The Human Component of the Coral Reef Ecosystem: A Framework for Sustainability

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Coral Reef Ecosystems

• Ecological foundation for diverse communities
• Support multibillion dollar fishing & tourism industries
• Threatened by pollution, over-exploitation, climate change

How do we ensure that decisions and policies provide sustainable coral reefs?
1. Understanding Decisions

Decision Maker Workshops
- Identify priority issues
- Elaborate potential management options

2007: US Virgin Islands
2009: Florida Keys
2010: Puerto Rico
Guánica Bay Watershed, Puerto Rico

Land-Based Sources of Pollution

- Farming
- Urbanization
- Sewage

Management Options

- Shade-grown coffee
- Cover crops
- Hydro seeding
- Dredge reservoirs
- Remove relic irrigation
- Lagoon restoration
DPSIR Systems Thinking Exercise

• Provide an overview of DPSIR
• Breakout groups build DPSIR on a management option from the Guánica Bay Watershed Management Plan
• Real-time using CmapTools software
Lagoon Restoration
Response: What are the specific decision options?
Response: What are the specific decision options?

* Re-flood lagoon
* Plant wetland vegetation
Lagoon Restoration

**Pressures**: Why is this management action proposed? What pressures is it intended to reduce?

**Response**: What are the specific decision options?

- Re-flood lagoon
- Plant wetland vegetation
Lagoon Restoration

**Pressures**: Why is this management action proposed? What pressures is it intended to reduce?
- Reduce sediment/Nutrient levels

**Response**: What are the specific decision options?
- Re-flood lagoon
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Lagoon Restoration

**Drivers:** What socio-economic sectors are causing these pressures and may be impacted by decisions?

**Pressures:** Why is this management action proposed? What pressures is it intended to reduce?

**Response:** What are the specific decision options?

*Reduce sediment/Nutrient levels*

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Drivers: What socio-economic sectors are causing these pressures and may be impacted by decisions?

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Agriculture/Housing

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Drivers: What socio-economic sectors are causing these pressures and may be impacted by decisions?

Pressures: Why is this management action proposed? What pressures is it intended to reduce?

State: What affect do these pressures have on the ecosystem?

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Reduce sediment/Nutrient levels
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Lagoon Restoration

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- Re-flood lagoon
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Drivers:
- Agriculture/Housing

Pressures:
- Reduce sediment/Nutrient levels

State:
- Coral
- Light
- Algae

Drivers: What socio-economic sectors are causing these pressures and may be impacted by decisions?
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**Drivers:** What socio-economic sectors are causing these pressures and may be impacted by decisions?

- **Agriculture/Housing**

**Pressures:** Why is this management action proposed? What pressures is it intended to reduce?

- **Reduce sediment/Nutrient levels**
- **Coral**
- **Light**
- **Algae**

**State:** What affect do these pressures have on the ecosystem?

**Impact:** Why do we care? What benefits from the reef do we stand to lose?

- **Re-flood lagoon**
- **Plant wetland vegetation**

**Response:** What are the specific decision options?
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Agriculture/Housing

Drivers: Agriculture/Housing

Pressures: Reduce sediment/Nutrient levels

State: Coral Light Algae

Impact: Snorkeling Fishing Biodiversity

Response: Re-flood lagoon Plant wetland vegetation
Drivers: What socio-economic sectors are causing these pressures and may be impacted by decisions? What sectors benefit from services?

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Lagoon Restoration

- Re-flood lagoon
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Coral Light Algae

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Pressures: Reduce sediment/Nutrient levels

Drivers:
- Agriculture/Housing
- Tourism/Rec
- Fishing

State:
- Coral
- Light
- Algae

Impact:
- Snorkeling
- Fishing
- Biodiversity
DPSIR Framework as a Tool

Driving Forces
Socioeconomic sectors and cultural factors that drive human activities (causes)

Pressure
Human activities that place stress on the environment (pollutants)

Fosters a ‘systems’ approach
Provides a tool to organize and catalog information
Identifies information and issues important to stakeholders

Response
Response of society to the environmental situation (policies, decisions)

State
Condition of the environment (composition, distribution, quality)

Impact
Effects of environmental degradation (changes in attributes, services)
2. Link Stressors to Reef Attributes

- Dose-response relationships
- Human-disturbance gradients
- Linking landscape activity to coral condition

![Diagram showing sampling along a gradient of human disturbance](image)

\[ r^2 = 0.49, \quad p = 0.002 \]
3. Connecting Reef Condition to Ecosystem Services

Literature Review

- What services have been identified?
- How were services measured?
- How can reef attributes be translated into services?
- What indicators estimate delivery of services?

Principe et al. EPA Report 2011
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Tourism & Recreation

Fishing

Ecosystem Integrity

Natural Products

Shoreline Protection
### Coral Reef Attributes

<table>
<thead>
<tr>
<th>Coral Reef Attributes</th>
<th>Shoreline Protection</th>
<th>Harvesting</th>
<th>Tourism &amp; Recreation</th>
<th>Future Natural Products</th>
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<td>Coral sand beaches</td>
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Coordinated, inter-Agency Assessment for Guánica Bay, PR

Where are the services and what is the condition of reef attributes?

- NOAA: 160 stations (fish and benthic cover) near Guánica Bay; also tissue and sediment contaminant analyses
- EPA: 60 stations (5 assemblages) across southwestern PR to include Guánica Bay
4. Modeling and Mapping Reef Ecosystem Services
Two Types of Models
Bundled Ecosystem Services

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5. Understanding Decisions

- Historic review of decisions and decision landscape
  - What decisions were made, by whom, why
  - Development of social networks for specific decisions
- Workshops with decision makers and stakeholders to elicit values
- Surveys of residents and visitors to quantify market and nonmarket values
- Workshops with scientific experts to quantify benefits of individual options
Reef ES & Decision Support Database

- Management options
- Legislation
- Clients and partners
- Scientific literature

- Jurisdiction- or topic-specific
Our Partners

- EPA
- National Oceanic and Atmospheric Administration (NOAA)
- USDA NRCS
- USGS Caribbean Field Station
- Caribbean Coral Reef Institute (CCRI), University of Puerto Rico
- National Coral Reef Institute (NCRI), Nova Southeastern
- The Nature Conservancy (TNC)
- Center for Watershed Protection (CWP)
- Carnegie-Mellon University
- University of Miami, Rosenstiel School of Marine Sciences (RSMAS)
- University of the Virgin Islands
- National Fish and Wildlife Foundation (NFWF)
- USVI Department of Planning and Natural Resources (DPNR)
- Puerto Rico Departamento de Recursos y Ambientales (DNRA)
- Florida Department of Environmental Protection (DEP)
Thank you