

Long-Term Changes in Benthic Community Composition Observed by the Coral Reef Evaluation and Monitoring Project (CREMP) in the FKNMS

CREMP TEAM

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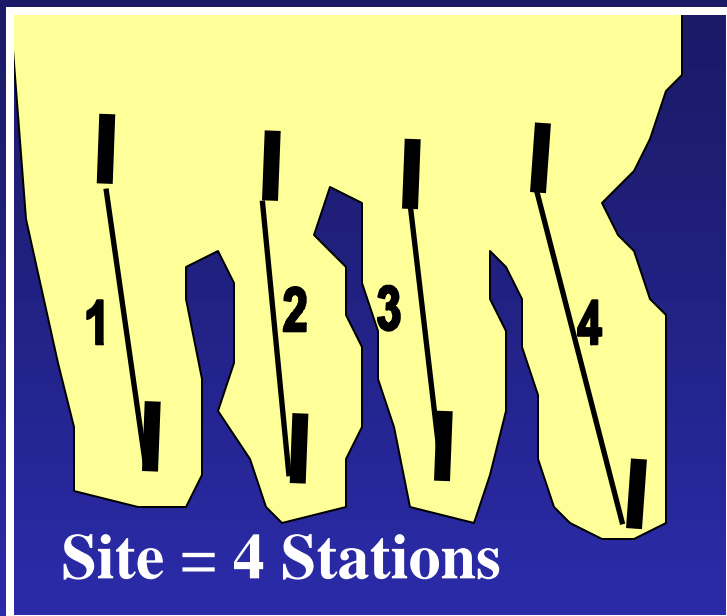


CREMP is funded by the US EPA and NOAA

CREMP Overview

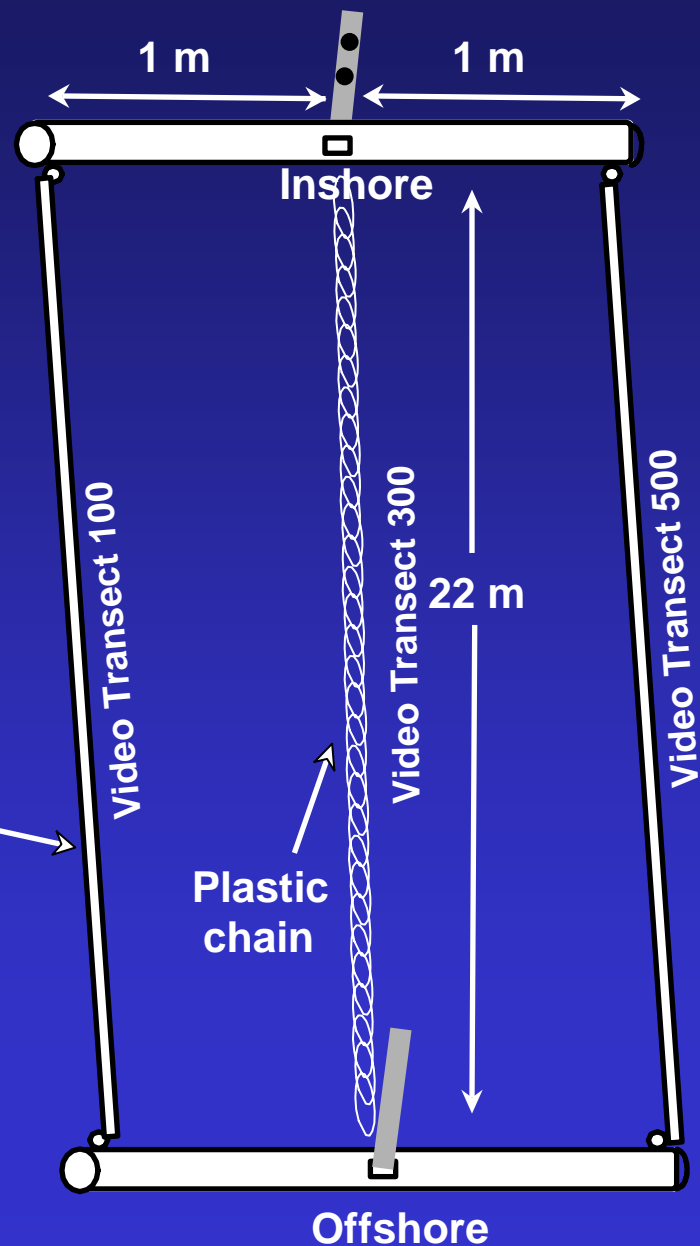
- Established in 1994 as part of the EPA's Water Quality Protection Program
- Cooperative effort between the NOAA, US EPA, and FWC/FWRI
- Primary objective was to document status and trends of coral resources within the FKNMS via fixed sites and repeated surveys
- Initial spatial design included four habitat types (shallow and deep forereefs, patch reefs, nearshore hardbottom communities) in 3 regions (Upper, Middle, and Lower Keys)
- Forty sites were selected and installed in 1995. Monitoring commenced in 1996

CREMP Site & Station Layout



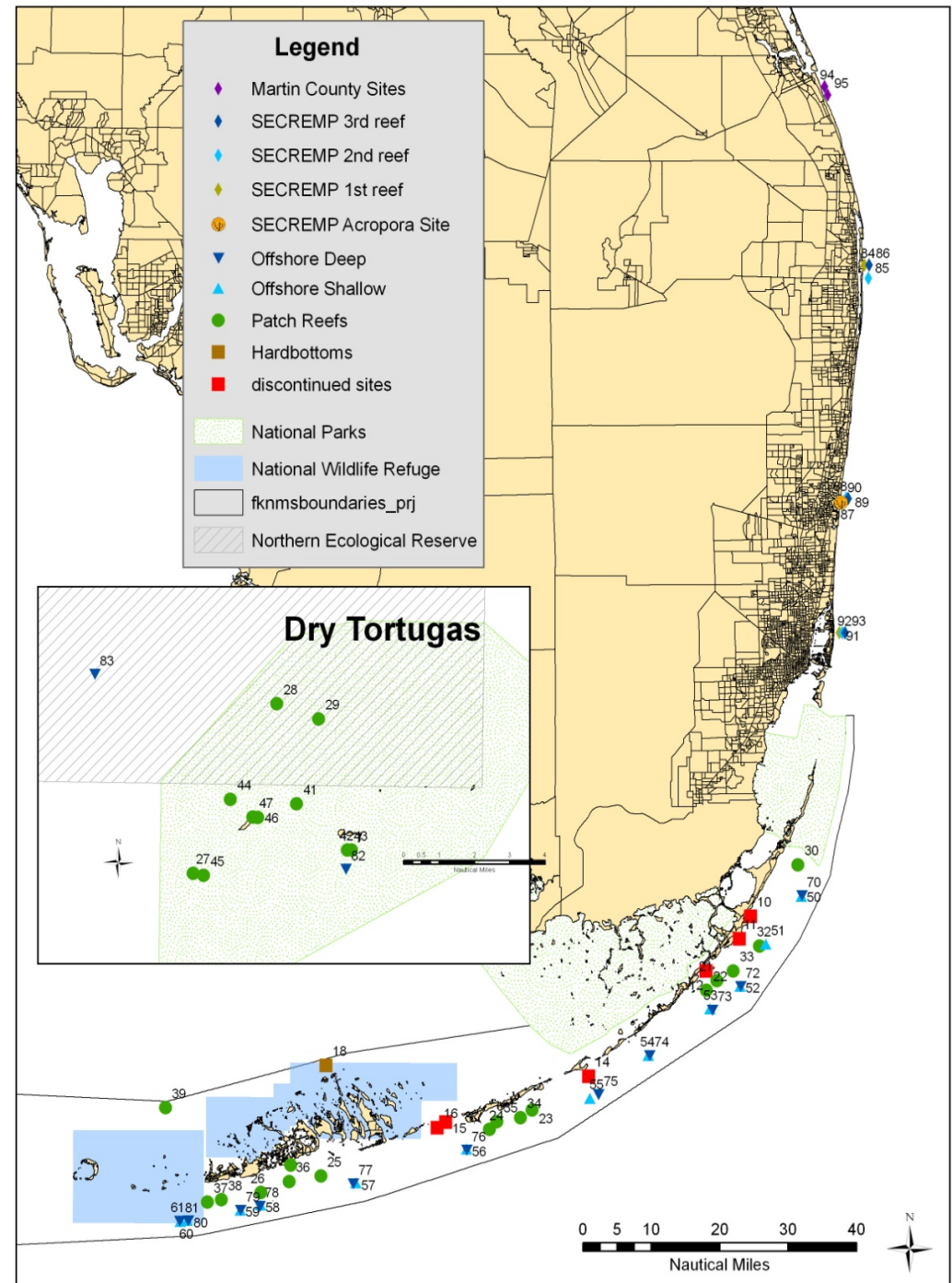
Site ↑

Station →



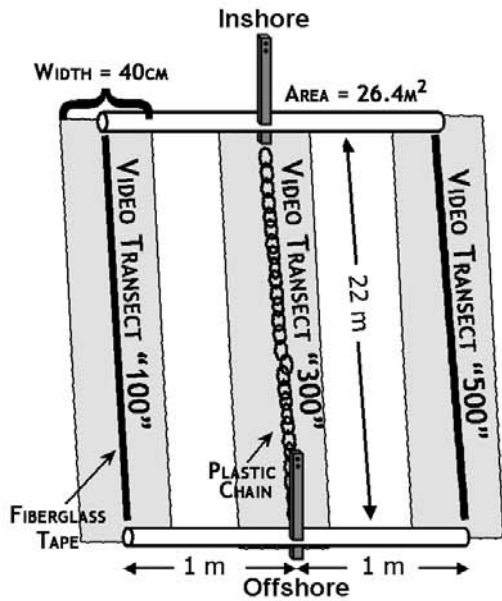
Current Sampling Effort

- Initially 160 stations at 40 fixed sites in Florida Keys
- Presently 109 stations at 40 sites.
 - Station reduction in 2001
 - Removal of nearshore hardbottom sites
 - Six additional patch reef sites installed in 2009.
 - Two sites in Lower Keys now classified as backcountry patch reefs
- Expansion into SE FL (SECREMP) - 64 Stations and 17 sites (started 2003)
- Expansion into Dry Tortugas – 39 Stations at 11 sites (started 1999)

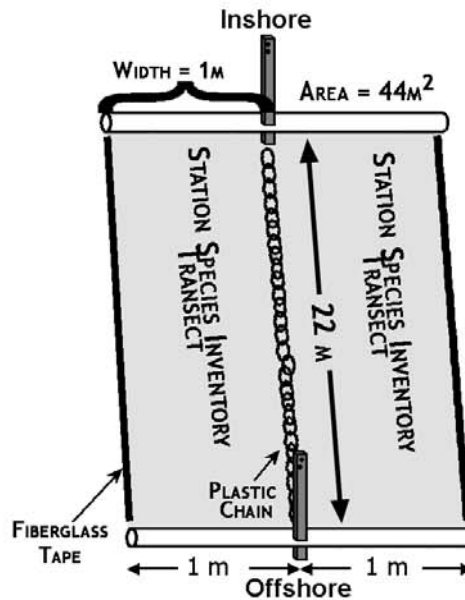


CREMP Annual Monitoring Methods

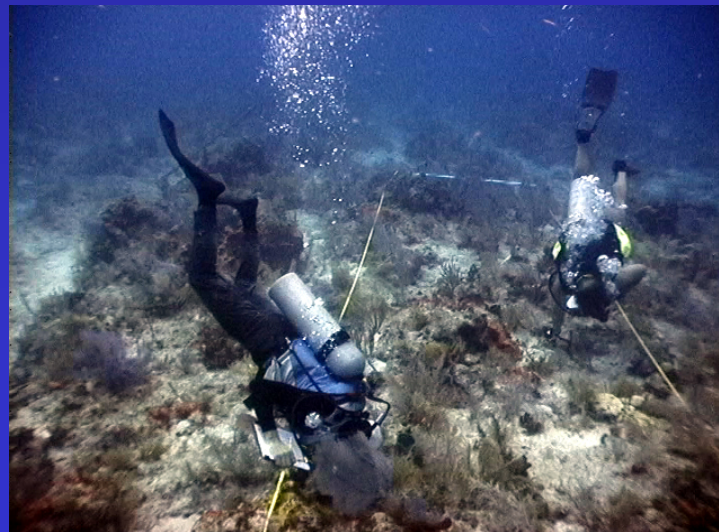
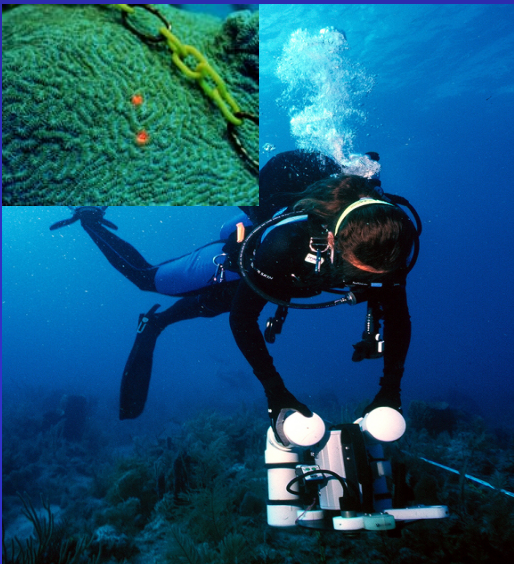
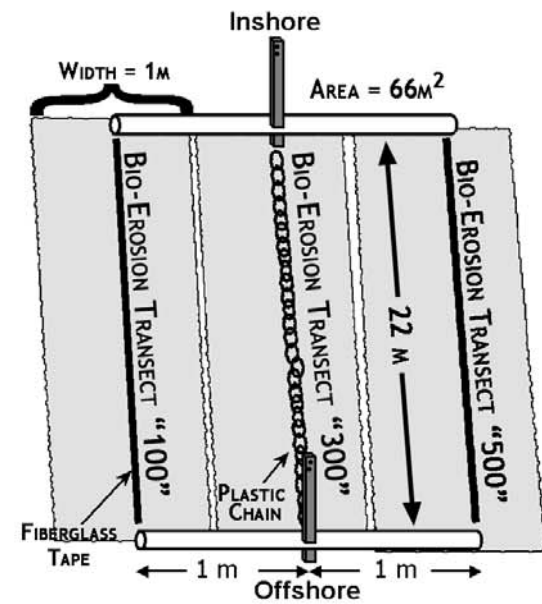
BENTHIC COVER SURVEY



STATIONS SPECIES INVENTORY SURVEY



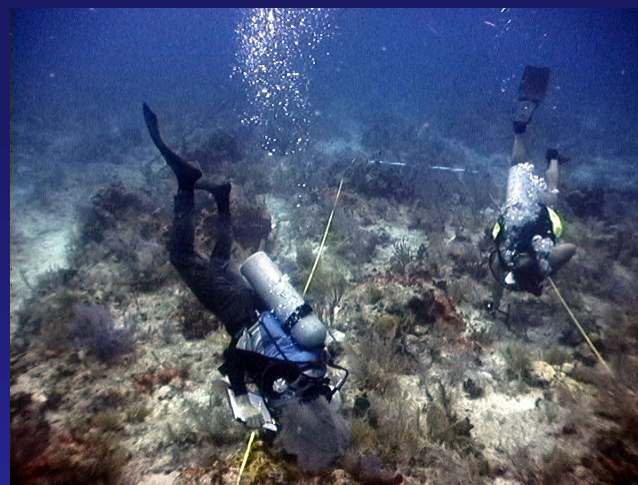
BIO-EROSION SPONGE SURVEY



CREMP Annual Monitoring Methods

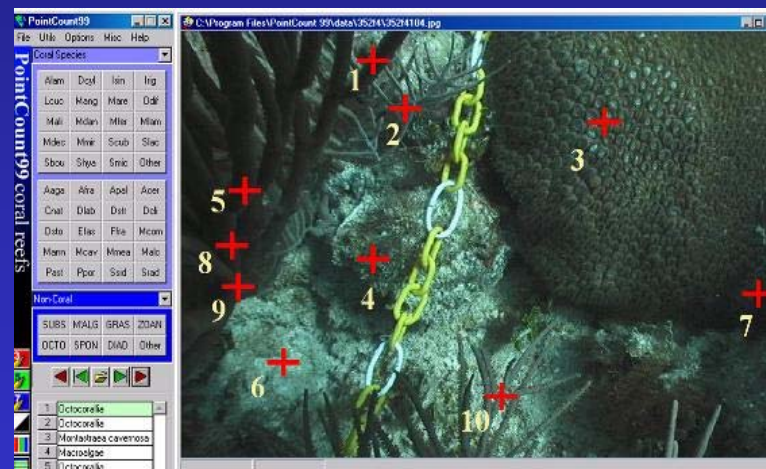
1. Station Species Inventory

- Mean species richness (number of species per station)



2. Video Transects

- Automated process extracts 65-85 frames per transect
- 15 random points placed per frame; equals $\sim 1 \text{ pt}/80\text{cm}^2$
- Images analyzed in Point Count '99
- Data pooled for each station and square root transformed

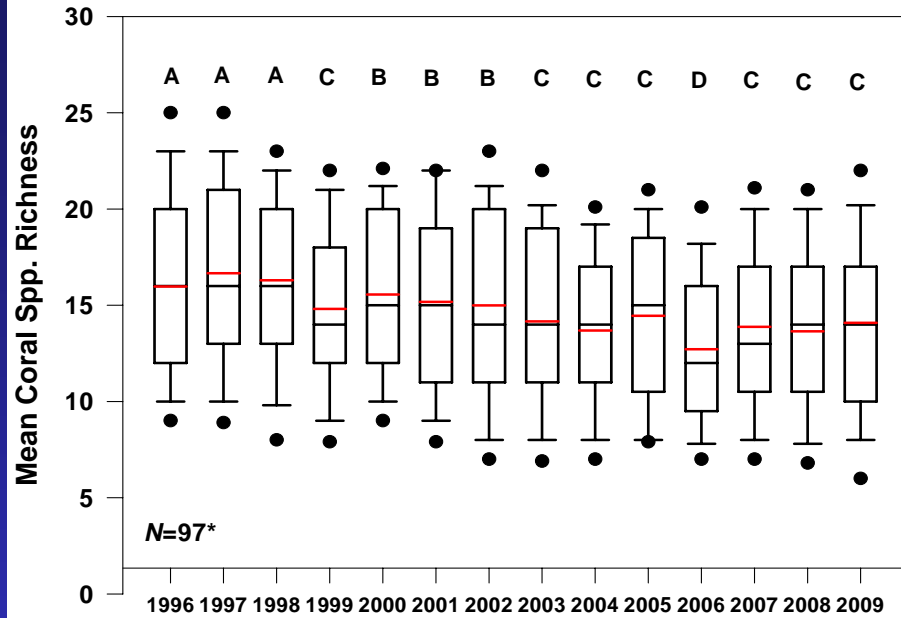


3. Clionid Sponge Surveys

- Sum total no. of 25cm^2 grids occupied by *Cliona spp.* per station
- Quantify mean clionid area (cm^2/m^2)

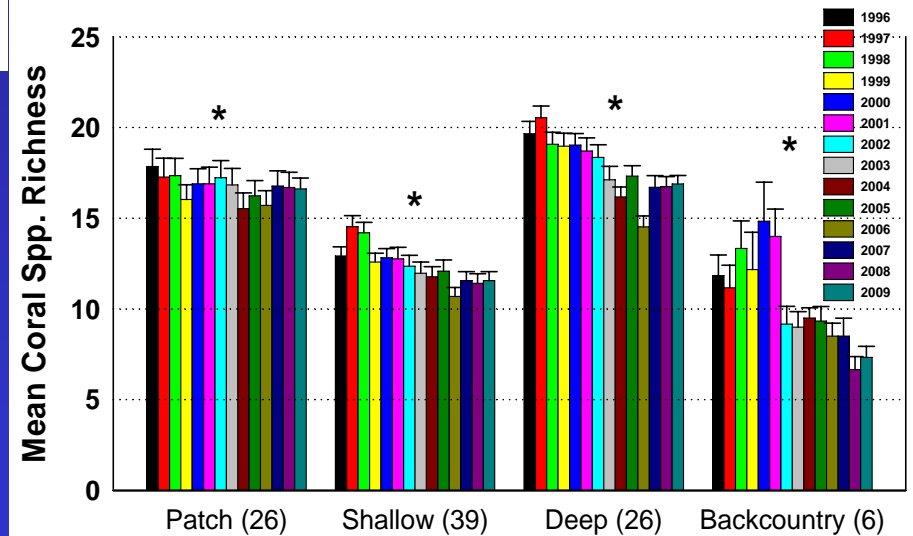
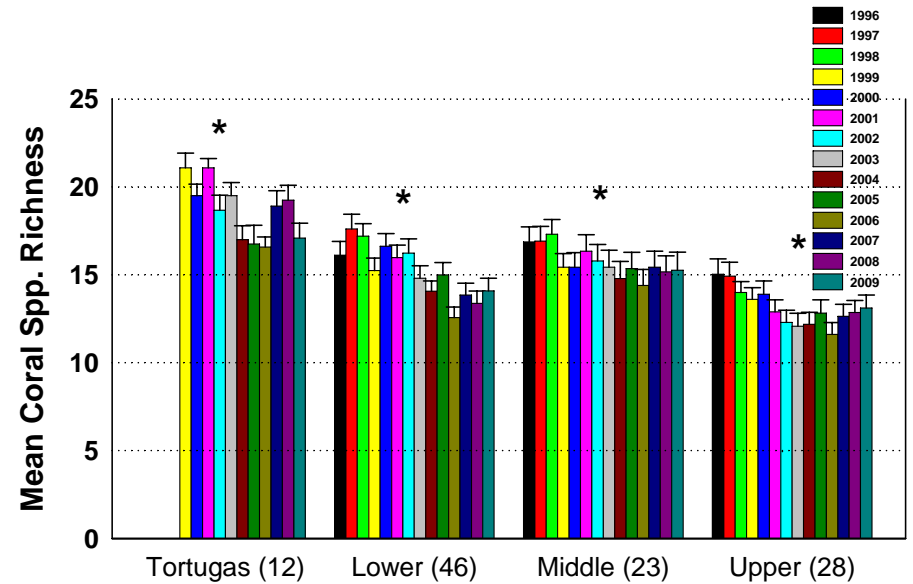


Mean Species Richness



* Includes only Florida Keys station data

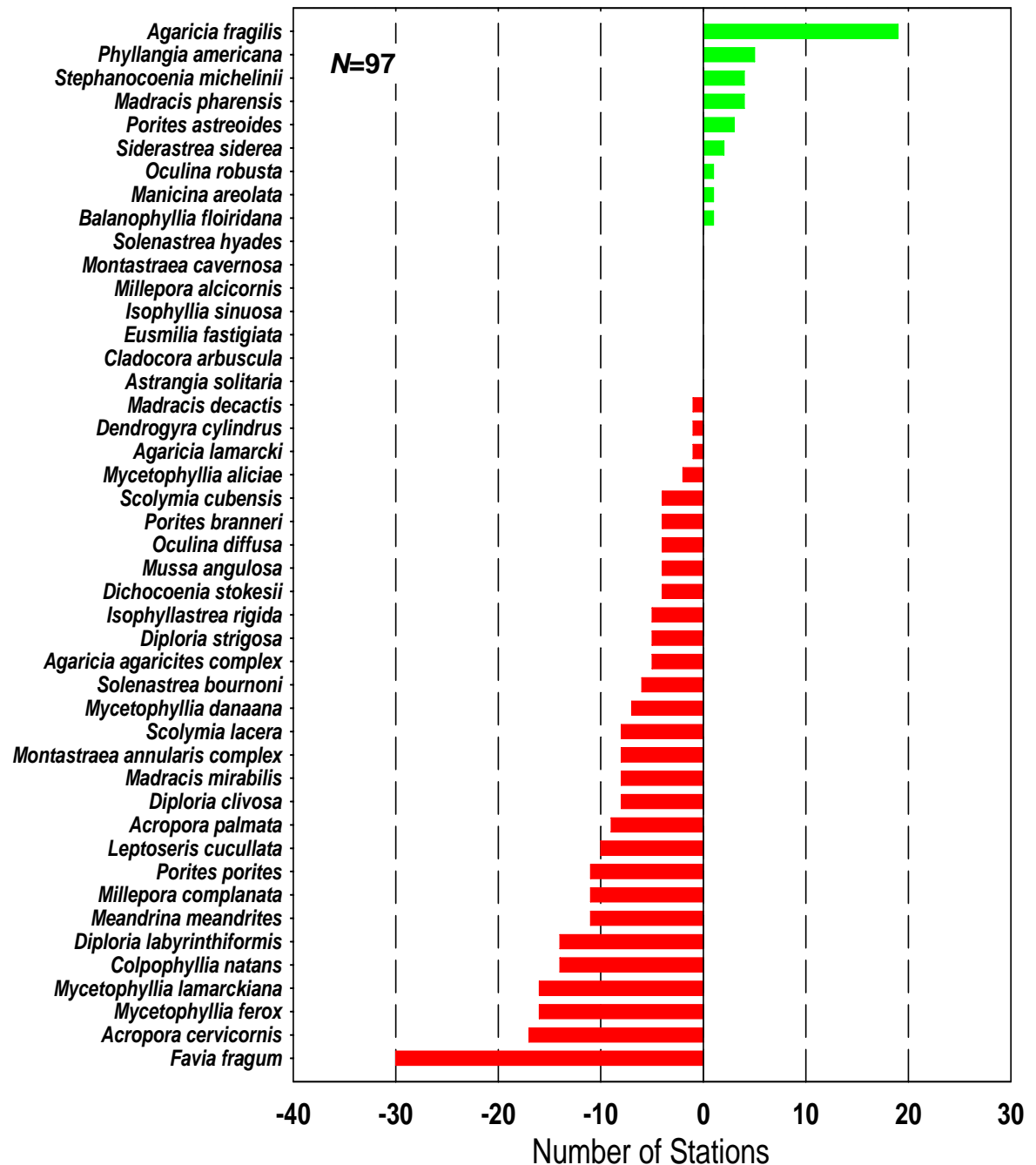
- Mean species richness lower in 2009 than 1996
- Values can be separated into four time periods (A – D)
- Declines observed across all habitats and regions



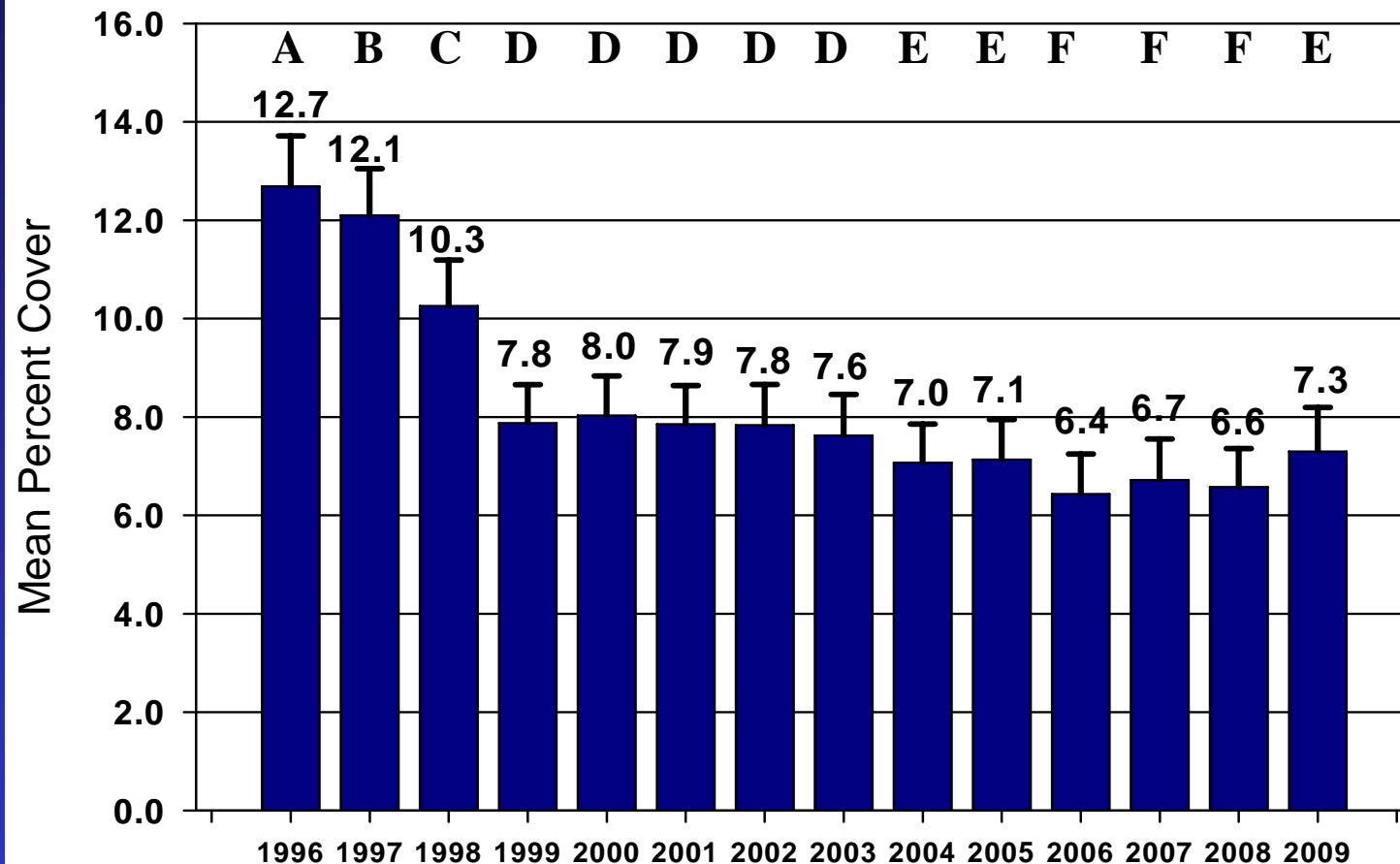
Change in species presence/absence 1996 to 2009

➤ *Favia fragum*, *Mycetophyllia* spp., and *A. cervicornis* have disappeared from >50% of stations occupied in 1996

➤ Distribution for 9 species has been reduced by ≥ 10 or more stations.



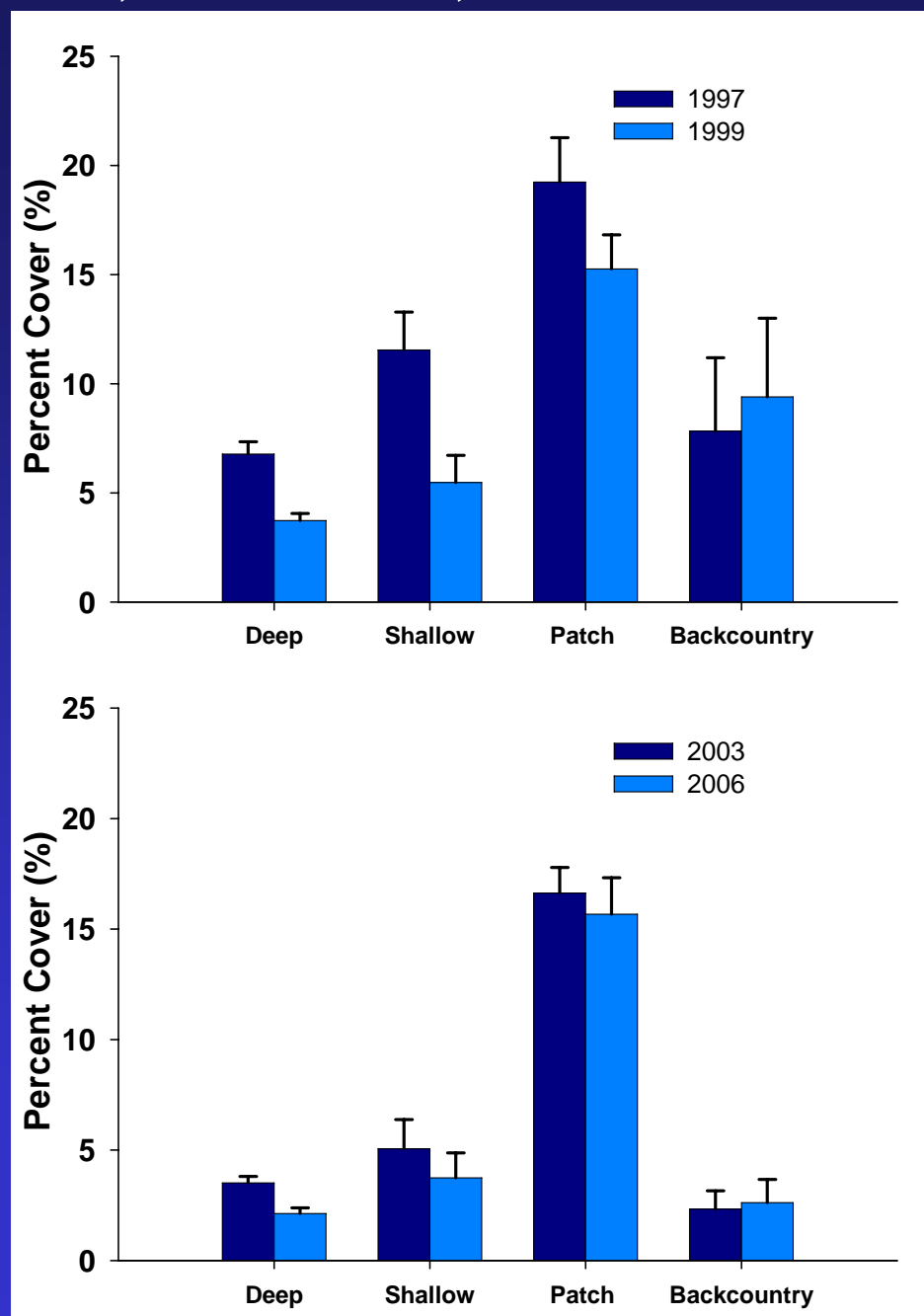
Stony Coral Cover Florida Keys 1996-2009



- $N = 97$ Stations in the Florida Keys (excludes hardbottom sites, Dry Tortugas, or new patch reefs installed in 2009)
- Values can be separated into six time periods (A – F)
- Between 2008 and 2009 recorded first significant increase cover

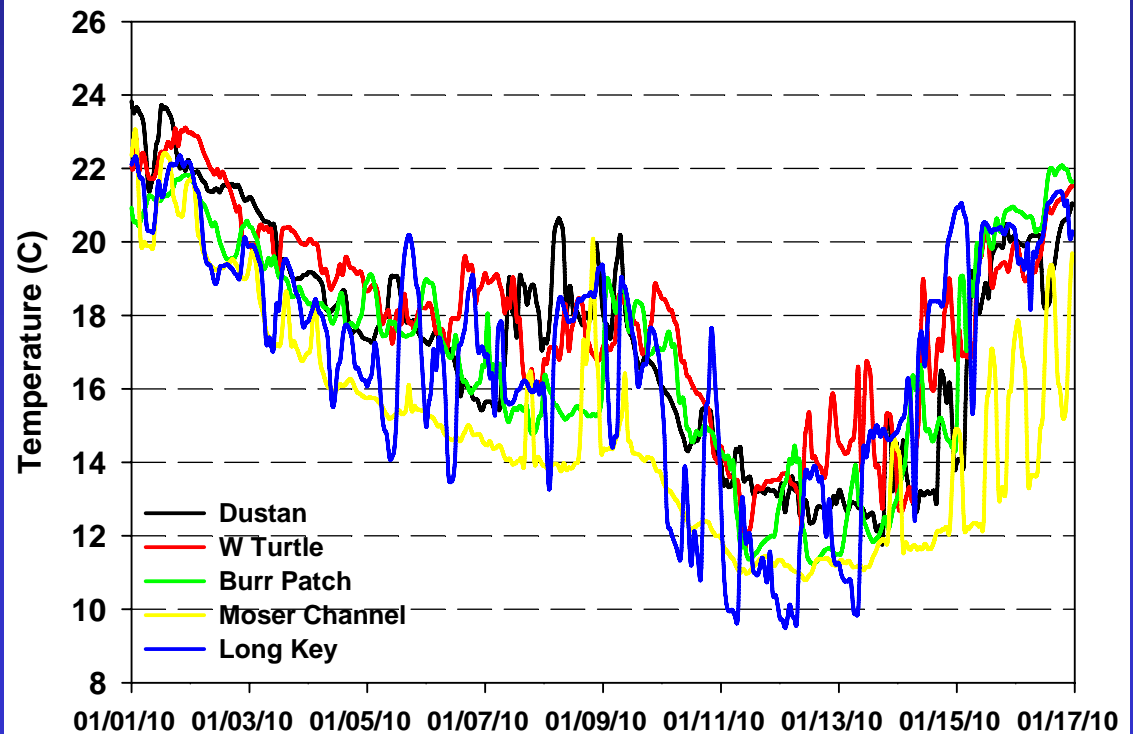
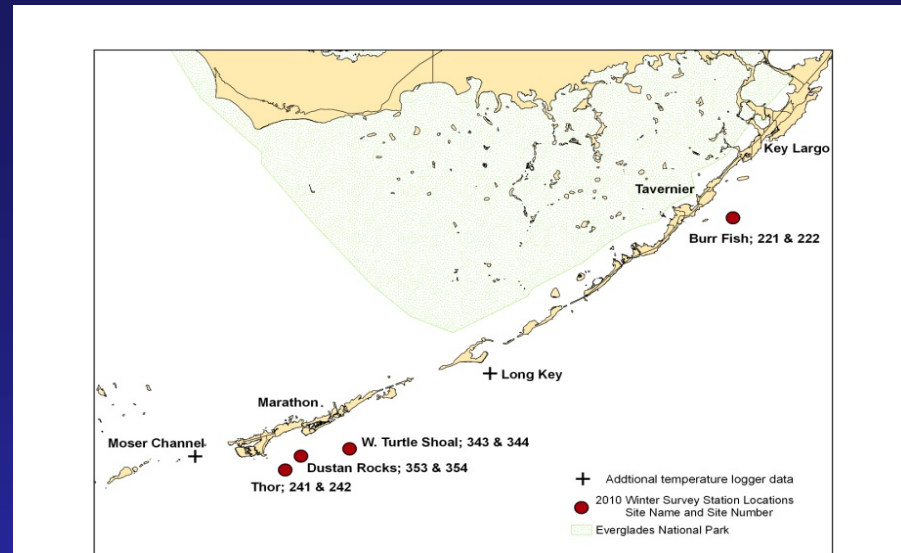
Causes of Decline: Heat, Hurricanes, & HABs

- 1997 & 1998 ENSO
- ~50% proportional change in cover at deep and shallow forereef sites; ~25% at patch reefs
- Minor bleaching year in 2003
- Record number of storms affected the Keys in 16 month period during 2004 and 2005
- Declines more apparent at deep and shallow sites than on patch reefs between 2003-2006
- Diatom algal bloom in 2001 impacted backcountry reefs



Causes of Decline: Cold

- Lethal temperature for corals is 16°C ($\sim 60^{\circ}\text{F}$)
- CREMP recorded 12°C temperatures starting on January 11th, 2010
- Temperature at or near FL Bay exchanges reached 9°C
- Exposure under 16°C lasted between 4 to 5 days
- Highest mortality observed at sites closest to shore
- Temperatures not as depressed at forereef sites

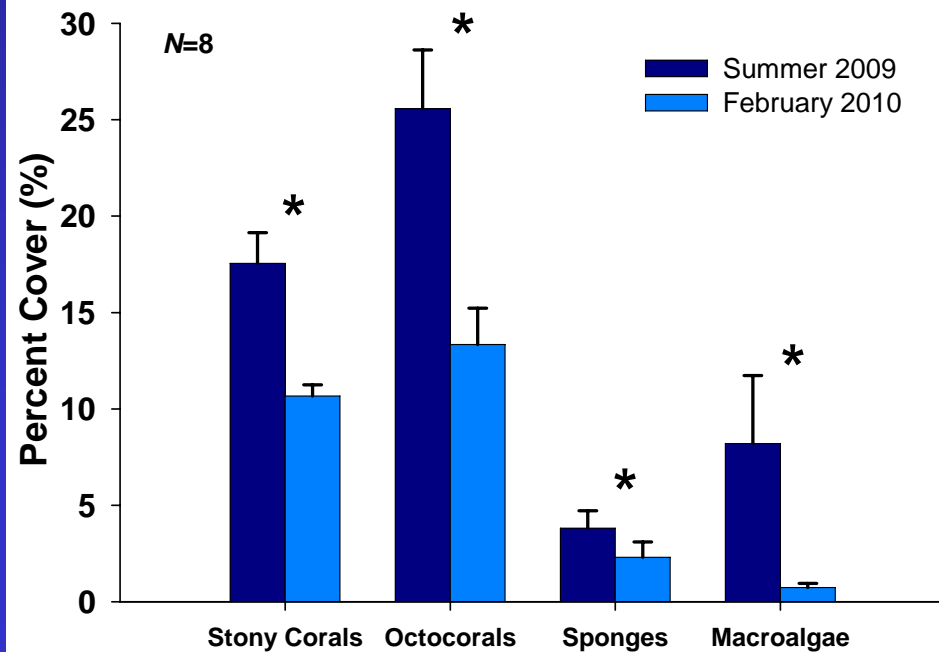


Causes of Decline: Cold

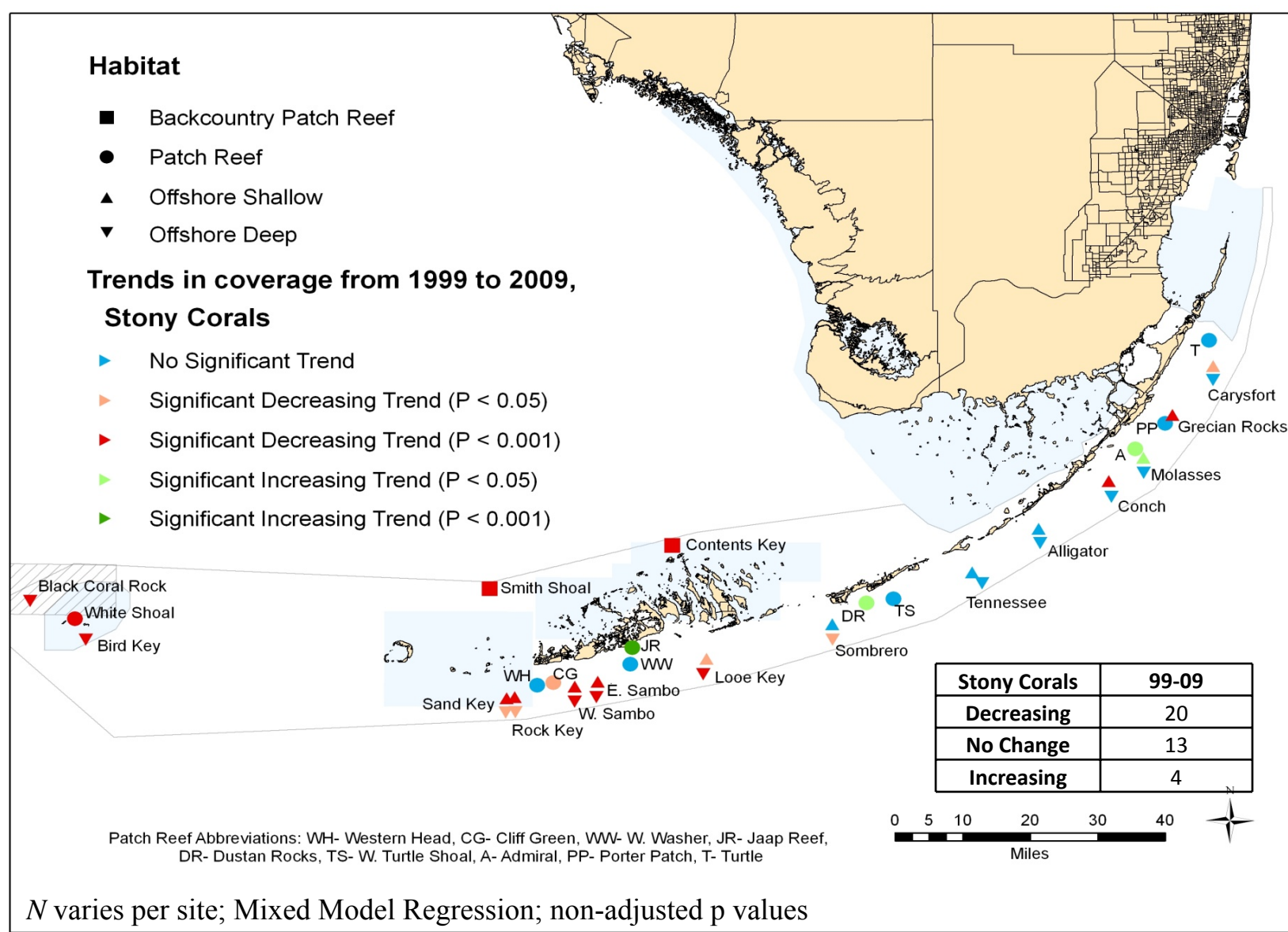
Summer 2009

February 2010

- Significant decline in all benthic groups (Wilcoxon paired sample test $df=7$; $p<0.001$)
- Approximately 40% and 50% change in stony and soft coral cover, respectively
- *Montastraea* spp. had greatest decline (in terms of percent cover)
- *Siderastrea siderea* most tolerant species (low prevalence and severity)

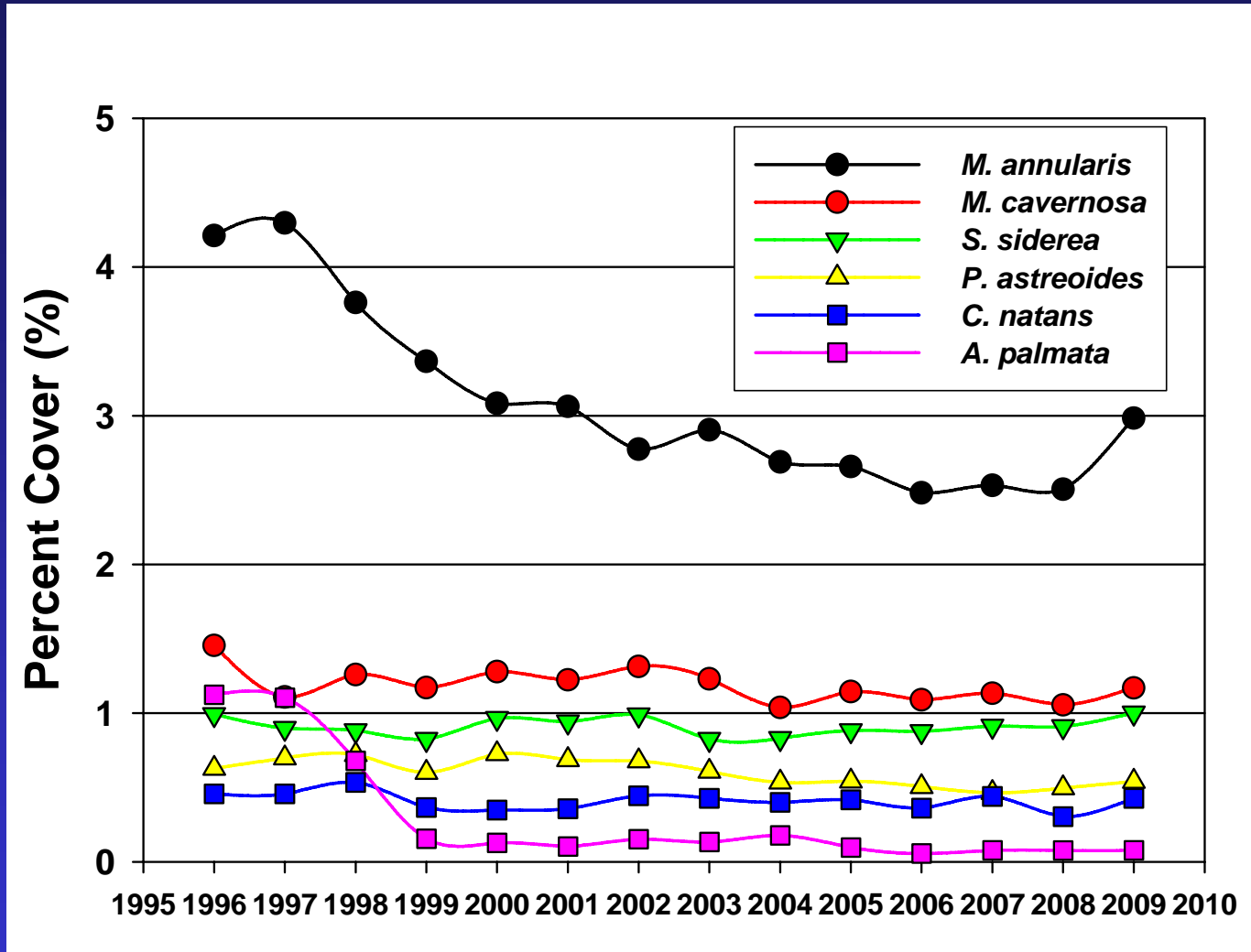


Trends in Coral Cover



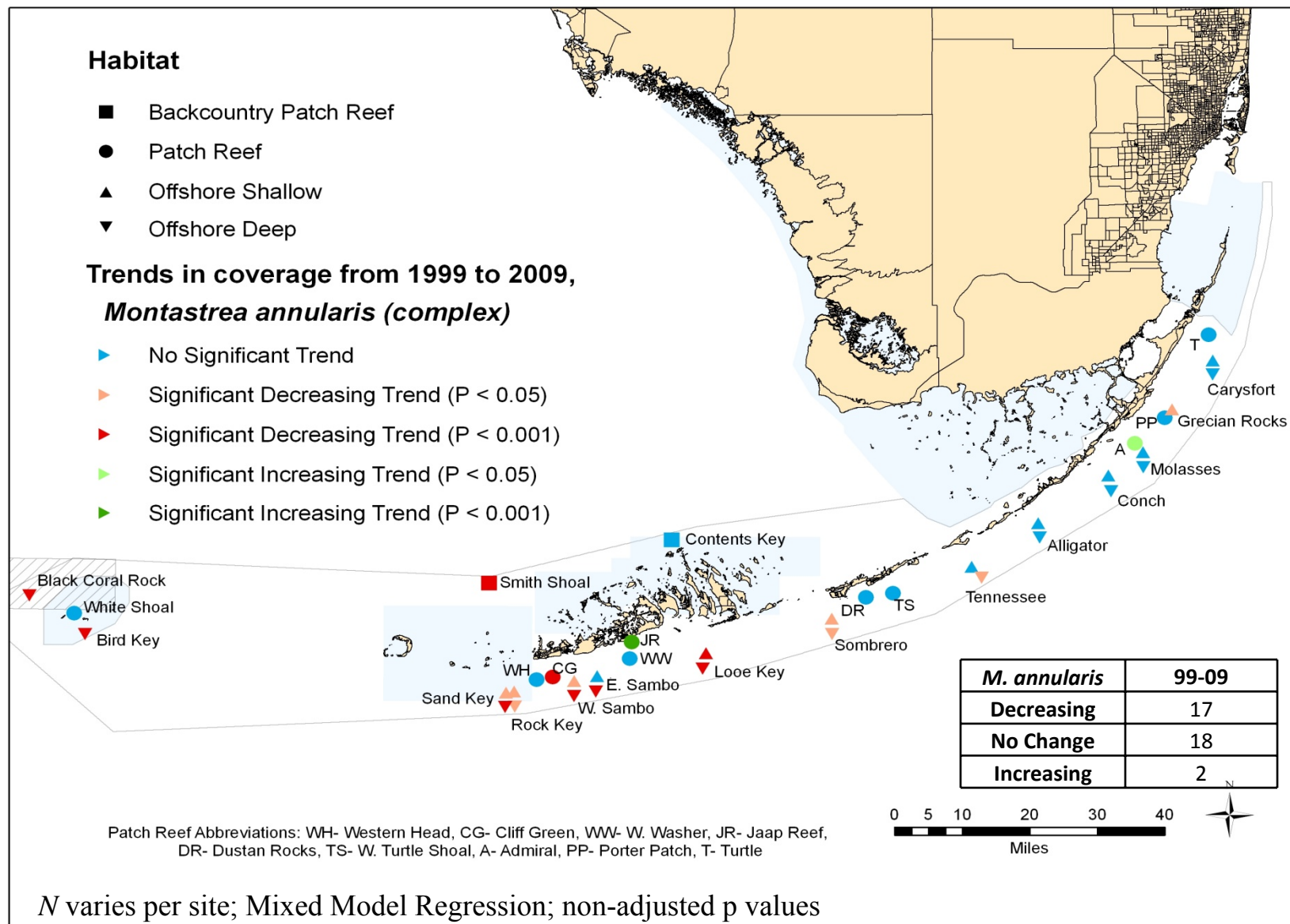
- Negative trend for 54% of all sites
- Trend is negative for 16 of 19 of sites in Lower Keys and Dry Tortugas

Trends in Species Percent Coral Cover 1996-2009



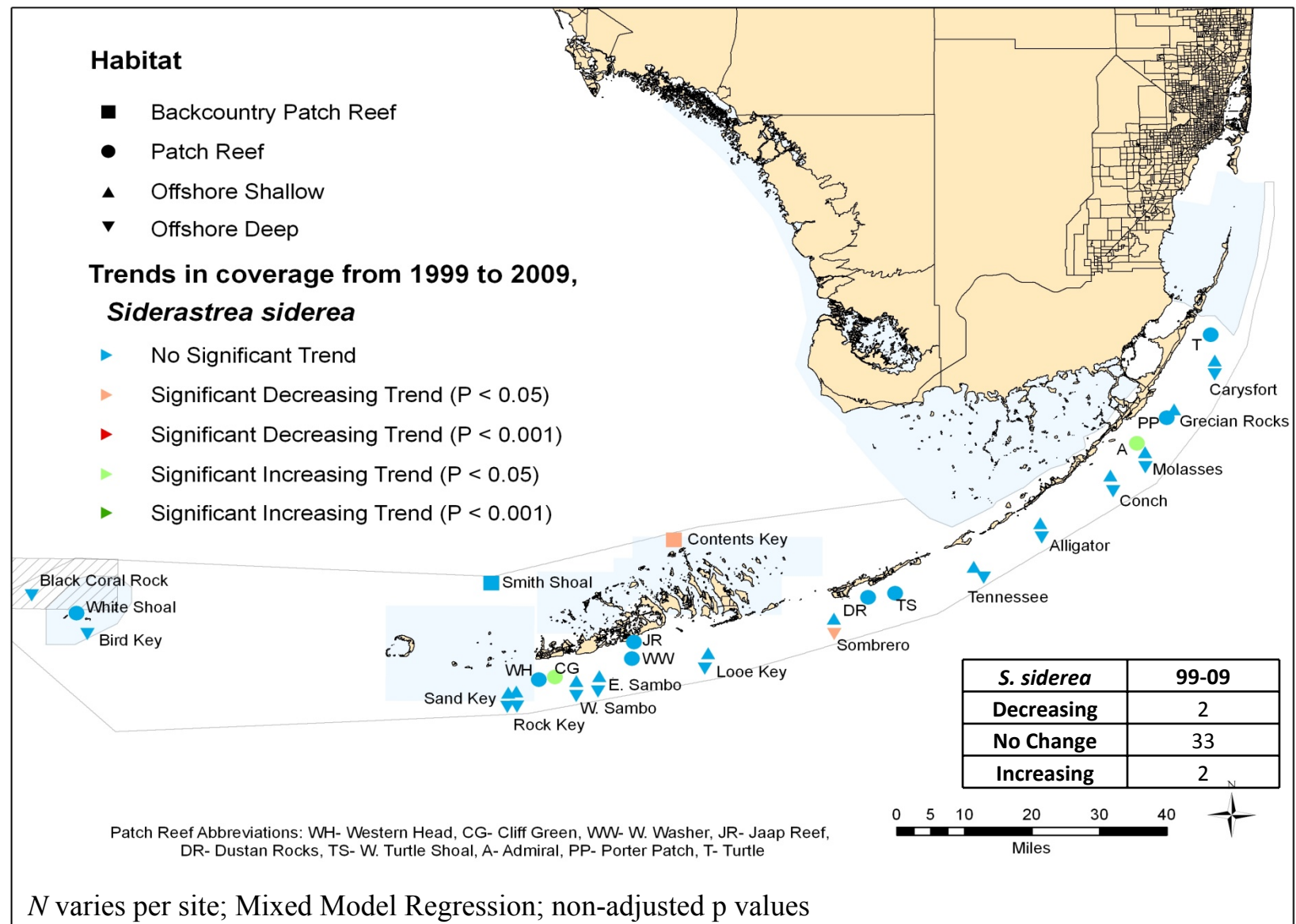
- Pooled together for Florida Keys stations ($N = 97$), *Montastraea annularis*, *M. cavernosa*, *Colpophyllia natans*, *Acropora palmata*, and *Porites astreoides* all show decreasing trend in cover since 1999.
- Only *Siderastrea siderea* shows no trend in cover.

Trends in *Montastraea annularis* complex Cover



- Trends for *M. annularis* are similar to overall trends in coral cover
- Trend is negative for 13 of 19 sites in Lower Keys and Dry Tortugas

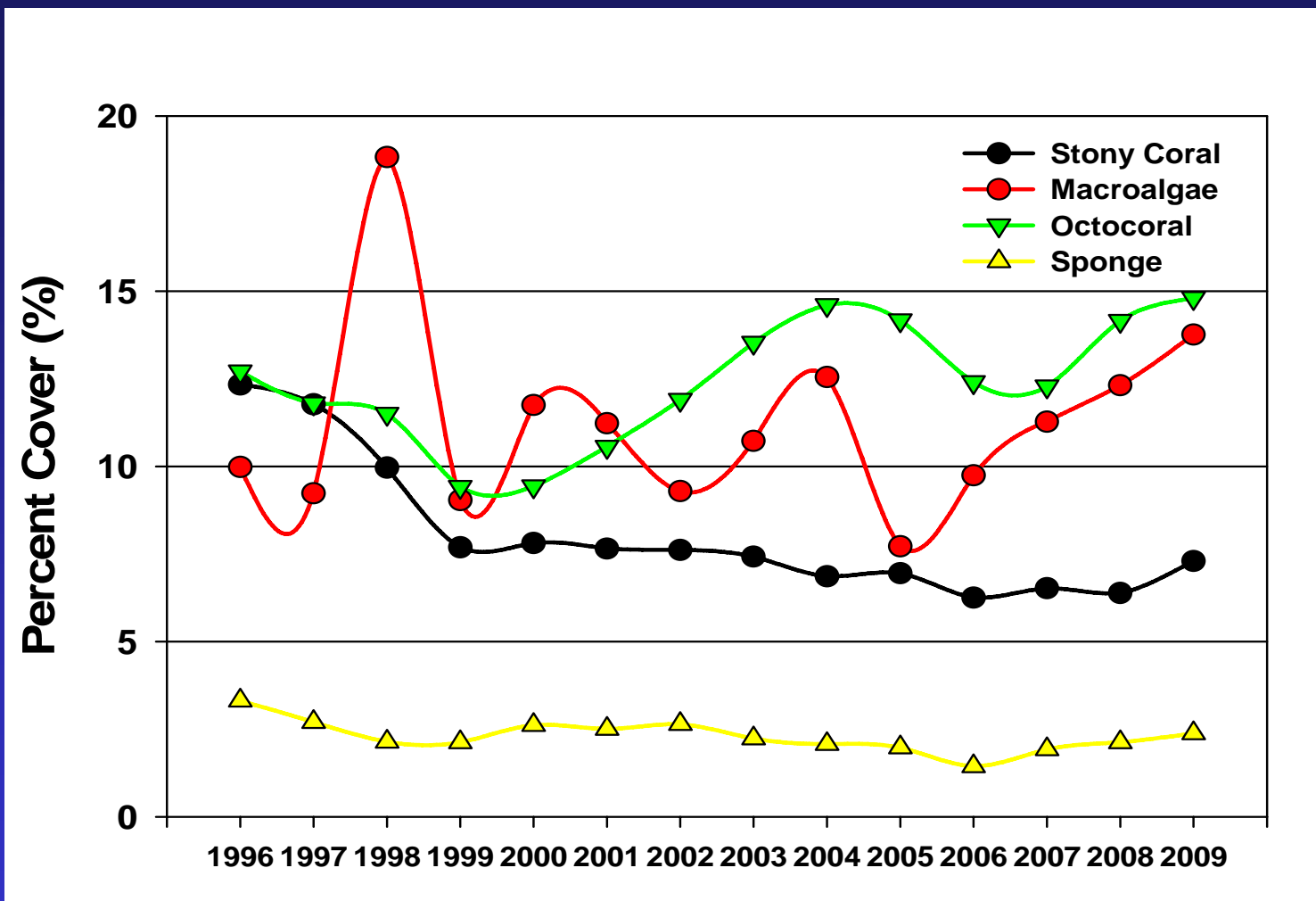
Trends in *Siderastrea siderea* Cover



➤ No trend identified for *S. siderea* at 89% of sites.

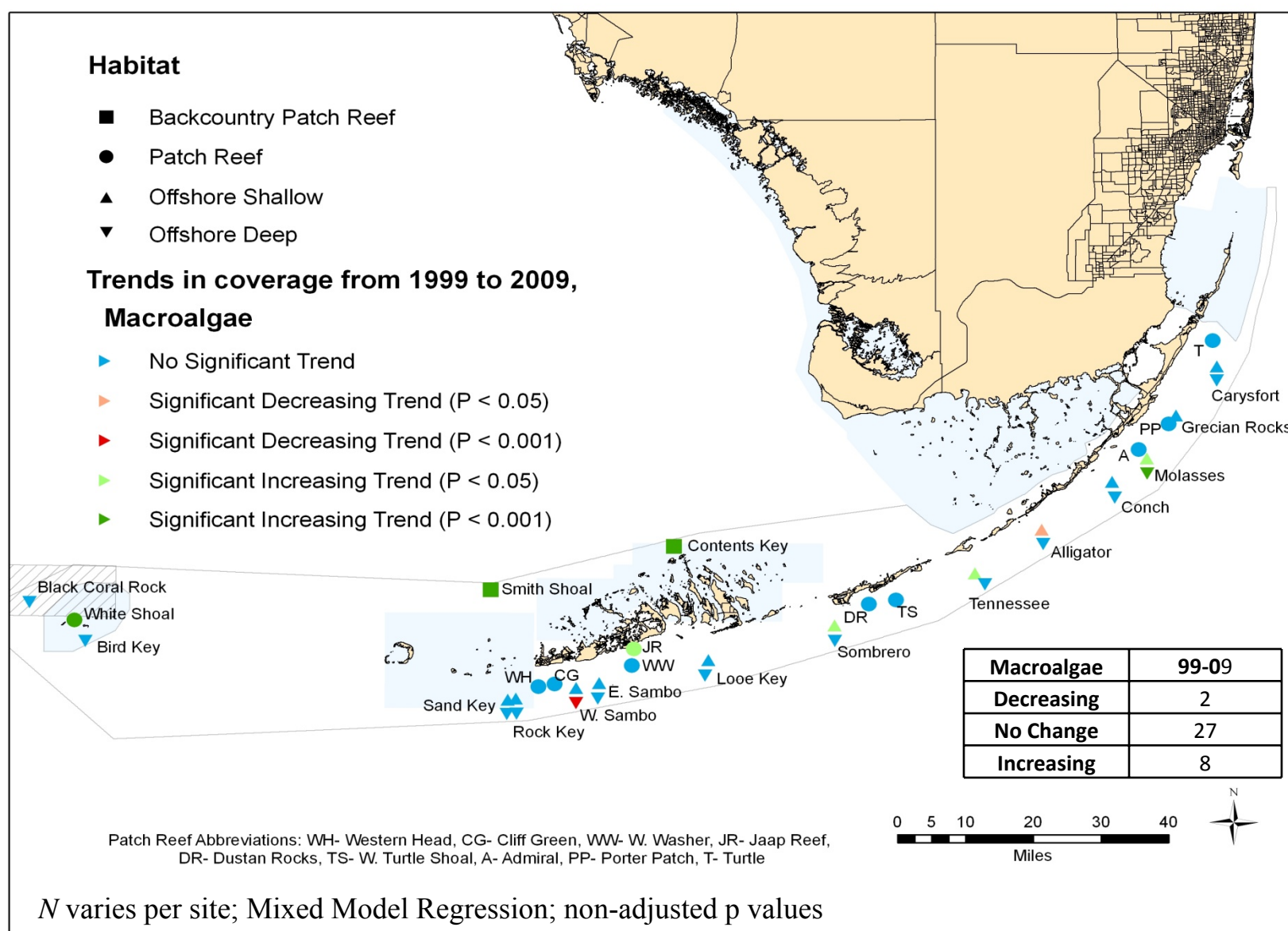
➤ *S. siderea* may mitigate cover decreases in Florida Keys unlike *Porites astreoides*

Trends in Benthic Cover



- $N = 97$ stations in the Keys
- Short term trends are positive for all taxa since 2006
- Overall trend for octocoral cover is positive while trends for sponge and coral cover are negative; no overall trend for macroalgae cover

Trends in Macroalgal Cover

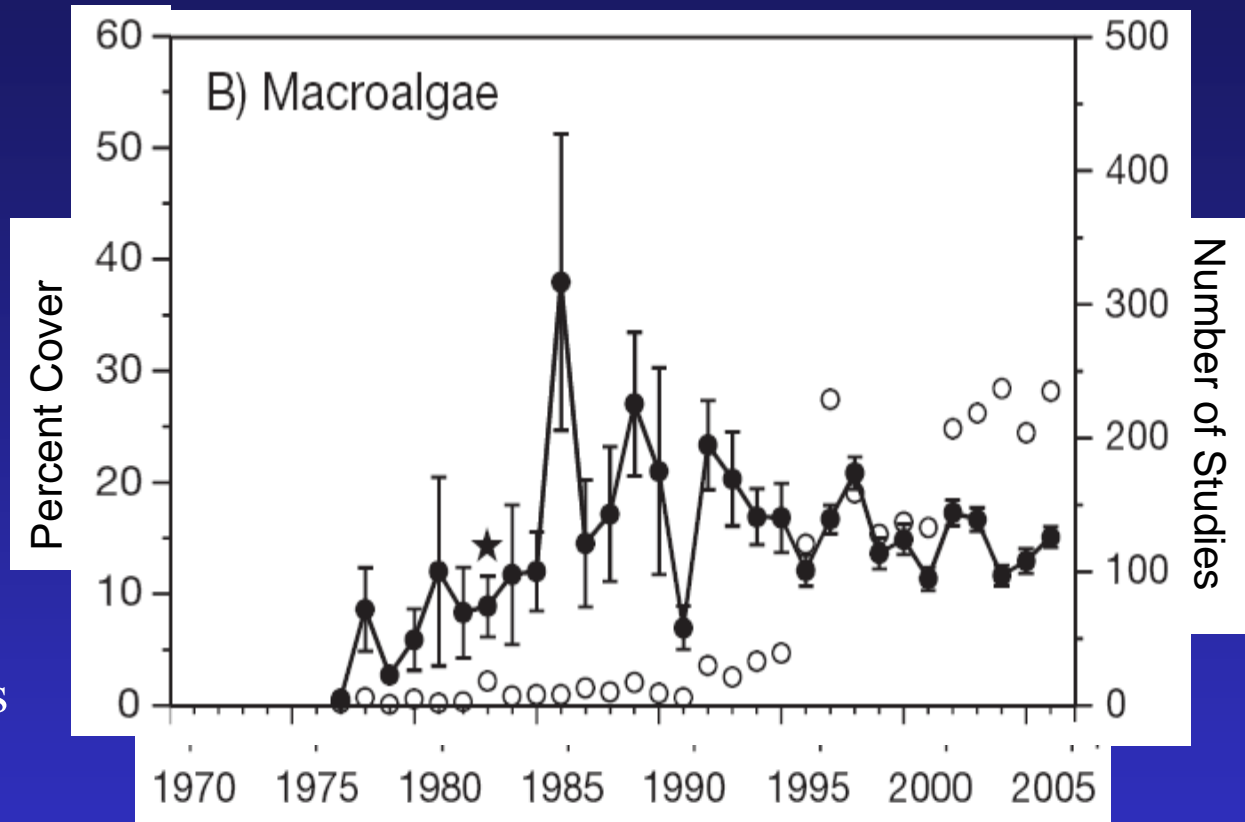


➤ No trend for macroalgae at majority of sites (73%)

➤ Backcountry sites primarily responsible for overall increase in macroalgal cover

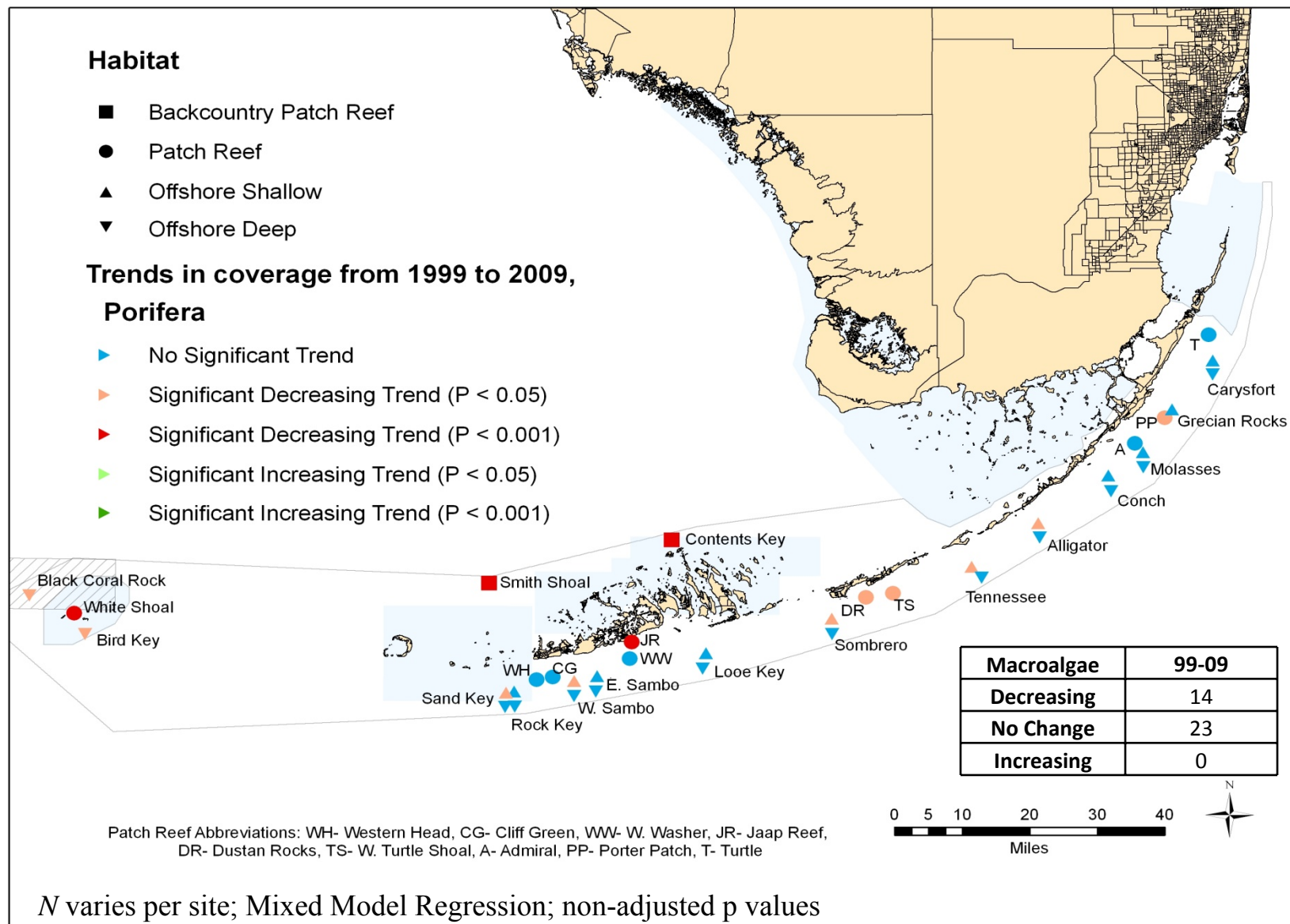
Trends in Macroalgal Cover

- Consistent with findings across wider Caribbean
- Keys reefs have not undergone phase shift to macroalgal dominated reefs
- Observed short term spikes (e.g. after 1997/1998 thermal stress event)
- Appears reefs in the Keys may have appropriate top down controls to regulate macroalgae cover
- Mean macroalgal cover in the Keys slightly less than on Caribbean reefs



From Schutte et al. 2010, MEPS, Vol. 402

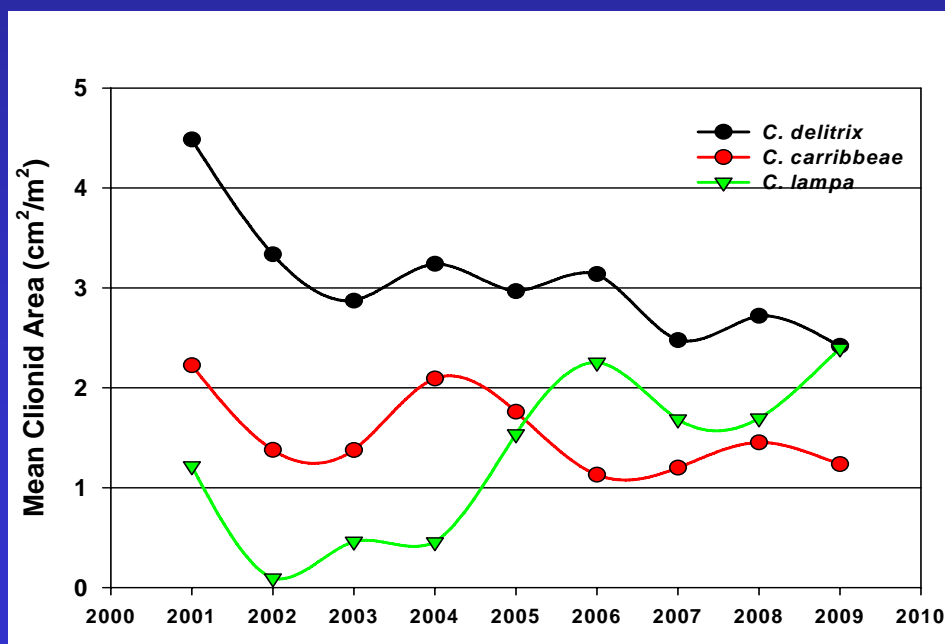
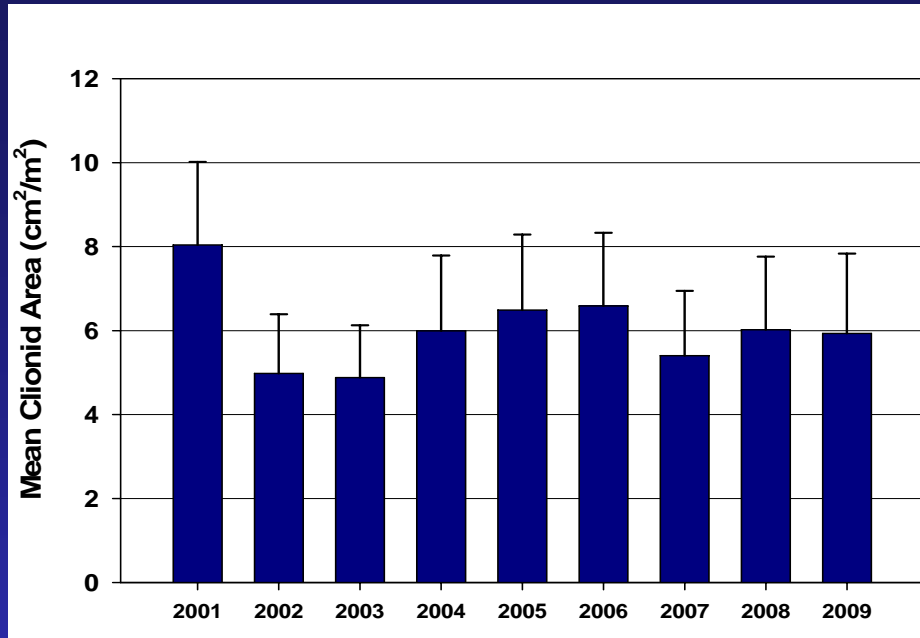
Trends in Sponge Cover



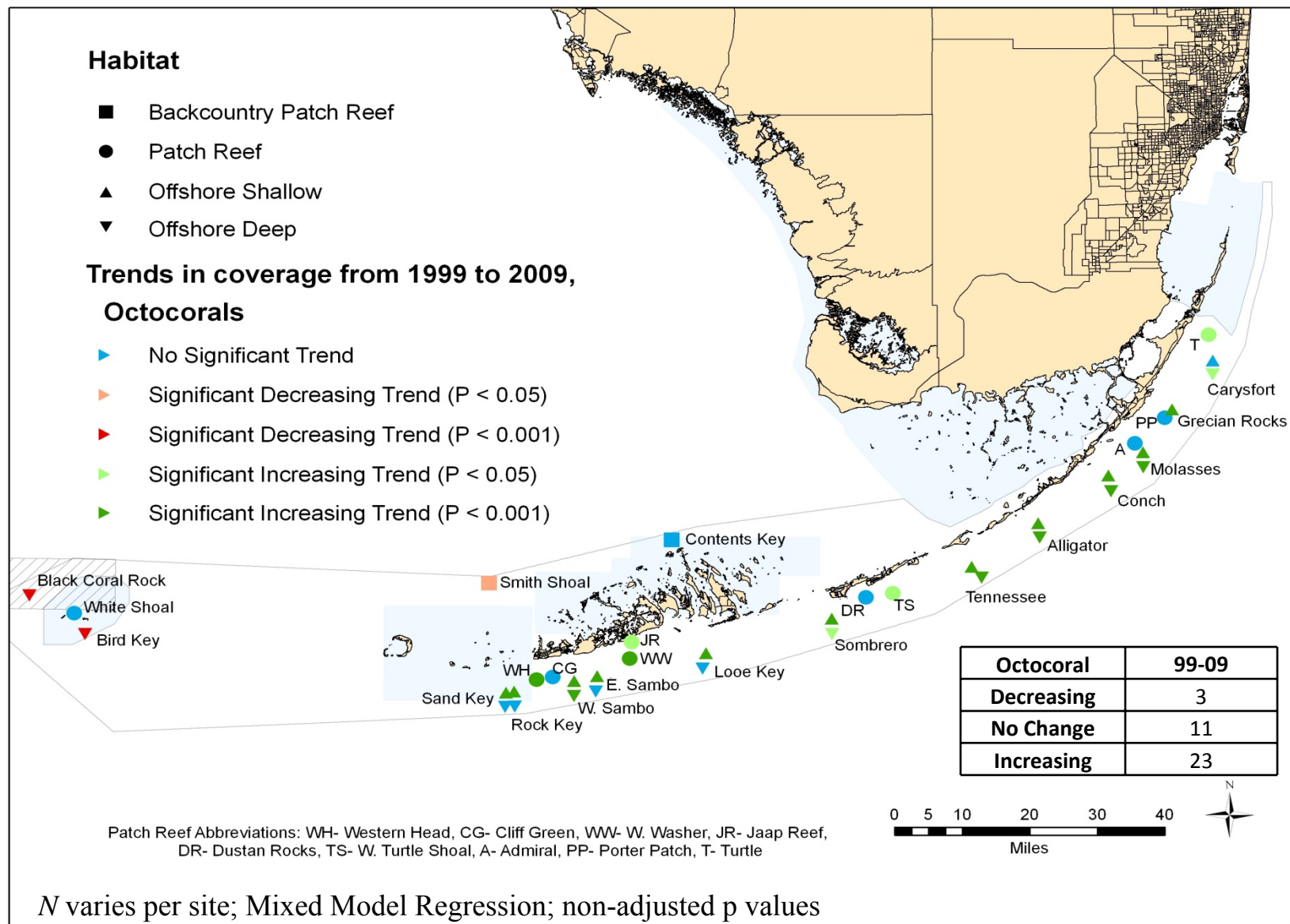
- Trend is negative at 38% of sites
- No clear pattern identifies why certain sites have declined

Trends in Clionid Cover

- Previously reported the Keys undergoing sponge phase shift (Ward-Page et al. 2005)
- Mean clionid area (all spp. pooled) has remained relatively similar since 2001
- *Cliona delitrix* shows declining trend since 2001. Decreased at 30% (11 of 37) of stations monitored
- Decrease may be linked to declining *Montastraea spp.* cover or poor proxy for assessing water quality



Trends in Octocoral Cover



- Trend is positive at 62% of sites
- All shallow forereef sites show a strong ($p < 0.001$) increasing trend

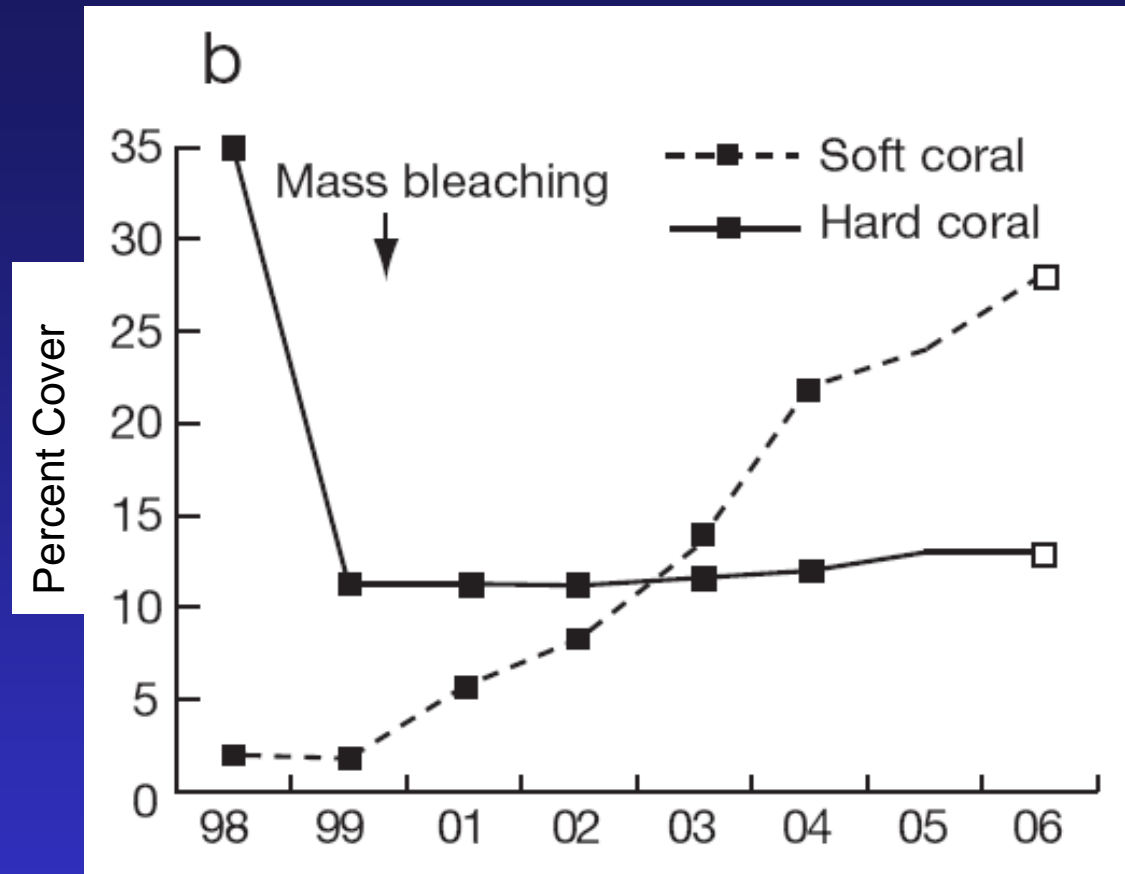
Trends in Octocoral Cover

➤ Similar finding in Seychelles after mass bleaching in 1998 but previously not reported for Caribbean

➤ Trend most apparent on shallow forereefs where *Acropora palmata* and *Millepora complanata* have disappeared.

➤ Multiple genera responsible for shift in cover

➤ Resiliency in Florida Keys linked to initial high cover, reproduction, growth rates



From Norstrom et al. 2009, MEPS, Vol. 376

Trends in Octocoral Cover – Molasses Shallow

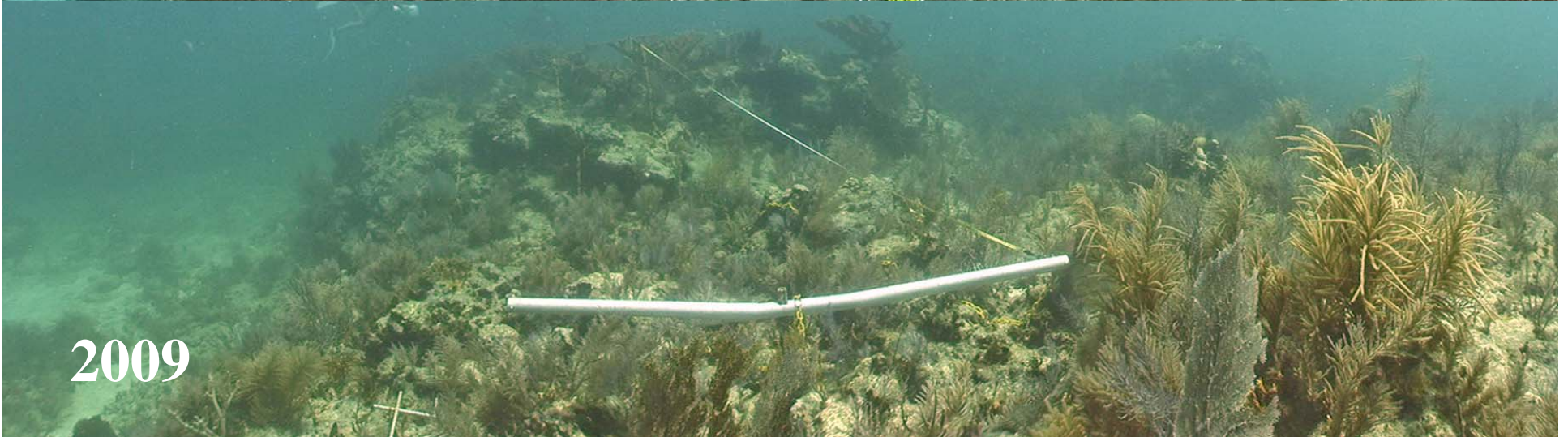


Trends in Octocoral Cover – Molasses Shallow

2001



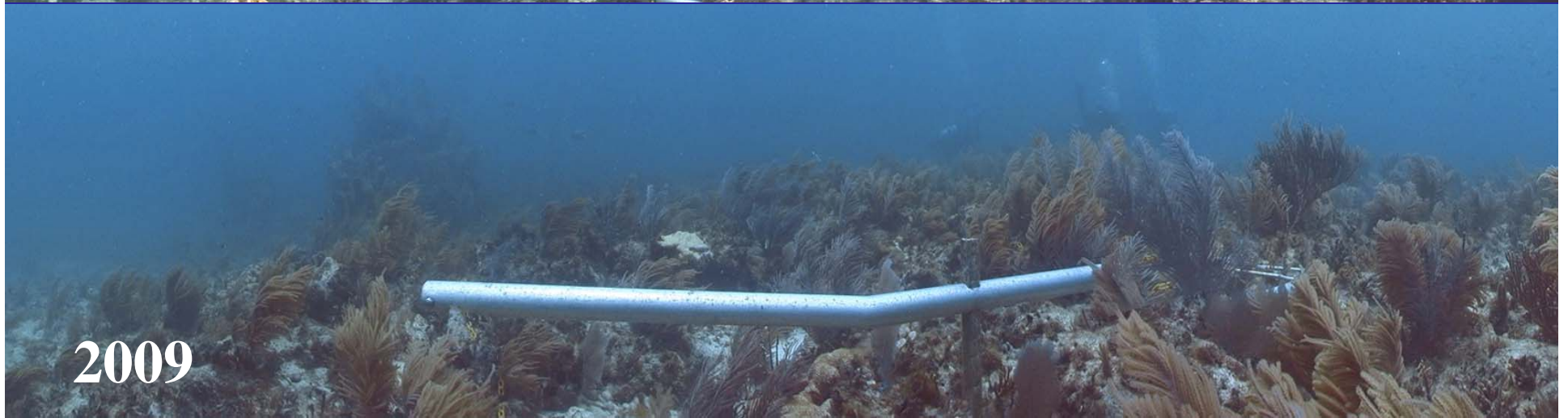
2009



Trends in Octocoral Cover – Conch Shallow

2001

2009



Summary

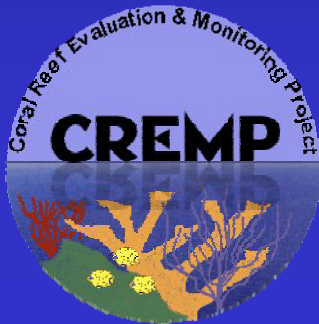
1. CREMP has recorded a 43% decline in coral cover since project inception and mean species richness has decreased in all regions and habitats
2. The most notable decreases occurred between 1997-1999 and 2003-2006 during ENSO years and intense hurricane seasons
 - 54% of all sites show a declining trend since 1999
 - 2009 was the first year CREMP ever recorded an increase in coral cover
 - Patch reefs will decrease in cover in 2010 more than any other year
 - *Montastraea annularis* and *M. cavernosa* severely impacted by 2010 winter
3. Keys entering into a new alternative state dominated by octocorals
 - Most apparent on shallow forereef sites replacing *A. palmata* and *M. complanata*, trend starting at patch and deep sites
 - Sponge cover shows a negative trend while macroalgal cover has remained similar throughout the project
4. Coral Cover within the most intensively managed areas (SPAs) has declined by 67% since 1996

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