Biotechnology: Contributions to Coral Reef Science
Coral reefs are declining worldwide, with 58-70% adversely affected by human activities.

Declines likely caused by local, regional, and global stresses; latter two most widely reported in media:

- Global warming (El Nino)
- African dust
- Emerging infectious diseases

Local impacts relatively unknown.

Resource managers uncertain whether or how to ameliorate adverse impacts.
The REAL PROBLEM

- Developing ‘useful’ understanding of the causes and mechanisms of coral reef declines
  - Scientists
  - Resource Managers

www.sci.sdsu.edu/PHAGE
The REAL PROBLEM

- Developing tools to diagnose and mitigate the causes of coral reef declines

TECHNOLOGY = The ability to perceive reality and to alter conditions and effects
Current monitoring methods ignore important links in the biological hierarchy

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Communities</th>
<th>Populations</th>
<th>Individuals</th>
<th>Organs</th>
<th>Tissues</th>
<th>Cells &amp; Molecules</th>
<th>Stress</th>
</tr>
</thead>
</table>

- **Ecosystem**: Infer
- **Communities**: Monitor
- **Populations**: Monitor
- **Individuals**: Monitor
- **Organs**: Monitor
- **Tissues**: Monitor
- **Cells & Molecules**: Monitor
- **Stress**: Monitor
Biotechnology Industry

Tools: Genomics and Proteomics and Cell Biology

Methodology & Philosophy:

Biomedical Sciences

⇒ Cellular Diagnostics and Therapeutics
Environmental Cellular Diagnostics

- All life is based on the cell
- Cellular diagnostics is the ability to measure “cellular health”

≈ Diagnose the health of any species on the planet . . .
Cellular Diagnostics and Coral Reef Decline

Mechanisms of Coral Bleaching

(Global and Regional)
Oxidative Stress

- Same Process in Corals that is associated with Parkinson’s Disease, Alzheimer’s Disease, and Aging
- U.S. NOAA, U.S. NPS, Australian Institute of Marine Science
- College of Charleston, Univ. California-Berkeley, Med. Univ. South Carolina, Univ. Newcastle Upon Tyne (UK)
- Cousteau Society, Mote Marine Laboratory
- Environmental Moorings, Intl., IIDEXO
## Sampling Locations

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Dept</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rodriguez Key</td>
<td>3 m</td>
</tr>
<tr>
<td>2 SW Three Sisters</td>
<td>6 m</td>
</tr>
<tr>
<td>3 Between Molasses and Pickels</td>
<td>10 m</td>
</tr>
<tr>
<td>4 SW Molasses</td>
<td>18 m</td>
</tr>
<tr>
<td>5 White Bank</td>
<td>6 m</td>
</tr>
<tr>
<td>6 Algae reef</td>
<td>6 m</td>
</tr>
<tr>
<td>7 <strong>Alina’s reef</strong></td>
<td>6 m</td>
</tr>
<tr>
<td>8 East Bache Shoal</td>
<td>6 m</td>
</tr>
</tbody>
</table>

Map by Mike Callahan
MDR function

- Protein complex that detoxifies xenobiotics
- Suggests fertilizer, pesticide or chemical contamination.
Possible Sources

“Mount Trashmore”
Dade County landfill

Several drainage canals
Ongoing Research: Coral Reef Ecosystems
Most Forecasting Methods Ignore Important Links in the Biological Hierarchy

- Ecosystem
- Communities
- Populations
- Individuals
- Organs
- Tissues
  - Cells & Molecules
  - Stress
Significant Regressors

- March water temperature ($R^2 = 0.37$, $P < 0.002$).

- NOAA currently uses water temperature to predict coral bleaching hot spots.
A Better Regressor: Chloroplast Small Heat Shock Protein

Probability of coral condition in September

$X^2 = 13.4, P < 0.0005$
$R^2 = 0.45$

chlpsHsp concentration in March
Pg chlpsHsp/µg total protein
Prognosis: How long will a coral reef live if stresses remain unabated?
Resource Managers = Clinicians/ Caregivers

Biotechnologies

- “Dipsticks” to diagnose disease
- Topical antibiotic creams for coral diseases
- Long-term: Cellular and genetic markers to select “stress-tolerant corals” for coral reef restoration
Acknowledgments

- U.S. NOAA
- Florida Keys NMS
- NPS (Biscayne)
- Flower Gardens NMS
- U.S. Geological Survey
- Environmental Moorings Intl.
- Oxis Research, Inc.
- College of Charleston
- Univ. S. Florida
- Medical Univ. S. Carolina
- The Cousteau Society
- Mote Marine Laboratory
- IIDEXO
- Bermuda Biol. Station
Ecological Forecasting

• Genomic Integrity
  Stress Causes Genetic Damage

How fit will offspring be?

Down’s Syndrome  =  Oxidative Stress  =  \( \downarrow \) Recruitment

Spina Bifida  =  Nutritional deficiency =  Planula deformations

Miscarriage  =  Toxin exposure  =  No spawning
Differences in stress responses: 2000 vs. 2001

![Graph showing differences in stress responses between 2000 and 2001.](image)