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 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
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

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 ~1 pt/80cm²
   - Images analyzed in Point Count ‘99
   - Data pooled for each station and square root transformed

3. Clionid Sponge Surveys
   - Sum total no. of 25cm² grids occupied by Cliona spp. per station
   - Quantify mean clionid area (cm²/m²)
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

* Includes only Florida Keys station data
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.

![Graph showing change in species presence/absence](image-url)
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
Lethal temperature for corals is 16°C (~60°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
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

Habitat
- Backcountry Patch Reef
- Patch Reef
- Offshore Shallow
- Offshore Deep

Trends in coverage from 1999 to 2009, Stony Corals
- No Significant Trend
- Significant Decreasing Trend (P < 0.05)
- Significant Decreasing Trend (P < 0.001)
- Significant Increasing Trend (P < 0.05)
- Significant Increasing Trend (P < 0.001)

<table>
<thead>
<tr>
<th>Stony Corals</th>
<th>99-09</th>
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<tbody>
<tr>
<td>Decreasing</td>
<td>20</td>
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<tr>
<td>No Change</td>
<td>13</td>
</tr>
<tr>
<td>Increasing</td>
<td>4</td>
</tr>
</tbody>
</table>

N varies per site; Mixed Model Regression; non-adjusted p values

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

**Habitat**
- Backcountry Patch Reef
- Patch Reef
- Offshore Shallow
- Offshore Deep

**Trends in coverage from 1999 to 2009, Montastrea annularis (complex)**
- No Significant Trend
- Significant Decreasing Trend (P < 0.001)
- Significant Increasing Trend (P < 0.001)

<table>
<thead>
<tr>
<th></th>
<th>99-09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreasing</td>
<td>17</td>
</tr>
<tr>
<td>No Change</td>
<td>18</td>
</tr>
<tr>
<td>Increasing</td>
<td>2</td>
</tr>
</tbody>
</table>

*N* varies per site; Mixed Model Regression; non-adjusted p values

- 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

**Habitat**
- Backcountry Patch Reef
- Patch Reef
- Offshore Shallow
- Offshore Deep

**Trends in coverage from 1999 to 2009,**

*Siderastrea siderea*
- No Significant Trend
- Significant Decreasing Trend (P < 0.05)
- Significant Decreasing Trend (P < 0.001)
- Significant Increasing Trend (P < 0.05)
- Significant Increasing Trend (P < 0.001)

<table>
<thead>
<tr>
<th><em>S. siderea</em></th>
<th>99-09</th>
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<tbody>
<tr>
<td>Decreasing</td>
<td>2</td>
</tr>
<tr>
<td>No Change</td>
<td>33</td>
</tr>
<tr>
<td>Increasing</td>
<td>2</td>
</tr>
</tbody>
</table>

*N* varies per site; Mixed Model Regression; non-adjusted p values

- 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

Habitat
- Backcountry Patch Reef
- Patch Reef
- Offshore Shallow
- Offshore Deep

Trends in coverage from 1999 to 2009, Macroalgae
- No Significant Trend
- Significant Decreasing Trend (P < 0.05)
- Significant Decreasing Trend (P < 0.001)
- Significant Increasing Trend (P < 0.05)
- Significant Increasing Trend (P < 0.001)

No trend for macroalgae at majority of sites (73%)
Backcountry sites primarily responsible for overall increase in macroalgal cover

N varies per site; Mixed Model Regression; non-adjusted p values
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

**Habitat**
- Backcountry Patch Reef
- Patch Reef
- Offshore Shallow
- Offshore Deep

**Trends in coverage from 1999 to 2009, Porifera**
- No Significant Trend
- Significant Decreasing Trend (P < 0.05)
- Significant Decreasing Trend (P < 0.001)
- Significant Increasing Trend (P < 0.05)
- Significant Increasing Trend (P < 0.001)

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

Macraalgae | 99-09 |
--- | --- |
Decreasing | 14 |
No Change | 23 |
Increasing | 0 |

*N* varies per site; Mixed Model Regression; non-adjusted *p* values
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

- **Habitat**
  - Backcountry Patch Reef
  - Patch Reef
  - Offshore Shallow
  - Offshore Deep

**Trends in coverage from 1999 to 2009, Octocorals**

- No Significant Trend
- Significant Decreasing Trend (P < 0.05)
- Significant Decreasing Trend (P < 0.001)
- Significant Increasing Trend (P < 0.05)
- Significant Increasing Trend (P < 0.001)

<table>
<thead>
<tr>
<th>Octocoral</th>
<th>99-09</th>
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<tbody>
<tr>
<td>Decreasing</td>
<td>3</td>
</tr>
<tr>
<td>No Change</td>
<td>11</td>
</tr>
<tr>
<td>Increasing</td>
<td>23</td>
</tr>
</tbody>
</table>

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

N varies per site; Mixed Model Regression; non-adjusted p values

Patch Reef Abbreviations: WH- Western Head, CG- Cliff Green, WW- W. Washer, JR- Jaap Reef, DR- Dustan Rocks, TS- W. Turtle Shoal, A- Admiral, PP- Porter Patch, T- Turtle
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
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.
CREMP Team

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