The MARS Deep-Sea Observatory in Monterey Bay

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Monterey Bay Aquarium Research Institute

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January 2011

Monterey Bay Aquarium Research Institute (MBARI)

MBARI founder David Packard:

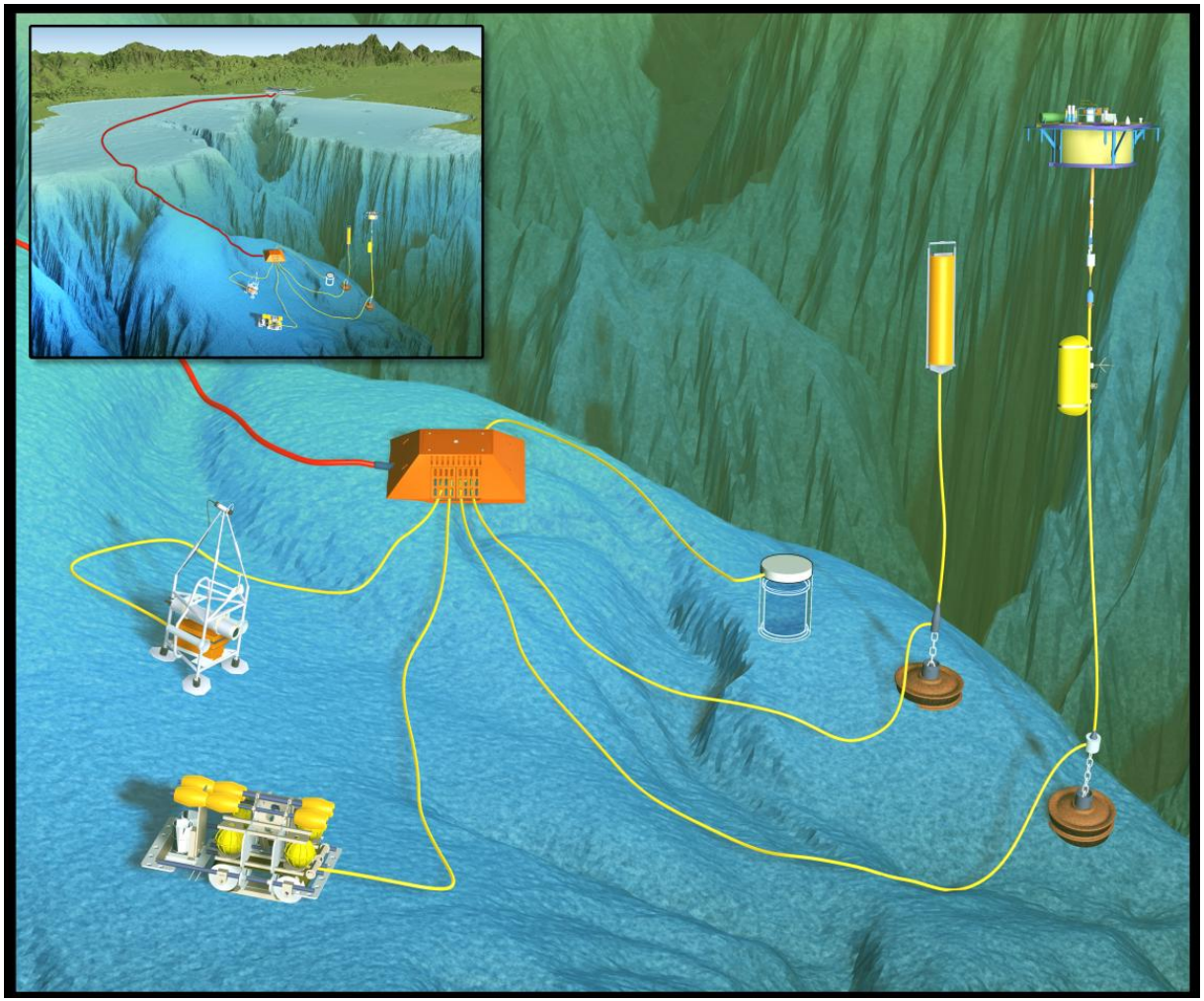
"Send instruments to sea, not people.

Return information to shore, not samples"

Outline

- Overview of the Monterey Accelerated Research System (MARS) ocean observatory
- Four representative science experiments on the MARS observatory
  - Monterey Ocean-Bottom Broadband (MOBB) Seismometer
  - Free-Ocean Carbon Dioxide Enrichment (FOCE) Experiment
  - Benthic Rover
  - Deep-Sea Environmental Sample Processor (ESP)
- Towards synergistic ocean observation
  - State-of-the-art of autonomous underwater vehicles (AUVs)
  - AUV docking
  - AUV triggering on detection of events
- Conclusions and discussions

The Monterey Accelerated Research System (MARS) Ocean Observatory



- Depth: 890 m. 52-km undersea cable.
- 37 km from MBARI.
- 8 ports: 9 kW power and 100 Mbps x 8 ethernet communications.
- Development cost: 6 years (2002-2008), $13.5M.

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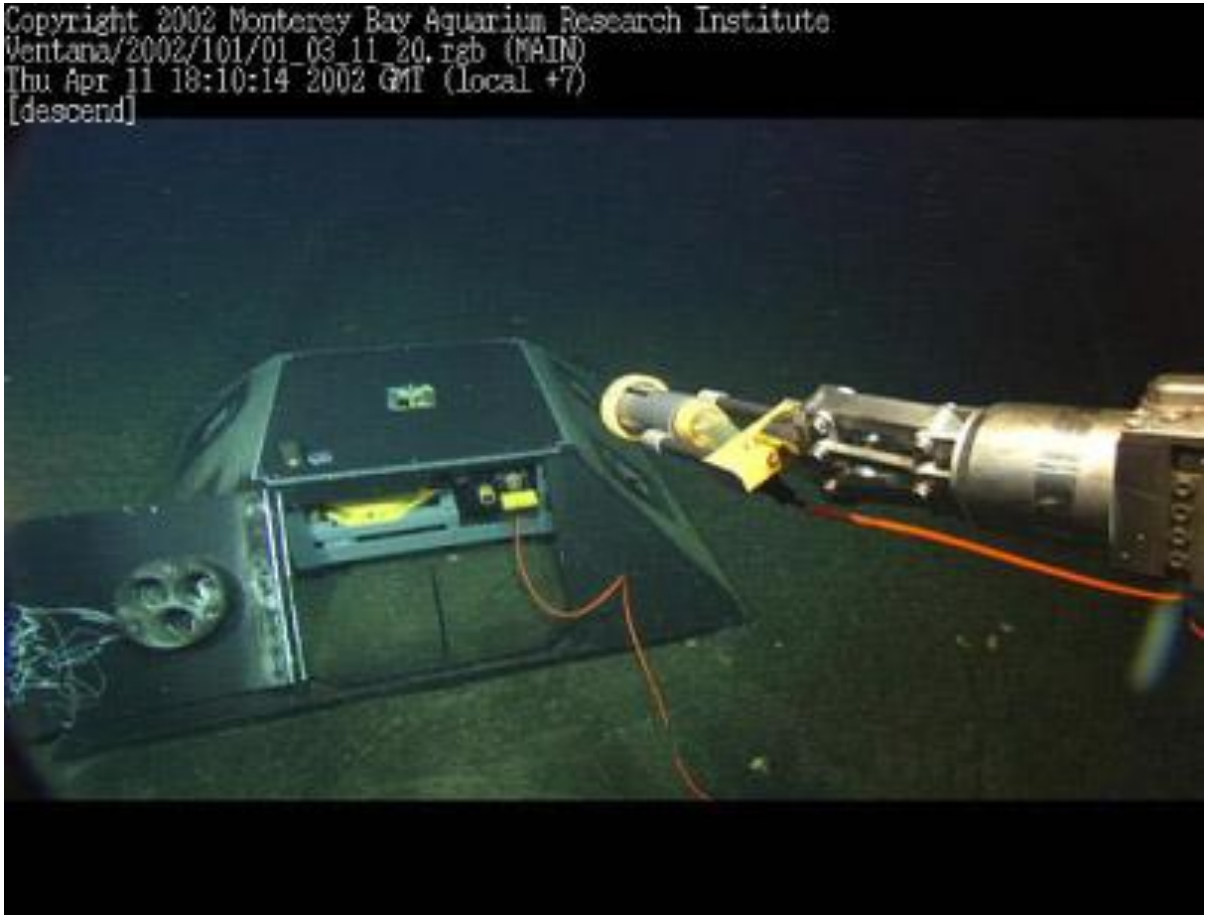
MARS Workflow Process

- Proposal
- Design, test, re-design, re-test in lab
- Stage for pre-deployment test
- Test, modify as necessary, in MBARI's test tank
- Stage for deployment
- Deploy
- Operation
- Recover

Monterey Ocean-Bottom Broadband (MOBB) Seismometer
(installed in February 2009)



- Monitoring seismicity in real time. No need to recover the seismometer. (*Traditionally, data can only be accessed when the seismometer has been recovered --- have to wait for several months.*)
- No longer limited by battery and hard drive capacities.
- Can easily reprogram the seismometer when needed.

Chief Engineer: Paul McGill

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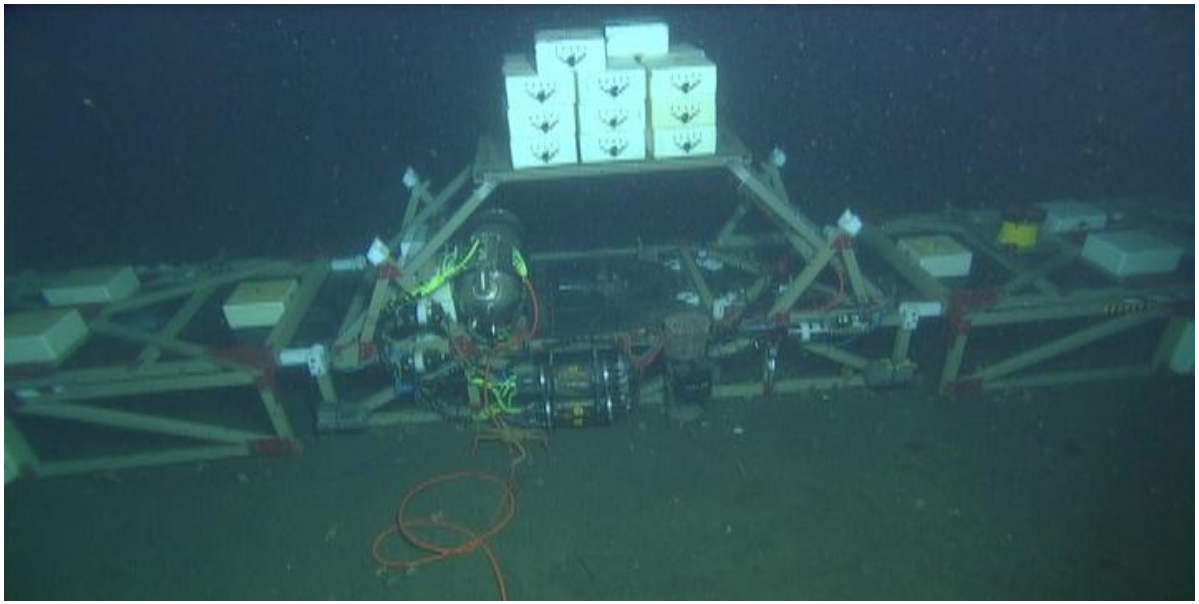
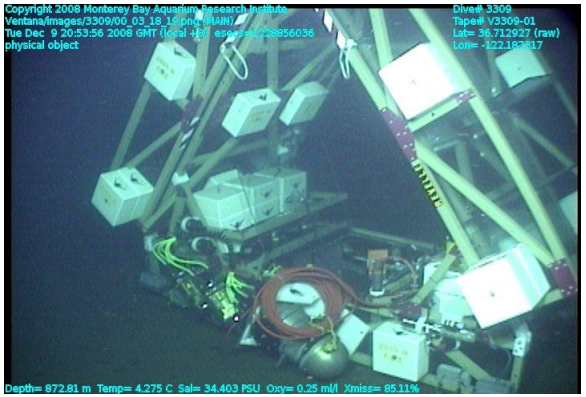
Free-Ocean Carbon Dioxide Enrichment (FOCE) Experiment
(installed in December 2008)





Principal Investigator:
Dr. Peter Brewer

- Oceans absorb roughly 1/3 of all the CO_2 that humans release into the atmosphere, and thus become more acidic. This has significant effects on marine plants and animals.

- FOCE on MARS is the first carefully controlled study of ocean acidification on deep-sea animals in their native habitat.

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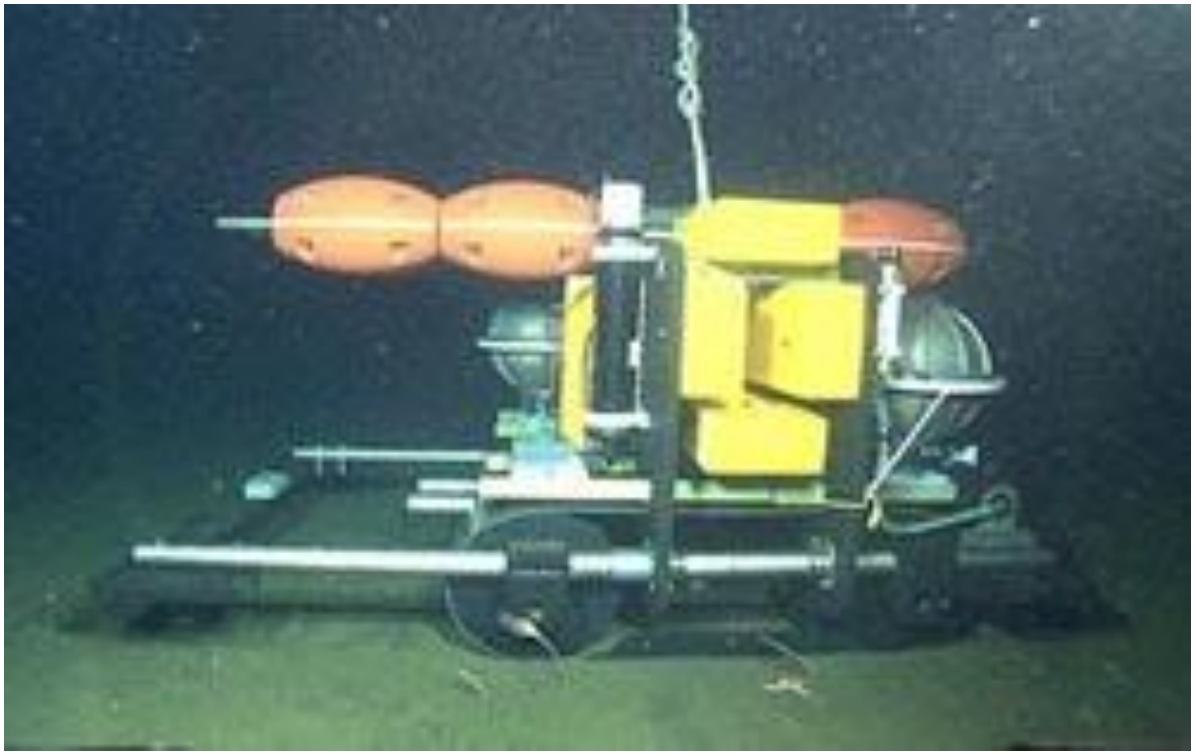
Benthic Rover
(installed in July 2009)



Principal Investigator: Dr. Ken Smith

- A mobile physiology lab for studying carbon cycling in the deep ocean.
- Performs long time series of measurements (e.g., oxygen) at the sediment interface at different locations, thus avoiding numerous separate expeditions and ROV dives.
- MARS' constant data link to shore greatly facilitates testing and refinement of the benthic rover.

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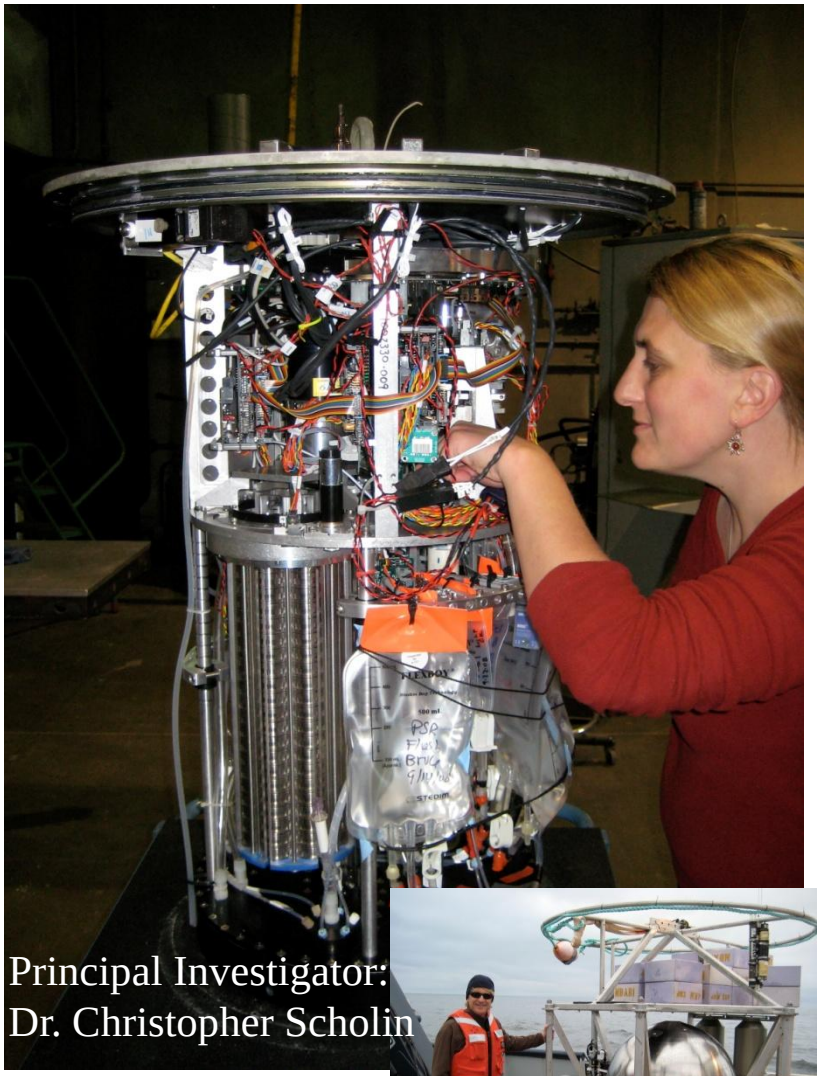
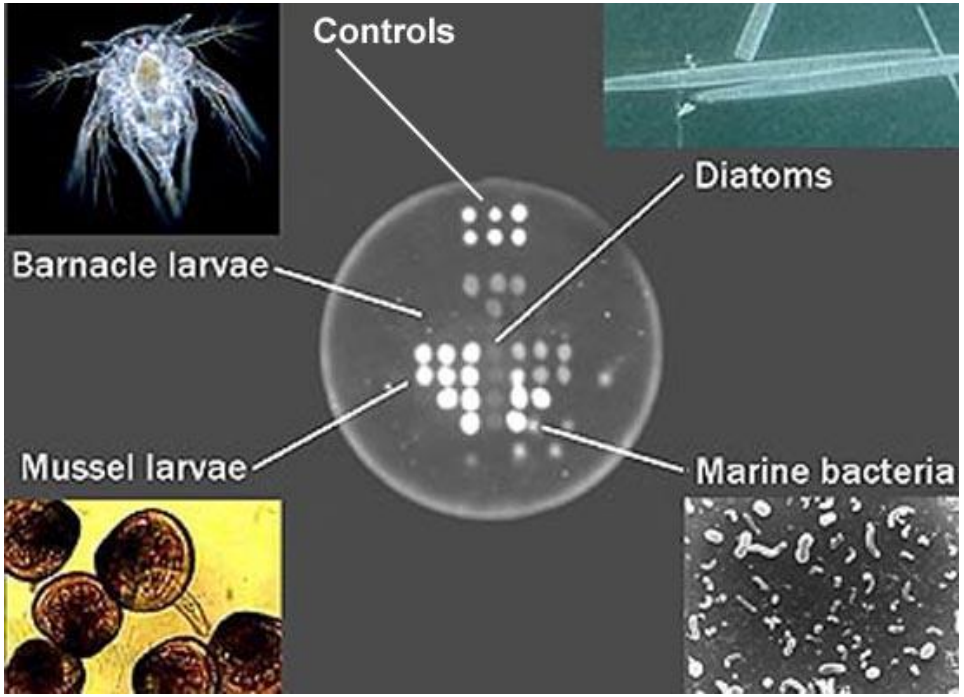
Deep-Sea Environmental Sample Processor (ESP)
(installed in September 2009)



Principal Investigator:
Dr. Christopher Scholin



- An automated molecular biology lab.
- ESP on MARS analyzes the sample as soon as it is collected and transmits the results back home without delay.
- Scientists can use other MARS sensors to decide when the ESP should take samples: adaptive sampling.

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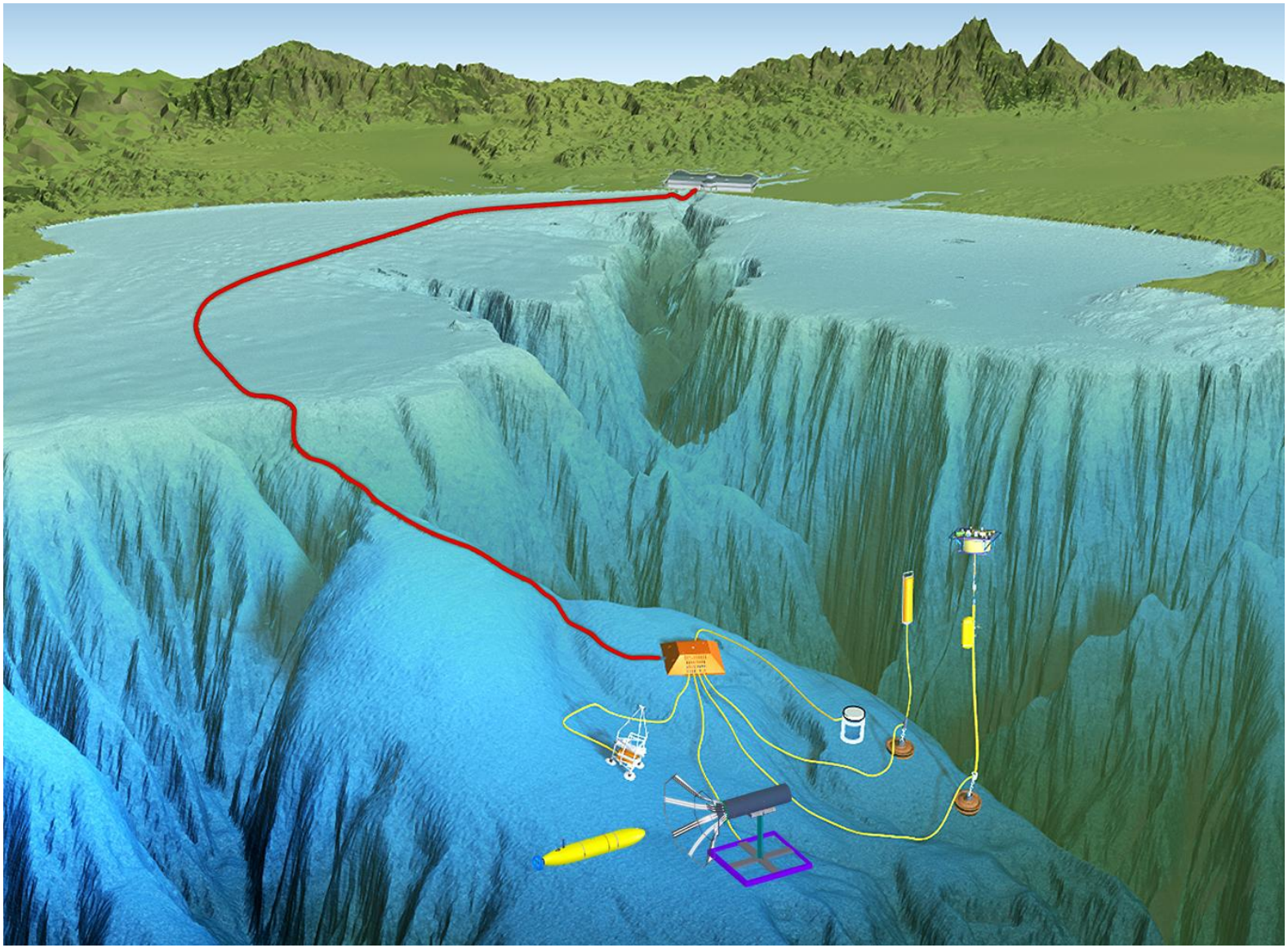
Towards Synergistic Ocean Observation: Observatory + AUVs



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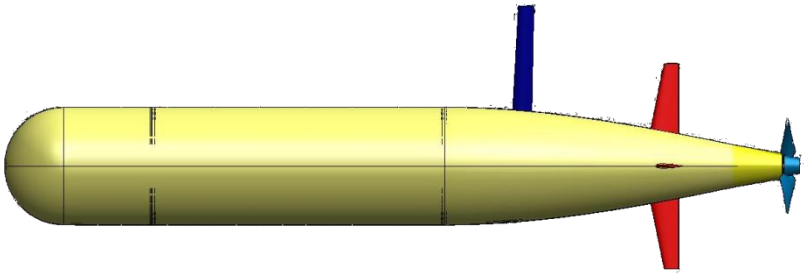
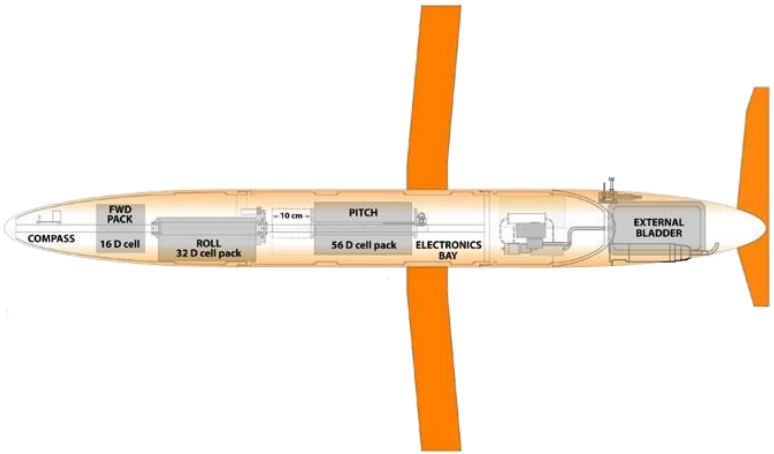
State-of-the-art of AUVs

MBARI Dorado
500 kg. 1.5 m/s.
Carries many sensors, but only lasts a day.



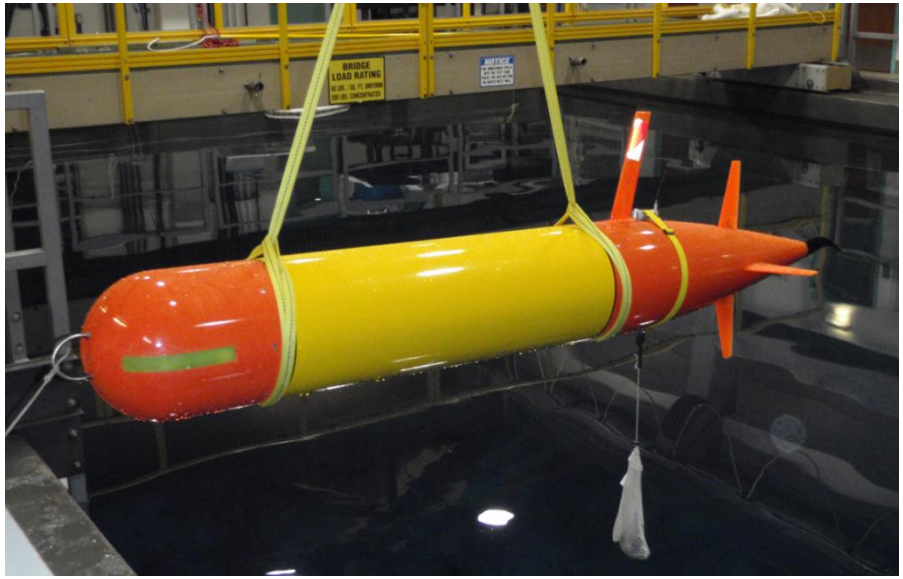
MBARI Tethys
110 kg. 0.5 m/s and 1 m/s.
Can run slowly for a long distance or faster for a shorter distance. Can wait in drifting mode until something interesting happens.



Scripps Spray (Russ Davis)
48 kg. 0.27 m/s.
Can run for months, but can only carry a few sensors, and goes quite slowly.

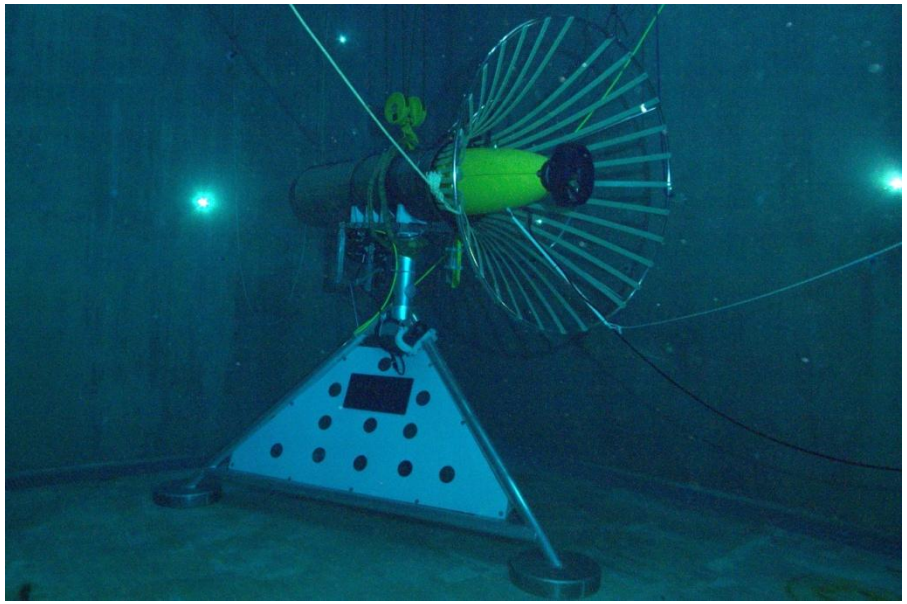
Bellingham

MBARI Tethys AUV



- Carrying 8 W sensors, at speed 1 m/s: range > 1000 km.
- With minimal sensors, at speed 0.5 m/s: range > 4000 km.
- Ability to trim to neutral buoyancy and drift.

AUV Docking



- Autonomous homing and docking
- Batteries recharge
- Data download
- Mission upload
- Vehicle sleep/wakeup
- Code modification & recompile

Bellingham, Hobson, McEwen, and McBride

AUV Triggering on Detection of Events

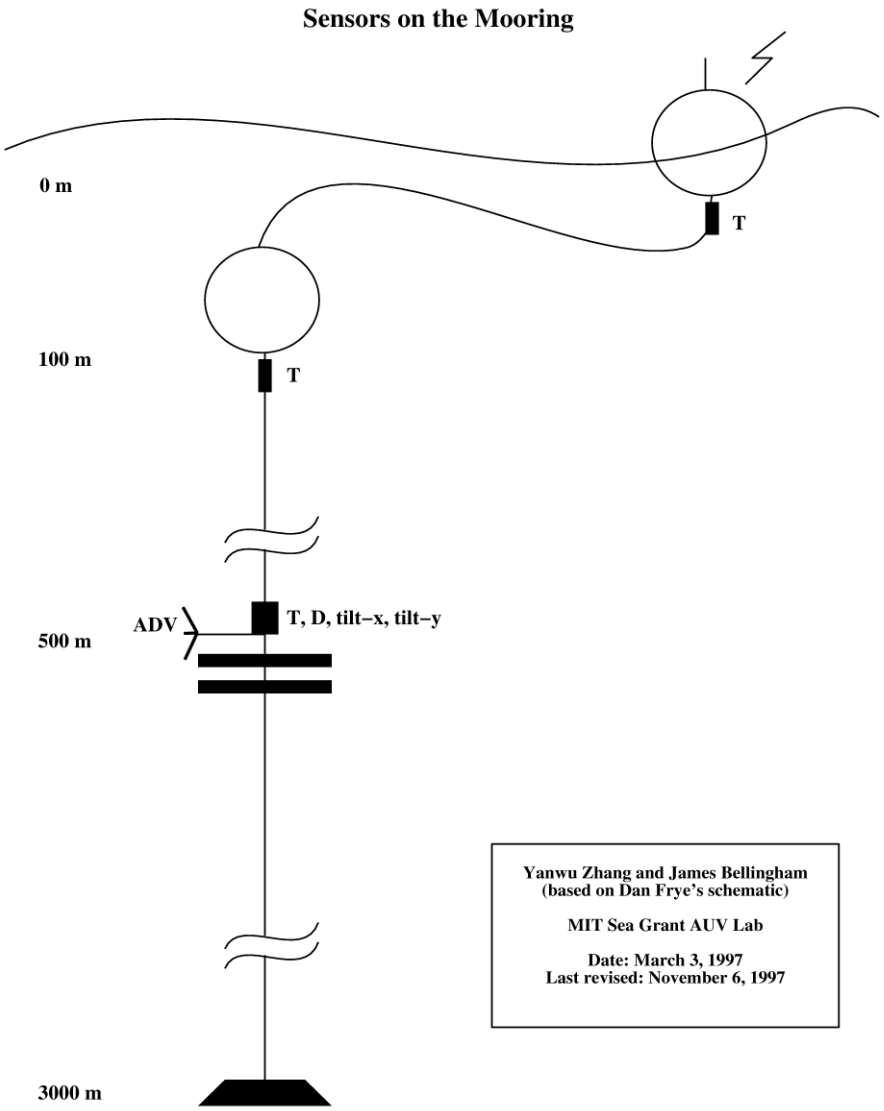
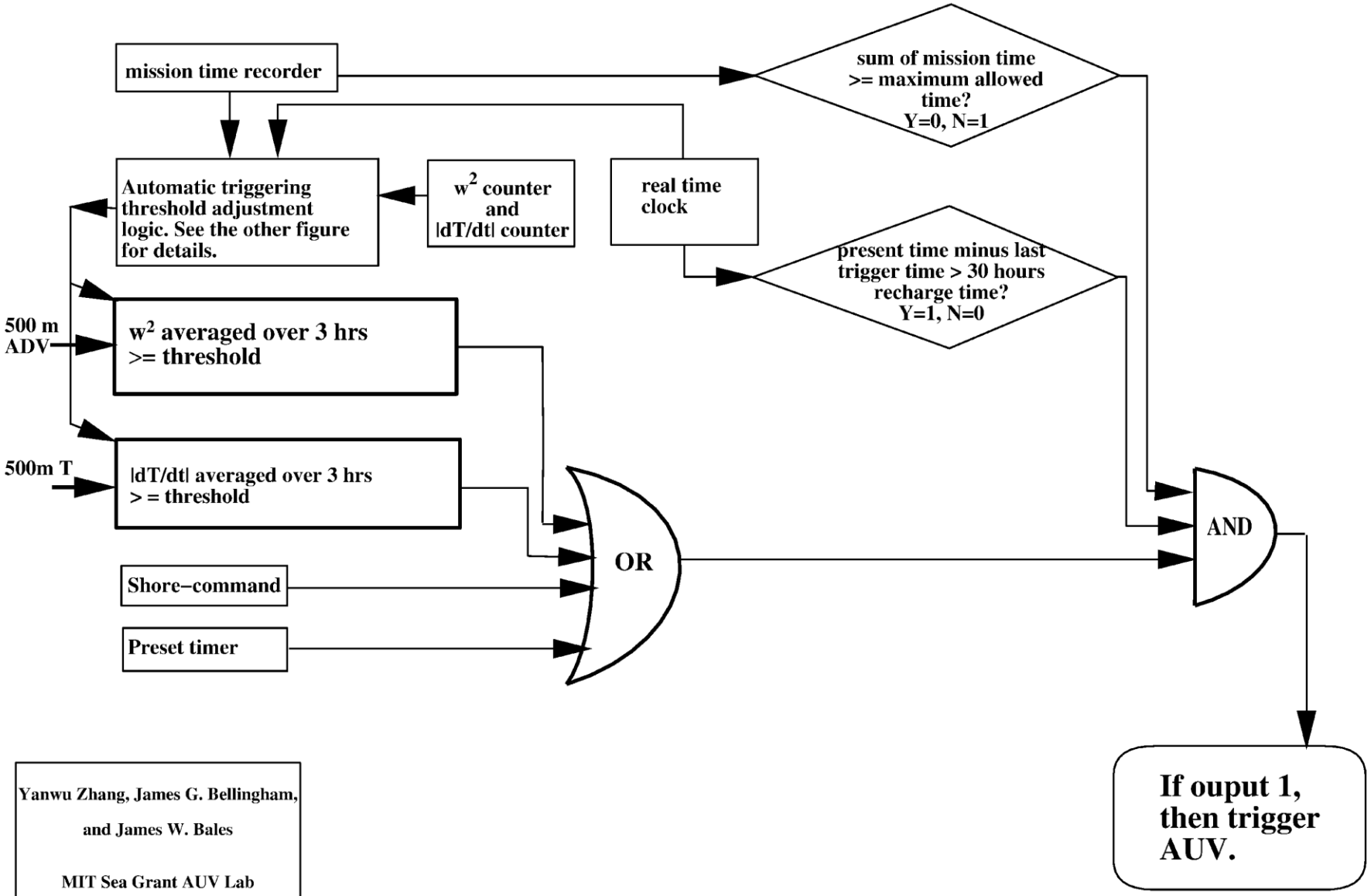


Figure 1. Mooring configuration.

Automatic AUV Triggering Based on Mooring Measurements



Yanwu Zhang, James G. Bellingham, and James W. Bales

MIT Sea Grant AUV Lab

Date: March 3, 1996
Last revised: November 23, 1997

Conclusions and Discussions

- The MARS ocean observatory has so far hosted 11 science experiments (some completed and removed), and more coming …

- Key considerations in selecting the location of an ocean observatory:
  - Science value: what are the ocean features or events to observe or capture?
  - Logistic support: how far is it from shore base?
  - Risk from fishing activities.

- Synergistic ocean observation calls for collaborative use of fixed and moving platforms.