

# Integrating Near Real-Time Data for Coral Reef Ecosystem Forecasting

NOAA's Integrated Coral Observing Network (ICON)

Atlantic Oceanographic and Meteorological Laboratory

Laboratory Review, March 18, 2008

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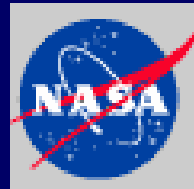
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**The ICON Team!**

**Mike Shoemaker, Jules Craynock, Lew Gramer, Derek  
Manzello, Mike Jankulak, Chris Langdon, Nancy Ash,  
Madeleine Adler, Emy Rodriguez, John Halas...and many  
colleagues!**



# A true interagency, international collaborative effort!



# **NOAA's Five Mission Goals are Supported:**

**Ecosystems Mission Goal: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem Approaches to Management**

**Climate Mission Goal: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond**

**Weather and Water Mission Goal: Serve Society's Needs for Weather and Water Information**

**Technology and the Mission Support Goal: Provide Critical Support for NOAA's Mission**

**Commerce and Transportation Mission Goal: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation**



# ~~ ICON Vision Statement ~~

The ICON vision is to serve as a model for all of NOAA in establishing a high quality *in situ* coral reef monitoring network, and for the integration of near real-time *in situ*, satellite, radar and other data for ecological forecasting in coral reef ecosystems.

<http://ecoforecast.coral.noaa.gov>



# Goals

For the next few years, the ICON Program will be focusing upon:

- Integrating data from diverse independent sources, especially for developing Ecological Forecasting models for use by Marine Protected Area managers and researchers
- Ensuring consistency with NOAA's Integrated Ocean Observing System (IOOS)
- Forging international partnerships
- Facilitating development and transition to operations of promising relevant *in situ* instrumentation



## Key Research Questions:

1. What are the long term trends of meteorological and oceanographic parameters at key U.S. coral reef areas?
2. Can data from various sources be integrated in real time to provide ecological forecasts at coral and coastal ecosystem areas?
3. What are the key environmental correlates related to coral bleaching and other coral ecosystem concerns such as disease, and spawning and migrating organisms?



# Existing ICON stations...



Salt River, St. Croix  
June, 2002



La Parguera,  
Puerto Rico  
January, 2006

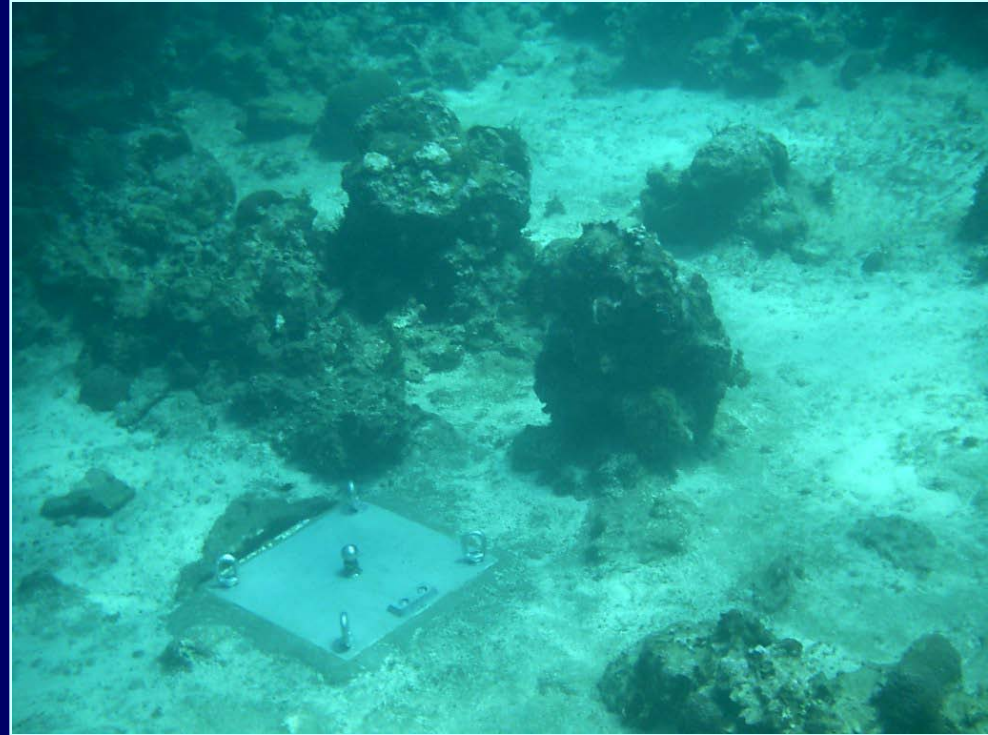


Discovery Bay,  
Jamaica  
June, 2007



# Other stations in the works...

- **Little Cayman, Cayman Islands**  
Target date: Summer, 2008  
Project Funded
- **St. Thomas, USVI**  
Target date: Winter, 2008 - 2009  
Project Funded
- **Kenting National Park, Taiwan**  
Target date: Summer, 2009  
Project Funded
- **Saipan, CNMI**  
Target date: Winter, 2009 - 2010  
Proposal Under Review



Bottom plate at Discovery Bay, Jamaica, before station installation.





# Atmospheric Sensors

- Air Temperature
- Wind Speed
- Wind Direction
- Barometric Pressure
- Humidity
- Precipitation
- Light
  - Photosynthetically Available Radiation (PAR)
  - Ultraviolet Radiation (UVR)



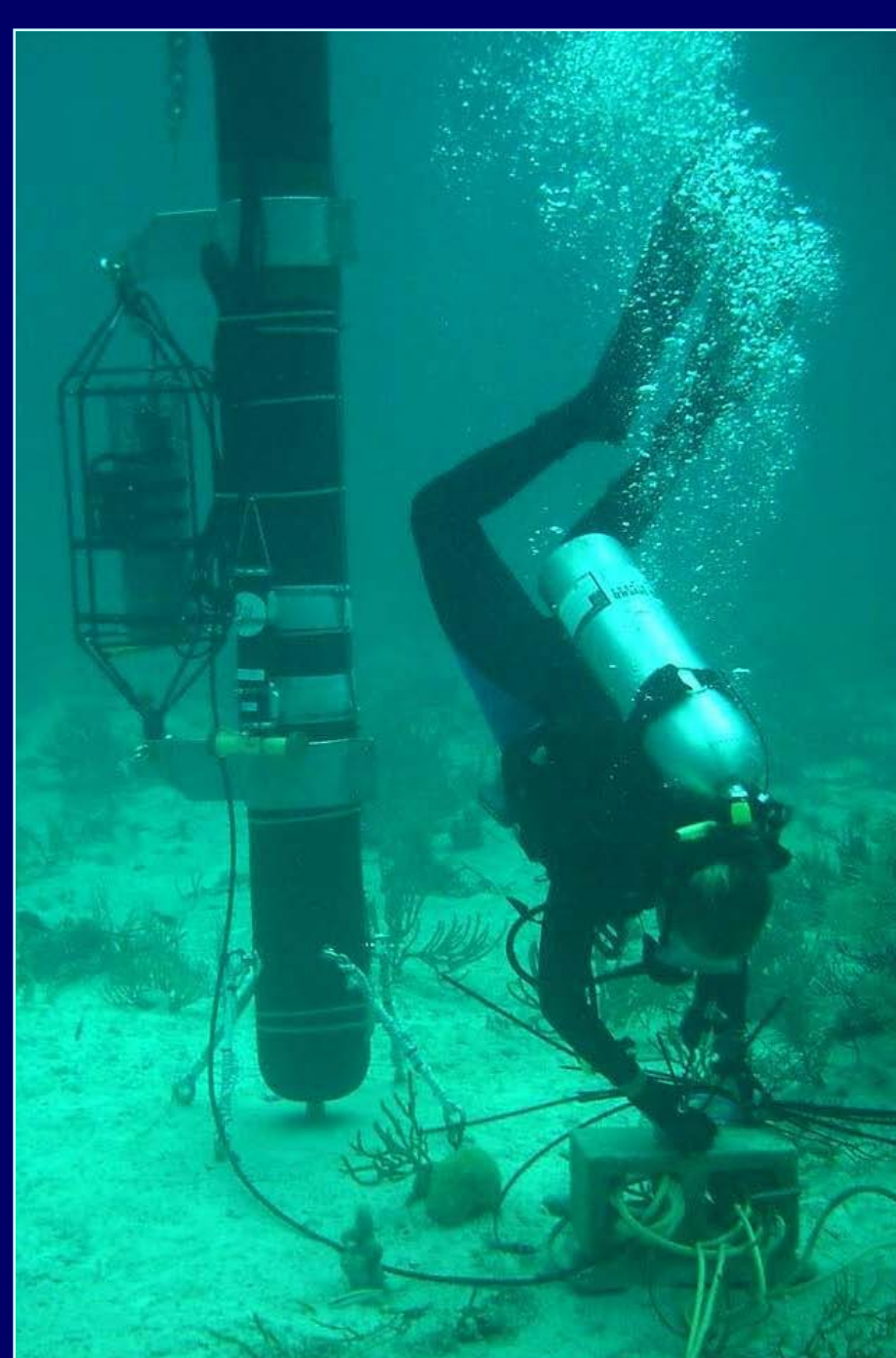
# Oceanographic Sensors

## Standard Suite (shallow and near bottom)

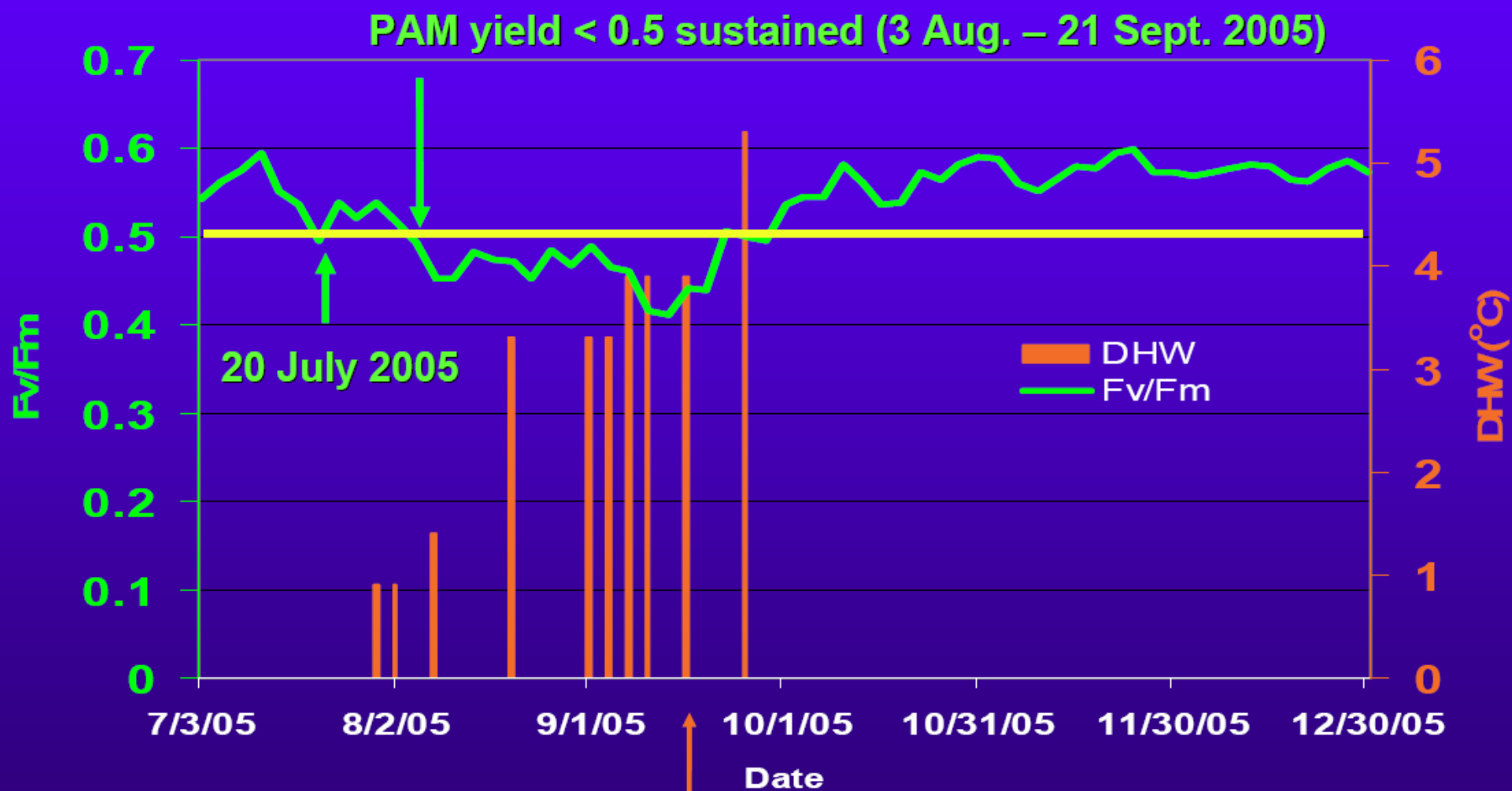
- Sea Temperature
- Salinity
- Light (UV, PAR)

## Additional Sensors

- pCO<sub>2</sub> (ocean acidification)
- Pulse Amplitude Modulating (PAM) Fluorometry (real-time monitoring of coral stress response)



# Timing of chronic photoinhibition vs. satellite-based bleaching alert



“Bleaching alert Level 1” (17 Sept. 2005)

Satellite SST product



# Integrating Coral Data for Research and Decision Support

- Data integration is an important direction for NOAA's Coral Reef Conservation Program
- Integration of coral data is one of the recommendations by the U.S. Commission on Ocean Policy



# ***Ecological forecasts* predict the impacts of physical, chemical, biological, and human-induced change on ecosystems and their components.**



## **Molasses Reef, Florida Keys National Marine Sanctuary (MLRF1)**

### **Ecological Forecast - Details**

Ecological Forecast: 'Release of planulae by mustard-hill coral', for Tuesday, 2007-Apr-17 (Day 106)

Heuristic Model: 'Porites astreoides spawning (sea temperature + photo-accumulation + lunar phase)'

Stimulus/Response Index (S/RI) = 57, because:

Photo Accum was Somewhat High (406.094) during period All Day

Lunar Phase was New Moon (0.96) during period All Day

Spawning Seatemp was Conducive (25.409) during period Night Hours

## Some ICON-relevant ecological forecasts (existing or planned for development):

- Coral bleaching (e.g., high sea temperatures + high irradiation+ low winds + low tides)
- Spawning events (fish, coral and other invertebrates)
- Predicting larval transport and survival
- Physical oceanographic events (e.g., onshore flux)
- Coral disease (high nutrients + high temperatures)
- Etc. (research models drive sensor deployment and forecasts)



# Science Results

## Coral Bleaching Papers:

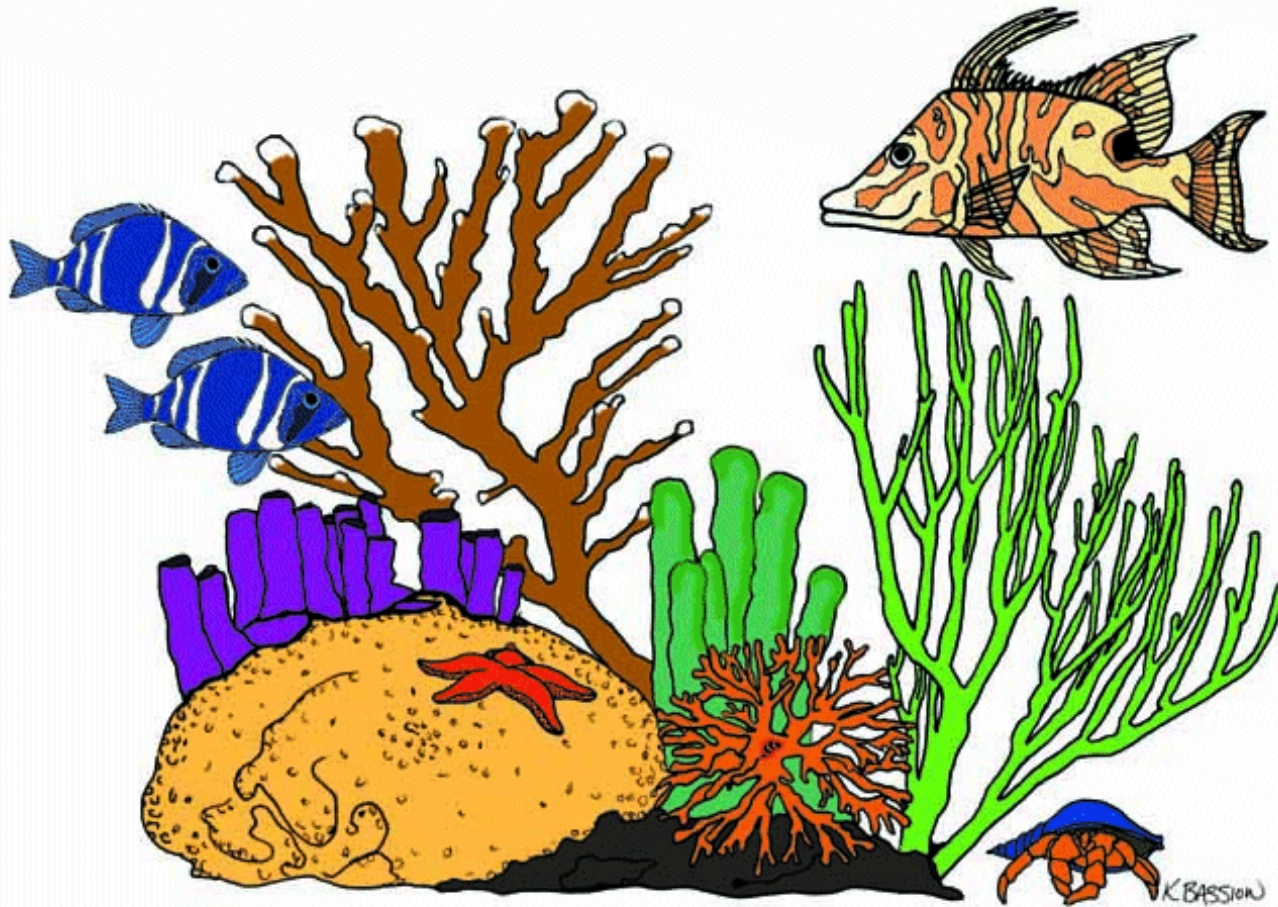
- Hurricanes favor bleaching recovery; reviewed our data and other sources (Proc. Nat. Academy Sciences)
- High sea temperature, high irradiance, and other factors are important in bleaching response (Marine Poll. Bulletin; Bull. Mar. Sci.; 8<sup>th</sup>, 9<sup>th</sup>, 10<sup>th</sup> Intern. Coral Reef Symposia; NOAA Tech. Memoranda)
- Only remote real-time monitoring of coral physiology under environmental stress, using Pulse Amplitude Modulating Fluorometry (submitted to Coral Reefs)

## Ecological Forecasting:

- White Paper #5: Ecological Forecasting. *In: Ecosystem Science Capabilities Required to Support NOAA's Mission in the Year 2020* (S.A. Murawski and G.C. Matlock, editors)
- Three papers submitted for 11<sup>th</sup> International Coral Reef Symposium, July 7-11, 2008 (Stimulus/Response Index, MPA Decision Support, Satellite & In Situ Integration for EF)

## Marine Monitoring and Information Infrastructure:

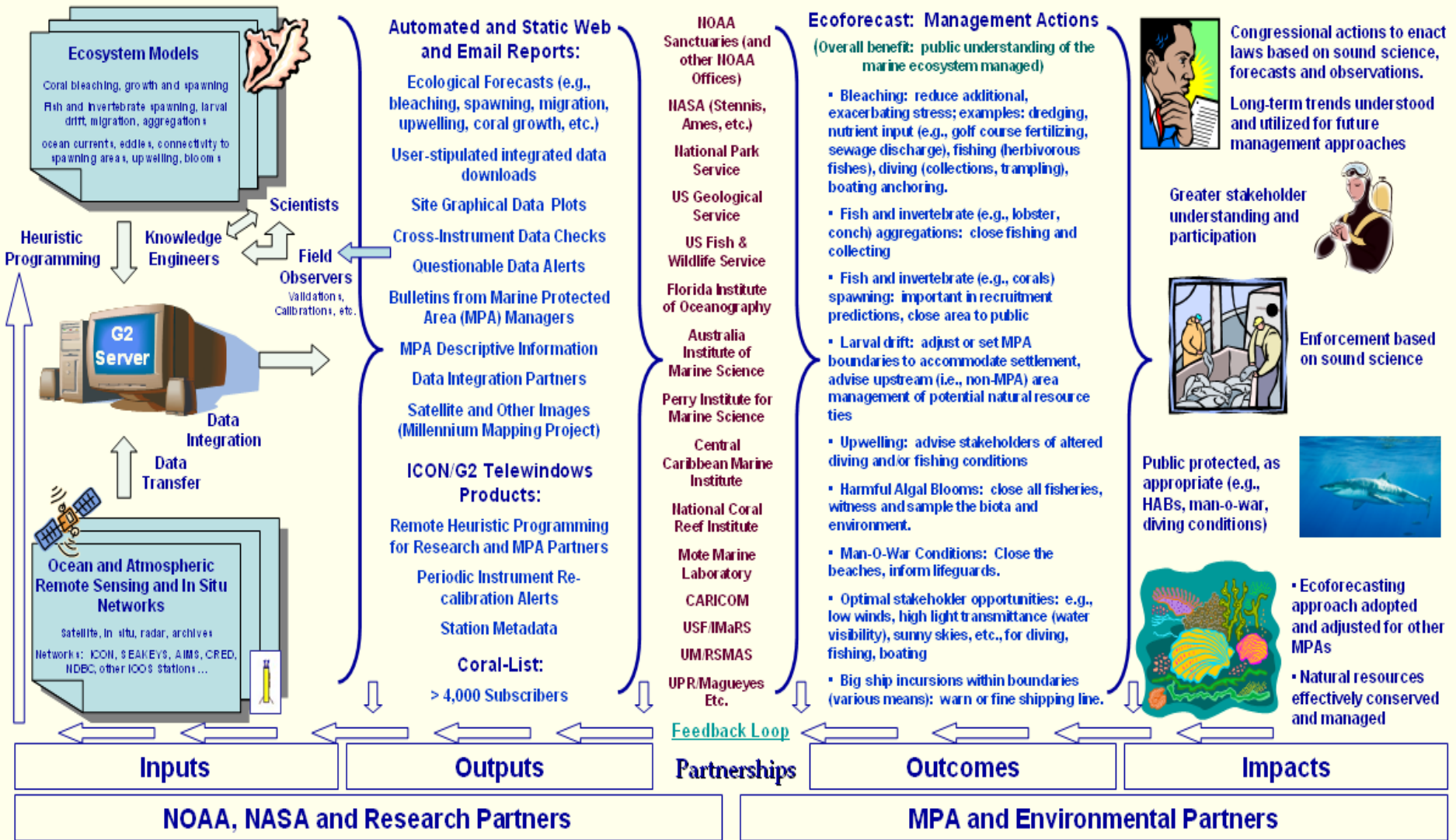
- Infrastructure and capabilities of a near real-time meteorological and oceanographic *in situ* instrumented array, and its role in marine environmental decision support [book chapter] *In: Remote Sensing of Aquatic Coastal Ecosystem Processes*
- The Integrated Coral Observing Network: Sensor Solutions for Sensitive Sites (3<sup>rd</sup> Intern. Conference on Intelligent Sensors, Sensor Networks, and Information Processing)



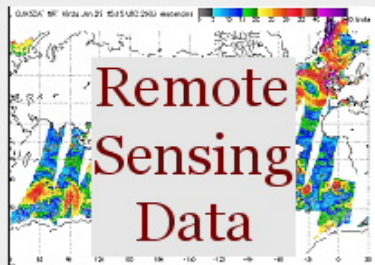
# Coral Health And Monitoring Program

Integrated Coral Observing Network

# ICON/CREWS Decision Support System for Marine Protected Area Managers: An Integrated System Solution







**Public Data Access**

**Ecological Forecasts**

**ACCESS:**

- MPA Managers:** Decision Support
- Scientists:** Research Validation
- Public:** Information Access

**OPeNDAP Researcher Access**

**Researcher design of Ecoforecasts via ICON/G2 Toolkit**