Causes and Consequences of Mass Bleaching in Papahānaumokuākea

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• **1996 Mass Bleaching in Kāneʻohe Bay, Oʻahu** (Jokiel and Brown 2004)
  • Prolonged thermal stress and UV
  • 2002 more severe; primarily affected *Montipora* in western atolls
• **2014 & 2015**: Hawaii’s first back-to-back bleaching event.
AUGUST 10, 2015
Maximum Degree Heating Weeks

Couch et al. in prep
Objectives

1. Assess the extent and severity of bleaching event across islands/atolls, habitats and species.

2. Determine how well remotely-sensed thermal stress metrics predicted bleaching levels.

3. Assess the potential long-term consequences on the composition and 3D structure of PMNM coral communities.
**Methods**

1. **Extent and Severity of Bleaching**
   - **4-8 sites** permanent transects at French Frigate Shoals, Lisianski Island, Pearl and Hermes Atoll, Midway Atoll
   - **Habitats**: Forereef, Backreef (shallow: 1-7m; moderate: 8-15m)
   - Conducted 3, 10x1-m belt transects
   - **Recorded**: species, lesion type and severity of condition.
   - **Bleaching Incidence** = % of colonies that were >50% bleached.
   - **Survey conducted in**: September 2014 and August 2015.
Methods

2. Thermal Stress Metrics:
   • NOAA Coral Reef Watch Program’s 5km night-only degree heating week for each study site at the time of survey.

3. Coral Cover and 3D Structure:
   • Photo quads and CPCe along each transect to assess changes in % coral cover and benthic community structure.
   • Structure-from-motion photogrammetry and geospatial software used to quantify 3D changes in habitat complexity.
Bleaching Patterns by Atoll/Island

Binomial generalized linear model with Tukey HSD post hoc test

Couch et al. in prep
Did Thermal Stress Predict Bleaching?

% Bleaching Incidence vs. Degree Heating Weeks

- Orange dots: 2014
- Teal dots: 2015

$R^2 = 0.4168$

$p < 0.00001$

Couch et al. in prep
How Does Bleaching Vary Across Habitats?

Couch et al. in prep
How Did Corals Vary in their Bleaching Susceptibility?

Couch et al. in prep
How Did Coral Cover Change after the Bleaching Event?

Couch et al. in prep
Coral Cover Change by Species

Couch et al. in prep
How Did Coral Cover Change after the Bleaching Event?

- September 2014: 70.66% Coral Cover
- August 2015: <1% Coral Cover
3D analysis of reef structure and composition
3D analysis of reef structure and composition
3D analysis of reef structure and composition
How did Thermal Stress Compare to Previous Events?

Sea Surface Temperature (°C)

Degree Heating Weeks (°C-weeks)

MIDWAY ATOLL

LISIANSKI ISLAND

Couch et al. in prep
How did Bleaching Compare to 2002?

2002
(Kenyon & Brainard 2006)

2002 data not presented

Couch et al. in prep
Conclusions

• In 2014, PMNM experienced the 3rd and most severe mass bleaching.
• The 2014 and 2015 thermal stress events vastly different.
• Lisianski Island experienced the highest thermal stress with 45% of colonies bleached by September 2014.
• Highest bleaching in sheltered shallow habitats dominated by Montipora.
• Coral loss was associated with reductions in both habitat complexity.
• MID experienced higher thermal stress in 2014 compared to 2002, but lower bleaching and promising recovery, which highlights importance of bleaching history and possible potential for local acclimation.
• Study highlights need for continued monitoring of bleaching risk, long-term ecosystem impacts and to identify factors important for resilience.
Mahalo!

- Field Support
  - Crew of the Hiʻialakai
- Ruth Gates
- Scott Godwin
- Donahue Lab
- Funding:
  - NOAA/Papahānaumokuākea
Extra slides
What Climatic Processes are Driving Mass Bleaching in Hawaii?

- Climate change
- El Niño
- Pacific Decadal Oscillation
- “The Blob”
How extensive was mass bleaching on Eastern Lisianski Island?

Surveyed 8 km of reef area
Took images every 10 sec
2 - 5m depth
560 total images
300 images with coral
91%
% cover change by species and region

<table>
<thead>
<tr>
<th>Region</th>
<th>Species</th>
<th>2014 % Cover</th>
<th>2015 % Cover</th>
<th>p value</th>
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<tbody>
<tr>
<td>FFS</td>
<td><em>Porites lobata</em></td>
<td>12.44 (2.11)</td>
<td>15.22 (3.70)</td>
<td>0.5745</td>
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<tr>
<td></td>
<td><em>Porites lichen</em></td>
<td>6.77 (2.40)</td>
<td>4.24 (2.51)</td>
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<tr>
<td></td>
<td><em>Porites compressa</em></td>
<td>3.88 (1.66)</td>
<td>4.84 (1.97)</td>
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<td></td>
<td><em>Porites evermanni</em></td>
<td>1.59 (1.05)</td>
<td>0.09 (0.09)</td>
<td>0.1038</td>
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<tr>
<td></td>
<td><em>Montipora capitata</em></td>
<td>1.36 (0.31)</td>
<td>0.75 (0.19)</td>
<td>0.1412</td>
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<tr>
<td></td>
<td><em>Pocillopora damicornis</em></td>
<td>1.22 (0.05)</td>
<td>0.31 (0)</td>
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<td>Montipora dilitata</td>
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<td>0 (0)</td>
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<td><em>Porites compressa</em></td>
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<td>9.94 (6.26)</td>
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<td><em>Porites lobata</em></td>
<td>10.515 (1.99)</td>
<td>8.88 (1.71)</td>
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<td><em>Montipora capitata</em></td>
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<td><em>Montipora patula</em></td>
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<td>0.14 (0.07)</td>
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<td>18.18 (4.70)</td>
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<td>3.06 (0.83)</td>
<td>0 (0)</td>
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<td><em>Pocillopora ligulata</em></td>
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<td>9.00 (4.35)</td>
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<td>12.34 (3.75)</td>
<td>3.46 (1.30)</td>
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