A Decision Support System for Ecosystem-Based Management of Tropical Coral Reef Environments

Partnerships

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- NOAA AOML / ICON/CREWS-CRCP (James Hendee, L. Gramer)
- NASA Headquarters (Woody Turner, Paula Bontempi)
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- NOAA
  - NESDIS Coral reef Watch
Location of shallow tropical coral reef ecosystems (Source: ReefBase). The four coral reef biogeographic regions that are typically recognized by marine biogeographers are shown in circles: (1) Indian, (2) Indo-Pacific, (3) Pacific and (4) Caribbean.
Research, monitoring, management of corals requires:

- Sampling a range of time and space scales
- Synoptic observing tools
- Frequent and repeated observations
- Long-term observations
- Timely data delivery and easy access
NOAA NESDIS
Coral Reef Watch
(Mark Eakin and team)

Mission:

To provide remote sensing tools for the conservation of coral reef ecosystems.

Coral Reef Watch aims to assist in the management, study, and assessment of impacts of environmental change on coral reef ecosystems.
Objectives of the Program

- Assess and meet user needs
  - End-to-end evaluation and feedback mechanism
- Assess value of high-spatial resolution (1 km) data
  - (MODIS, AVHRR, other)
- Link to higher-resolution geomorphological maps
  - Global Coral Reef Millennium Map
  - (Landsat – 30 m pixels, GIS layers)
- Link to real-time in situ observations
  - (ICON/CREWS, SeaKeys, Ocean observing system)
- Help design future remote sensing tools:
  - Hyperspectral and Infrared Imager (HyspIRI)
  - Landsat Data Continuity Mission (LDCM)
  - NPP, NPOESS, other environmental satellites
- Help managers/researchers communicate and
Coral Reef Watch DSS (Decision-Support System)

- Near-real time suite of products to monitor and forecast thermal stress that may cause coral bleaching
- Empirical models and satellite data
- Open distribution via email/Internet/other
- Products:
  - night-time only 50 km SST anomaly,
  - coral bleaching HotSpots,
  - Degree Heating Weeks, and
  - Satellite Bleaching Alerts.
- http://www.osdpd.noaa.gov/PSB/EPS/SST/methodology.ht
CRW-Operational SST-based products

Operational 2002

Coral – specific

Bleaching Alert Areas

Operational 2002

2002

2002

2003

2009
The 2005 Bleaching Event in the Western Hemisphere. The image shows the Degree-Heating Weeks (DHW) accumulated through 1 November, 2005. Note high DHW (yellow-orange colors) in the eastern Caribbean Sea. Significant bleaching took place in the U.S. Territories and adjacent islands.

DHW corresponds to one week of SST exceeding the maximum summer SST by one °C. A value of two DHWs indicates two hot weeks, but is also equivalent to one entire week of SST exceeding the maximum summer SST by two °C.
New: High-resolution Degree Heating Weeks

Left: 50-km DHW product
Right: Equivalent 1-km DHW product for 3-day period ending on August 20, 2005

Land mask colors are reversed between the images with zero DHW shown as black in the NOAA image and white in the USF image.

High resolution preserves spatial patterns of importance to reefs

- High-resolution (1-km) AVHRR SST imagery (NOAA-16 satellite) showing small-scale (1020 km, < 1 °C) frontal eddies (annotated with black arrows) along the shallow isobaths in the Florida Straits
- January 22, 2002 at 7:36 GMT and January 23, 2002 at 18:45 GMT.
- Eddies are due to shelf wave dynamics, and they cannot be detected by other coarser resolution data (4 km or lower).
Sample product: Global 8 km resolution DHW

* Rama Nemani and NASA Ames supercomputer

Accumulation of 12 weeks of hotspots by the first week of January 2008 at moderate (8 km) resolution.
Sample product: Millennium Map

**Figure 4.** Sample Millennium Coral Reef Map geomorphological classification, based on Landsat-7 data.

**Figure 5.** Sample Millennium Map products for the Florida Keys displayed on Google Earth.
Other possible “enhancements”

- Cold water stress index
- Marine Spatial Planning support via CRW
  - Variables: SST, CHL, SSH, other?
  - Generating monthly, weekly climatologies
- Anomalies
- Long-term time series
- Trends in variables
- Plotting and data extraction capabilities
Florida Reef Tract

Critical low SST temperature threshold is ~ 13° C: mass mortality in scleractinian coral communities

Dr. Tianran Chen, South China Sea Institute of Oceanology, Guangzhou, China
Summary

- Survey sent to users, now waiting for returns
- Improve ‘bleaching early-warning system’ by moving to higher spatial resolution satellite images to better monitor local-scale conditions that the current 50km global products may miss
- Improve data delivery, using formats and online tools that enhance decision-making
- Integrate with global reef maps from the Coral Reef Millennium Map (30 m resolution)
- Integrate with real-time in situ obs. (ICON/CREWS, SeaKeys, etc.)
- Assist in defining education objectives (formal, informal)
Ultimately, the goal is to improve our ability to alert reef managers around the world of bleaching-level stress, so they can take appropriate actions. Specifically, this will help them to better:

- Communicate with stakeholder groups
- Deploy targeted monitoring of bleaching events
- Focus research on reef resilience
- Reduce other stresses during bleaching
- Design/employ experimental mitigation techniques