Importance of Coral Reefs

Coral reef ecosystem goods & services valued at ~$400 billion annually

Traditional Culture & Food

$Multibillion Recreation Industry

Shoreline Protection

Major Locus of Global Biodiversity
Threats to Coral Reefs

Overfishing & Destructive Fishing

Coastal Development & Pollution

Coral Bleaching

Disease

Ocean Acidification

Among others...
Reef degradation manifests as ecological phase shift from... 

...diverse, productive, and coral-rich, to... 

...low diversity, low productivity, and coral-poor.
Coral Reef Assessment

Transects: detailed, laborious, small footprint

“Manta-Tow”: quick, semi-quantitative, larger footprint

Most surveys are very sparse, undersampling reef area across local and regional scales
Coral Reef Condition

The most common metric for reef condition is proportional cover of benthic types, primarily coral.

Existing survey data (US Caribbean, Hawaii, Great Barrier Reef) do not follow expected trends with respect to environmental factors. For example, coral cover should increase with aragonite saturation and decrease with marine pollution.

Either our understanding of reefs is incorrect, or our data are inadequate (low density, mismatched scales). Or maybe both.
Overarching Science Question (Threshold)
Q1. What is the relationship between coral reef condition and biogeophysical forcing parameters?

CORAL Science Objectives (Threshold)
O1. Make high-density observations of reef condition for a large fraction of world's reef area (green in map below, $10^3$ more than current, in situ observations).
## CORAL Technology: PRISM

<table>
<thead>
<tr>
<th>Observables/Parameter</th>
<th>CORAL Requirements</th>
<th>PRISM Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Range</td>
<td>400-800 nm</td>
<td>350-1050 nm</td>
</tr>
<tr>
<td>Spectral Sampling</td>
<td>≤10 nm</td>
<td>2.85 nm, 1242 &amp; 1608 nm</td>
</tr>
<tr>
<td>Radiometric SNR</td>
<td>&gt;300 @ 400-800 nm</td>
<td>&gt; 600 @ 400-800 nm</td>
</tr>
<tr>
<td>Polarization Sensitivity</td>
<td>≤1%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Spectral Uniformity</td>
<td>&gt;90%, &lt;10%</td>
<td>&gt;95%, &lt;5%</td>
</tr>
<tr>
<td>Cross-Track, IFOV Mixing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>≤10 m</td>
<td>@28kft ≤8 m</td>
</tr>
</tbody>
</table>
PRISM records the intensity of the wavelengths for each pixel in the scene. The spectral “signature” is used to identify reef composition (coral, algae, sand) and model primary production.
CORAL Observations

Coral’s first objective is to generate these products for all study areas. Coral’s second objective is to analyze these products in relation to biogeophysical forcing parameters. The result will be a new understanding of how environment shapes whole reef ecosystems, which is vital to their conservation.
CORAL Validation

Benthic Reflectance

Water Optical Properties

Benthic Cover

Benthic Productivity
### CORAL Science Team

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Org.</th>
<th>Roles &amp; Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Heidi Dierssen</td>
<td>UConn</td>
<td>Co-I Optical calibration/validation (Level 2)</td>
</tr>
<tr>
<td>Dr. ZhongPing Lee</td>
<td>UMB</td>
<td>Co-I Optical calibration/validation (Level 2)</td>
</tr>
<tr>
<td>Dr. Eric Hochberg</td>
<td>BIOS</td>
<td>PI Benthic cover calibration/validation (Level 3)</td>
</tr>
<tr>
<td>Dr. Steve Dollar</td>
<td>UH</td>
<td>Co-I Benthic cover calibration/validation (Level 3)</td>
</tr>
<tr>
<td>Dr. Bob Carpenter</td>
<td>CSUN</td>
<td>Co-I Benthic community productivity &amp; calcification calibration/validation (Level 4)</td>
</tr>
<tr>
<td>Dr. Robert Green</td>
<td>JPL</td>
<td>Co-I Digital Numbers (DNs) to benthic composition (Levels 0-3)</td>
</tr>
<tr>
<td>Dr. Pantazis Mouroulis</td>
<td>JPL</td>
<td>Co-I Digital Numbers (DNs) &amp; radiance products (Levels 0-1)</td>
</tr>
<tr>
<td>Dr. Bo-Cai Gao</td>
<td>NRL</td>
<td>Co-I Atmospheric &amp; glint correction (Level 2)</td>
</tr>
<tr>
<td>Dr. ZhongPing Lee</td>
<td>UMB</td>
<td>Co-I Water column correction (Level 2)</td>
</tr>
<tr>
<td>Dr. Eric Hochberg</td>
<td>BIOS</td>
<td>PI Benthic cover product; primary productivity &amp; calcification products (Levels 3-4)</td>
</tr>
<tr>
<td>Dr. Stéphane Maritorena</td>
<td>UCSB</td>
<td>Co-I Primary productivity &amp; calcification products (Level 4)</td>
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</tbody>
</table>

**Calibration/Validation**

**Data Products**

**Science Facilitators at International Locations**

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<tr>
<td>Dr. Patrick Colin</td>
<td>CRRF</td>
<td>Co-I Palau liaison</td>
</tr>
<tr>
<td>Dr. Stuart Phinn</td>
<td>UQ</td>
<td>Collaborator Great Barrier Reef liaison</td>
</tr>
<tr>
<td>Dr. Arnold Dekker</td>
<td>CSIRO</td>
<td>Collaborator Great Barrier Reef liaison</td>
</tr>
</tbody>
</table>

**Level 0**

- **Level 0**: Digital Numbers (DNs)

**Level 1**

- **Level 1**: \( L_{TOT}(\text{geo}) \)

**Level 2**

- **Level 2**: \( R_b \)

**Level 3**

- **Level 3**: Biological Oxygen Productivity (P)
- **Level 3**: Calcification (G)

**Level 4**

- **Level 4**: Benthic Cover Product (BC)
- **Level 4**: Benthic Community Productivity and Calcification Calibration/Validation (Ed, LUE)
# CORAL Schedule

## Milestones / Reviews / Conferences
- **Kick-Off 7/30/15**
- Science Team Review #1 - 10/8/15
- PIP Submission 10/29/15
- CAM 11/12/15
- JPL Review 12/1/15
- Confirmation (HQ) 12/10/15
- FRR 2/1/16
- Ocean Sciences #1 (Start) - 2/21/16
- Science Team Review #2 - 7/29/16
- Science Team Review #3 - 7/31/16

## Campaigns
- Florida
- Palau
- Mariana Islands
- Great Barrier Reef (Australia)
- Hawaii

## Science Activities
- SDS & Field Support Team Development
- Establish Reef Condition
- Model Reef Condition vs. Forcings
- Publish
- Closeout

![Diagram with phases and milestones]

- Completed Milestones/Reviews/Conferences
- Milestones/Reviews/Conferences
- Primary Campaign Windows
- Secondary Campaign Windows
- Science Activities

[Diagram Legend]