Monterey Accelerated Research System (MARS)

Presented by: Craig Dawe Technical Support Manager/MARS Operations Manager MBARI

What is MARS?

This is Mars

And so is this

Monterey's, MARS is a cabled observatory

MARS is a single "science node“ 891 meters below the surface of Monterey Bay.

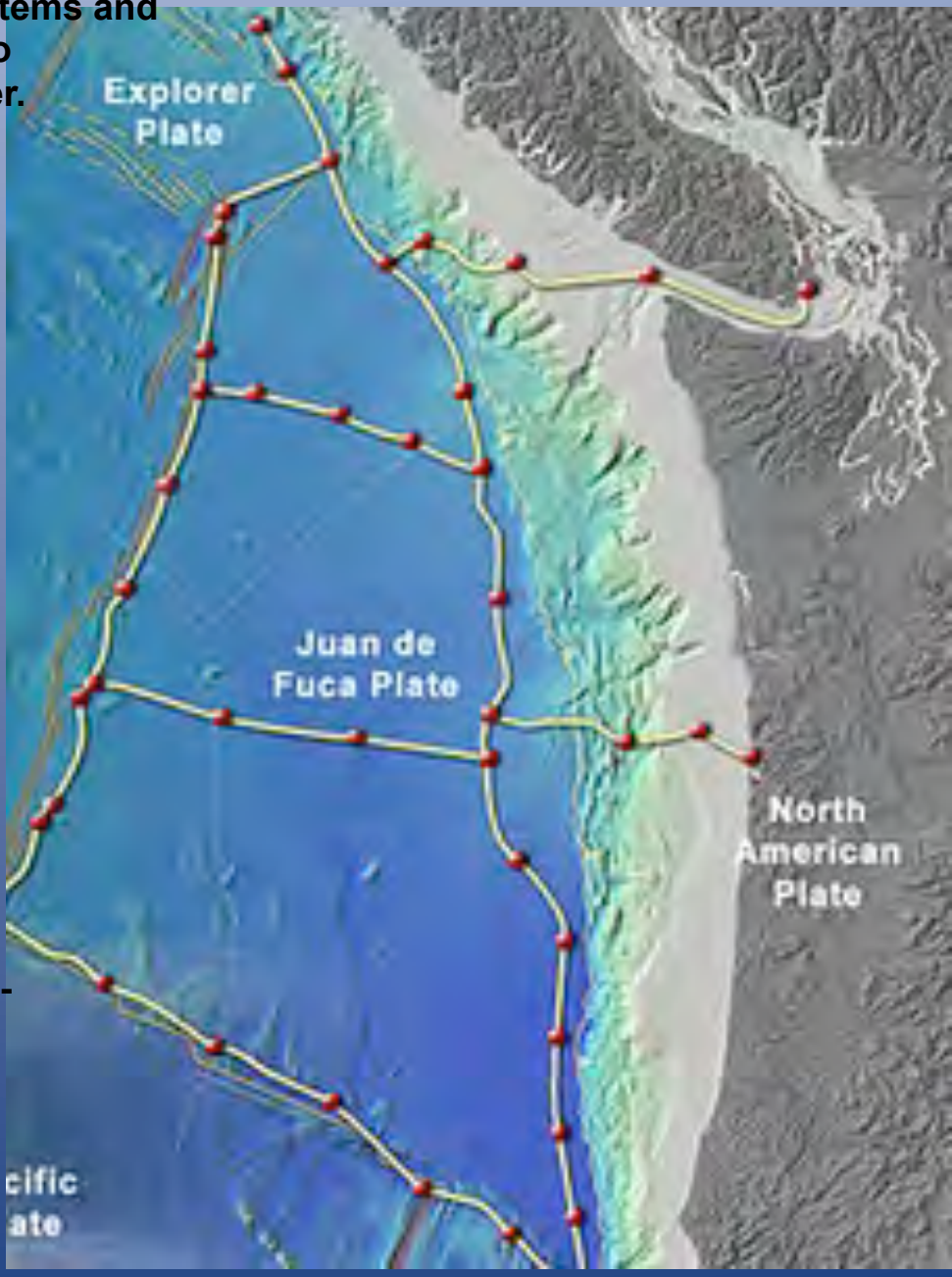
The node has eight ports. Each of which is equipped with an underwater mate-able connector.

It is connected to the shore through 52-km of subsea telecom cable that carries data and power.

Why MARS

MARS is the offspring of the Neptune Project and the Ocean Observing Initiative.

- **A plan to instrument the Juan de Fuca Plate with the next generation oceanographic observing system. Regional Scale Network (RSN)**
- **Coastal observing systems**
- **Global observing systems and**
- **Cyber-infrastucture to**
- **connect it all together.**



- **Several Institutions tasked with design of the RSN:**
  - **University of Washington Applied Physics Lab (UW APL)**
  - **Woods Hole Oceanographic Institute (WHOI)**
  - **Jet Propulsion Laboratory (JPL)**
  - **Maripro**
  - **Alcatel**
  - **MBARI**

  Each responsible for a portion of the project.

MARS was to be a test-bed for this effort.

- **New instruments**
- **New techniques**
- **New experiments**
  - **All need in-situ testing in a cost effective environment.**
- **MARS MBARI meet many of the requirements:**
  - **Inexpensive access**
  - **Near shore location**
  - **Extensive local support system**

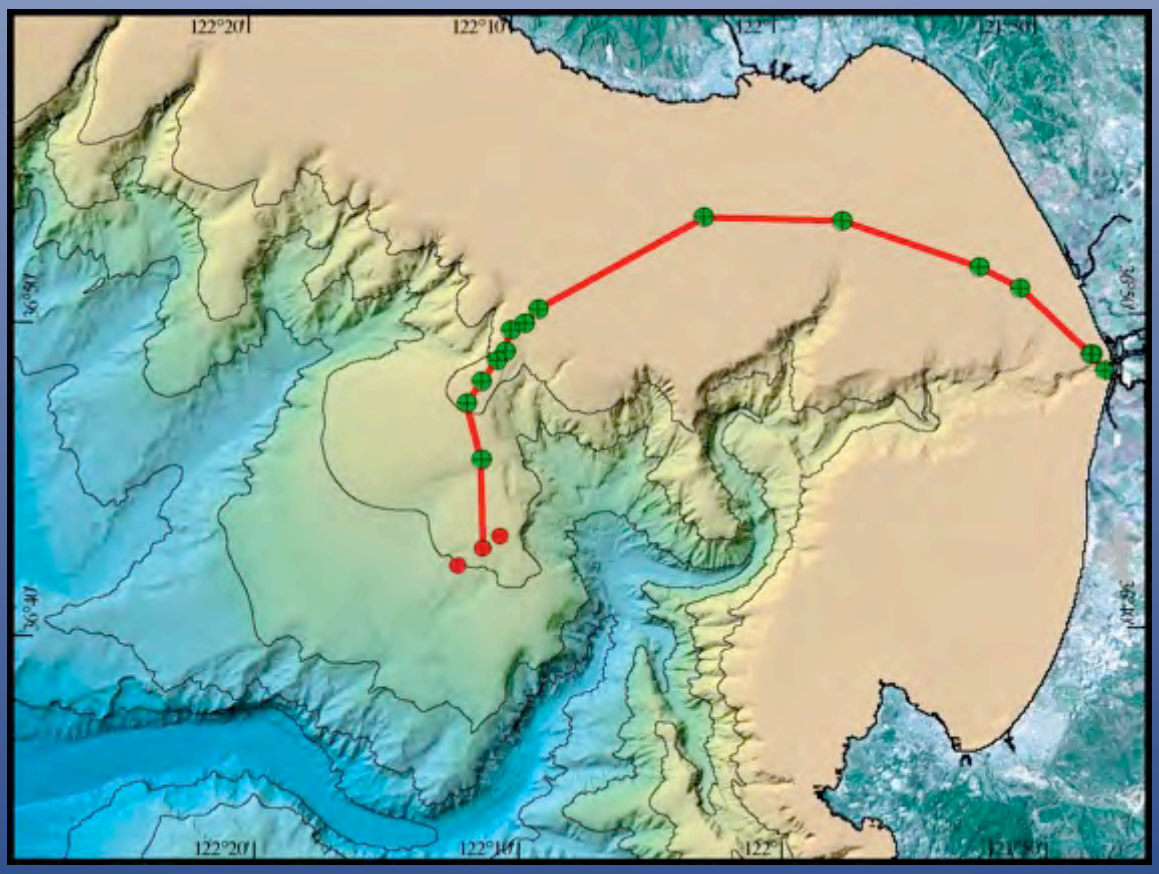
MARS provides a relatively deep water site (890m) with an easy 2 hour commute from Moss Landing Harbor

- **MBARI has ships and ROVs operating in the Bay 200+ days essentially year round**
- **The MARS supports science projects from proposal, through design, test, deployment and data distribution.**

Construction and Installation

- Many challenges
  - Selection of the cable route
  - Design of the equipment
  - Permits
  - Local hazards

Route Selection

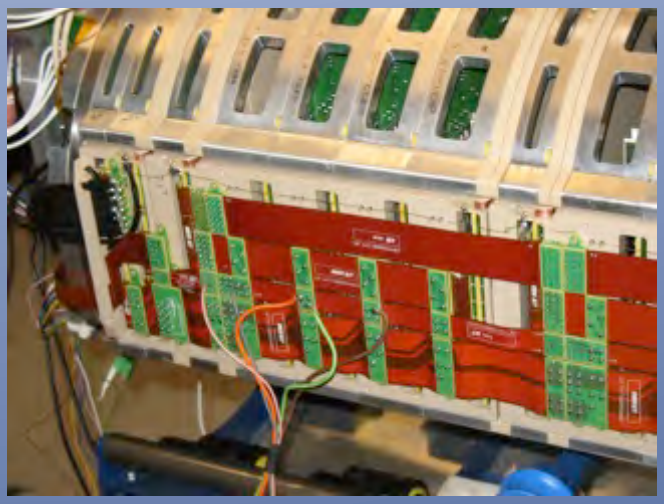


A direct route would be straight down the canyon. Experience from past efforts indicate that to be unwise!
The chosen route allows for 80% of the cable to be buried (protected).

System Design

Trawl Resistant Frame
•Designed to protect the electronics from fishing activity

Medium Voltage Converter
•Steps the 10Kv down to 375vdc.
•Huge cooling issues, immersed in flourinert.



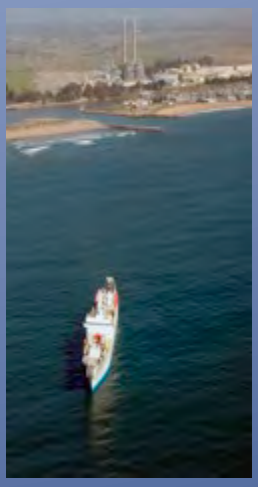
Electronics Packaging
•Large volume conduction cooled
•All titanium to resist corrosion.

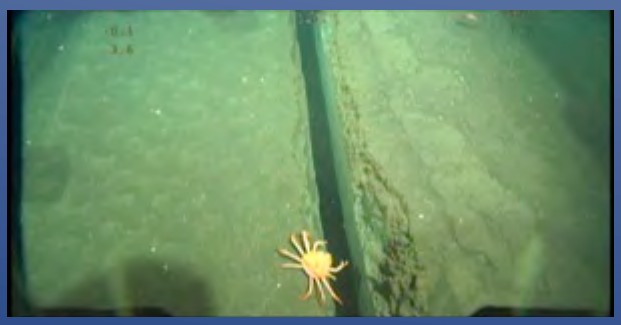
Low Voltage Electronics
•Control and montoring of 48 and 375 vdc for 8 ports
•Data transport via network routers
•Fiber optic data transport.

Installation

Directional Drilling under the harbor mouth to the North side of the Monterey Submarine Canyon

- Protects cable
- Avoids a shore landing
- Cable pulled to shore from the Global Sentinal.



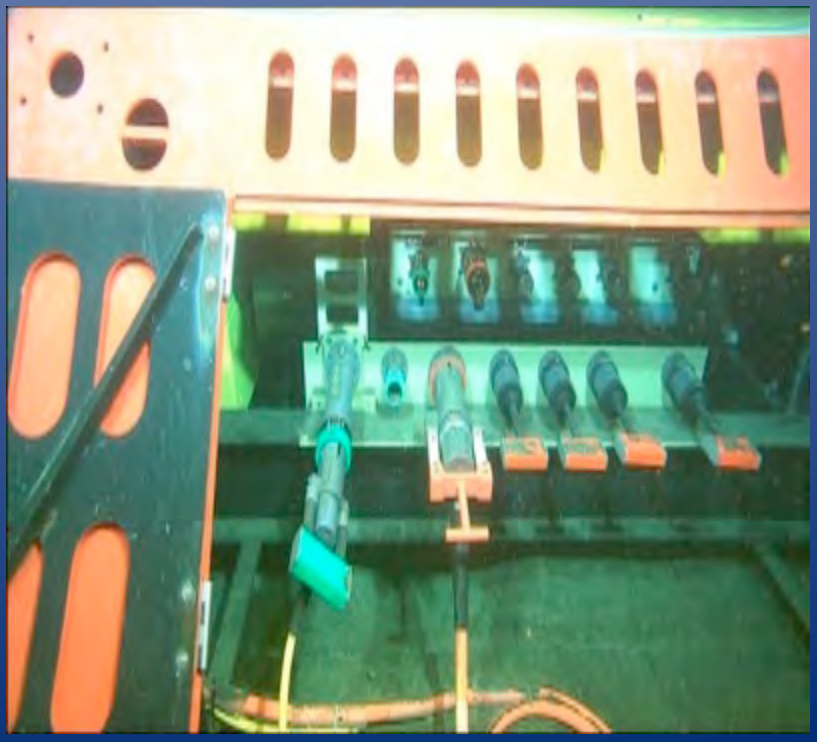


A plow is lowered down the cable to the seafloor where it buries the cable in a trench 0.5- 1.0 meters deep

After completion of the cable lay the TRF is lowered to the seafloor. Placement is observed from an ROV on board the cable lay ship

The ROV Ventana transported the electronics package to the TRF on the seafloor.

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



Local Hazards

Pelicans

•Their wing span is such that they short out the power lines. This is bad for the pelicans and does shutdown our system.

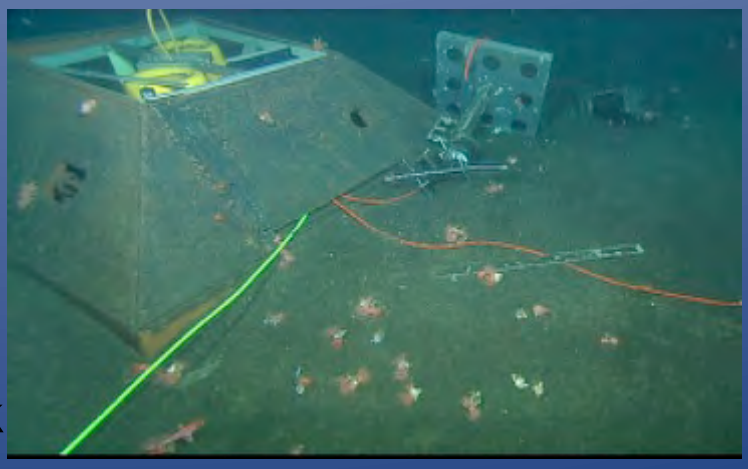
Rats

•They are scavengers and it turns out they really like the cladding on fiber optic cable to make nests with. They have been responsible for at least two failures on the MARS system

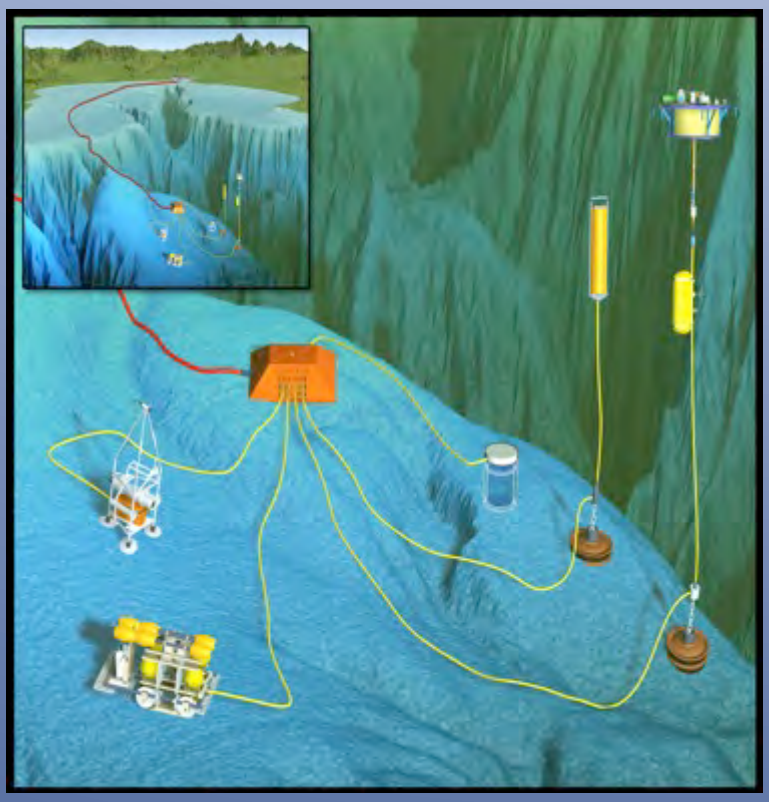
Fisherman

•There is an active trawling near the MARS site which has impacted one of our experiments 3 times.

•We have seen the results and tried to speak with the fisherman. Unfortunately for us he has the right to make a living.



MARS Details



- 9 kW of power for science (currently rated at 6kW)
- 8X 100 Mbit/sec Ethernet ports
- Precision time distribution
  - ~5 uSec
- 375 vdc
- 48 vdc
- Deep water - 890 meters
- Accessible - 2 hrs from MBARI
- Extended geographic coverage with extension cables
- Extensive shore side support
  - Staging, ships, ROVs, expertise
- A comprehensive workflow process – from proposal through development, test, deployment, and data management

Typical Underwater Mate-able Connector

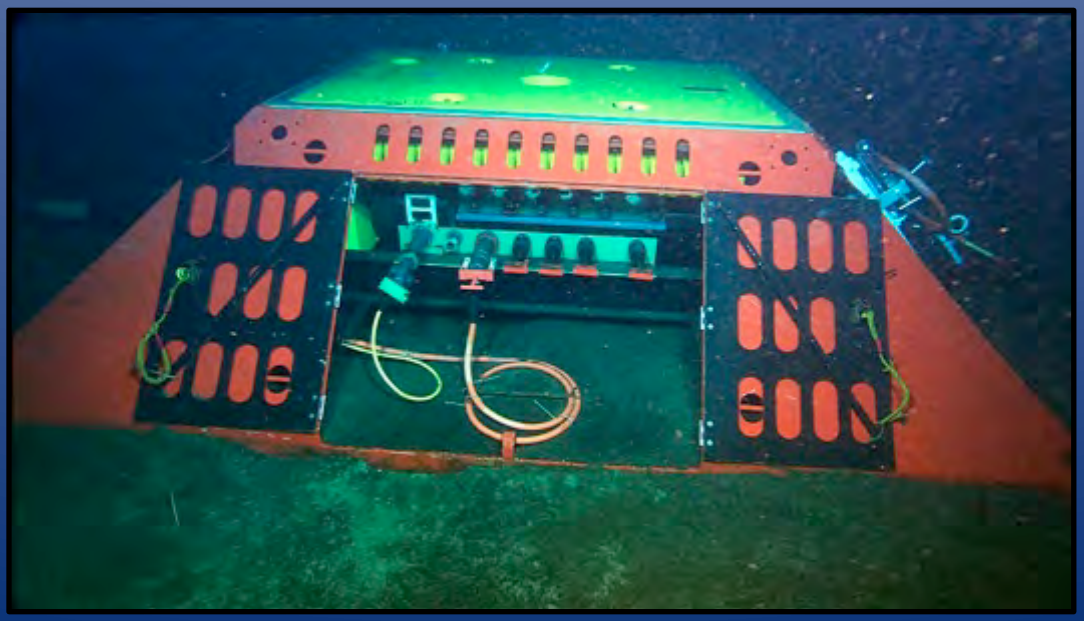
Science and instrument testing schedule for MARS

1. Installed Nov 2008 Sensors project CTD PI: D. Edgington, MBARI
2. Installed Dec 2008 FOCE (Free Ocean CO2 Experiment) PI: P. Brewer, MBARI
3. Installed Jan. 2009 Eye-in-the-Sea PI: E. Widder, ORCA
4. Installed Feb. 2009 MOBB, Monterey Ocean Bottom Broadband PI: B. Romanowicz, UC Berkley
5. Installed Feb.2009 Deepwater Echo Integrating Marine Observatory System (DIEMOS) PI: J.K. Horne, UW
6. Installed Aug. 2009 Benthic Rover – PI: K. Smith, MBARI
7. Installed Oct 2009 Deep ESP- Environmental Sample Processor PI: C. Scholin, MBARI
8. Feb, 2010 Bottom pressure recorder (BPR) and a precision tiltmeter, PI: Bill Chadwick, NOAA
9. Jan 2010 Ocean Bottom Siesmometer (OBS) PI: Orcutt, Scripps
10. Aug. 2010 Acoustic Communications Base Station- PI: Lee Freitag, WHOI
11. Oct 2010 Photographic Benthic Observing System (PhoBOS) PI: Dawe MBARI
12. April 2011 Oct 2011 Tongji Observatory Dr H. Zhou Tongji Unversity People's Republic of China
13. Oct 2011 Sediment event Sensor (SES) K. Smith MBARI
14. Oct 2012 Ghostbusters High Temp Ph sensor K.Din University of Minnesota

Sensors

D. Edgington MBARI

- Seabird CTD
- First Science instrument on MARS.
- Demonstration effort of:
  - The MARS installation
  - SIAM (Software Infrastructure and Applications for MOOS)
  - SSDS (Shore Side Data system)
  - PUCK (Programmable Underwater Connector with Knowledge) enabled technology
  - SIIM (Science Instrument Interface Module)
    - Support of legacy oceanographic instruments
    - Up /down convert data from one format to another
    - Up/down convert power



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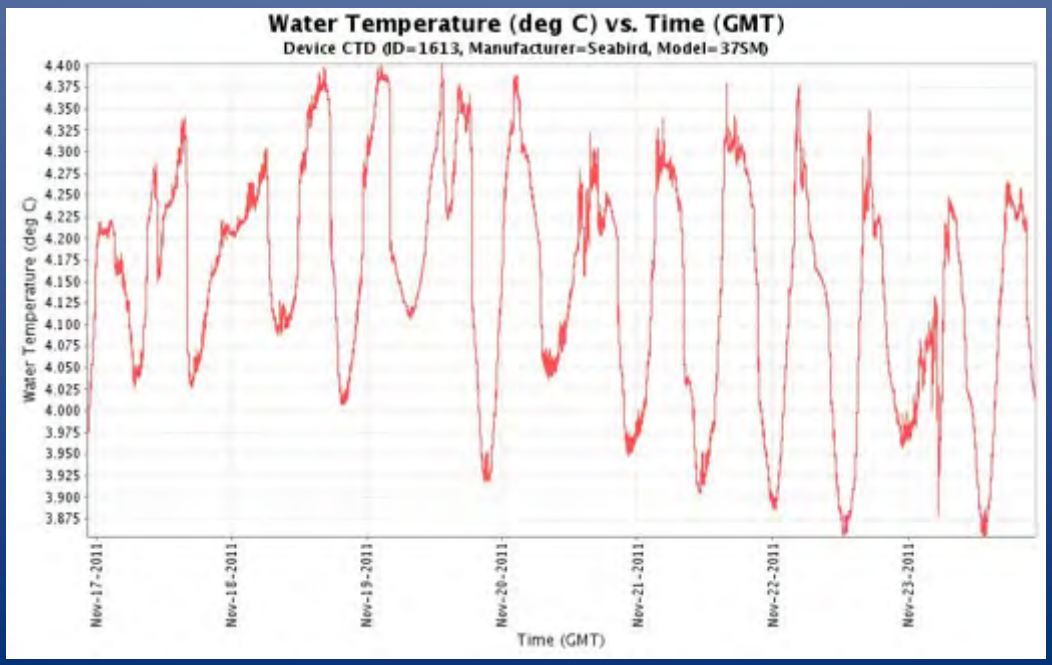


FOCE

Free Ocean CO2 Experiment

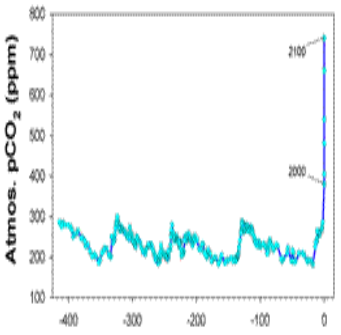
Dr. Peter Brewer

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

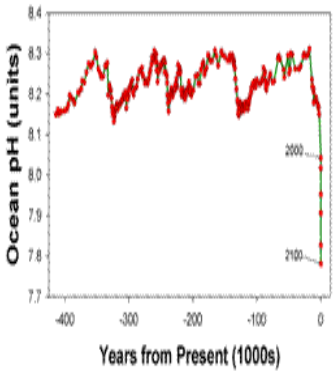
Deployed Dec 9, 2008

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?

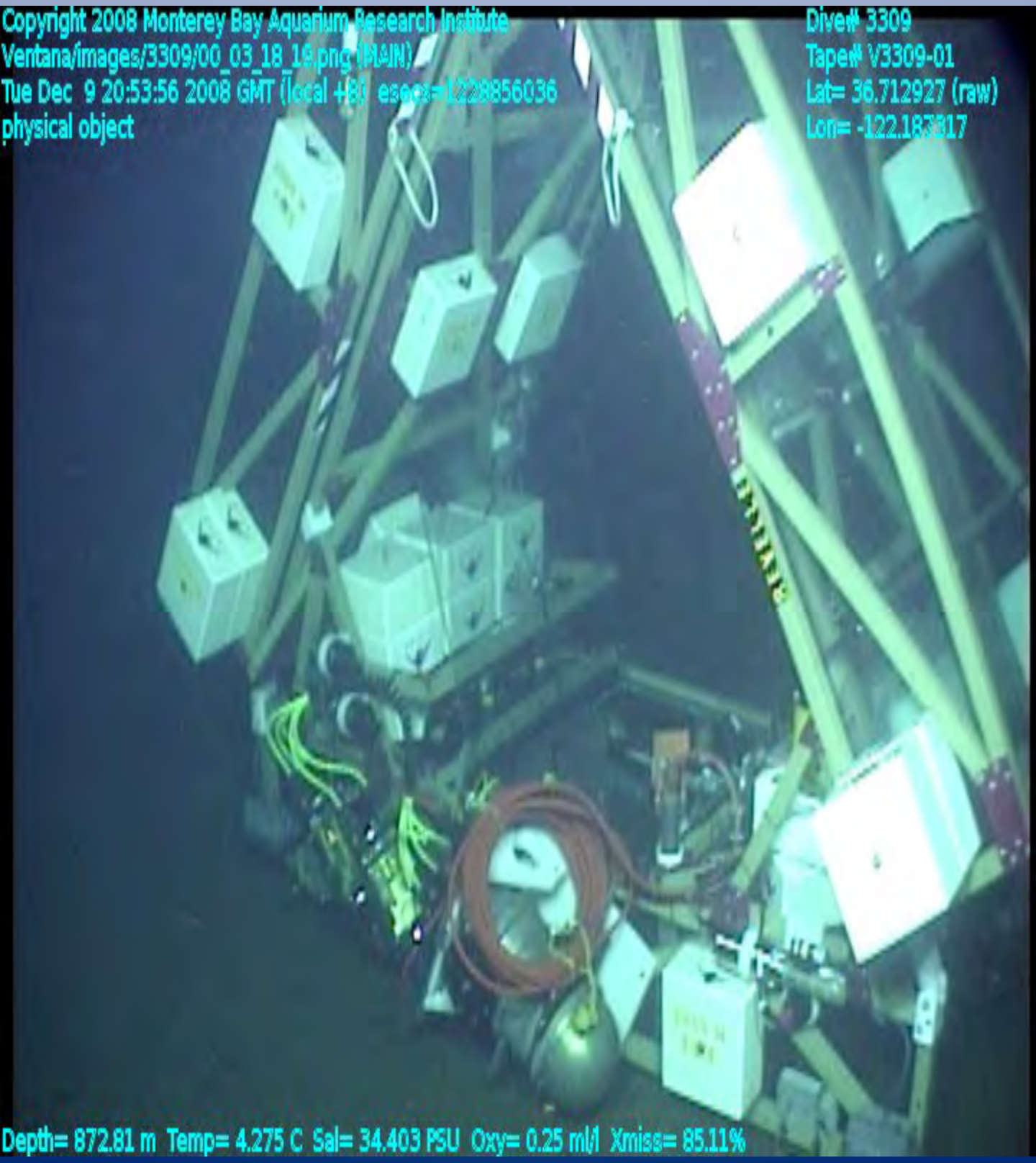


Atmosphere



Ocean

FOCE prior to unfolding on the bottom



Eye-in-the-Sea

Dr. Edith Widder

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

Deployed January 21, 2009

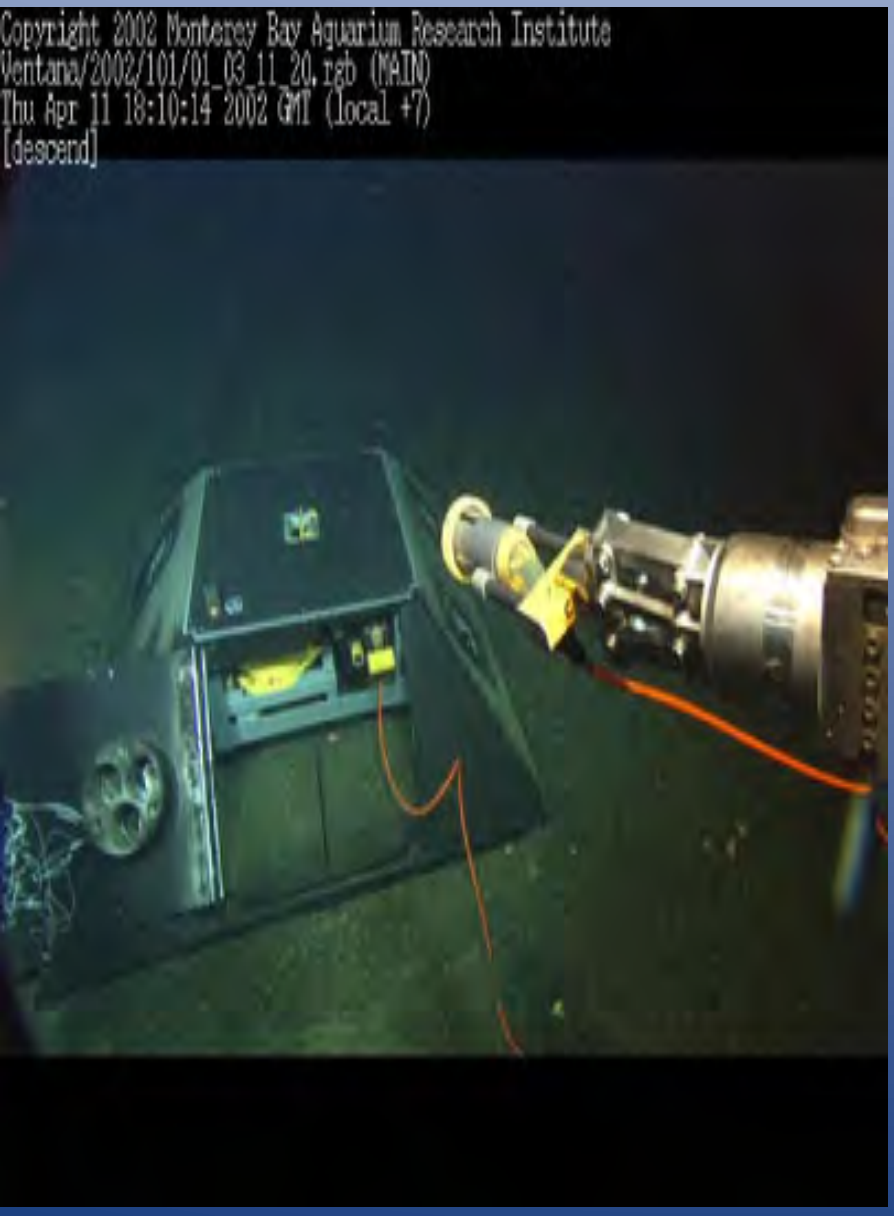
- Objective is to collect unobtrusive video observations of deep sea animal behavior using red lights, no thrusters (no noise)
- Connected to significant education and outreach program


ORCA

MOBB

Monterey Ocean Bottom Broadband

Deployed February 26, 2009



Seismic Observatory

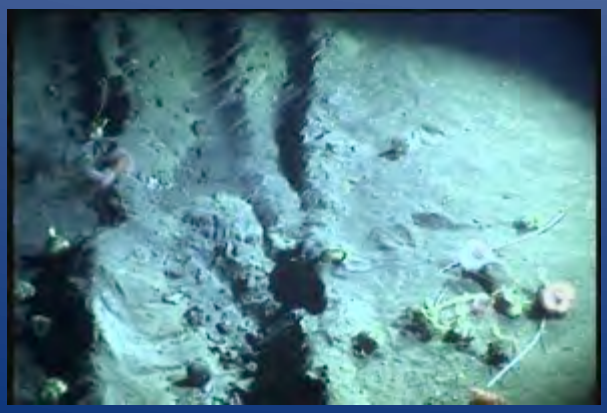
- Only continuously recording seismometer west of the San Andreas fault system
- Hookup to the MARS cable will provide data in real time, avoiding use of lithium batteries

Cable Laying

•Cable laying is difficult without use of expensive ships
•Cable burial was impossible with out the use of a plow or trenching ROV
•By adopting terrestrial methods (Ditch Witch) we are able to trench

Cables buried 6-12 inches over 90% of the cable run.

•Easy to remove
•Provides protection
  •From fishing activity
  •From “shark” bite
•Low Impact

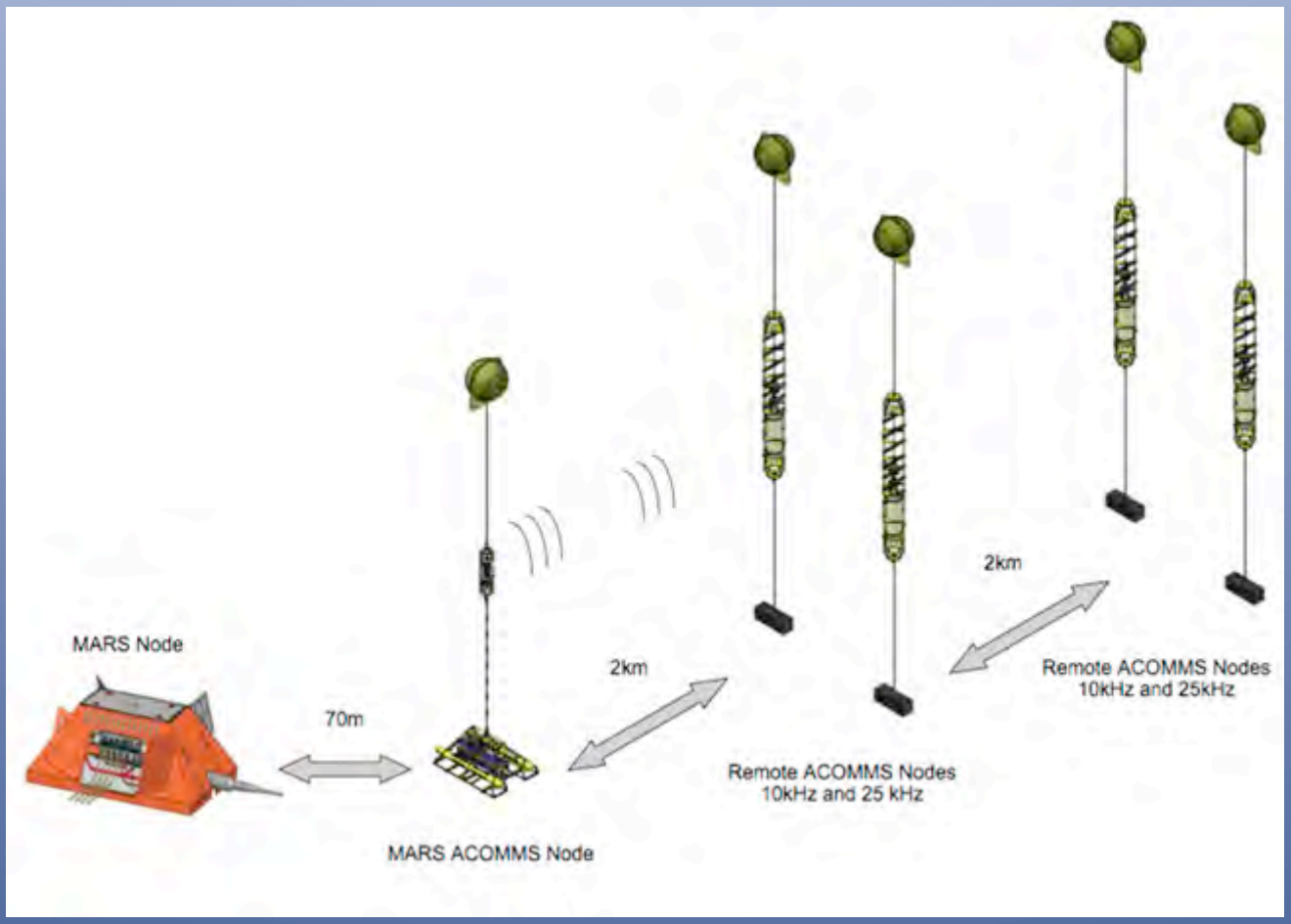


Seafloor Immediately following cable lay activities

Seafloor two days later

ACCOMS

l Frietag WHOI



- Acoustic modems provide a means to communicate with remote equipment with out laying cable.

  Advantages

  - No cable or expensive converters to transmit data over long distances
  - Reduced installation time
  - Reduce incident of trawl damage

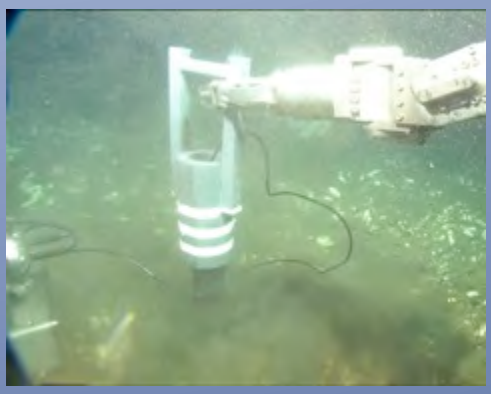
  Disadvantages

  - Remote expression requires battery replacement
  - Reduced bandwidth communications

Benthic Microbial Fuel Cells BMFC

(Power from Mud)

C. Reimers OSU P Girgius Harvard

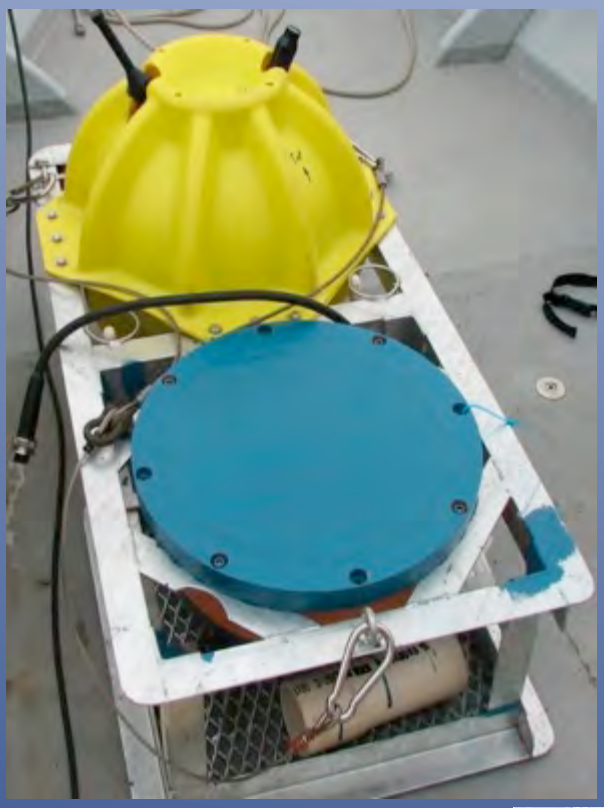


Past experiments by this group saw power generation from the potential gradient in sediments.

In October 2011 this was taken several steps further by using the power to run an acoustic modem and communicate remotely to a modem connected to the MARS facility, eliminating the need for battery replacement.

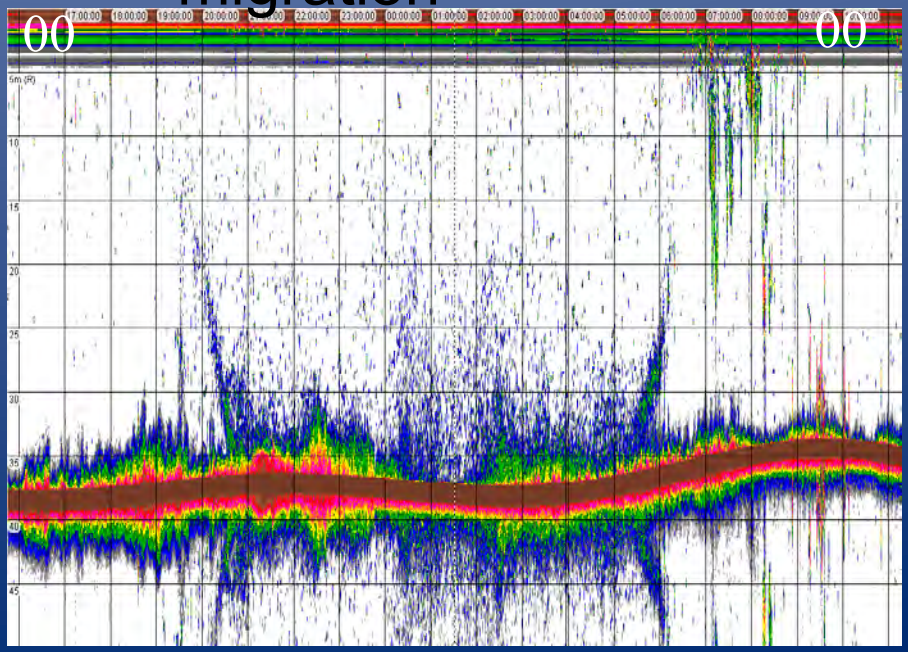
EK60 Echosounder Specifications

Deployed Feb 2009



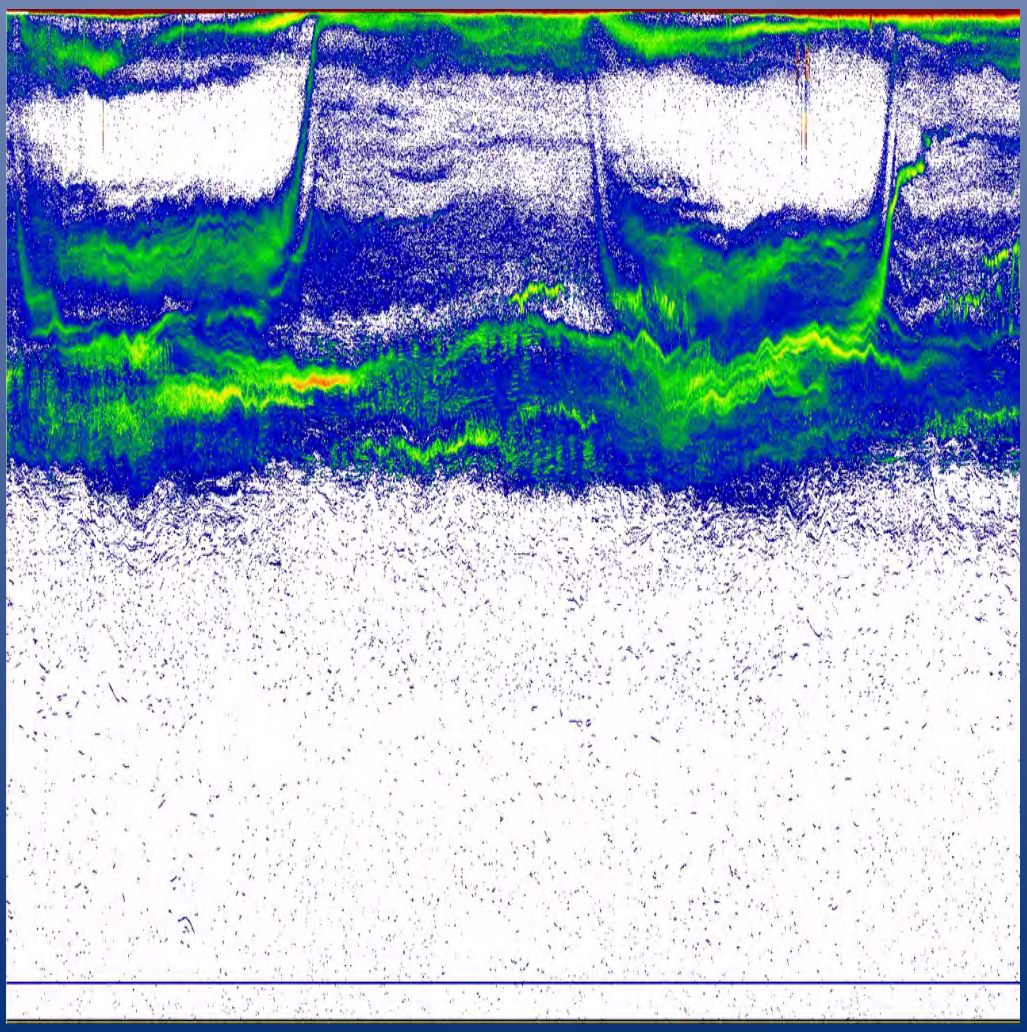
- Echosounder: Simrad EK60; 38 kHz; 7º beam
- custom mounted in Benthos sphere
- real-time monitoring and display via internet

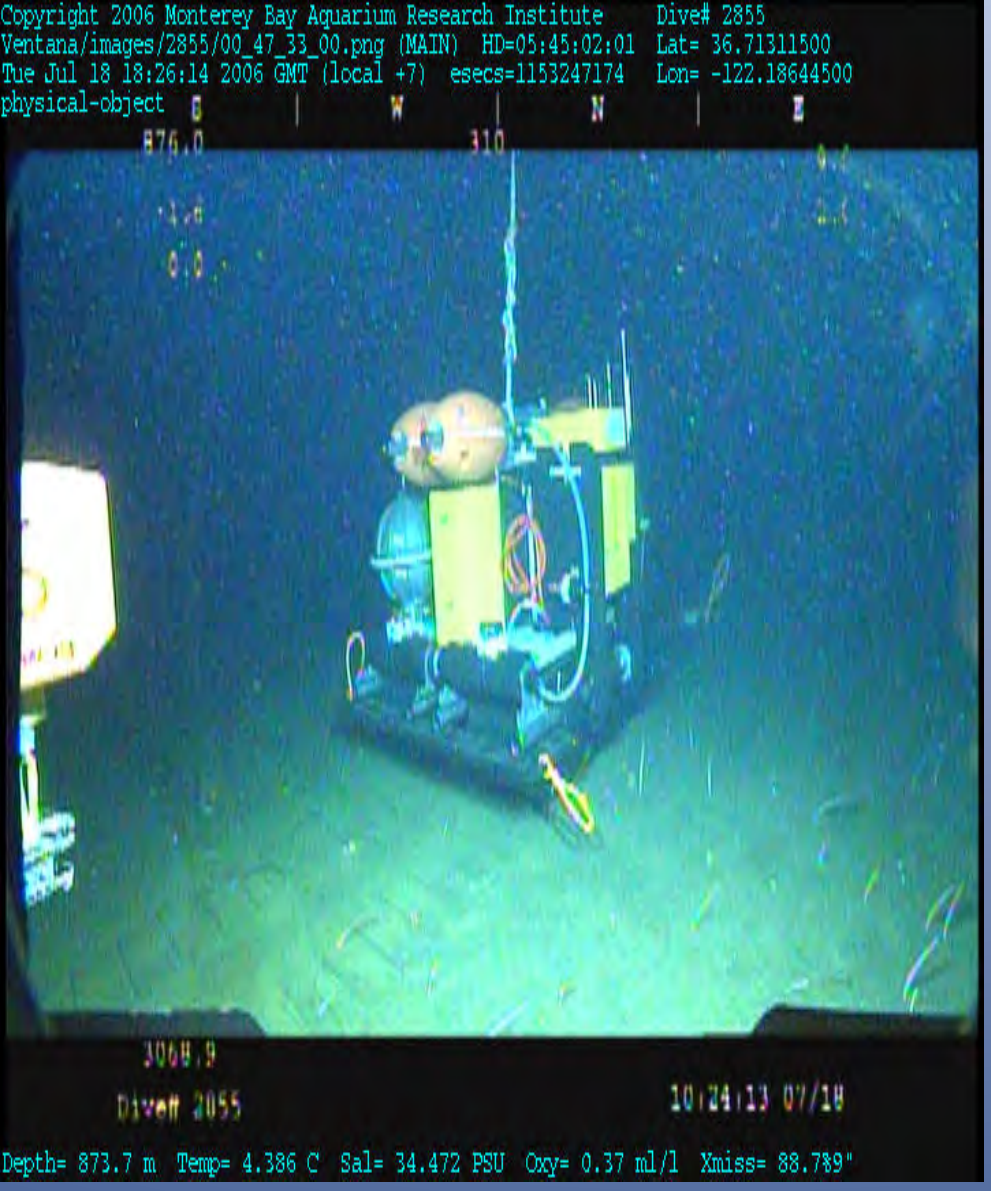
Fish diel vertical migration



Echosounder Specifications

- Simrad EK60; 38 kHz; 7^{o} splitbeam
- custom mounted in Benthos sphere
- real-time command/monitoring from shore





Benthic Rover

Dr. Ken Smith, MBARI

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

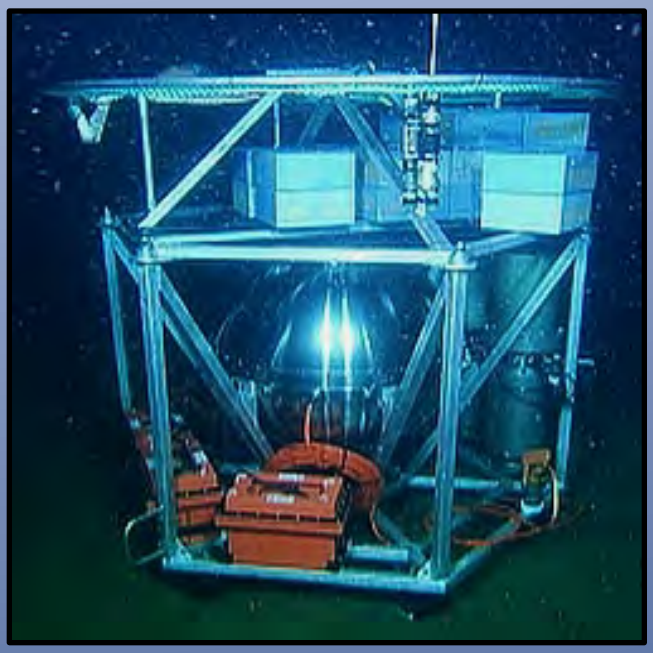
Deployed August 6, 2009

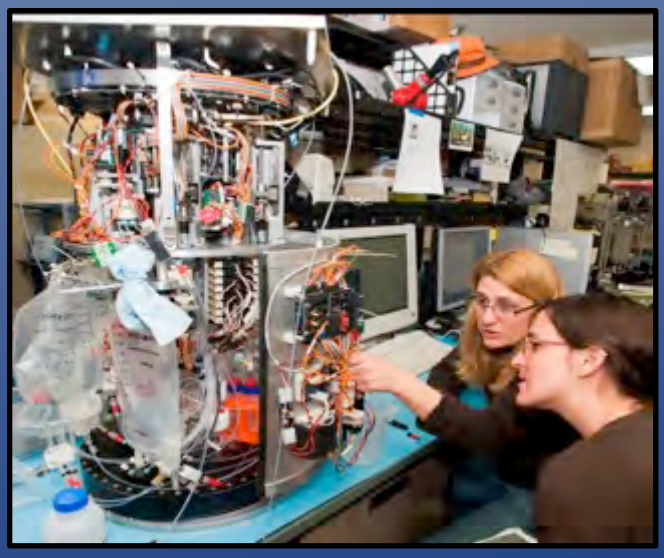
- Typically used in autonomous mode, connected to MARS for testing and refinement
- Performs a time series of measurements at the sediment interface, thus avoiding numerous separate expeditions and ROV dives

Benthic Rover deployment on MARS Ocean Observatory

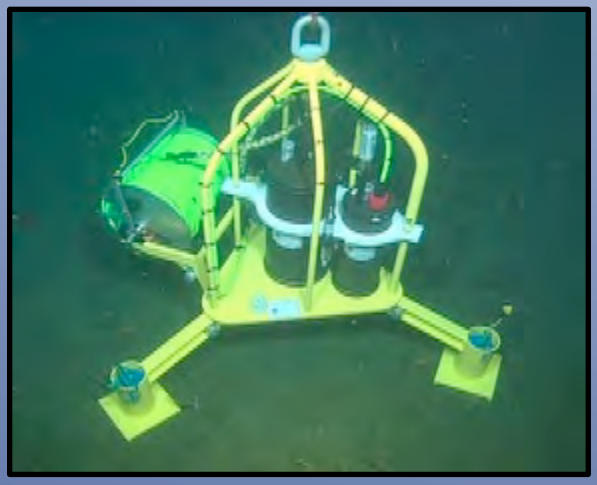
Deep ESP
Deep Environmental Sample Processor

- Collects water samples
- Several stages of filtration obtain a variety of microbes.
- Dissolves the material collected to obtain DNA, RNA, and proteins.
- Analyzes the genetic material and identifies microbes and their gene products.
- ESP also archives samples for further laboratory-based analyses after the instrument is recovered.
- Scheduled for re-deployment Nov 2013
- Chris Scholin, Doug Pargett, Brent Roman, Scott Jensen, Chris Preston, Roman Marin and Cheri Everlove (MBARI).

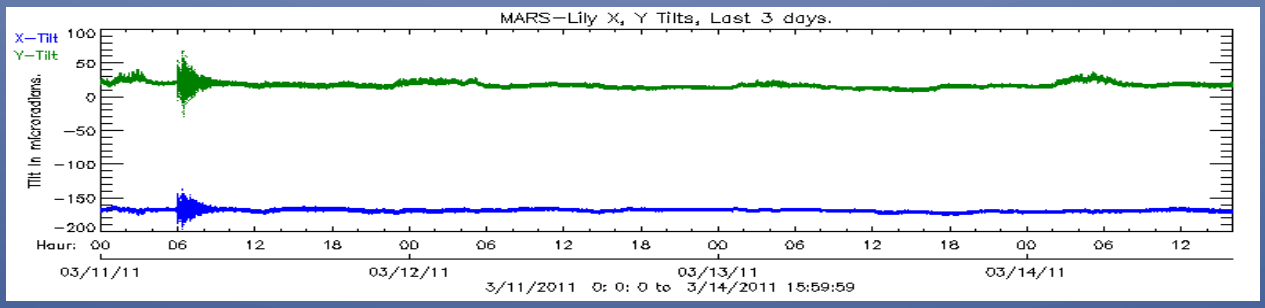


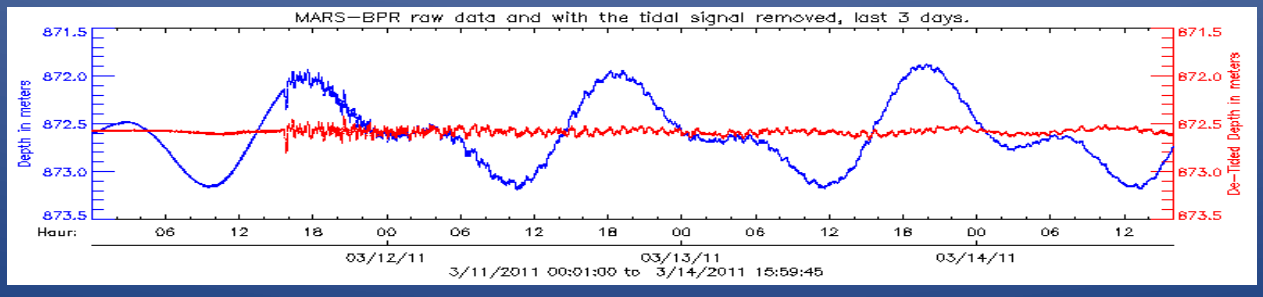


Bottom Pressure Recorder (BPR)/Tilt Meter



- Precise pressure and tilt sensors
  - Measure vertical movements of seafloor
- Designed to monitor submarine volcanoes
- Deployed June 2010
- Recovered Nov 2011

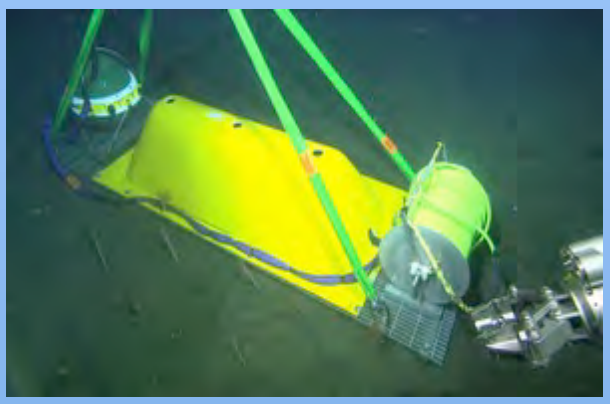




Bill Chadwick,Chris Meinig, Scott Stallin, Nick Delich and Dirk Tagawa (OSU/ PMEL).

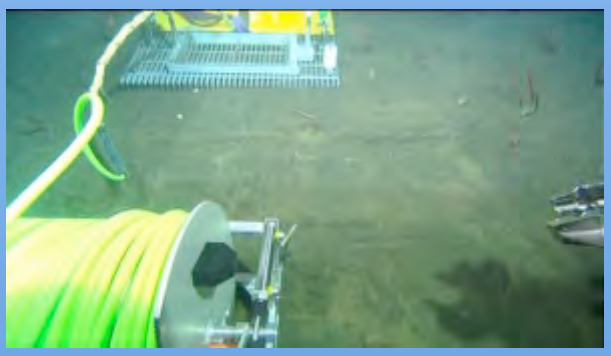
LOOKING Ocean Bottom Seismometer OBS

- Monitors motion in the earth's crust that is generated by earthquakes.
- Operated by the Scripps Institute of Oceanography of the UCSD
- Part of the National Science Foundation's Ocean Observing Initiative (OOI).
- Used todevelopment of the Cyber infrastructure for the OOI.



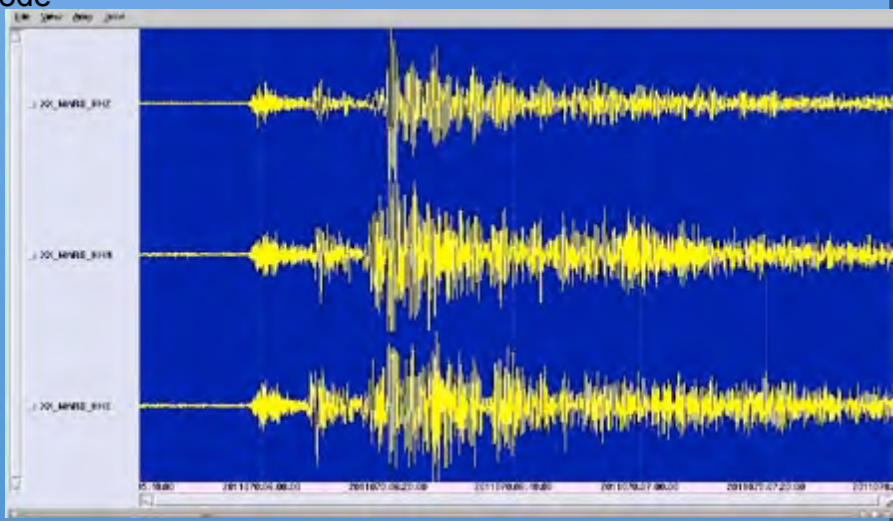
OBS Trawl resistant frame and cable spool

Seismometer housing deployed off launch frame



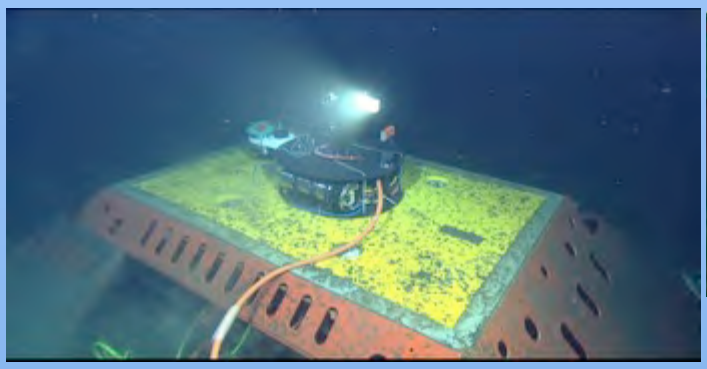
Deploying the cable to the MARS node

The spool above and to the left
- holds up to 100 meters of cable
- an underwater connector
- Deployed with the instrument
- Easy way to lay the cable
- Then connect to MARS.

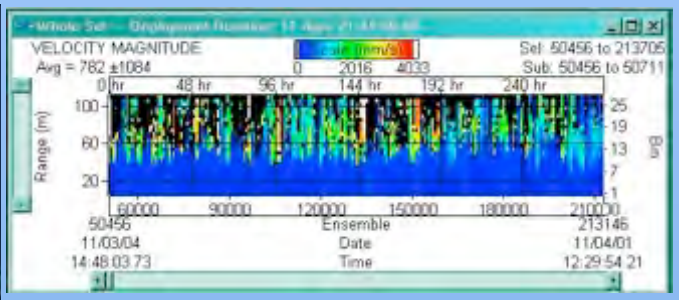


Data from the OBS showing the Japan 9.0 magnitude earthquake March 11, 2011

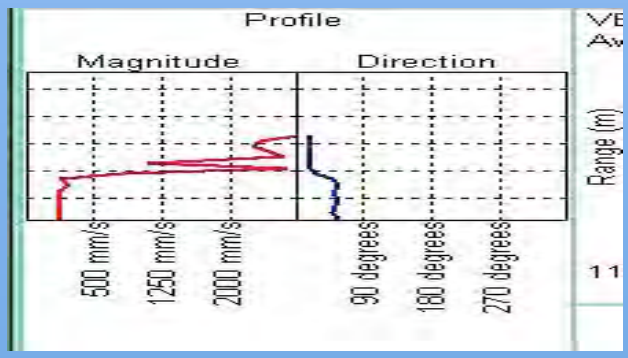
Photographic Benthic Observing System PhoBOS



PhoBOS deployed and connected to MARS

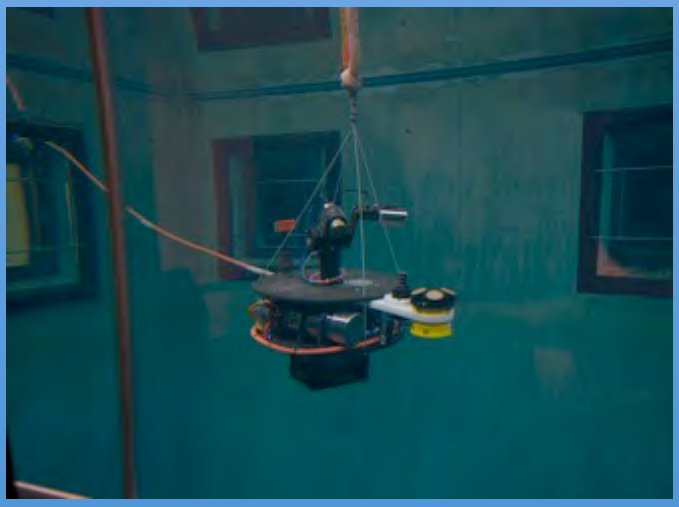


Typical ADCP data for a 3 day period

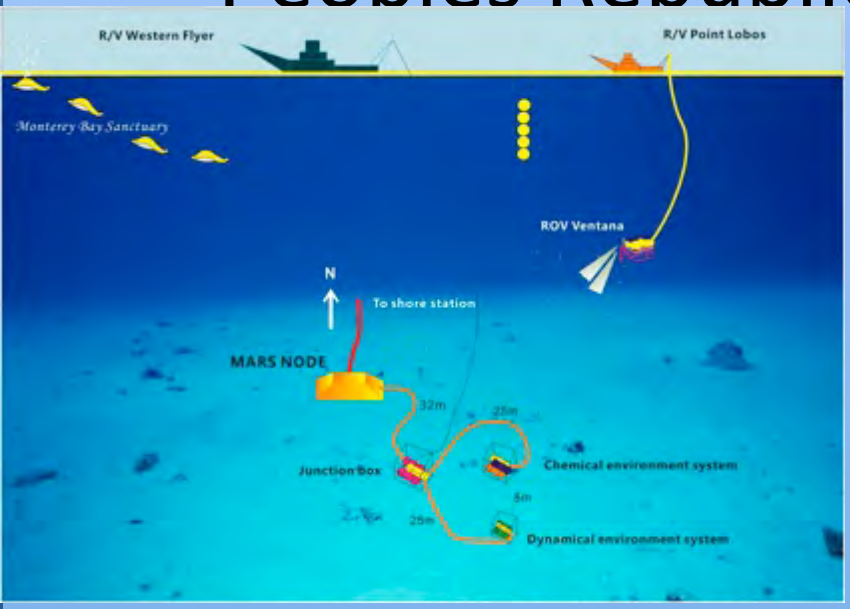


Typical instantaneous data from the ADCP used to deploy equipment

- Developed as a tool to aid in operations,
- Become a valuable science tool
- Provides real time information about the physical conditions of the ocean at the MARS site.
- Future plans include:
  - web access to the video and data for use in educational settings
  - Upgraded camera system to HD quality
  - Improved lighting.



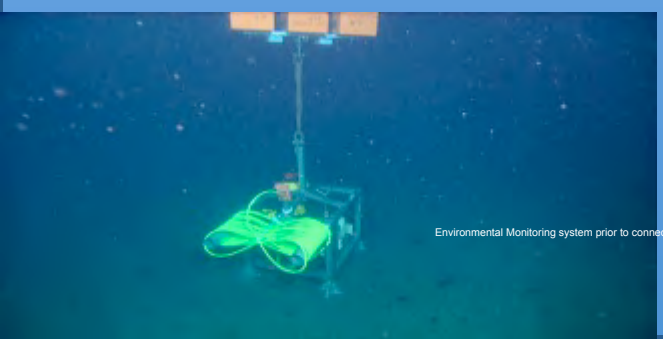
University of Tongji
Ocean Observing System
Peoples Republic of China



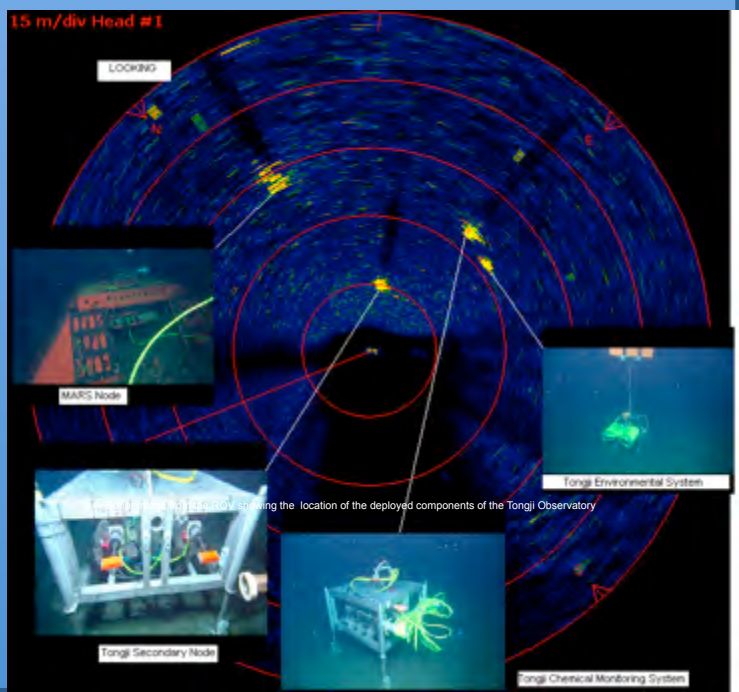
This system is composed of three parts:

- Main node
  - Control electronics
  - Data transport equipment
  - Video observation system
- Chemical environment system
  - Anion analyzer (Cl^-, SO_4^{2-}, NO_3^-)
  - AMT pH sensor
  - Oxygen Optode
  - Chlorophyll Flourometer,
  - METS methane sensor
  - ISUS nitrate sensor
- Dynamic Environment System
  - ADCP
  - Acoustic Doppler Velocimeter
  - Conductivity Temperature Depth sensor (CTD)
  - Turbidity sensor

- Very complex deployment
- Required two ships and an ROV to place all the equipment correctly on the seafloor.
- Recovery will be done by reversing the procedure
- Required due to the weight of the equipment.



Environmental Monitoring system prior to connection



ROV showing the location of the deployed components of the Tongji Observatory

Tongji installation at the Monterey Accelerated Research System (MARS)

April 21, 2011

M B A R I

Thank You

Questions?