Integrated Coral Observing Network (ICON)
and
The Coral Reef Early Warning System (CREWS)

Vision Statement

Our 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.

Dr. Jim Hendee
NOAA/OAR/AOML
Jim.Hendee@noaa.gov

Goals

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

- **Integrating data from diverse independent sources**
- **Ensuring consistency with NOAA's Integrated Ocean Observing System (IOOS), and the Coral Reef Ecosystem Integrated Observing System (CREIOS)**
- **Forging international partnerships**
- **Facilitating development and transition to operations of promising relevant *in situ* instrumentation**

Specialized work:

- Install Monitoring Stations Near Coral Reefs
- Produce Research Products
- Develop Information Systems for Marine Protected Area (MPA) Decision Support

Existing stations…

- Lee Stocking Island, Bahamas

  Data stream since May, 2001

- St. Croix, U.S. Virgin Islands

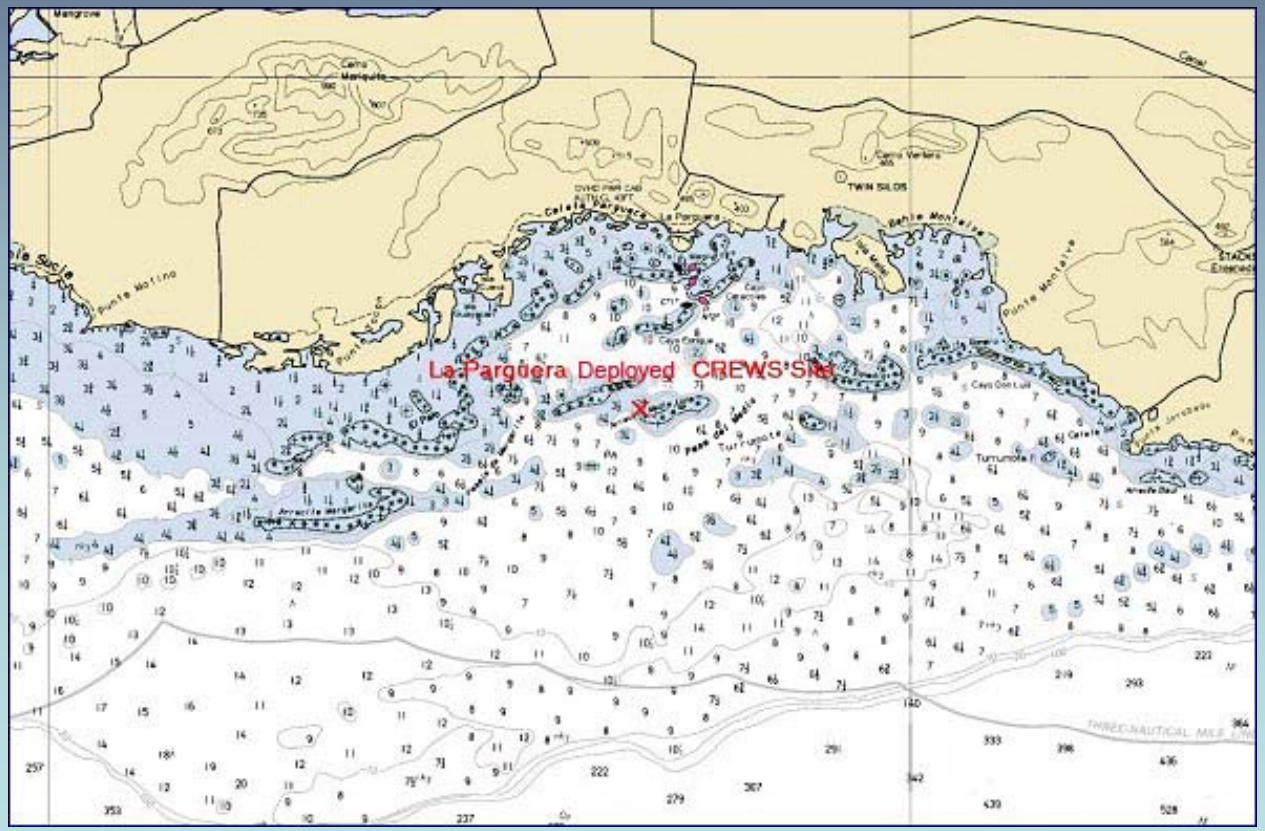
  Data stream since June, 2002

- La Parguera, Puerto Rico

  Data stream since January, 2006

La Parguera, Puerto Rico

- Began transmitting data on January 14, 2006
- Site of new Caribbean Coral Reef Institute
- Site of new collaborative to study the role of carbon dioxide in coral reef ecosystems
- Site of new Telemetered Instrument Array (TIA)



New stations in the works…

- Discovery Bay, Jamaica

  Bottom plate installation slated for February 27th

- Heron Island, Queensland, Australia

  Site survey completed in November, 2005; bottom plate slated for May, 2006

- Puerto Morelos, Mexico

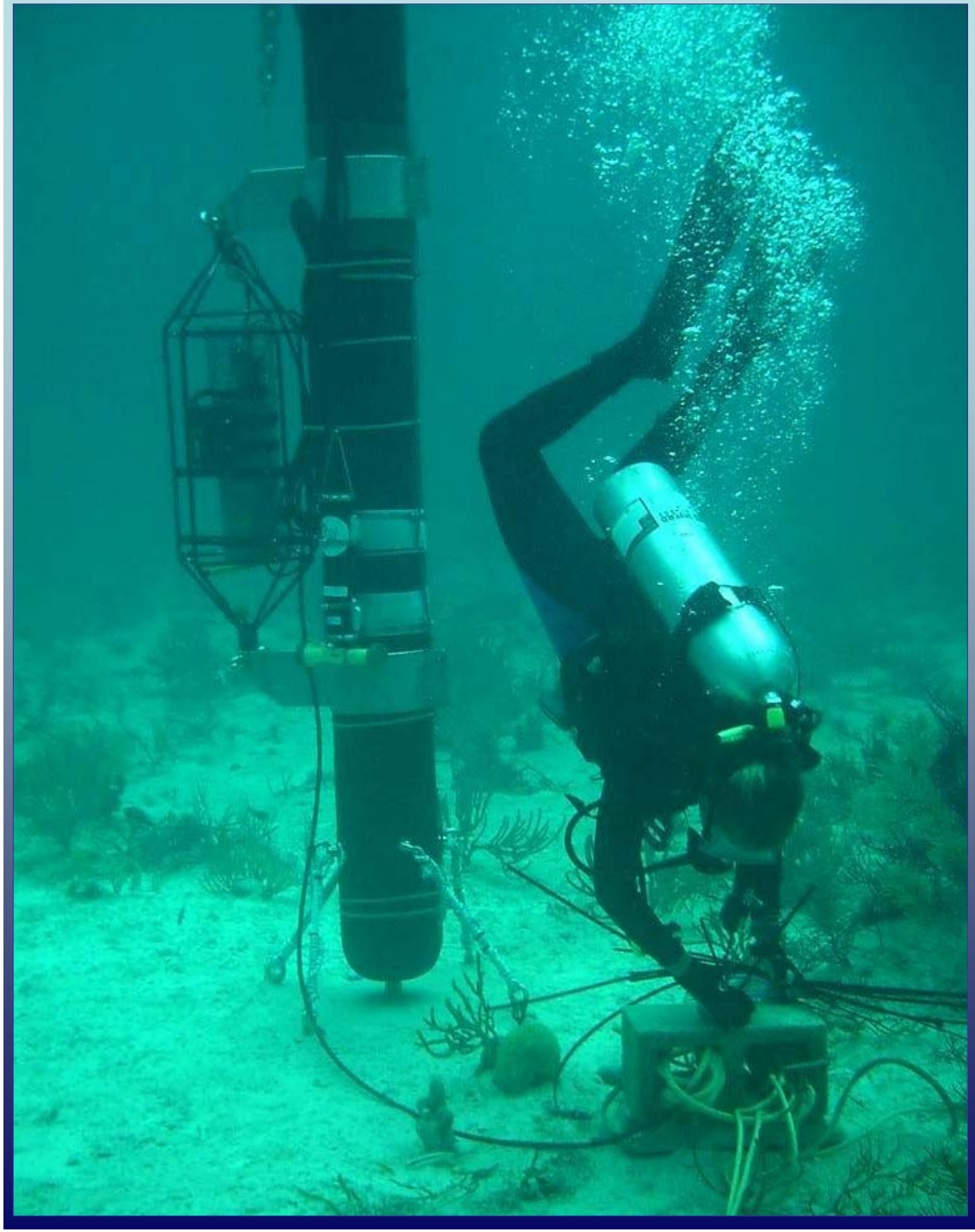
  Site survey in July, 2006

- Little Cayman, Cayman Islands

  Site survey in June, 2006

- Antigua, Lesser Antilles

  Co-PI with Dr. Rod Zika of RSMAS

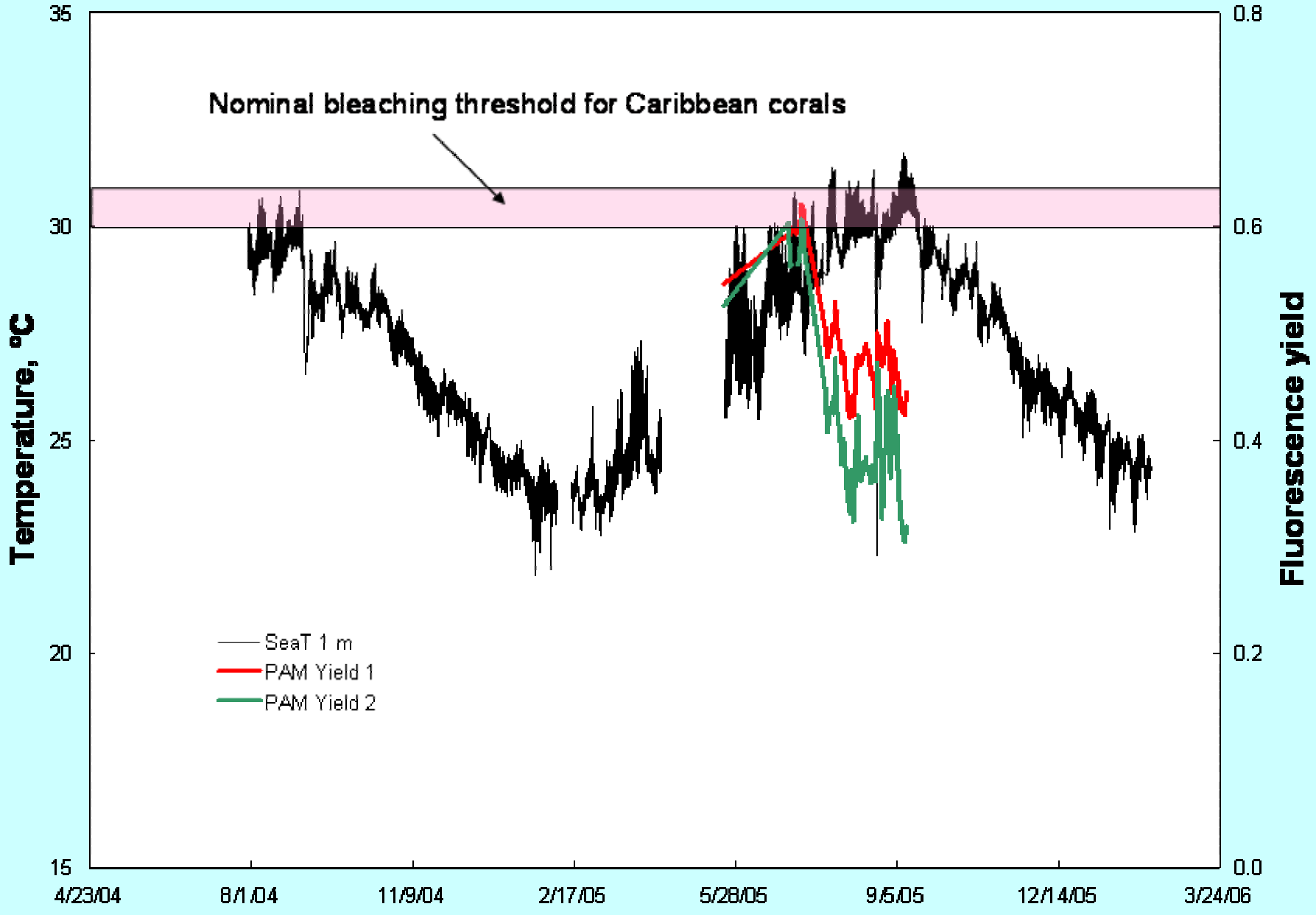


The Instruments

A stable pylon-style coral monitoring platform provides the opportunity to position instruments of various sizes, shapes and configurations at various heights above the ocean and depths throughout the water column.

Meteorological instruments measure air temperature, wind speed, barometric pressure, humidity, precipitation and light (PAR, UV).

The basic oceanographic instruments measure sea temperature, salinity and light (PAR, UV). Optional instruments measure pCO2, Pulse Amplitude Modulating (PAM) fluorometry, and transmissometery. New instrumentation may record nutrients, acoustic signals from fish and plankton, particle counts.



Near real-time (hourly) recording of PAM-fluorometry output captured the exact time that two species (*Agaricia tennuifolia* and *Siderastrea siderea*) of corals began to experience [photothermal stress].

The Science

- Two **peer-reviewed papers** and one peer-reviewed book chapter utilizing data from St. Croix and Bahamas stations
- Hourly **Pulse Amplitude Modulating fluorometry data** from **two species of corals** at Bahamas site during 2005 bleaching
- Hourly **pCO_2 data** from Bahamas station
- Good **biological surveys before and after bleaching** episodes at Bahamas and St. Croix sites
- Very good **nearly continuous hourly data** (including sea temperature and light) from both sites for several years
- Data used for **science support for many scientists** working in the areas
- New Puerto Rico station will **support science** at the new University of Puerto Rico/NOAA collaborative **Caribbean Coral Reef Institute**

Information Systems

- **Continue to produce coral bleaching alerts**
- **Try new ecological forecasting models**

  (need more input from scientists and modelers)
- **New CHAMP/ICON/CREWS Page under construction**
- **Becoming proficient with G2 (artificial intelligence tool)**

  for data integration and expert system analyses
- **Focusing G2 efforts around MPA decision support**

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

New draft NOAA Technical Memorandum (Ecosystem White Paper #5) , "Near Real-Time Ecological Forecasting" is available upon request. Write to co-author Dr. Jim Hendee:

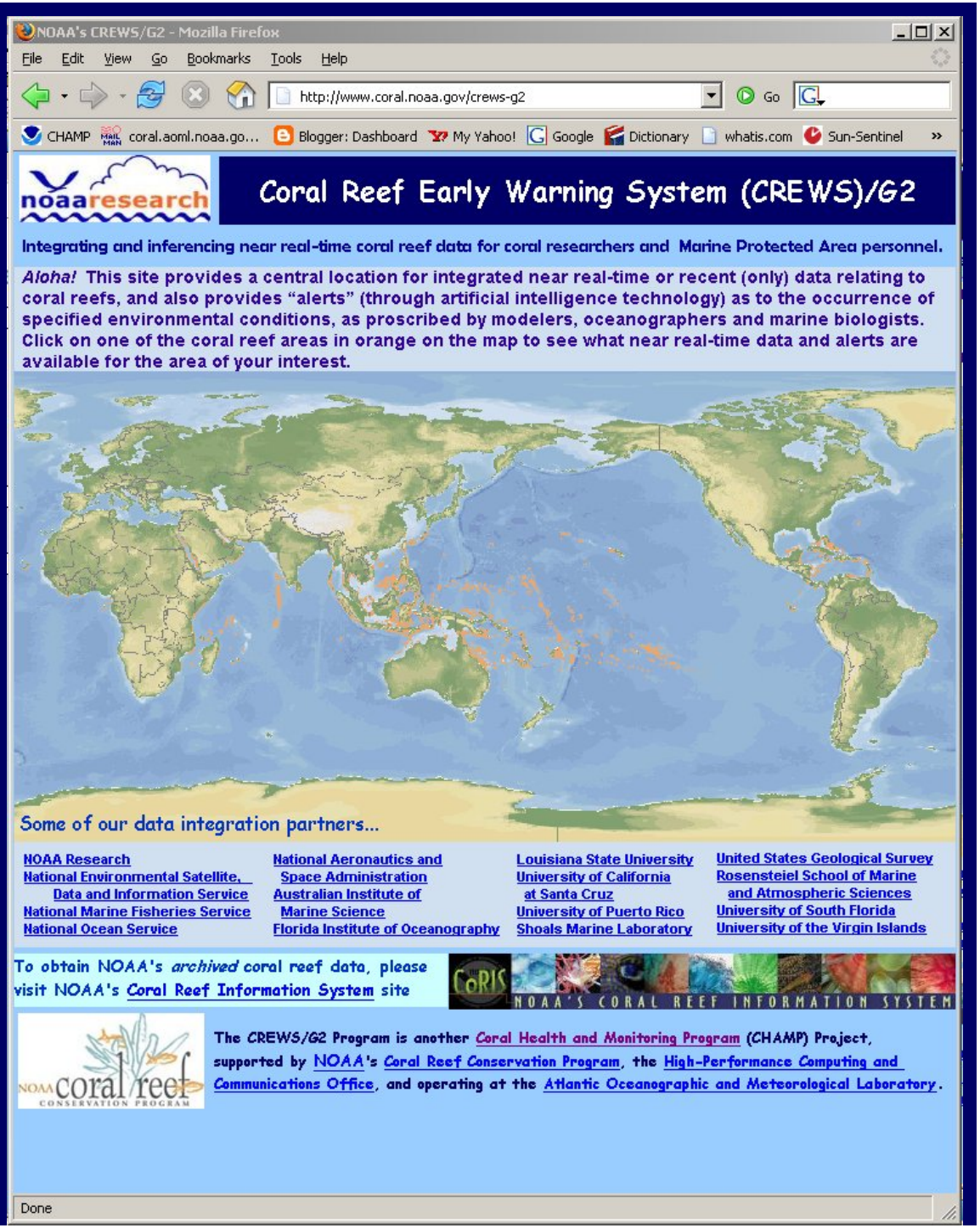
jim.hendee@noaa.gov

Examples of ecological forecasts within NOAA (existing or under development):

- Coral bleaching
- Predicting movement of hazardous spills
- Forecasting the effectiveness and optimal placement of MPAs
- Predicting coral reef health and recovery after disturbance
- Predicting larval transport and survival
- Development, persistence, movement and landfall of harmful algal blooms
- Beach closure forecasting
- Impact of climate change on coastal ecosystems
- Water quality forecasts
- Forecast of shellfish toxicity

New ICON Web interface will integrate data from CREWS, NMFS/CREI, AIMS, and SEAKEYS stations, satellite data, and other resources, using G2, and will still issue ecological forecasts, as before, providing for greatly increased *modeling* power.

G2 can also be used for scheduling (good for logistics), and *disaster management*, which will make it of use to AOML's Hurricane Research Division, and hopefully other organizations.



ICON Use Cases

What the heck is a “use case?”

Actors play different Roles

Actors:

- **G2 Developer**
- **G2 User (external Telewindows users)**
- ➔ **Online Web User**

Actor: **G2 Developer**

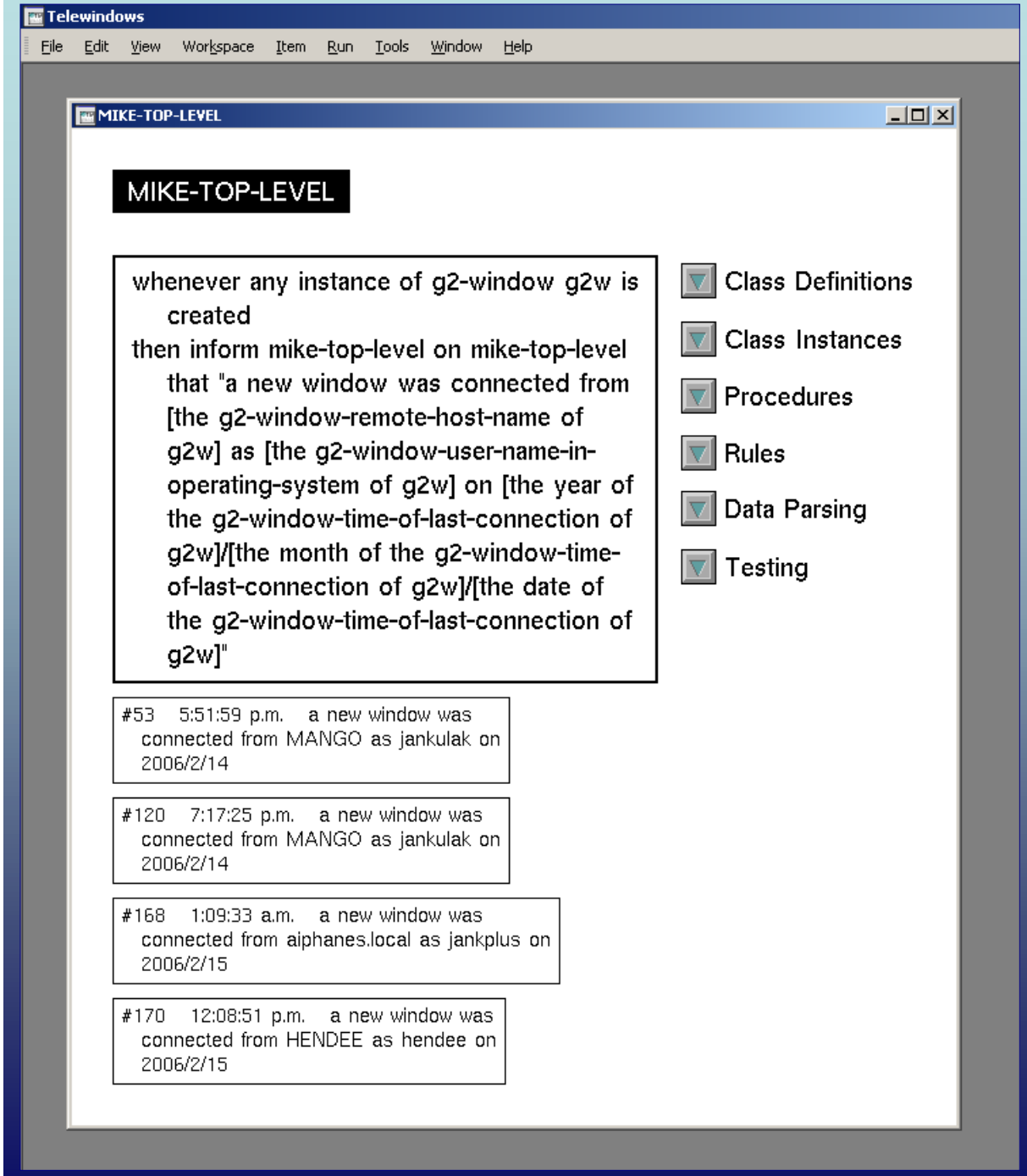
Roles:

- **Knowledge Engineer**
- **WebLink Administrator**
- **Network Administrator**
- **Database Administrator**
- **System Administrator**

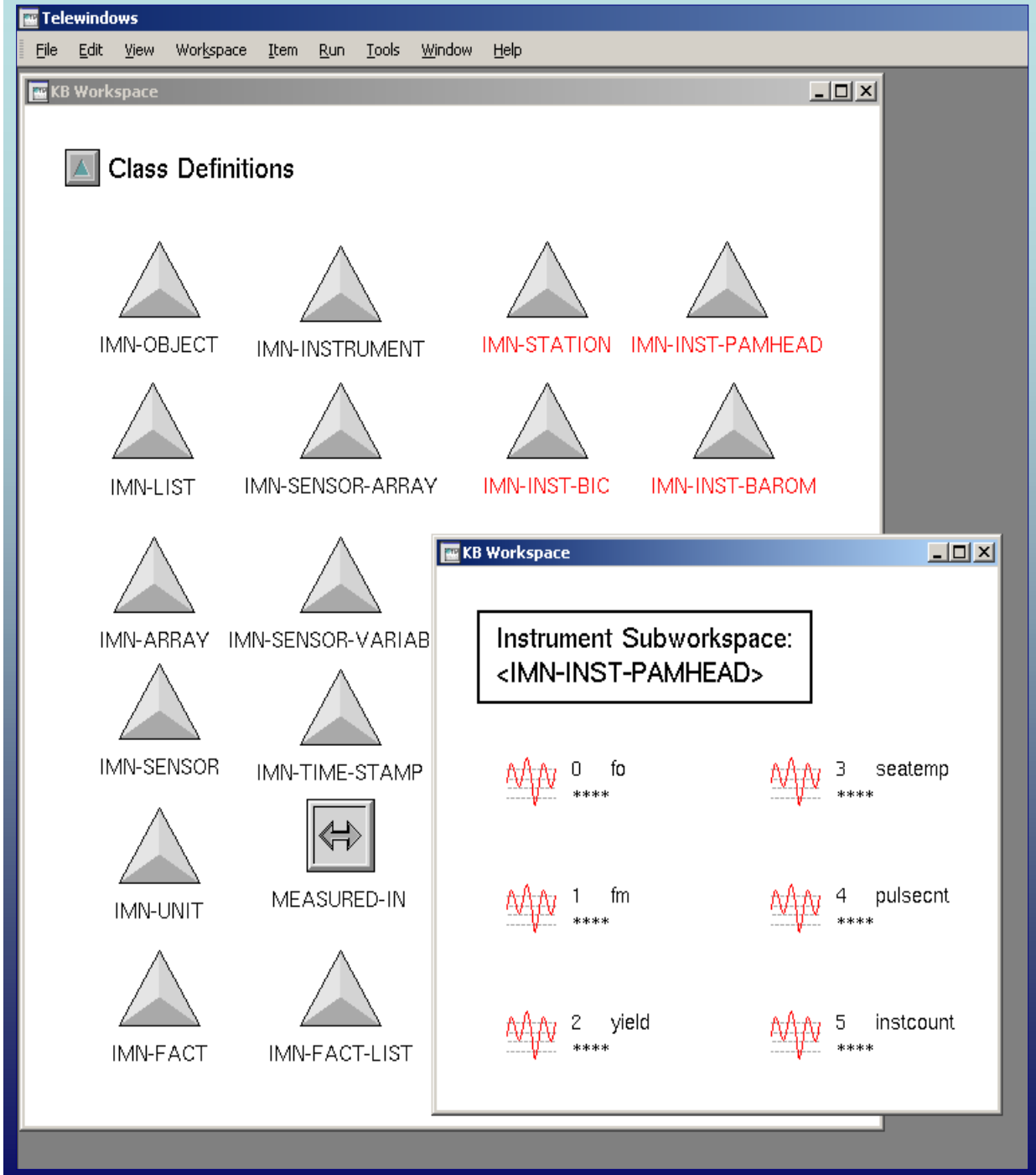
Actor: **G2 User** (external Telewindows users)

Roles:

- **NOAA Colleague**
- **Academic Colleague**
- **Other Colleagues**
- **G2 Consultant**



G2 Telewindows provide access for developers from anywhere on the Internet. (This view is not what the Web users see.) In this way, the integrated pool of data (in situ, satellite, radar, etc.) can be used for various purposes. Developers can work on their own workspaces, or share the same one.



The application is developed through object-oriented programming techniques; thus, everything (stations, satellites, ships, users, data streams, etc.) is represented as an object.

Telewindows

File Edit View Workspace Item Run Tools Window Help

MIKE-TOP-LEVEL

Operator Logbook 15 Feb 2006

Logbook 15 Feb 2006

KB Workspace

Class Instances

cmrc3

3000.0
2000.0
1000.0
0.0

KB Workspace

Instrument Subworkspace:
<CMRC3-CTD-DEEP>

0 cond
53.47
CMRC3-CTD-DEEP-COND

3 i-depth
4.473
CMRC3-CTD-DEEP-I-DEPTH

1 seatemp
23.09
CMRC3-CTD-DEEP-SEATEMP

4 salinity
36.85
CMRC3-CTD-DEEP-SALINITY

2 seapres
4.502
CMRC3-CTD-DEEP-SEAPRES

5 count
10.0
CMRC3-CTD-DEEP-COUNT

KB Workspace

Station Subworkspace:
<CMRC3>

18 logge
"Campbel
"s/n"

38 bic surf
"Biospherical Instruments Inc."
"s/n"

58 ctd deep
"Falmouth Scientific, Inc."
"s/n"

25 barom none
"Druck"
"s/n"

43 bic uw
"Biospherical Instruments Inc."
"s/n"

64 pam none
"Gademann GMB"
"s/n"

52 ctd shallow
"Falmouth Scientific, Inc."
"s/n"

97 bic deep
"Biospherical Instruments Inc."
"s/n"

CMRC3-FACT-LIST

Actor: **Online Web User**

Role: **Casual User** (i.e., the public)

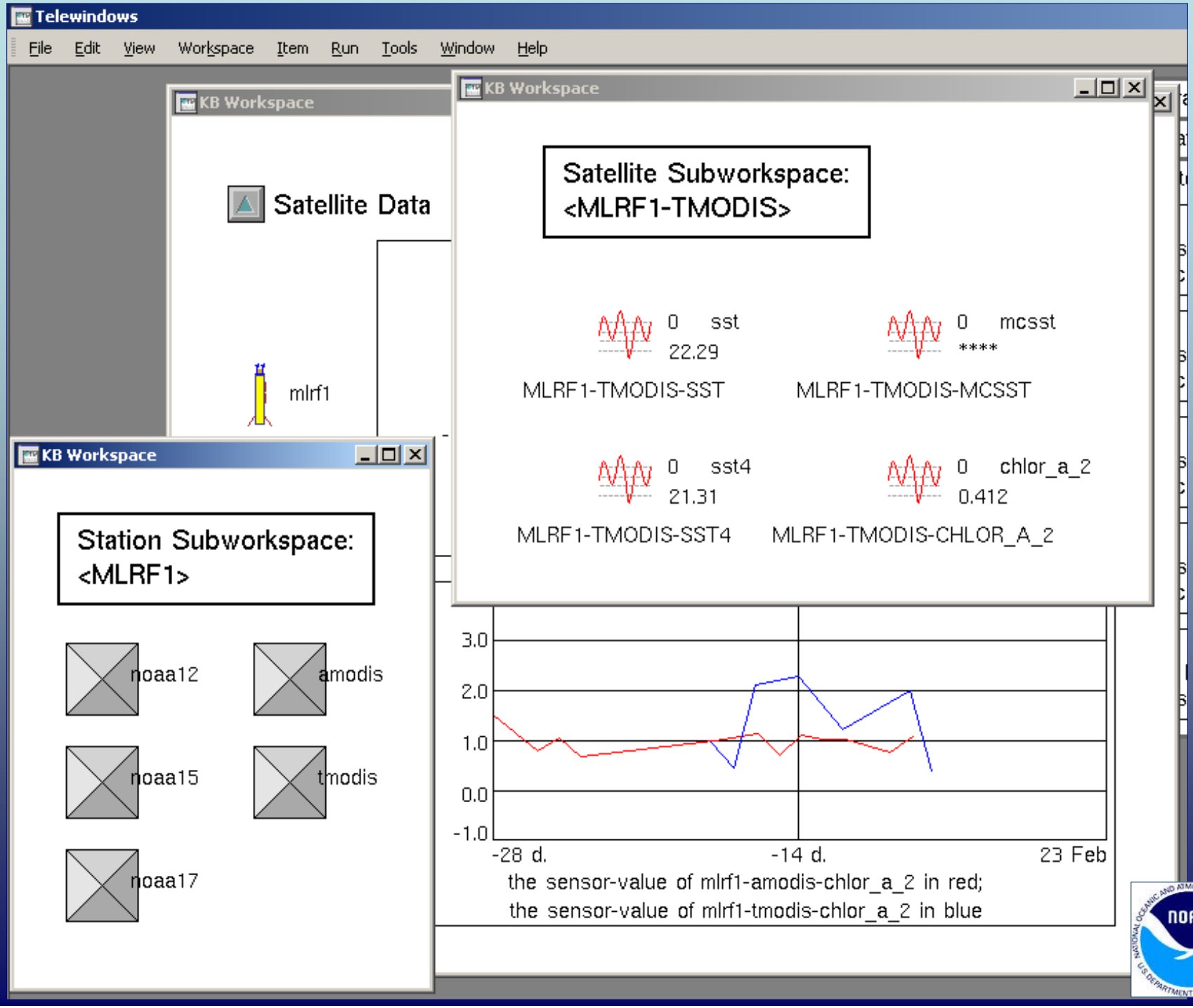
Basic Actions:

Inspect *operational* ecological forecasts

View canned graphs

Download selected data sets

Inspect instrument list and info


Telewindows
File Edit View Workspace Item Run Tools Window Help
KB Workspace
Satellite Data
mlrf1
KB Workspace
Satellite Subworkspace:
<MLRF1-TMODIS>
0 sst
22.29
MLRF1-TMODIS-SST
0 mcsst
****
MLRF1-TMODIS-MCSST
0 sst4
21.31
MLRF1-TMODIS-SST4
0 chlor_a_2
0.412
MLRF1-TMODIS-CHLOR_A_2
KB Workspace
Station Subworkspace:
<MLRF1>
noaa12
amodis
noaa15
tmodis
noaa17
3.0
2.0
1.0
0.0
-1.0
-28 d.
-14 d.
23 Feb
the sensor-value of mlrf1-amodis-chlor_a_2 in red;
the sensor-value of mlrf1-tmodis-chlor_a_2 in blue

For 02/14/2006

tmodis4 satellite period: local midnight (0346 hrs GMT)
tmodis4 satellite SST: 21.31

MLRF1 in situ period: midnight
MLRF1 in situ SST: 21.0 (somewhat-low)

For 02/10/2006

tmodis satellite period: local mid-day (1617 hrs GMT)
tmodis satellite SST: 22.31

MLRF1 in situ period: daylight-hours
MLRF1 in situ SST: 22.1 (somewhat-low)

For 02/14/2006

amodis4 satellite period: local pre-dawn (0633 hrs GMT)
amodis4 satellite SST: 20.55

MLRF1 in situ period: pre-dawn
MLRF1 in situ SST: 20.5 (low)

For 02/13/2006

amodis satellite period: local pre-sunset (1819 hrs GMT)
amodis satellite SST: 21.48

MLRF1 in situ period: afternoon
MLRF1 in situ SST: 21.3 (somewhat-low)

Our prototype expert system (being migrated to G2) integrates satellite and in situ SEAKEYS data for Molasses Reef.

Telewindows

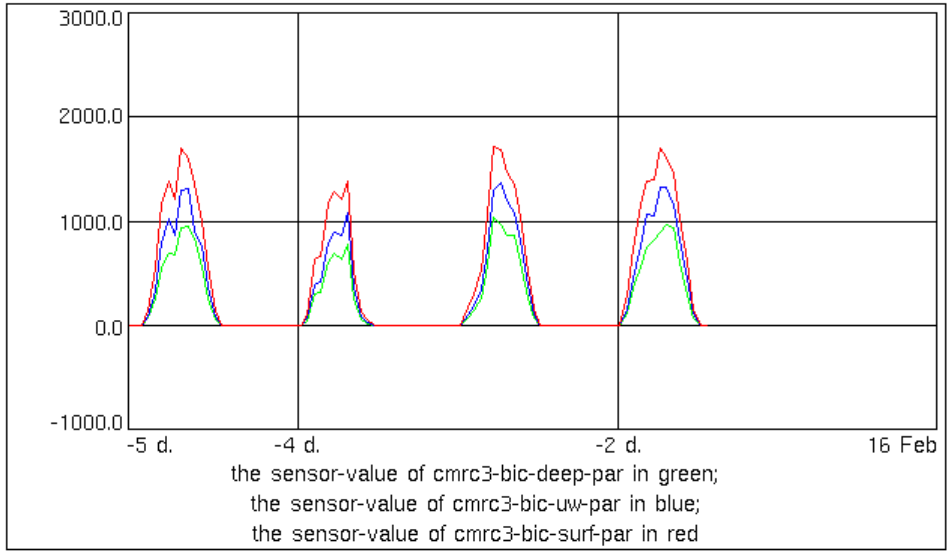
File Edit View Workspace Item Run Tools Window Help

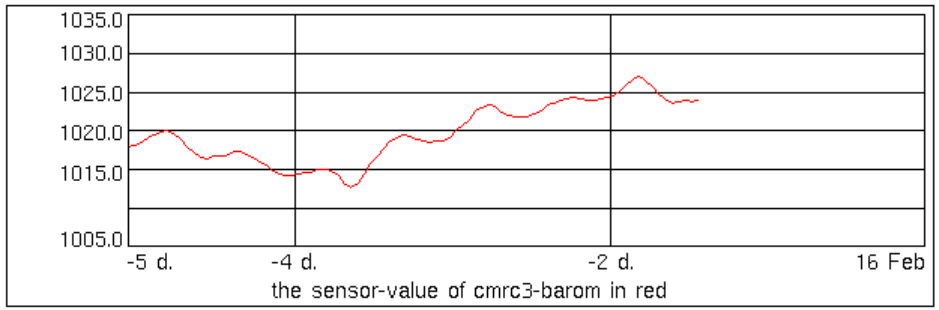
MIKE-TOP-LEVEL

KB Workspace

Class Instances

cmrc3





Operator Logbook 1

Operator Logbook 15 Feb 2006 ▼▲ Page 40

#164 12:01:50 a.m. Saving knowledge base "/usr/gensym/icon-kbs/gfr.kb" completed successfully

#165 12:01:50 a.m. Saving knowledge base "/usr/gensym/icon-kbs/sys-mod.kb" completed successfully

#166 12:01:50 a.m. Saving knowledge base "/usr/gensym/icon-kbs/uilroot.kb" completed successfully

#167 12:01:54 a.m. Resuming running of KB from where it last paused.

#169 1:19:51 a.m. Closing Telewindows connection!

G2 provides facilities for plots and graphs over any length of time.

Role: **Field Maintenance Crew**

Same Basic Actions, plus...

Update station instrument info, metadata

Biota observations and feedback

Miscellaneous observations or info

Role: **Researcher**

Same Basic Actions, plus…

- **Register as Researcher**
- **Create new graphs**
- **Submit special requests (especially new models)**
- **View *experimental* ecological forecasting modules**
- **Submit biota and/or physical observations**

Role: **MPA Manager**

Same Basic Actions, plus...

Update public information

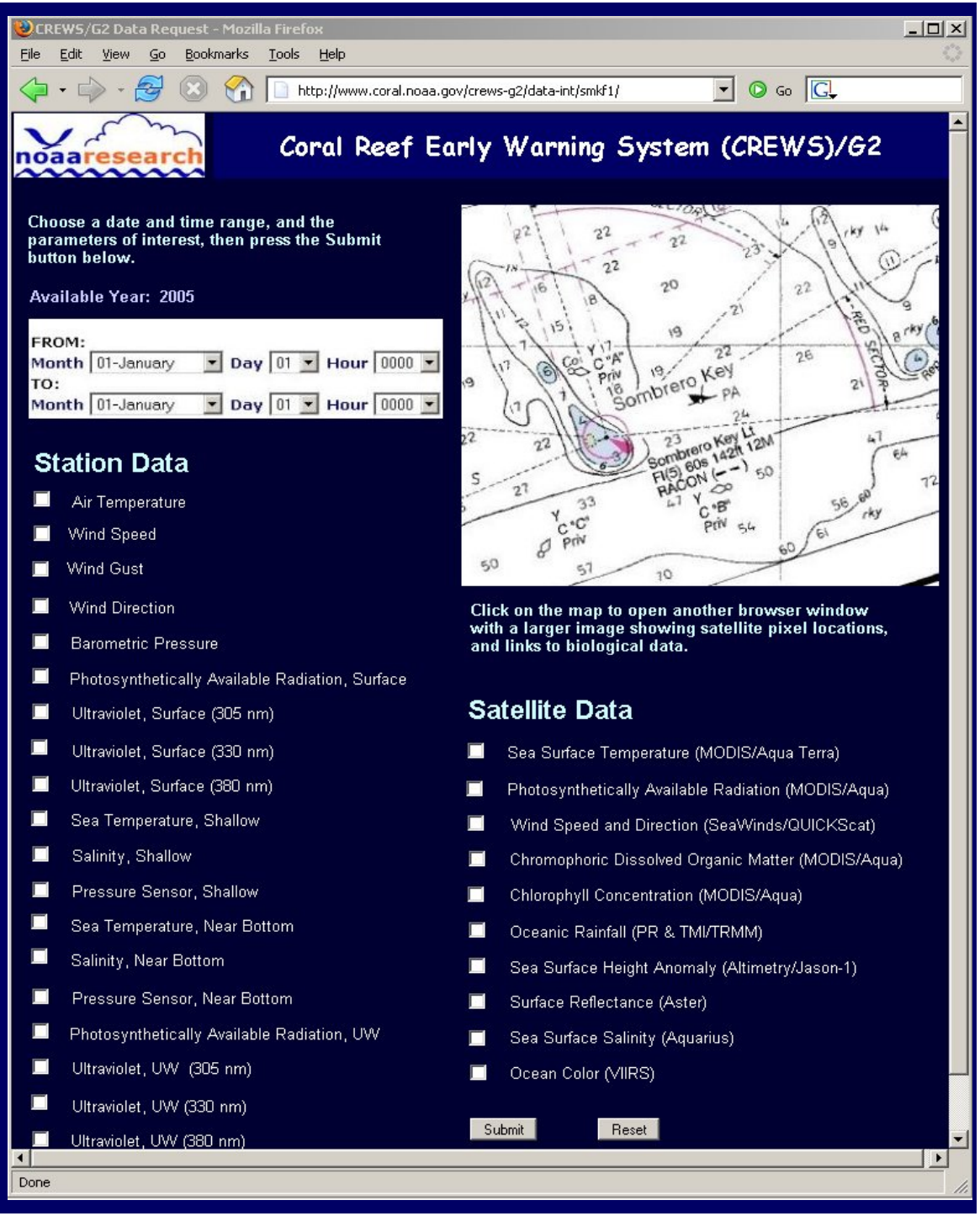
(including automated news alerts)

View special ecological forecasting modules

and…?

Example page for Sombrero Key data request, to obtain integrated “raw” near real-time *in situ* and satellite data, as well as biota data.

- User clicks on data type and date range for the data, then clicks the Submit button at the bottom of the page.
- Data are returned in tabular format, and spreadsheet ready (as in IMN).
- User clicks on image to obtain biological data, and station images (above, below).



Example page for G2 products, and station and satellite information updates.

User Login: different access privileges for other menu choices.

Station: Details, info updates, links to maps, Landsat and other images.

Sensors: Metadata, calibration info, updates.

Biota: Latest monitoring data, links to more info.

Graphs: Wealth of x/y, scatter and other plots, of all variables.

Alerts: Latest bleaching and other alerts (next slide).

Rules: For Knowledge Engineers, and the curious.

“An MPA Retreat: Establishing Coral Reef MPA Managers’ Requirements to Guide Integrative Observing System Tool Development”

- Continuation of the Think Tank series (this will be #5)
- To be held at La Parguera, Puerto Rico mid-August
- Up to 50 MPA Managers from the Atlantic and Caribbean
- Purpose is gain input from the managers in building new G2-based coral data integration Web interface for decision support
- Data types: CREWS stations, satellite, radar, biological monitoring, etc.
- Interesting note: there are over 350 MPAs in the Caribbean!
- *Ecological Forecasting* for MPAs will be main goal of the software

See you at Villa Parguera?