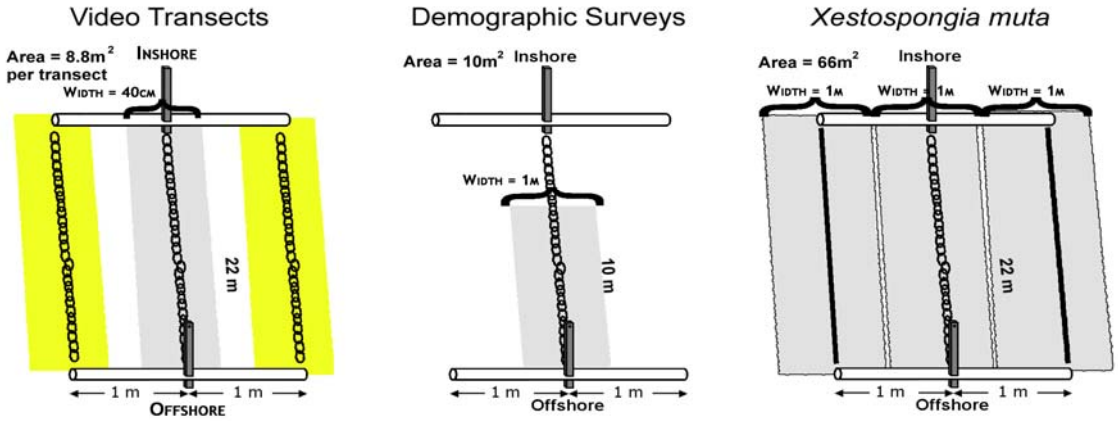

Figure 1: CREMP sites consist of two to four monitoring stations delineated by permanent markers. Stations are approximately 22m x 2m. Video transects survey 8.8m^2 of reef per station. Octocoral and stony coral demographic surveys are 1m x 10m belt transects. Three 1m x 22m belt transects are surveyed for *Xestospongia muta*. All surveys are conducted annually. Transects shaded in yellow represent previously filmed transects prior to modifications in 2011.

Results

2010 vs. 2011

- CREMP observed a significant increase in total stony coral cover between 2010 and 2011 Overall stony coral cover increased from 7.5±1.3% (±SE) to 8.0±1.3% (Table 1). The increase was primarily attributed to Lower Keys deep and shallow forereefs. Keys-wide, averaged for all deep and shallow forereef sites, both reef types demonstrated an annual gain in cover. At deep forereefs, total stony coral cover increased from 2.8±0.3% to 3.5±0.5%, while at shallow forereefs, cover increased from 4.5±1.1% to 5.2±1.1% (Table 2). This marks the second time in three years that CREMP has observed small, but significant increases in cover. CREMP also observed a significant increase in stony coral cover between 2008 and 2009. While this is encouraging, more analyses are required to understand the factors behind the increase.
- Overall octocoral cover did not significantly change between 2010 and 2011. Averaged for all sites, octocoral cover was 13.2±1.3% in 2010 and 13.6±1.3% in 2011 (Table 1). Octocoral cover remained similar across all habitat region pairings except two. A significant increase in cover was detected for Lower Keys patch reefs while Middle Keys patch reefs significantly decreased between years. In spite of the decline at Middle Keys patch reefs, octocoral cover, averaged for all patch reefs, did show a significant increase from 13.1±2.7% in 2010 and 14.1±3.0% in 2011 (Table 2).
- A significant difference in overall cover of sponge cover was documented between years (Table 1). Averaged for all sites, sponge cover rose from 2.7±0.4% in 2010 to 3.3±0.5% in 2011 (Table 1). Several habitat region pairings reflected this increase including Upper, Middle, and Lower Keys patch reefs and Upper shallow forereefs (Table 1). The most notable increase occurred on patch reefs, where cover increased from 2.6±0.5% in 2010 to 4.2±0.8% in 2011 (Table 2). Which sponge species are responsible for the increase on patch reefs is presently unknown but the increase may represent a successional state following the benthic mortality that occurred during the 2010 winter.
- Average macroalgal cover was similar between 2010 and 2011 (Table 1). Macroalgal cover was 18.4±2.4% in 2010 and 18.1±1.9% in 2011. There were significant differences identified for some habitat region pairings. Macroalgal cover significantly declined across years at Lower Keys deep forereefs and Upper Keys patch reefs, but significantly increased between years at Middle Keys shallow forereefs and patch reefs (Table 1). These differences reflect the annual variability in macroalgal cover across years and habitats. Macroalgal cover in 2011 was the third highest value recorded in project history. Some of the sustained increase in macroalgal cover can be attributed to the catastrophic mortality on patch reefs following the winter of 2010. Macroalgae often proliferates following major disturbances and in the aftermath of the winter mortality cyanobacterial blooms and aggressive fleshy macroalgae species that could rapidly uptake nutrients provided by decaying organisms increased substantially. Elevated macroalgal cover is also apparent at the deep forereefs. While deep forereefs generally contain the highest macroalgal cover, average cover in this habitat in 2010 and 2011 is much higher the annual mean for deep forereefs and suggests that that additional factors other than the winter mortality disturbance may be sustaining increased macroalgal abundance in the Florida Keys.

Table 1. Change in mean percent cover (±SE) at 10 habitat*region combinations and overall in the Florida Keys between 2010 and 2011. Significant differences between years are denoted by ↓ = significant decrease, ↑ = significant increase, and NC = no change. Regions defined as LK = Lower Keys; MK = Middle Keys; UK = Upper Keys. Habitats defined as BCP = backcountry patch reef; OD = deep forereef; OS = shallow forereef; P = patch reef. Number in parenthesis indicates number of sites sampled in each habitat*region combination.

	Stony Coral			Octocoral			Sponge			Macroalgae		
	2010	**2011**	**Diff.**	**2010**	**2011**	**Diff.**	**2010**	**2011**	**Diff.**	**2010**	**2011**	**Diff.**
LK BCP (2)	1.8±1.5	2.3±1.9	NC	0±0	0±0	NC	1.4±0.7	1.4±0.4	NC	42.2±20.2	45.6±6.8	NC
LK OD (5)	2.5±0.4	3.4±0.4	↑	12.2±1.1	13.3±1.4	NC	3.0±0.7	3.5±0.7	NC	33.7±2.3	25.8±3.2	↓
LK OS (5)	5.6±2.3	6.4±2.0	↑	11.6±1.8	12.6±0.9	NC	0.4±0.1	0.5±0.1	NC	9.0±1.2	7.8±2.4	NC
LK P (6)	22.2±3.6	23±4.0	NC	15.2±5.2	18.2±6.1	↑	3.9±0.9	6.1±1.3	↑	8±6.3	6.0±4.5	NC
MK OD (3)	2.7±0.8	3.5±1.8	NC	11.5±3.3	9.9±2.2	NC	7.7±2.7	6.9±1.5	NC	13.3±1.6	21.5±7.0	NC
MK OS (3)	1.9±0.4	2.2±0.4	NC	22.1±1.8	21.1±1.7	NC	1.6±0.5	1.4±0.3	NC	16±2.6	26.8±3.2	↑
MK P (4)	12.9±0.5	13±0.9	NC	12.3±2.7	10.5±2.4	↓	2.7±0.6	4.1±1.4	↑	7.1±0.8	18.4±5.5	↑
UK OD (3)	3.3±0.3	3.7±0.2	NC	14.9±2.1	13.4±2.5	NC	5.9±2.1	6.3±1.9	NC	31.8±13.8	23.8±1.5	NC
UK OS (4)	5.0±1.5	5.8±1.9	NC	17.2±2.6	17.3±2.3	NC	0.6±0.2	1.0±0.4	↑	12.7±5.8	14.5±4.0	NC
UK P (5)	5.5±1.8	5.3±1.5	NC	11.1±5.4	12±5.3	NC	1.0±0.5	1.8±0.6	↑	25.5±3.5	15.7±2.3	↓
OVERALL (40)	**7.5±1.3**	**8.0±1.3**	↑	**13.2±1.3**	**13.6±1.3**	NC	**2.7±0.4**	**3.3±0.5**	↑	**18.4±2.4**	**18.1±1.9**	NC

Table 2. Change in mean percent cover (±SE) averaged for all reefs within each habitat type between 2010 and 2011. Significant differences between years are denoted by ↓ = significant decrease, ↑ = significant increase, and NC = no change. Habitats defined as BCP = backcountry patch reef; OD = deep forereef; OS = shallow forereef; P = patch reef. Number in parenthesis indicates number of sites sampled in each habitat.

	Stony Coral			Octocoral			Sponge			Macroalgae		
	2010	**2011**	**Diff.**	**2010**	**2011**	**Diff.**	**2010**	**2011**	**Diff.**	**2010**	**2011**	**Diff.**
BCP (2)	1.8±1.5	2.3±1.9	NC	0.0±0.0	0.0±0.0	NC	1.4±0.7	1.4±0.4	NC	42.2±20.2	45.6±6.8	NC
OD (11)	2.8±0.3	3.5±0.5	↑	12.7±1.1	12.4±1.1	NC	5.1±1.1	5.2±0.8	NC	27.6±4.4	24.1±2.2	NC
OS (12)	4.5±1.1	5.2±1.1	↑	16.1±1.7	16.3±1.3	NC	0.8±0.2	0.9±0.2	NC	12±2.1	14.8±2.8	NC
P (15)	14.2±2.4	14.4±2.6	NC	13.1±2.7	14.1±3.0	↑	2.6±0.5	4.2±0.8	↑	13.6±3.5	12.5±2.7	NC
OVERALL (40)	7.5±1.3	8.0±1.3	↑	13.2±1.3	13.6±1.3	NC	2.7±0.4	3.3±0.5	↑	18.4±2.4	18.1±1.9	NC

Long-term Trends 11 years following the 1997/1998 ENSO

- The primary goal of this study was to evaluate the response of benthic communities in the Florida Keys in the 11-year period following the 1997/1998 El Niño-Southern Oscillation, a weather phenomenon that induced extensive ocean warming and was responsible for mass scleractinian mortality and coral reef decline worldwide during this time. In the Florida Keys, coral bleaching and increased disease prevalence associated with this event reduced coral cover by ~40% between 1996 and 1999. Other benthic taxa groups were also affected: octocoral cover declined by ~25% and sponge cover by ~38% between 1996 and 1999. While a leading objective was to determine whether stony corals have demonstrated some recovery following this disturbance, it was more pertinent to understand how the broader coral reef assemblage has responded. Benthic cover data were used to examine the linear trends of the five most spatially abundant benthic taxa (macroalgae, octocorals, sponges, stony corals, and zoanthids) and then were incorporated into multivariate analyses to assess whether temporal changes in their cover constituted a shift in community structure.
- Stony corals have demonstrated little to no recovery since 1999 (Figure 2). While stony coral cover did not indicate a decreasing trend Keys-wide, significant declines were found at deep and shallow forereefs (Figure 2). Cover declined in these two habitats from 5.4±1.3% (±SE) to 4.3±1.2% and from 3.6±0.5% to 2.8±0.3%, respectively, between 1999 and 2009 (Figure 2). Patch reefs, which generally have the highest stony coral cover of any reef type in the Florida Keys, were unchanged throughout the period, fluctuating between 15% and 17% cover annually (Figure 2).
- Declines in stony coral cover were associated with the mortality of the massive, framework-building coral *Montastraea. annularis*. *Montastraea annularis* can be abundant in all three reef habitats and is the most spatially dominant stony coral in the Florida Keys, contributing more to stony coral cover than any other species (Figure 3). Keys-wide, cover of M. annularis significantly declined after 1999. Most notable was the steady loss at deep forereefs, where cover declined from 1.4±0.3% (±SE) in 1999 to 0.6±0.2% in 2009 (Figure 3). Although initially low for deep reefs at project inception, *M. annularis* cover has been further reduced to a quarter of its 1996 value. A gradual decline is also apparent on shallow forereefs (Figure 3); however, the highly variable distribution of the species within this habitat precluded the detection of significant trends. Conversely, *M. annularis* cover did not indicate a negative trend on patch reefs, remaining consistent at 5.7±0.1% (±SE) throughout the period (Figure 3). The four other largest contributors to total stony coral cover in the Florida Keys, *C. natans, M. cavernosa, P. astreoides, and S. siderea*, did not demonstrate any significant trends Keys-wide, within habitats, or at the reef level (Figure 3).
- Octocorals demonstrated more resilience than any other benthic group in the Florida Keys. Octocoral cover significantly increased in all three habitats and Keys-wide after 1999 (Table 1). Increases in octocoral cover occurred every year except from 2005 to 2006 when a record number of hurricanes impacted the region in an 18-month span. Keys-wide, octocoral cover reached 15.8±1.6% (±SE) in 2009, the highest value ever measured by CREMP (Figure 2). The largest increase occurred on shallow reefs, where average octocoral cover more than doubled from 5.8±1.0% (±SE) to 13.8±1.7% between 1999 and 2009 and cover at nine of the 12 shallow forereefs significantly increased during this time.

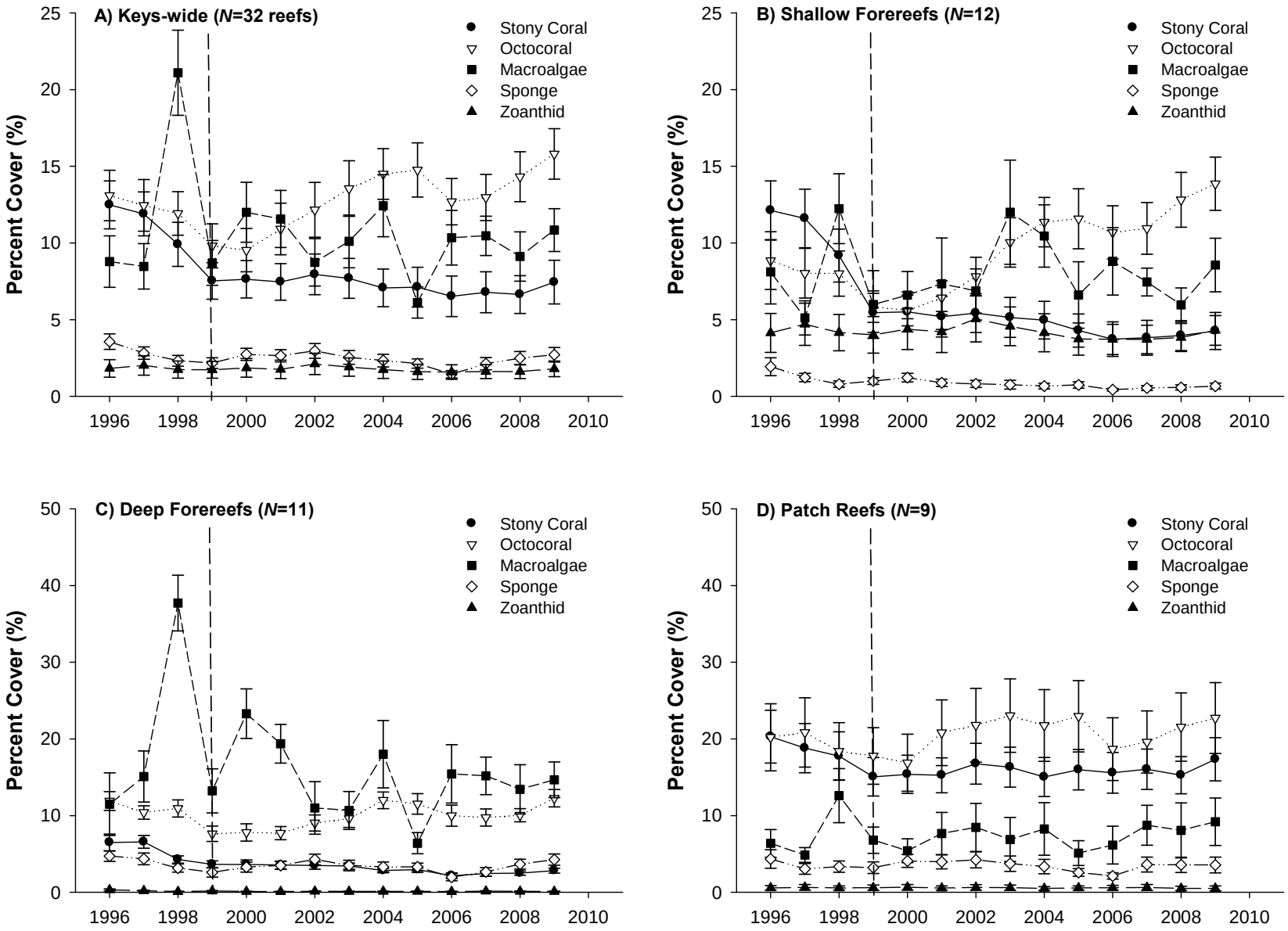

Figure 2. Annual percent cover (mean ± SE) of five benthic taxonomic groups from 1996 to 2009 for A) Keys-wide B) Shallow Forereefs C) Deep Forereefs and D) Patch Reefs. Dashed line indicates 1999 baseline after acute mortality during the 1997/1998 El Niño had abated. Corresponding linear trends estimating the change in percent cover year per year for the five benthic groups are listed in Table 2. Note: scale of y-axis for graphs A & B differ from graphs C & D.

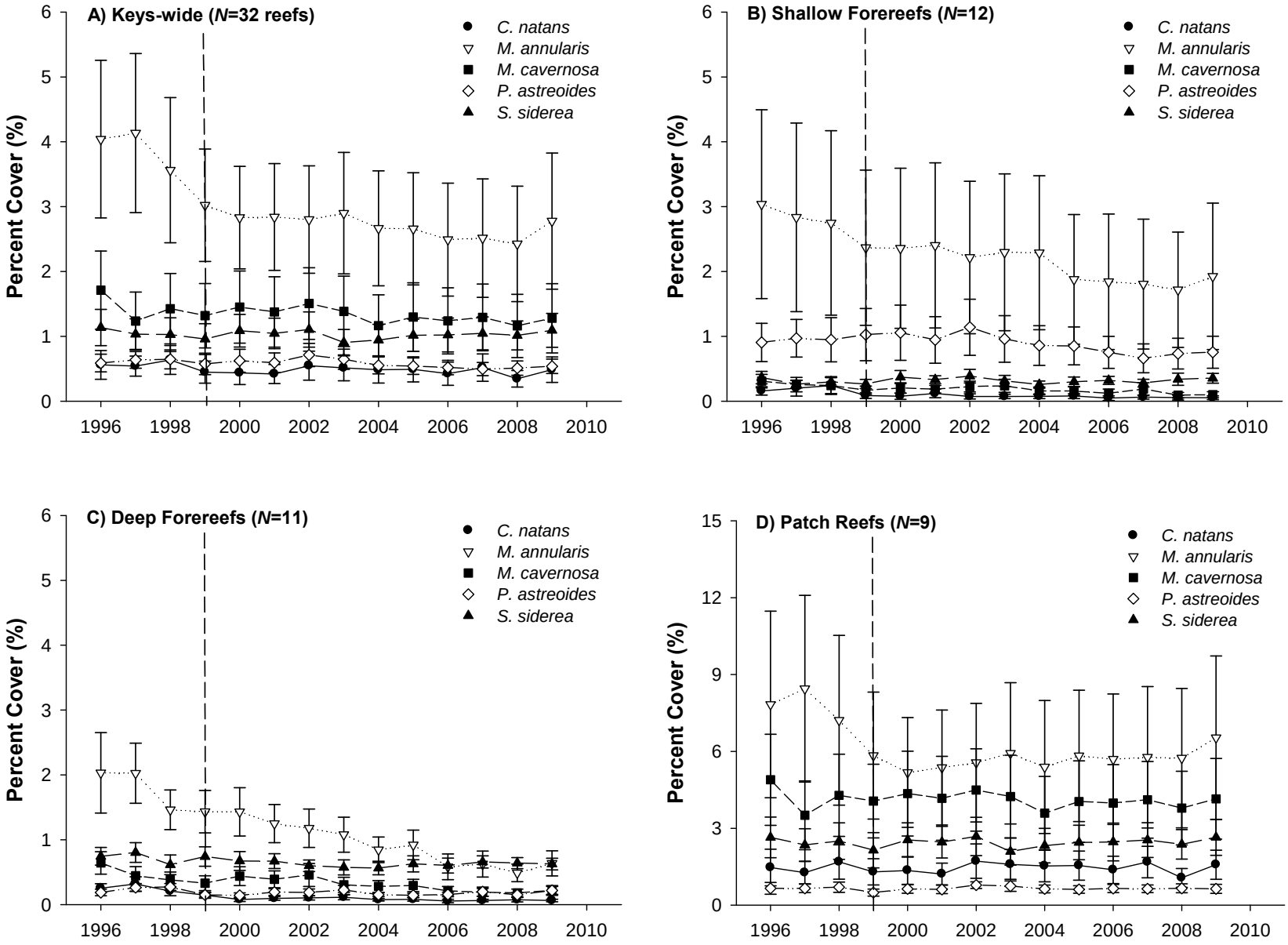

Figure 3. Annual percent cover (mean ± SE) of the five most spatially common stony corals from 1996 to 2009 for A) Keys-wide B) Shallow Forereefs C) Deep Forereefs and D) Patch Reefs. Dashed line marks 1999 baseline after acute mortality during the 1997/1998 El Niño had abated. Corresponding linear trends estimating the change in percent cover year per year for the five coral species are listed in Table 2. Note: scale of y-axis for graphs A, B, & C differ from graph D.