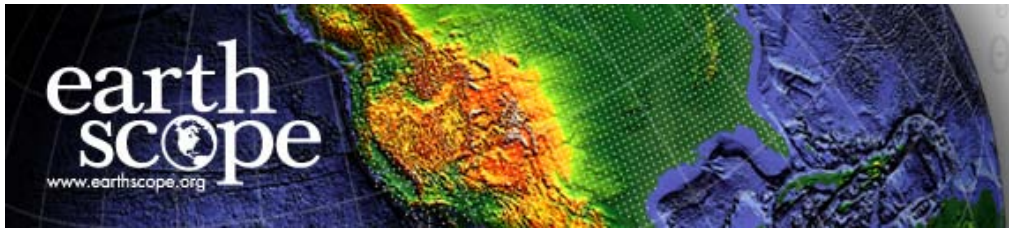
Ocean Observatories: The U.S. Case

Bob Houtman
U.S. National Science Foundation
16 September 2010

In-situ sensors allow us to hear the Earth



Carbon Retention in a Colored Ocean Time Series (CARIACO)

MARS
Monterey Accelerated Research System

OCEAN OBSERVATORIES INITIATIVE

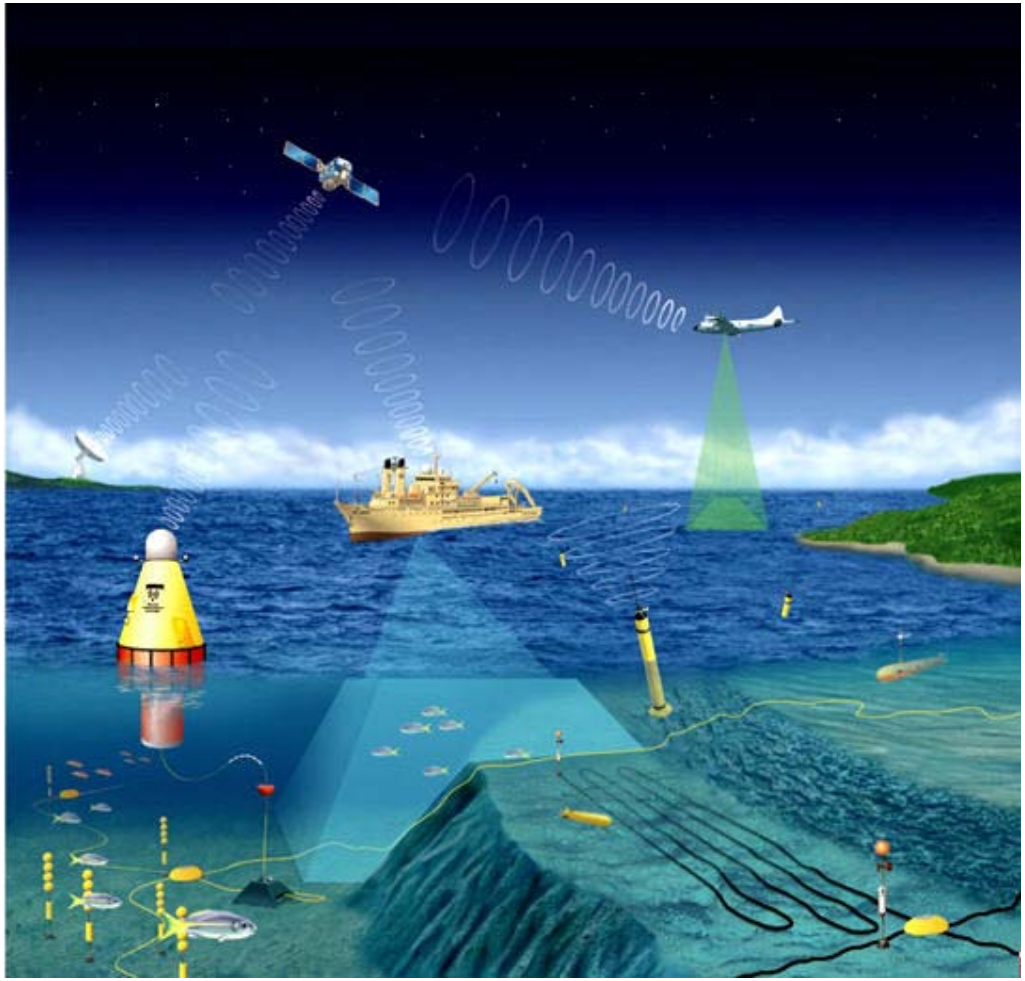
Bermuda Atlantic Time-series Study (BATS)

IOOS®
INTEGRATED OCEAN OBSERVING SYSTEM

Aloha Cabled Observatory
Hawaii Ocean Time-series (HOT)

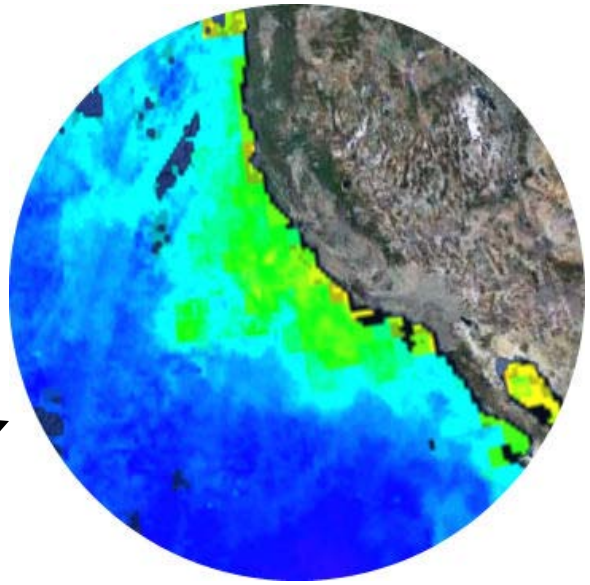
What is IOOS®?

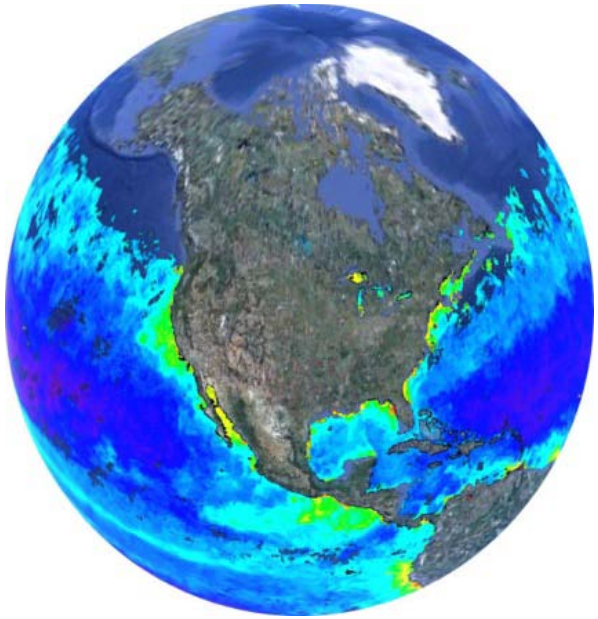
- An Integrated and Sustained Ocean and Coastal Observing and Prediction System.
- A collaborative framework.
- A network of many different land-, water-, air-, and space-based facilities and technologies:
  - Platforms
  - Instruments and Sensors
  - Telecommunications Systems
  - Computer Systems
- Contributes to the Global Ocean Observing System (GOOS)



A National and Regional Collaboration

17 Federal Agencies





11 Regional Associations

ALLIANCE FOR COASTAL TECHNOLOGIES

U.S. Data Management & Communications

Other Third Party Users

IOOS/GEOSS

Data also returned to providers with processing.

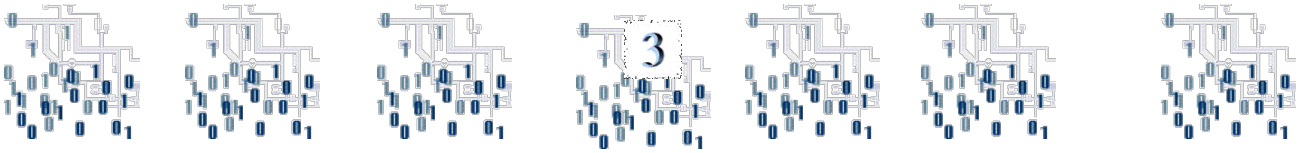
National Observing Systems

Regional Observing Systems

Data Management

Modeling

End Users (YOU!)



Federal States Industry Local Tribes Academia NGOs

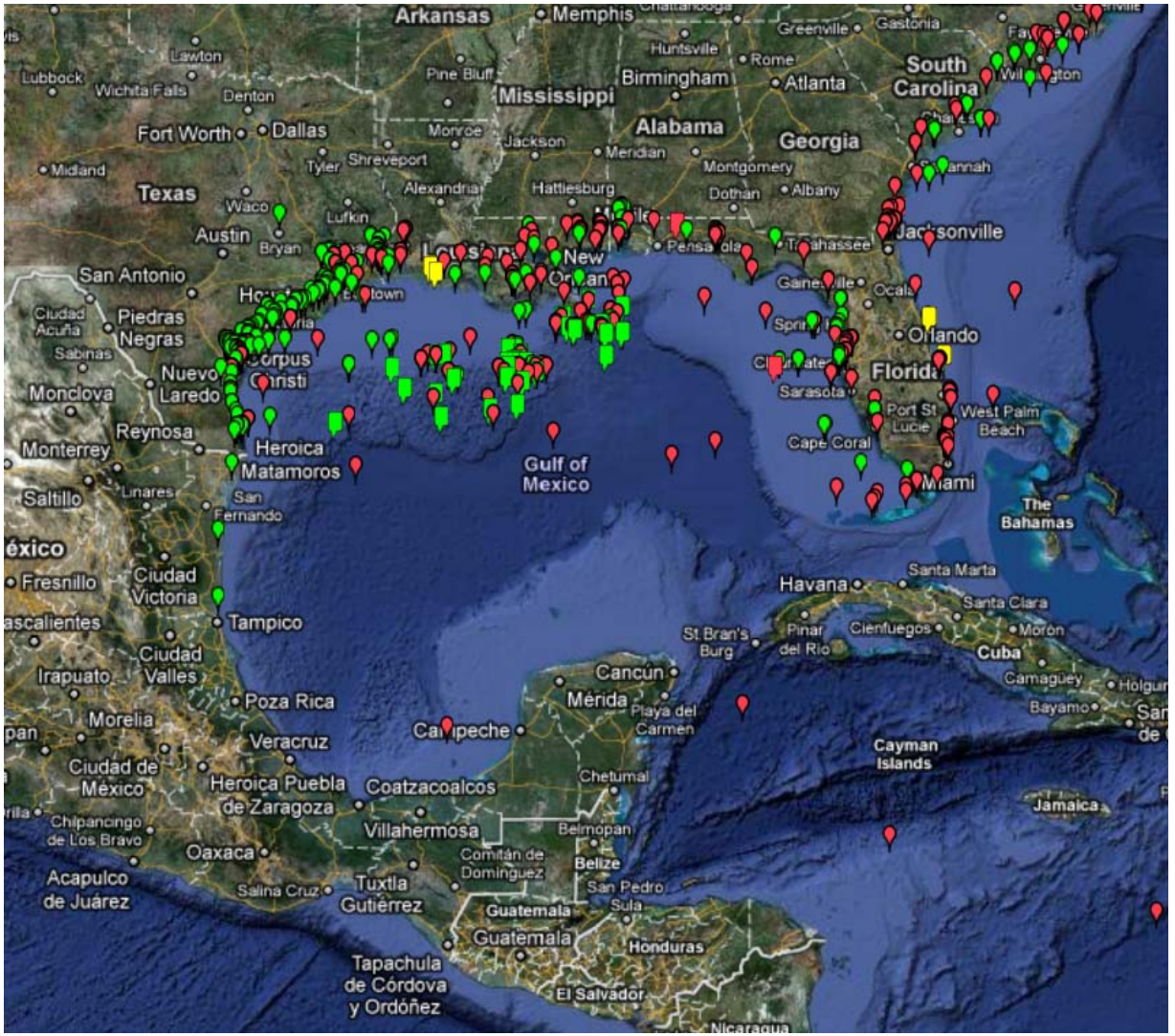
Data Providers

All Observing Assets in GOM (Fed/Non-Fed)

- Non-Federal Stationary
- Non-Federal Mobile
- Federal Stationary
- Federal Mobile
- Partial Federal Stationary
- Partial-Federal Mobile

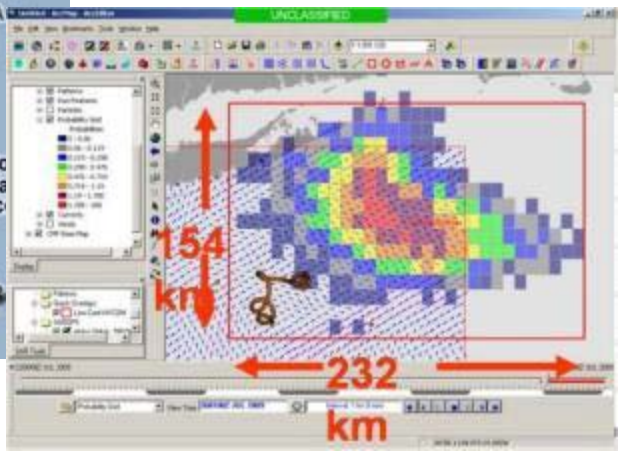
Includes: Private, Academic, State, NOAA/NDBC, NOAA/CO-OPS, NOAA/IOOS*

* Includes IOOS Regional Associations

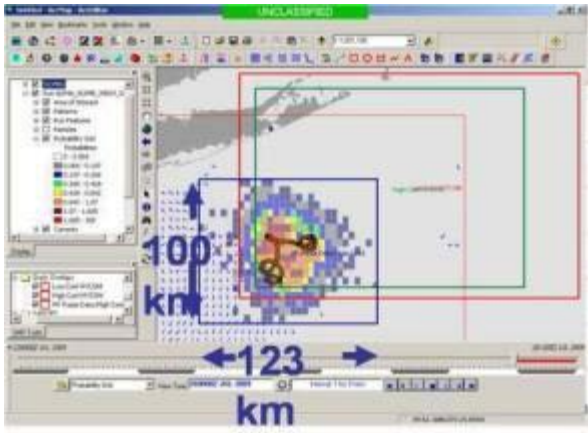


US IOOS®: Delivering New Observing Capability

- >100 Coastal High Frequency Systems
- Uses: SAR; Oil Spill; Harmful Algal Bloom; Ocean Circulation



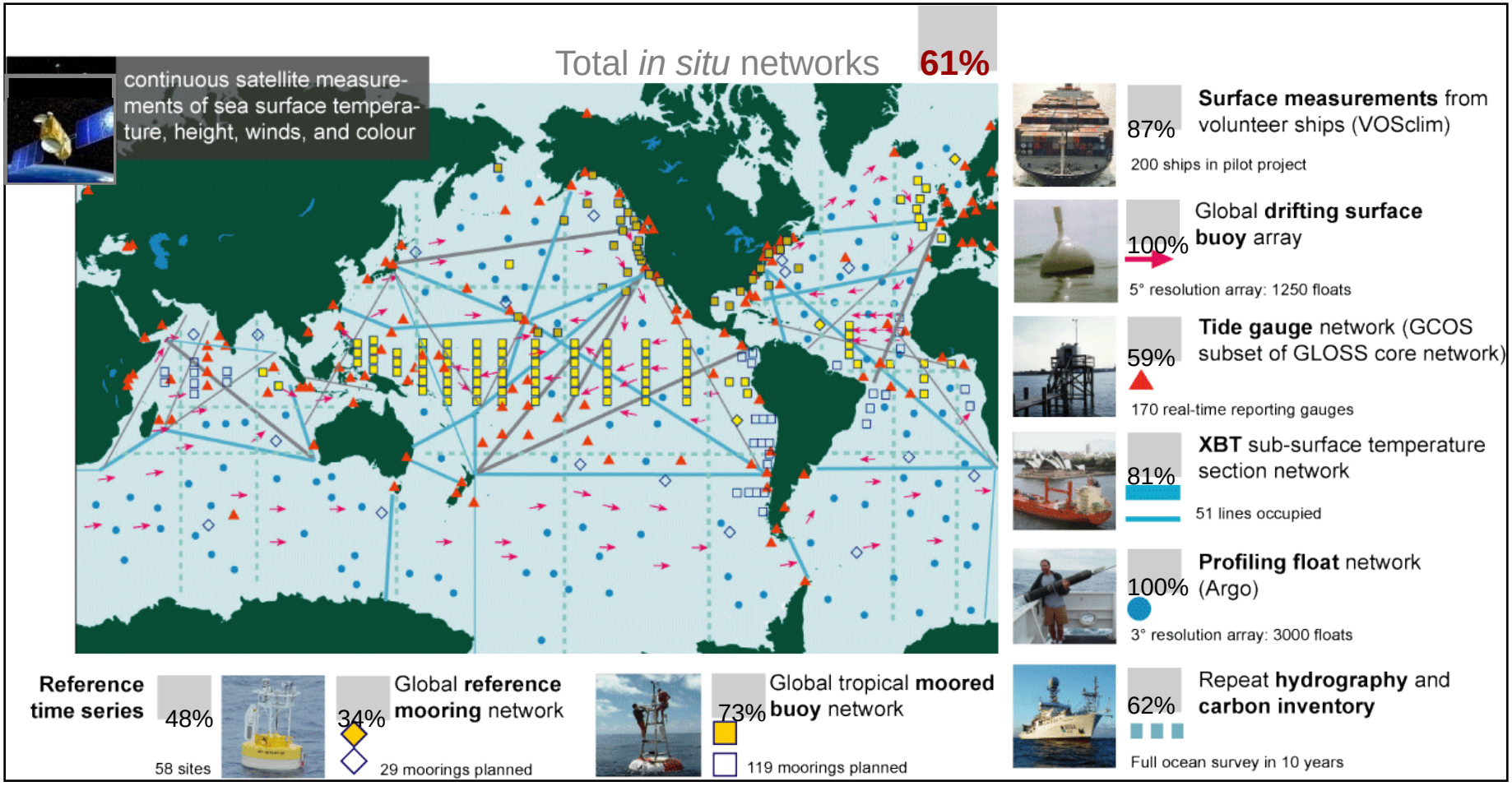
96 hr: Without HFR
36,000 Km^2



96 hr: With HFR
12,000 Km^2

The Initial Global Ocean Observing System for Climate

Status against the GCOS Implementation Plan and JCOMM targets



GCOS GOOS jcomm

IOOS®: Delivering the Benefits

Improve Safety

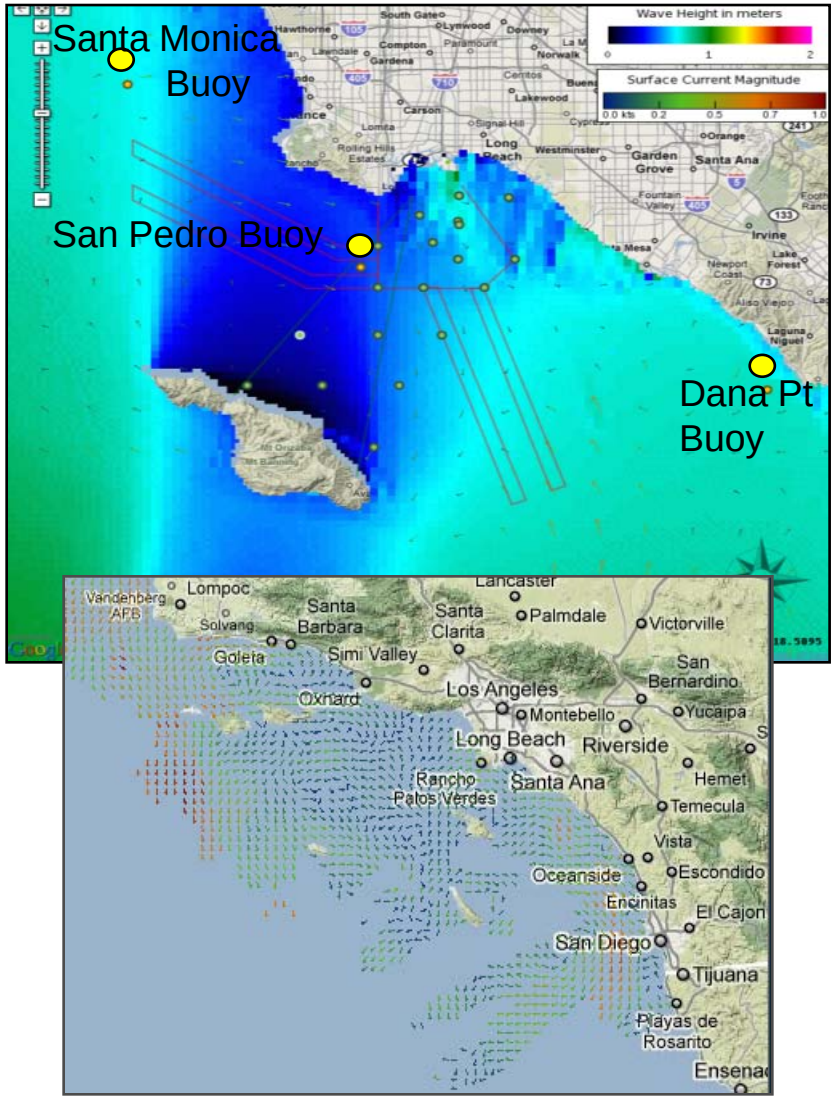
Enhance Our Economy

Protect Our Environment

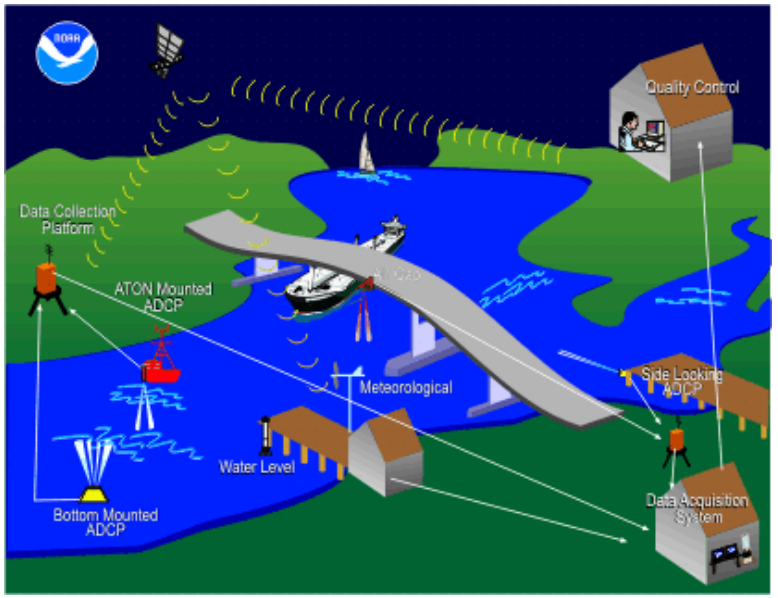
Protecting Coastal Communities

- Hazard and ecosystem assessment
- Oil and hazardous materials spill response
- Support for coastal management
- Habitat loss management
- Environmental mapping

Safe and Efficient Navigation

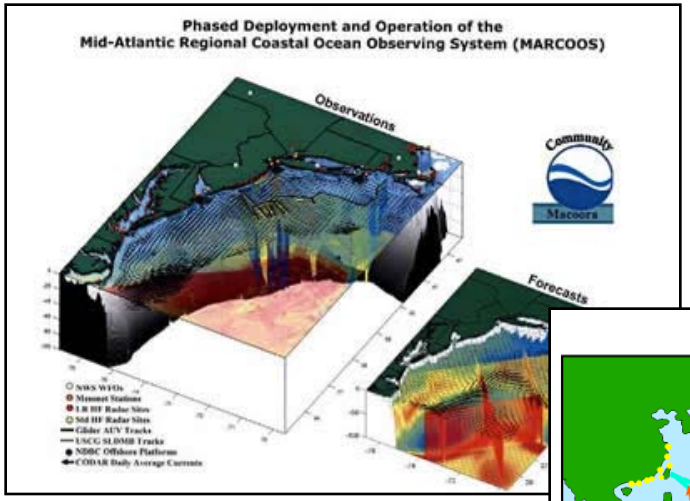


- Coastal Data Information Program (CDIP) providing wave observations, nowcasts, and forecasts.
- SCCOOS providing HF Radar surface currents.
- NOAA Physical Oceanographic Real-Time System (PORTS)

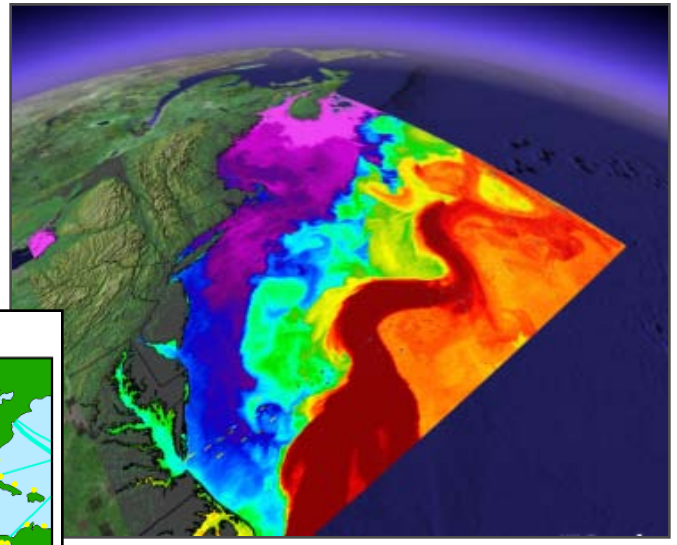


Benefits Across Disciplines

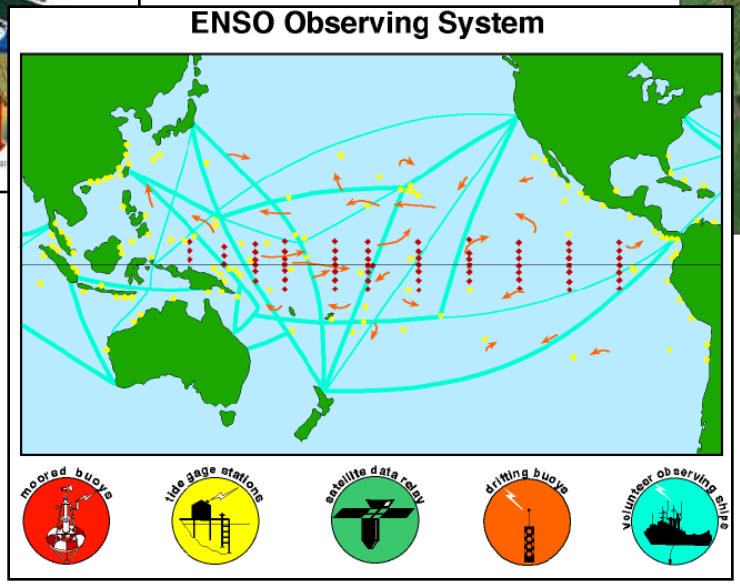
Public Utilities



Ecological Management



Weather & Climate



…Water Supply, Agriculture, Commercial Fishing, Energy, Tourism and more…

US IOOS® support to: Energy Sector

Pre -Construction

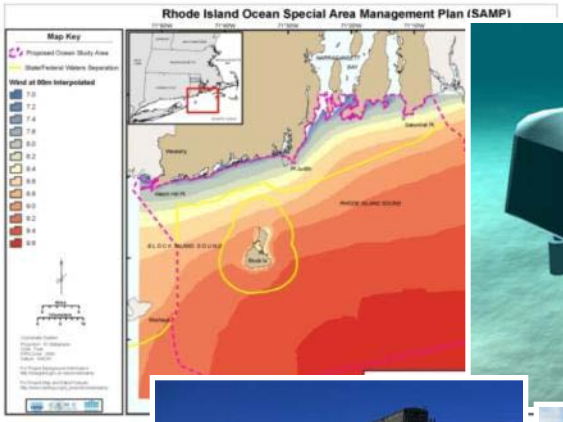
- Avian Studies
- Geophysical/Geotechnial Investigations
- Met Tower Installation
- Wave Sensor Deployment
- Staging Port Development

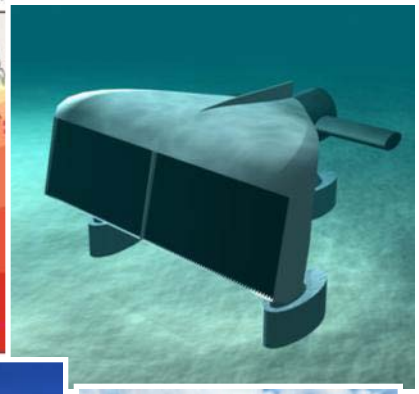
Construction

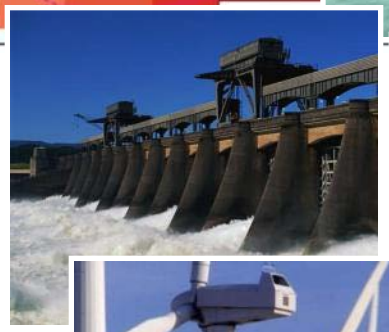
- Foundation Installation
- Sub-sea Electrical Cable Installation
- Offshore Substation Installation
- Turbine Installation

Post-Construction

- O&M Activities; Decommissioning

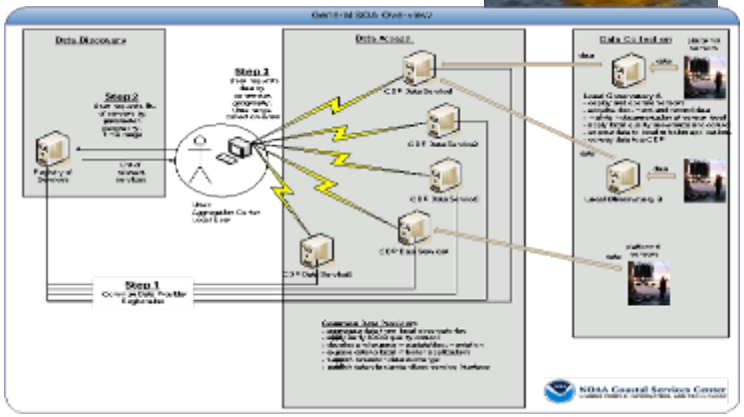






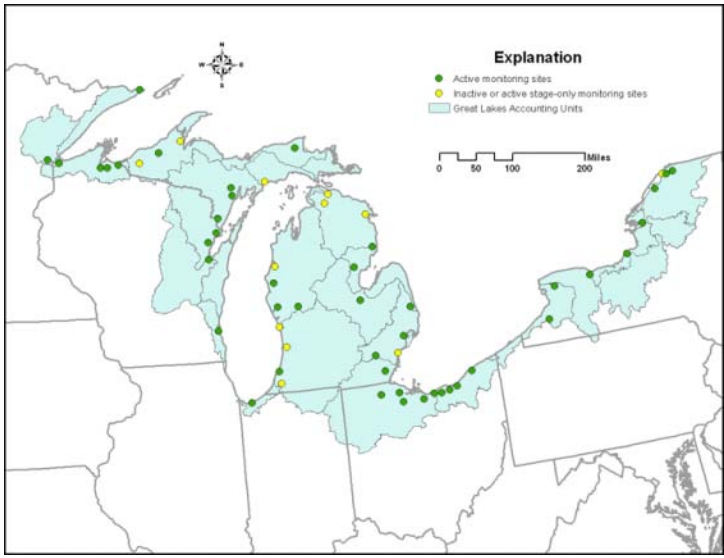
Industry Participation

- **The Observing Subsystem**
  - Buoys, gliders, gauges.
- **DMAC Subsystem**
  - Boeing, SAIC, and ASA working with IOOS regions
- **Modeling and Analysis Subsystem**
  - Noblis, Inc. helping create inundation forecasting (CIPS)
- **Partnerships**
  - Shell and NOAA NDBC
- **Value-Added Companies**
  - Surfline; ROFFS; Weatherflow



US IOOS® and US National Water Quality Monitoring Network - example

- Serve observational data according to common OGC/WMO standards
- Feeds multidiscipline prediction models for eutrophication, beach health, invasive sp., etc.
- Integrate watershed “circulation” model with GLOS/IOOS into a Virtual Observatory



USGS science for a changing world

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

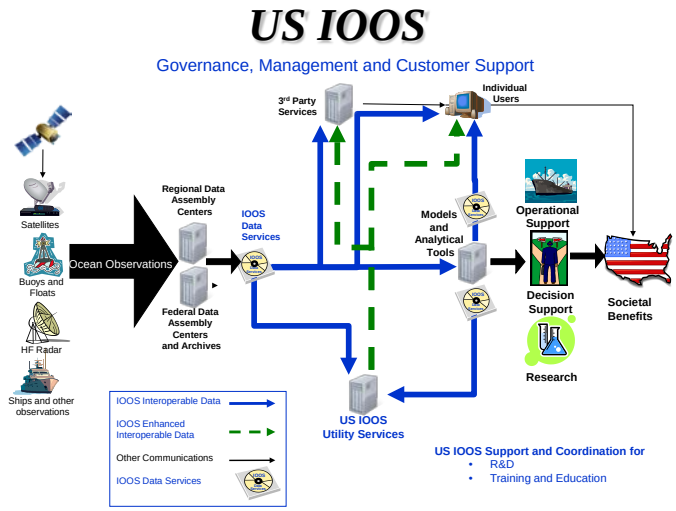
IOOS® INTEGRATED OCEAN OBSERVING SYSTEM

GLOS

The Future of U.S. IOOS

Operational IOOS

- Network of Observations
  - biological
  - physical
  - chemical
- Fully developed Data Management and Communications (DMAC)
- Robust Partnership with Regional Coastal Component
- Models & decision tools at resolution to support coastal communities



OCEAN OBSERVATORIES INITIATIVE

What is the OOI?

A system of systems that will document, for 25-30 years,

air-sea, water column and seafloor processes, across full ocean depths, using the best technical solutions available.

The Science Context for the OOI

The ocean, which covers 70% of the earth's surface, can hold 1,100 times more heat than the atmosphere, and does hold 96.5% of the freshwater, is critical to life on earth.

The potential societal impacts of further discovery in ocean science and of variability and change in the ocean are large.

OOI Science Themes

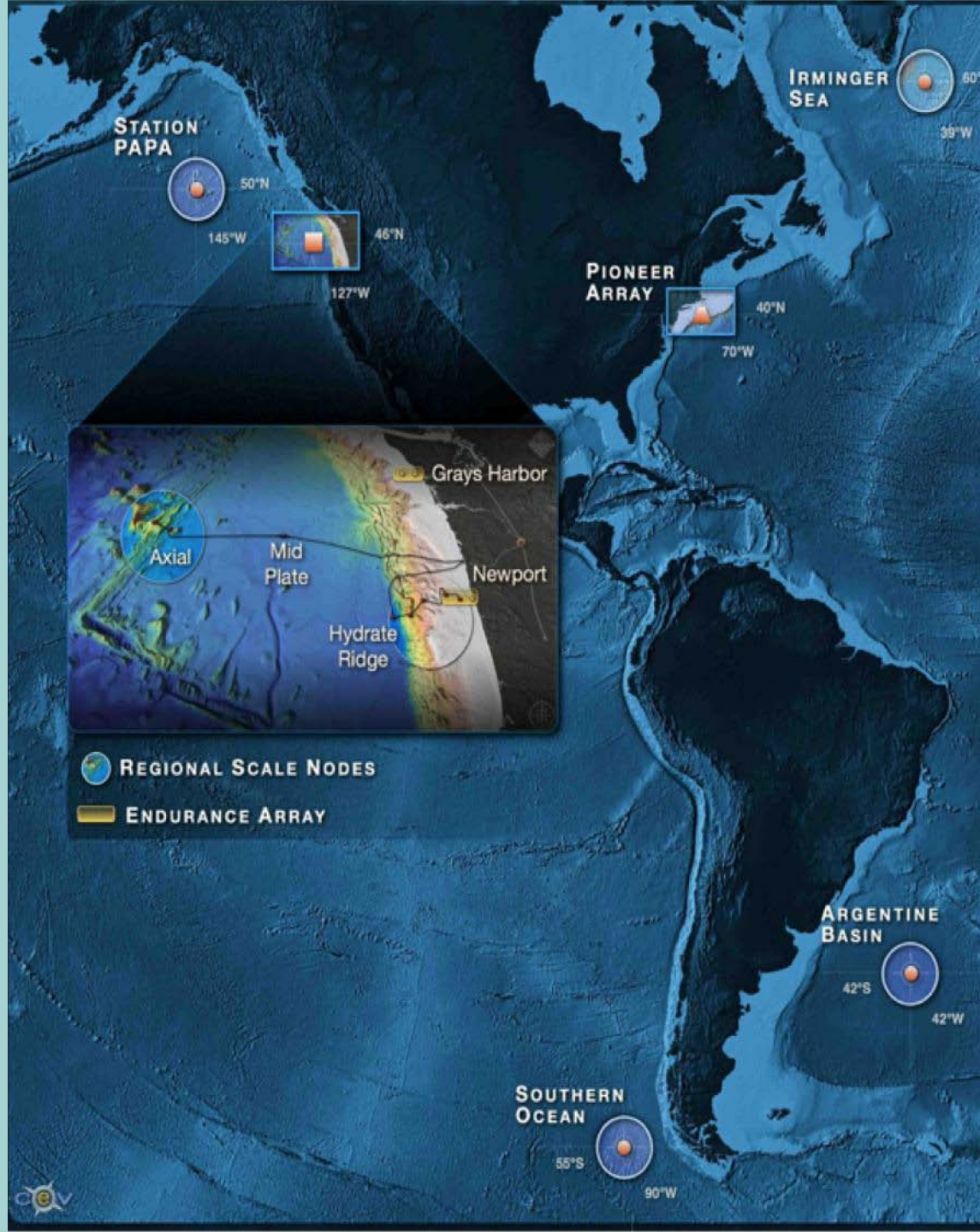
- Ocean-Atmosphere Exchange
- Climate Variability, Ocean Circulation, and Ecosystems
- Turbulent Mixing and Biophysical Interactions
- Coastal Ocean Dynamics and Ecosystems
- Fluid-Rock Interactions and the Sub-seafloor Biosphere
- Plate-scale, Ocean Geodynamics

Additional Science Foci

- Ocean ecosystem health
- Climate change
- Carbon cycling
- Ocean acidification

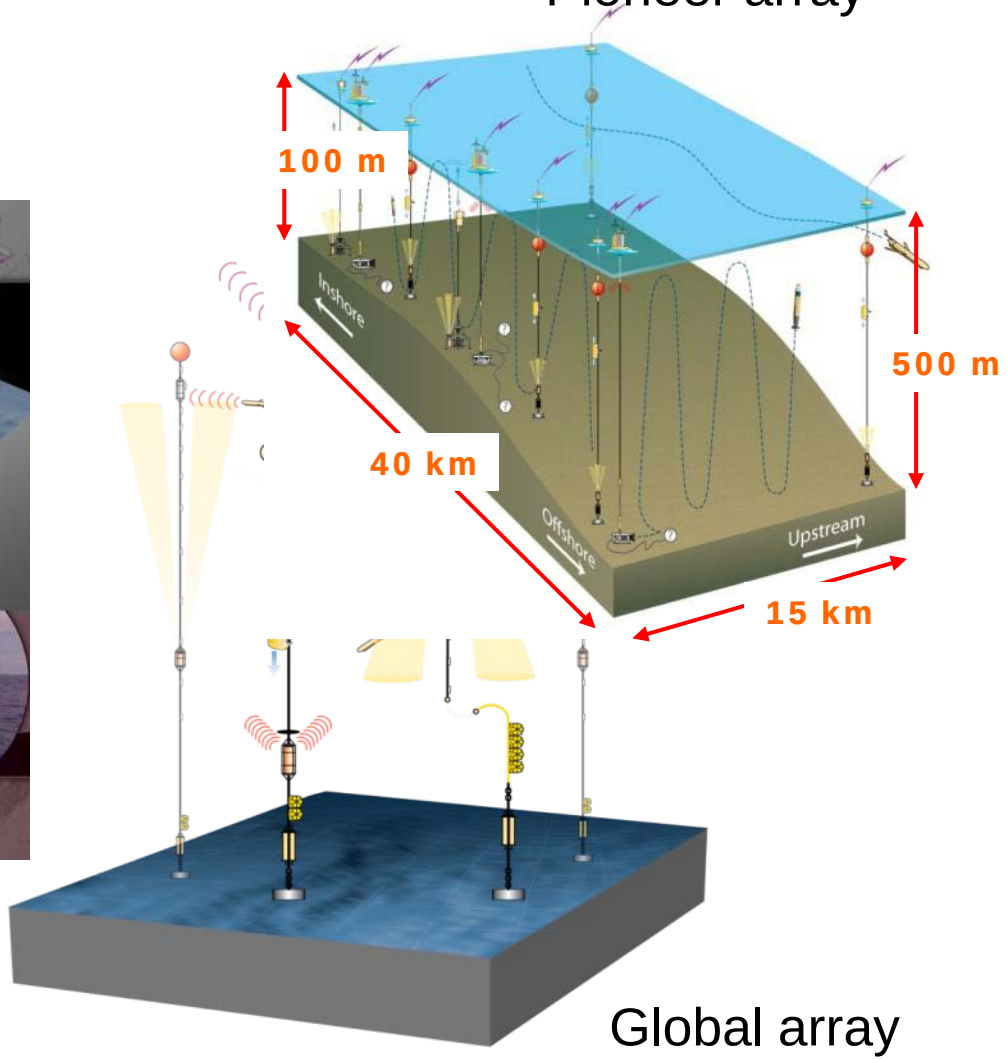
Baseline Design

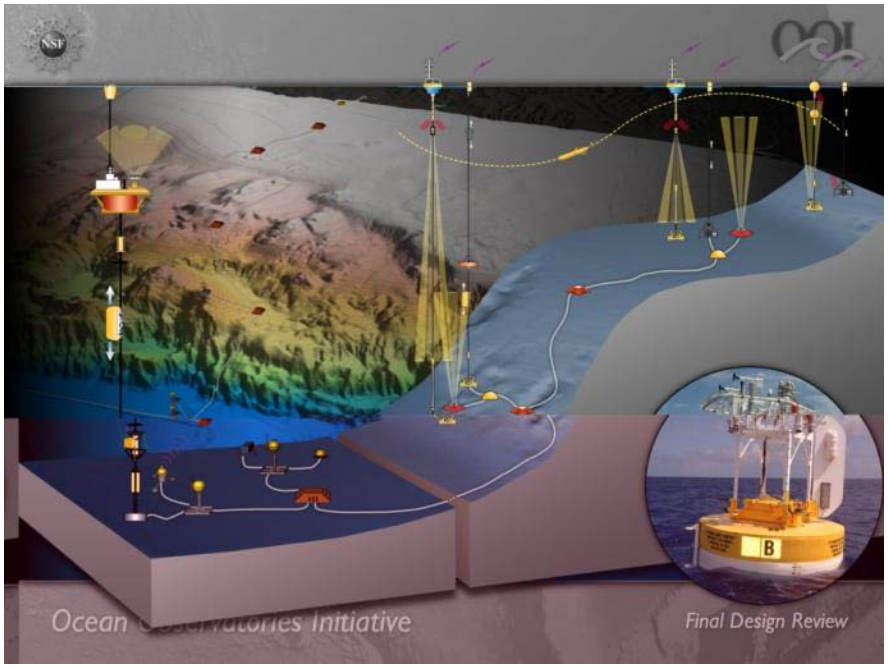
- **4 Global** sites
- **3 Regional cabled** sites in the NE Pacific
- **2 Coastal** arrays: Mid-Atlantic Pioneer Array, PNW Endurance Array
- **Each scale** incorporates mobile assets
- **Cyberinfrastructure**: enables adaptive sampling, custom observatory view, collaborative analysis
- Interfaces for education users



Coastal and Global Scale

Pioneer array





Endurance array

Global array

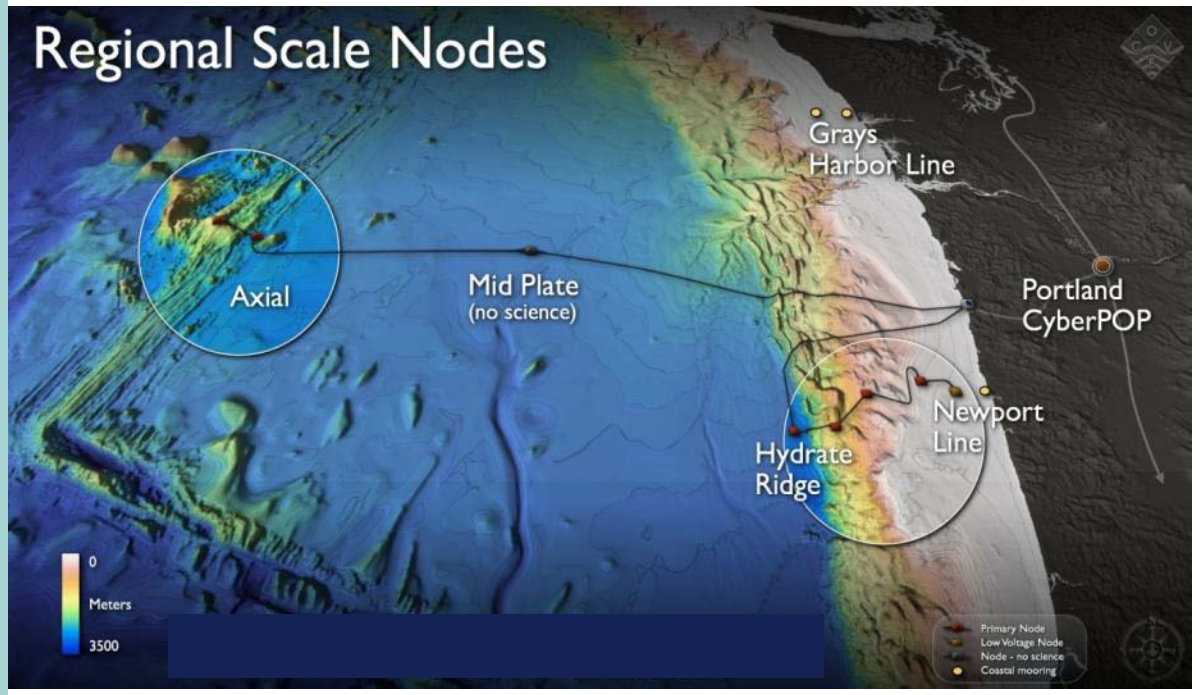
OOI assets off PNW coast are *unique*

Cable provides **high power** and **bandwidth** to

- Instrumented nodes on Juan de Fuca plate

- full water column moorings at Axial and Hydrate

- 2 moorings of Endurance Array connected to the cable

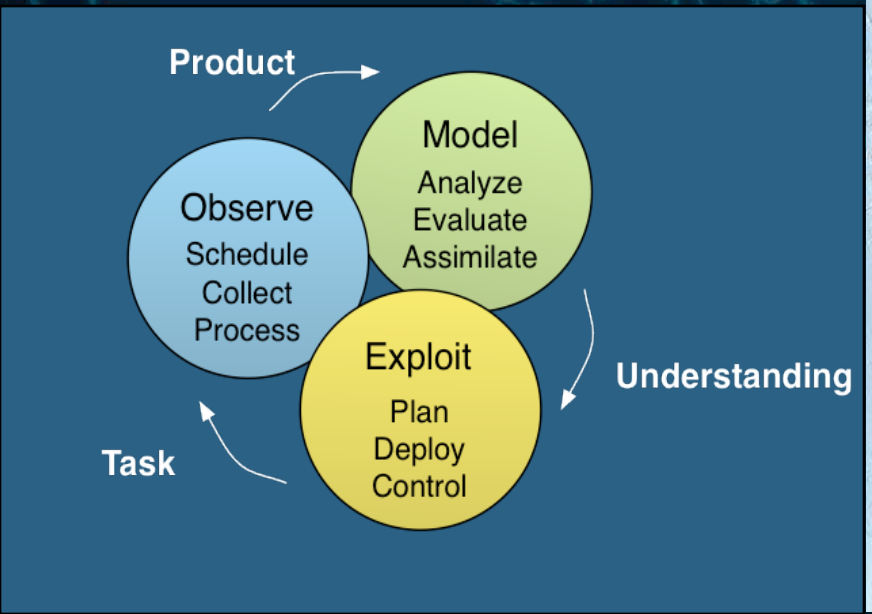


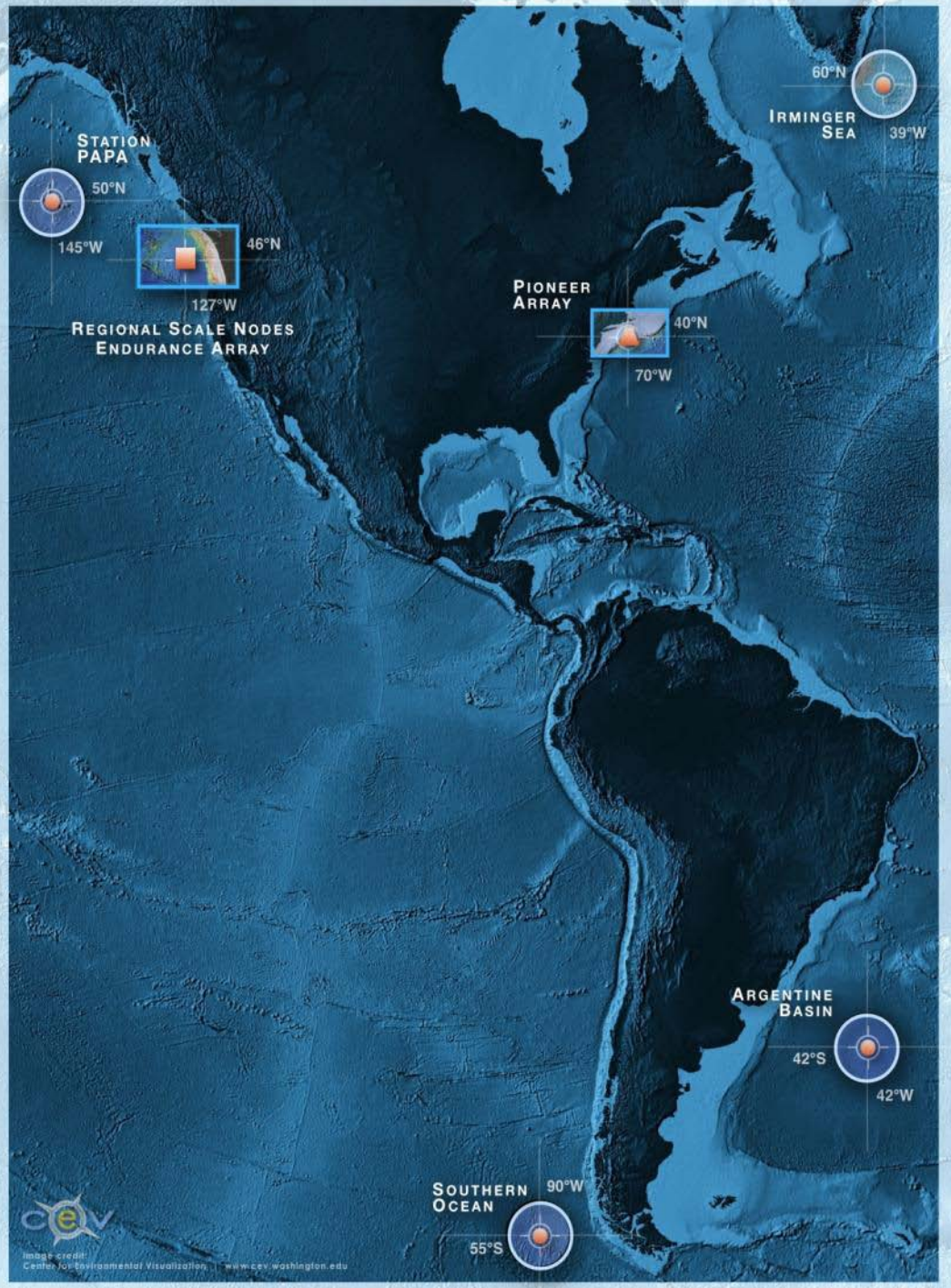
Cyberinfrastructure

- *Creates an interactive ocean laboratory integrated by leading-edge, multi-scalar software tools.*

broad access...

science, education, and policy

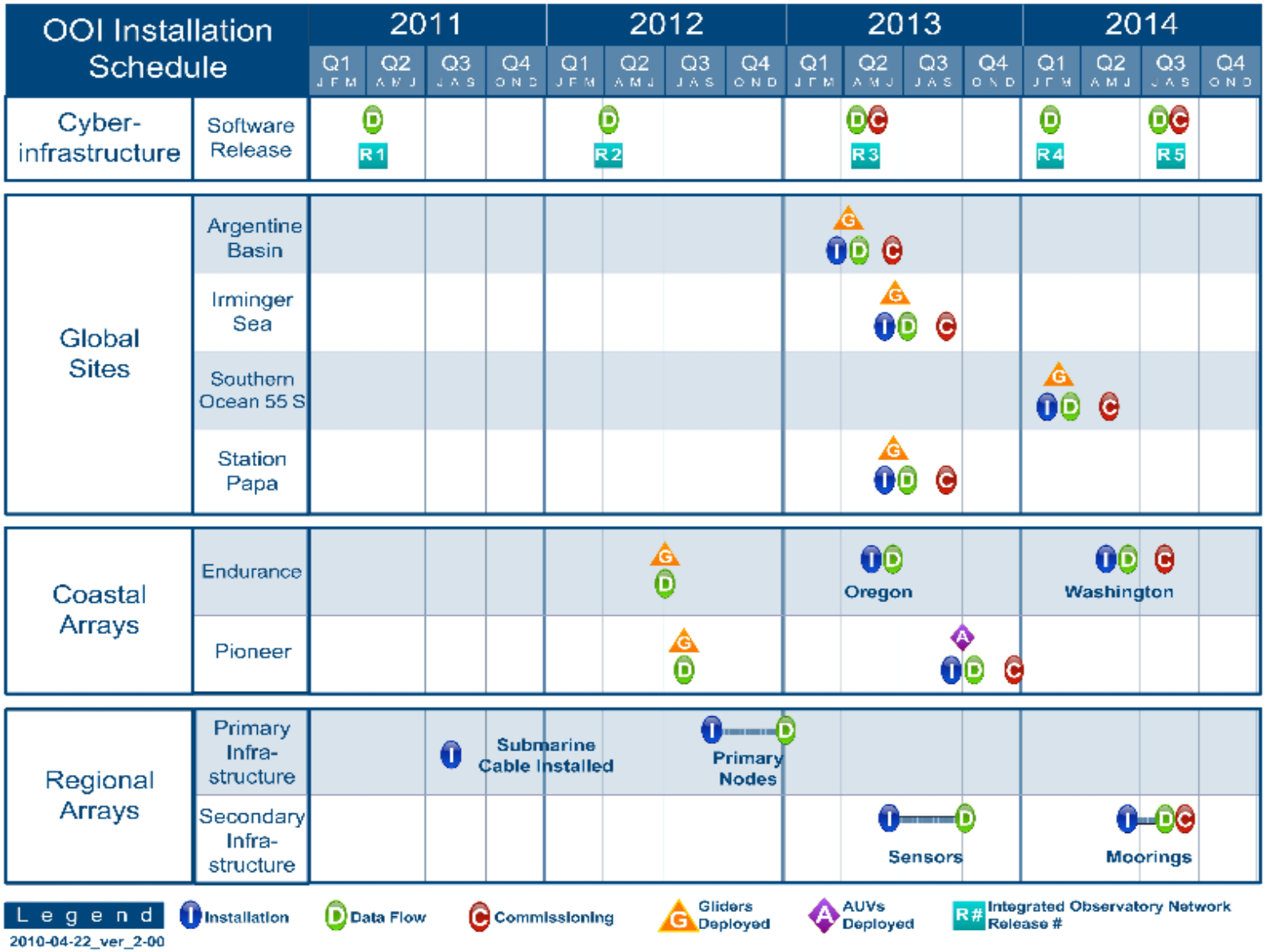




Scientific requirements underpin the infrastructure design and its capabilities

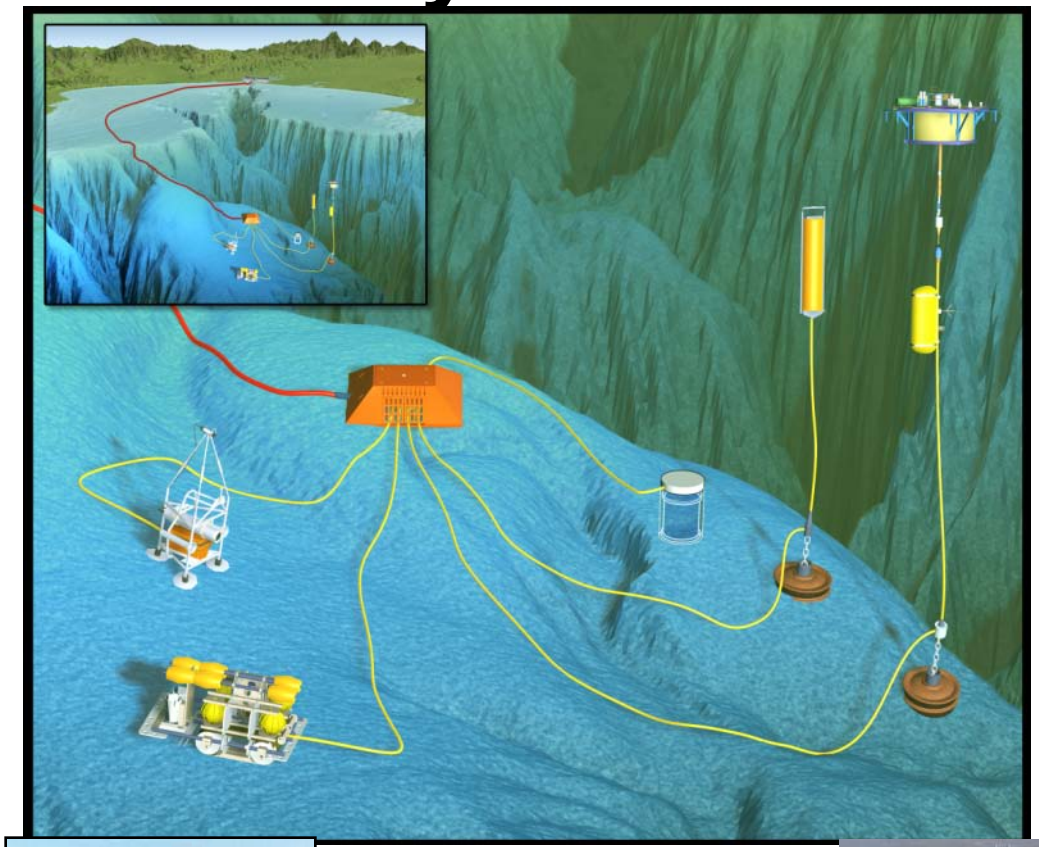
- Science Question
- Processes to be observed
- Spatial Scale
- Temporal Scale
- Measurements Required
- Sensors Required
- Sampling Requirements
- Site(s) Required for Science
- Experiment Description

OOI Construction Schedule



MARS

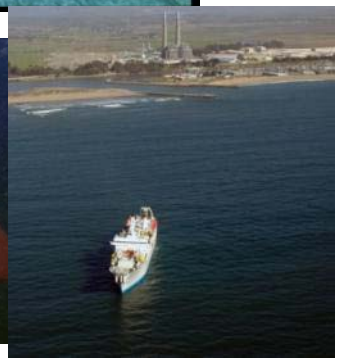
Monterey Accelerated Research System



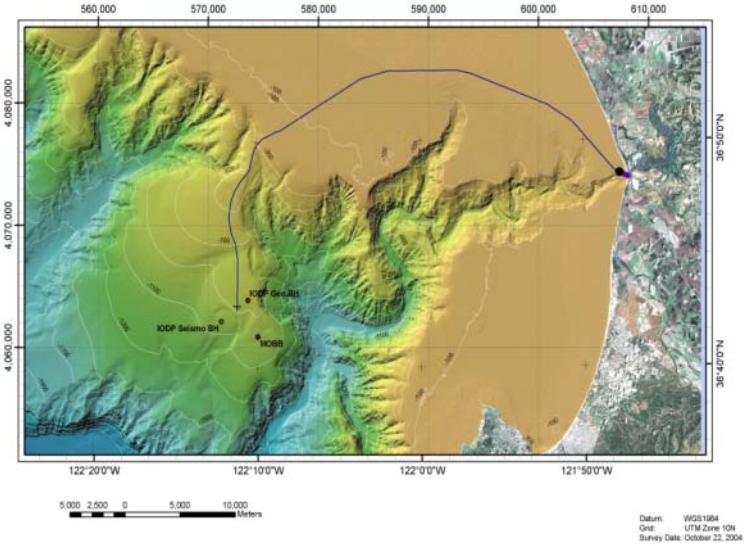
A test bed, cabled observatory

- 9 kW of power for science
- 8 science ports providing 100 Mbit/sec Ethernet and Precision time distribution ~5 uSec
- Deep water - 890 meters
- Accessible - 2 hrs from port
- A comprehensive workflow process – from proposal through development, test, and deployment
- Data routed to science users' IP address

MBARI Cable Laying Toolsled



What is MARS?



MARS is a single "science node" 891 meters below the surface of Monterey Bay, California. The MARS science node has eight ports. Each of the eight ports is equipped with an underwater mateable connector. The science node is connected to the shore through 52-km of subsea telecom cable that carries data and power.

The yellow portion houses the MARS electronics in an ROV removable section.

The MARS trawl-resistant frame.

ROV access door is open underwater connectors inside

On November 10, 2008, the ROV *Ventana* connected the main MARS telecom cable's power and fiber optic links to the MARS electronics node

FOCE

Free Ocean CO2 Experiment

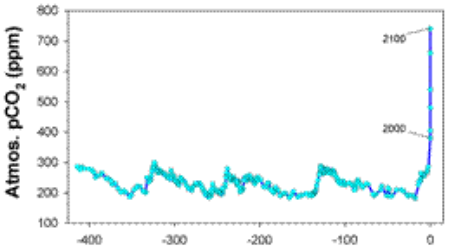
Dr. Peter Brewer

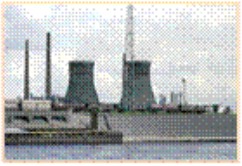
http://www.mbari.org/mars/general/foce.html

Deployed Dec 9, 2008

While over-fishing was the ocean crisis realized in the 20th century, ocean acidification will be the crisis of the 21st century.

What will be the ecology of the acidic ocean? How will the food chain be altered? What management practices will need to be changed?





Atmosphere

Ocean

Eye-in-the-Sea

Dr. Edith Widder

http://www.oceanrecon.org/research.htm

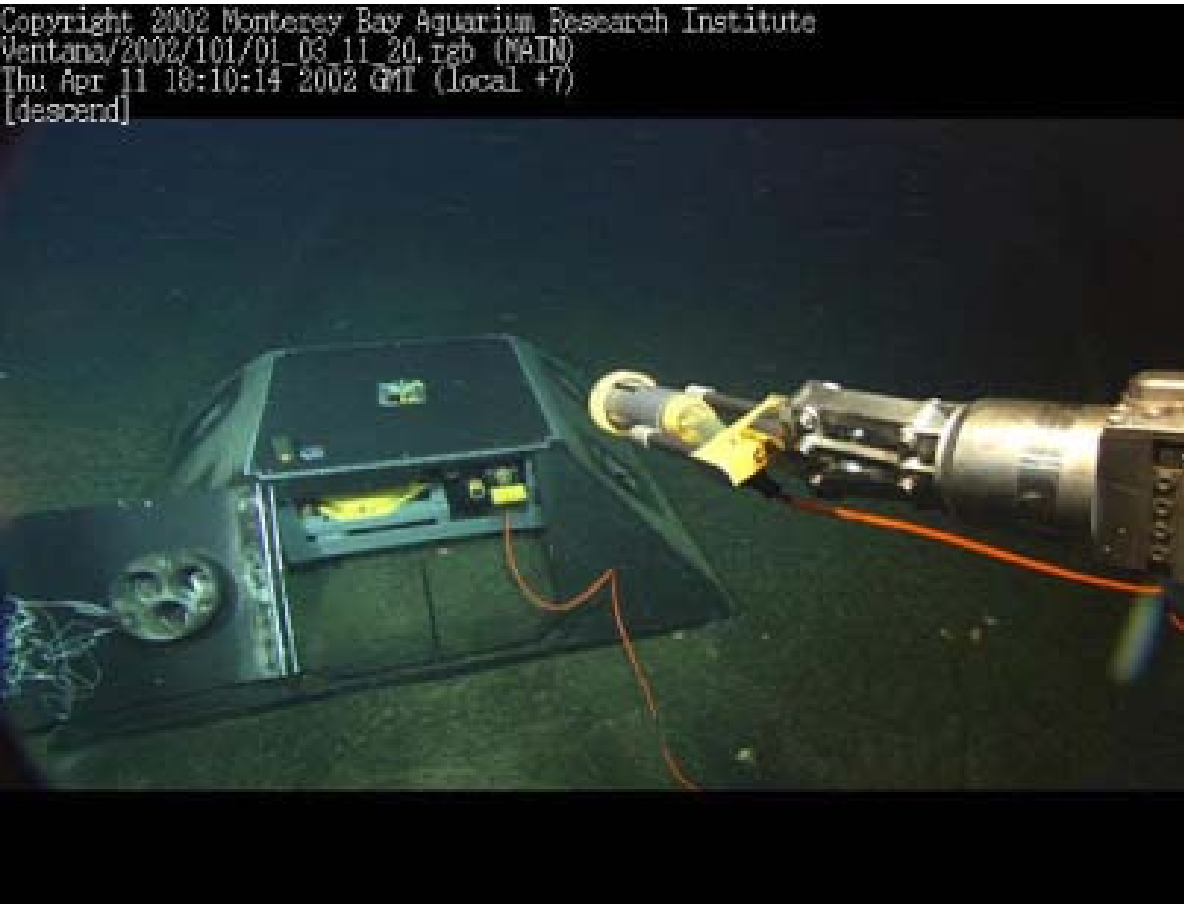
Deployed January 21, 2009

- Objective is to collect unobtrusive video observations of deep sea animal behavior using red lights, no thrusters
- Low light camera (10^{-7} lux) and LED bioluminescence array
- Connected to significant education and outreach program

MOBB

Monterey Ocean Bottom Broadband

Deployed February 26, 2009



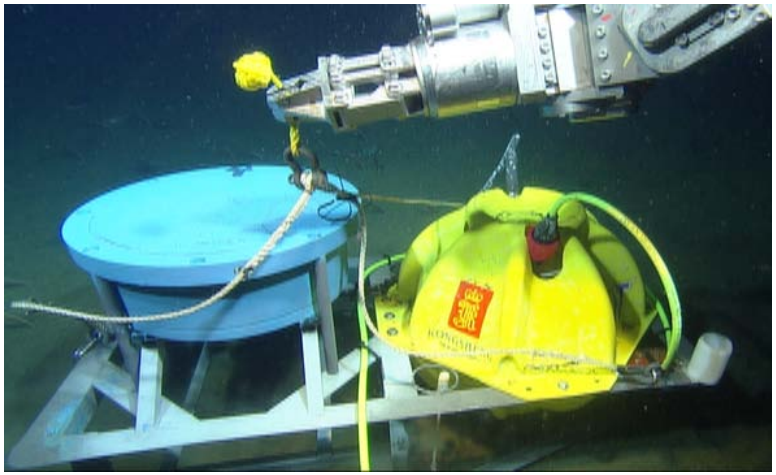
Seismic Observatory

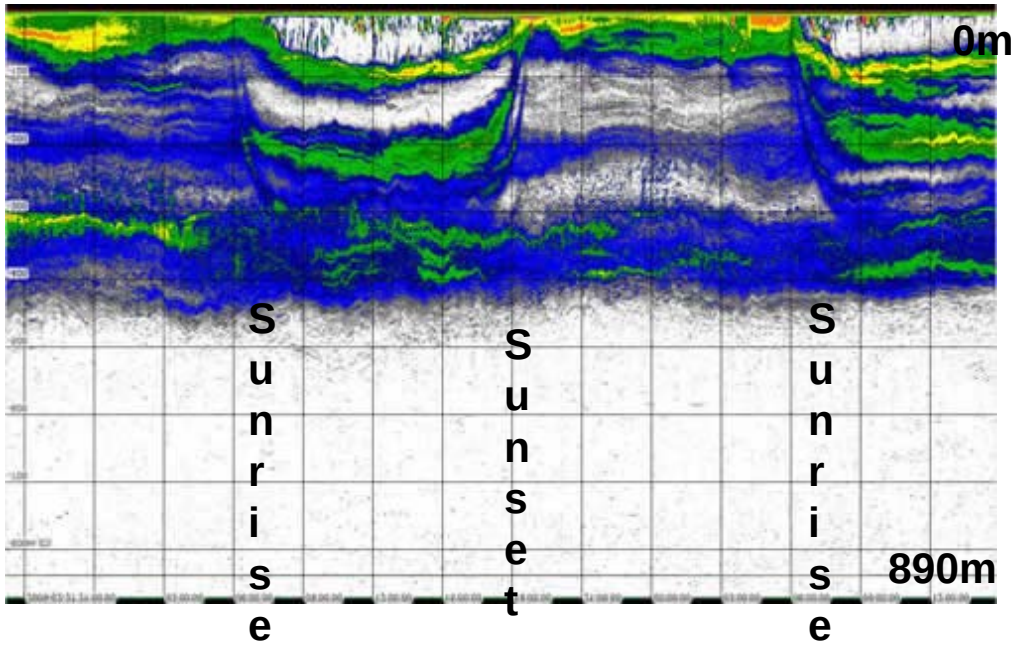
- Only continuously recording subsea seismometer west of the San Andreas fault system
- Hookup to the MARS cable provides data in real time, avoiding use of lithium batteries

DEIMOS EK60

Deepwater Echo Integrating Marine Observatory System

- **Upward looking EK60 Sonar** 38 kHz; 7º beam
- **Examine distributions and fluxes of pelagic animals over long periods**
- **John Horne, David Barbee, and Dick Kreisberg (Fisheries Acoustic Research /University of Washington).**

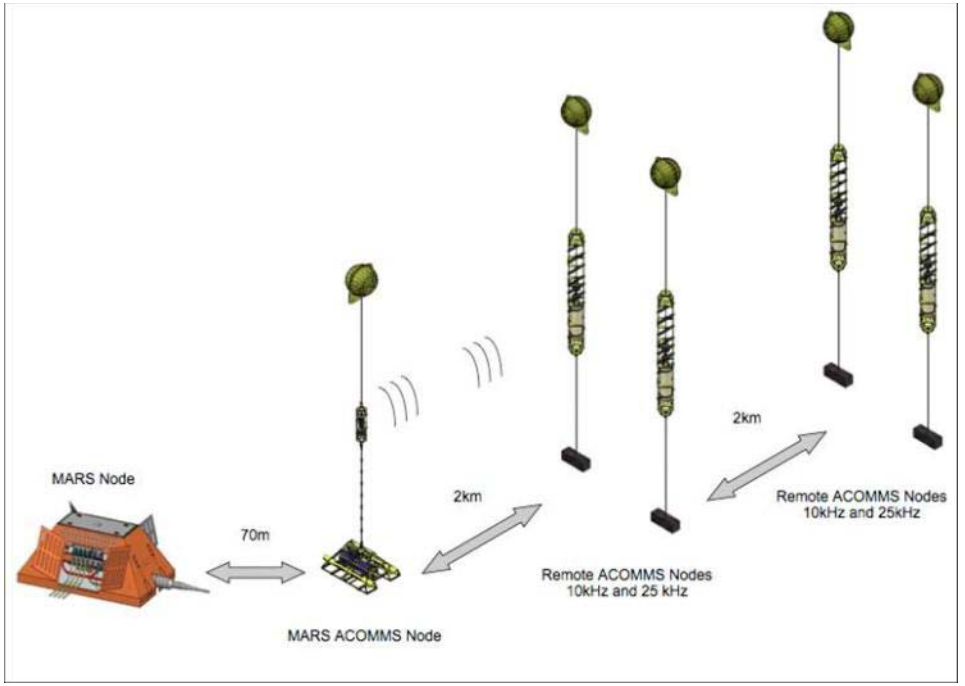




FAR/
UW

Acoustic Communications for Deep-ocean Observatories

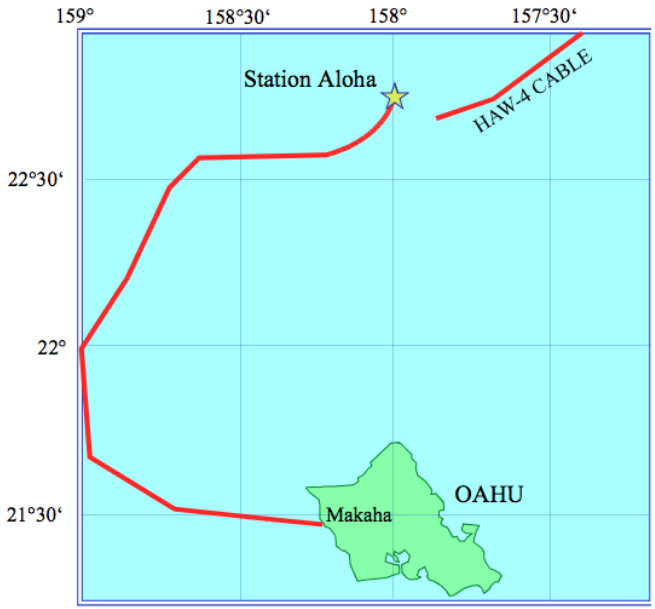
- Acoustic modem
- Prototype system for connecting remote instruments to a cabled observatory
- Reduce the need for ROV services.
- Deployed Feb 2010
- Lee Frietag, Keenan Ball, and Peter Koski (WHOI)



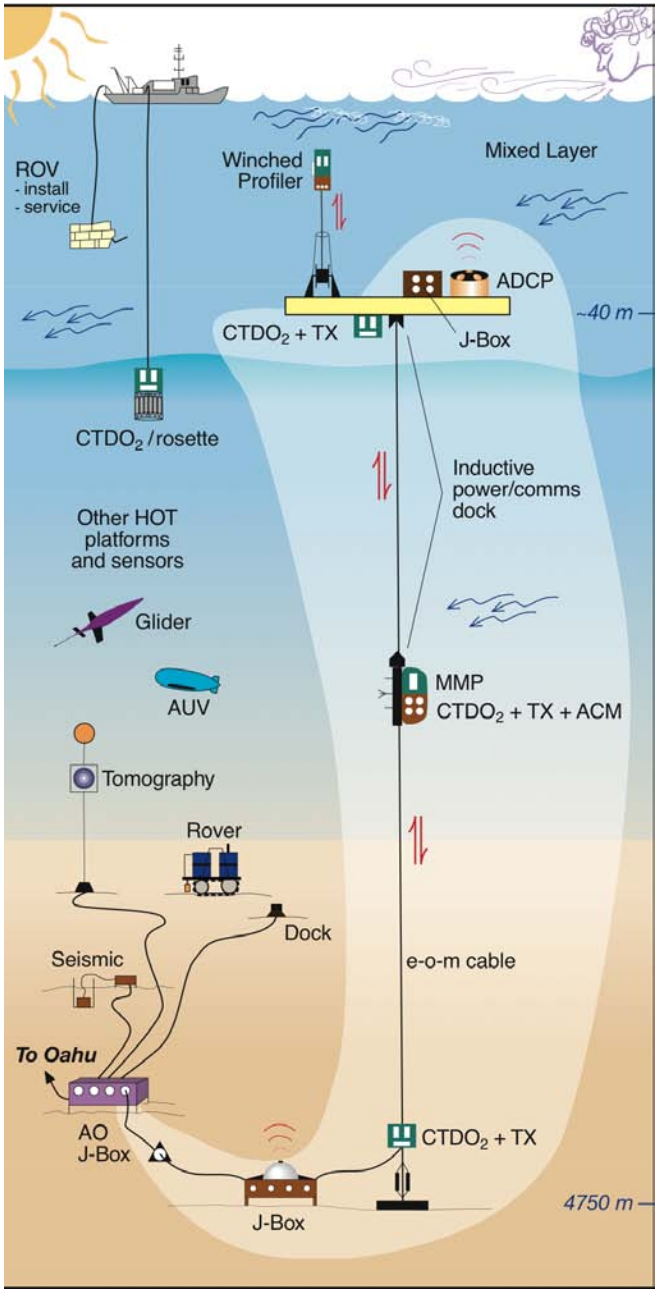
Station Aloha-Cable Reuse

Hawaii Ocean Time-series (HOT)

- Biogeochemical and physical measurements- temporal dynamics in the North Pacific subtropical gyre



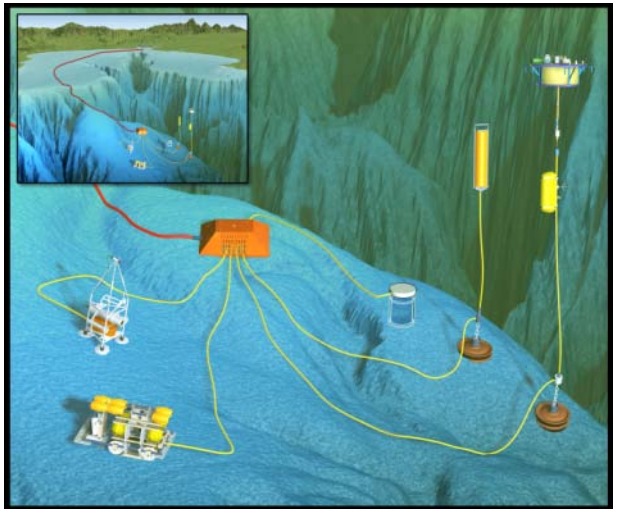
- Spatial sampling:
  - Bottom instruments
  - Mooring with vertical profilers
  - Autonomous nodes
  - AUV with docking station (perhaps from subsurface float)
  - Navigation, communications, timing



Questions

www.ioos.gov

www.oceanobservatories.org



http://www.mbari.org/mars