MOOS 2

A MIDTERM REVIEW OF THE MONTEREY OCEAN OBSERVING SYSTEM

MONTEREY HILTON HOTEL

JUNE 4-5, 2003

SUMMARY OF WORKSHOP

New MOOS mooring in Monterey Bay.

Background and Aims of Workshop

The Monterey Bay Aquarium Research Institute organized a workshop to provide a midterm review of the current status of its program in ocean observing, lessons learned to date, relevant external efforts, and emerging technological solutions. The workshop was designed to allow all stakeholders in the program, including science users, technology developers, marine operators, education specialists, and selected external observatory users, to provide input to shape the future program direction. In particular, the workshop was intended to address the question of how MOOS development should proceed so as to provide a system that is affordable, maintainable, and valuable to science. The list of participants in the workshop is attached to the end of this document as Appendix 1. Appendix 2 contains the workshop agenda. A CD-ROM is available with the electronic files from the presenters.

MBARI's director, Marcia McNutt, began the presentations by reminding the staff of why scientists are eager to build observatories. Observatories can:

- capture events as they happen
- provide the synoptic view
- promote interdisciplinary research
- avoid temporal aliasing
- (hopefully) lower the cost of acquiring information.

It was a natural move for MBARI to initiate a program in developing a new generation of ocean observing systems. MBARI already had significant in-house expertise in observatory-critical technology: moorings, ROVs, AUVs, autonomous sensors. MBARI controls its own ship schedule, so can reduce development time. With an independent funding structure, MBARI could begin without a national/international organizational plan. As an illustration of the last point, the national oceanographic community is now in its 7th year of planning for ocean observing, but the programs are not yet funded for development or operations. In contrast, MBARI has already secured external funding and is in the permitting stage for its MARS cabled observatory. The new-generation MOOS mooring already completed one test deployment. A bench-top version of the scientific sensor interface is ready for field packaging, and aspects of the data system are being tested on oceanographic data sets from current field programs.

MBARI scientists are interested in using ocean observatories for observing, sampling, and experimentation in both the upper water column and the benthos. In the upper water column, specific scientific issues include the relation of nutrient supply to community structure, carbon export from the euphotic zone to the deep sea, and ocean fertilization processes. At the seafloor, scientific themes include microbial processes, fluid fluxes, and geologic activity (earthquakes, strain events, landslides, volcanic eruptions).

In designing the MOOS program, the research staff has adhered to the following principles:

- Incremental Development - get science return at each development step;

- Portability – system should be deployable from a ship of opportunity anywhere;
- Configurability - components can be easily reprogrammed for many missions;
- Compatibility - set/adopt standards for power and communications;
- Expandability - design system for easy upgrade and expansion of capabilities;
- ROV Serviced - install/service/retrieve with ROVs for flexibility, cost savings;
- Integrated with AUVs - extend footprint without requiring dense network of nodes;

The MOOS program has been approved by the MBARI Board of Directors and is currently executing its implementation plan. The program is centrally managed under Keith Raybould as project manager. MOOS use of shared institutional resources (engineering time, ship time, machine shop time, etc.) is capped at 50% of the total available.

Current Status of Program

MOOS project manager Keith Raybould provided a summary of the current status of the program in comparison to what was proposed initially. A prototype of the MOOS mooring and cable was deployed in November, 2002, and much was learned from the failure of the cable during a severe storm in December. The controller for the MOOS test mooring was a new, more capable version that has also been successfully deployed on M2. Many aspects of this mooring design are being considered for NSF's DEOS (Dynamics of Earth and Ocean Systems) global mooring program. There is also some possibility that NSF will fund a portion of the development costs for this system.

MBARI also joined the NEPTUNE project as one of the implementing teams. MBARI's main role in this project is to provide a cabled observatory test bed (MARS) that will provide a facility for instrument development that is easily accessible year around. MARS is scheduled for installation in 2005. In anticipation of the availability of MARS, a cable-laying toolsled was developed for *Ventana* under the MOOS program to permit the connection of remote instrument packages to the main MARS node via fiber-optic extension cords. A similar toolsled is under development for *Tiburon* and will be showcased during the 2004 MOOS science experiment.

Considerable progress has been made in integrating autonomous underwater vehicles (AUVs) into observatory operations. The AUV *Dorado* was deployed during the MUSE science experiment in 2000, and the vehicle has now been transitioned to marine operations where it is available for general science use. As an initial primary mission, the AUV is beginning to run CTD (conductivity, temperature, depth) transects in Monterey Bay, with the hope of soon replacing the more costly but infrequent ship transects.

A project to develop a software infrastructure for instrumentation, SIAM, has demonstrated "plug and work" and device discover for a smart instrument network on the bench top. The software has automated the generation and handling of metadata. The system will be deployed on M1 in the summer of 2003. In a related development, the shore side data system (SSDS) has tested prototypes with the MOOS test mooring and the AUV-CTD time series.

MOOS Science Experiment for 2004 has targeted Shepard Meander at 3600m for a MOOS mooring deployment that connects surface instruments to two benthic instrument nodes via the OEM cable. Globalstar will provide communication to shore. Other MOOS developments planned for demonstration include a benthic profiler, SIAM plug and work software, and SSDS. This experiment is currently planned for late 2004, but may be delayed 6 months to better mesh with the schedule for the NSF-supported project for further work on the OEM cable design, in collaboration with Woods Hole Oceanographic Institution.

Several feasibility studies are exploring future capabilities for MOOS, including AUV docking and vertical profiling. Both of these projects were initiated in January, 2003.

Lessons Learned

The leaders of several MOOS efforts provided a summary of some of the important experience that has been acquired through MOOS developments and deployments to date. These lessons learned should be used to guide future developments.

MOOS Experiments

Jim Bellingham began by reviewing some of the strengths of the MOOS science experiments, such as the MUSE experiment in 2000. The field program widely engaged MBARI science and engineering, and well as participants from other institutions such as the Naval Postgraduate School, Scripps, Woods Hole, and the University of Washington. In addition to having a very valuable science result, the MUSE experiment tested early systems including the Environmental Sample Processor, the Vertical Profiler, and the *Dorado* AUV. In designing future experiments, there should be every attempt to retain a mix of individual PI experiments, coordinated PI experiments, and pooled assets. Participation in the experiments should be open to investigators outside of MBARI. Aspects of the experiment should rely on real time data collection, while still archiving data for later analysis. *Although the projects so far have been episodic, clearly there is a need to evolve to more continuous operations, such as are currently being undertaken with the AUV-CTD surveys."*

MOOS Mooring Deployment

The MOOS Mooring project has already tested its power system, controller, communications, software, mechanical configuration, load calculations, and snubber assembly. Mark Chaffey summarized both specific and general lessons learned from these tests. First, in the area of software systems and integration, there is a need for more pre-deployment verification of data streams, which in turn requires that either the hardware or a prototype is ready early to allow concurrent software development. The failure of the mooring cable during the storms of December, 2002, appear to have been caused by incompatibility between the floats and the EOM cable. Furthermore, the float clamps do not prevent the floats from moving along the cable, causing further concentration of stress. The theoretical calculations on cable loading consistently underestimated the mean and maximum loads experienced in the field. Some improvement in the code is needed. On the other hand, the anchor load calculations tracked reality quite well. During the MOOS deployment it became clear that the Pengo drum is too small, and there is need for an additional respooler. Coiling excess cable in figure 8's on the deck likely caused some damage to the fibers. The loss and subsequent recovery of the components of the MOOS mooring underscored the importance of having MBARI's name and phone number on all equipment. In general, Mark emphasized the importance of protecting the final test and integration procedures in the project plan.

New Mooring Controller Development

Duane Edgington summarized the lessons learned from the New Mooring Controller (NMC) project, a plan to replace the operational OASIS controller with a new modern operational system, develop the core MOOS controller, and test new technologies for MOOS (Java, Java processor, distributed nodes, wireless infrastructure). First, the idea of combining the development of an operational asset (with a timeline) *and* an new technology development project (MOOS) *and* new infrastructure projects (SideARM, SideKick, Java, distributed objects) was not leading to progress on any front. The technical solution of meeting the power budget by using two processors, with drivers running on one less capable processor, and everything else on the more capable processor, resulted in needlessly complex software. There was also a necessity to manage the flow of new requirements into the team, and to build responsibility into the producers of requirements for their cost and impact. Reviewers and stakeholders must provide their input in a timely fashion, and then get behind the design. Feedback late in the game had serious negative impact on the project. The project team found that the use of SCRUMS helped accelerate the development. At these daily, 15-minute meetings, each team member was asked:

- What did you do since last Scrum meeting?
- Do you have any obstacles?
- What will you do before next meeting?

The meetings were primarily for the truly committed members of the project team who were actively working on the development. Interested parties were welcome, but could not drive the meeting.

Instrumenting the Canyon

Charlie Paull pointed out the large difference between scientific perception of the geologic activity in Monterey Canyon versus reality. For example, the earlier notion was that large volumes of material moved down the canyon infrequently (e.g., once every few years) in major events. In fact, the removal, burial, and loss of the first generation of Canyon Dynamics remote instrument nodes (RINs) demonstrates that the upper canyon is incredibly active, with ~4-6 major events in one 14-month period. Given that these robust nodes were designed to return measurements in 8-knot currents and survive 14-knot currents, these events are obviously quite dramatic. Furthermore, the ambient conditions are of little importance for sediment transport in the upper canyon, justifying the observatory approach. Instruments need to be selected for appropriate robustness relative to the deployment strategy as well as their ability to make the required measurements. For example, the NOBSKA current meter is too fragile to be readily deployed.

Figure 1 - Before: Launched RIN off *Western Flyer* into axis of Monterey Canyon on June 4th, 2002

Figure 2 - After: Revisited RIN "site" after 30 days:
RIN moved 170m down canyon and was partly buried. Note battery cage wrapped around masts.
Another RIN deployed nearby was never found.
There was no obvious triggering event.

ROV Servicing of Observatories

Knute Brekke reviewed the insight gained from a number of projects in which ROV *Ventana* was used to install and service observatories. To date, the ROV has both installed and replaced instrument packages, with the latter being rather more difficult on account of the ROV having to deal with two copies of each package (the one being removed and the new one being installed) on each dive. Simple, robust instruments should be chosen over those that may have other desirable features, as some sensors have proven to be virtually impossible to install without damaging them. Time is well spent designing the packages for easy installation and in practicing complex operations in the MBARI test tank. However, the visibility in the test tank is rarely achieved in the field, and thus pilots should resist the temptation to become overconfident just because an operation proceeded smoothly in the test tank.

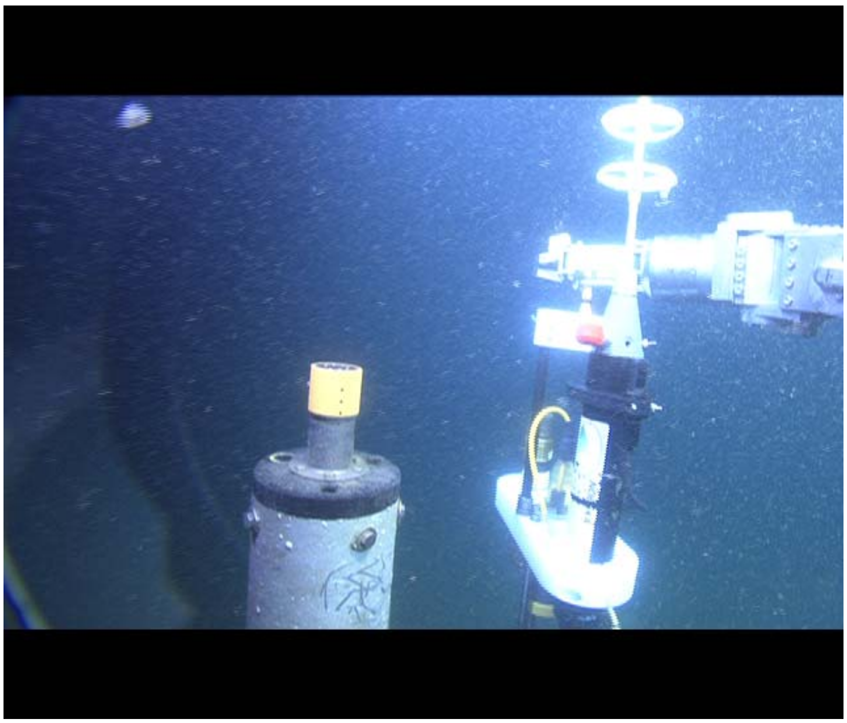

Figure 3 - This current meter proved too fragile for ROV deployment on benthic observatory.

Connections to the External Community

As the MOOS effort has progressed over the past 3 years, opportunities to connect with similar or complementary efforts in the external community have arisen. Because MBARI's aim is to produce observatory technology and methods that will be widely adopted by the oceanographic researchers, priority was placed in working in concert with these other efforts to the maximum extent possible. External collaborations were created to ensure that MBARI efforts were not being duplicated elsewhere and to aid in the setting of community standards.

The DEOS (Dynamics of Earth and Ocean Systems) is a national, academic committee that is leading the scientific and technical planning for open ocean observatory systems under NSF sponsorship. The goal is to complete a global network of observatories for monitoring climate, seismicity, geomagnetic field, and other time-varying global properties using autonomous moorings to fill in the large gaps in the world's ocean. One class of these buoys intended for remote, high latitude deployment will incorporate a diesel generator for power and a tri-mooring design, while a less expensive and more portable MOOS-style mooring may meet the needs in other locations. On account of DEOS interest in the MOOS design, NSF funding may become available to augment MOOS development in collaboration with Woods Hole. The need for over-the-horizon satellite communications and an EOM cable to the seafloor will be common to both MOOS and DEOS regardless of any other design divergence.

The external effort with which MOOS efforts are most closely integrated is NEPTUNE, a project plan to install a deep-sea, fiber-optic cabled observatory on the Juan de Fuca plate in the northeast Pacific. MBARI's role in the NEPTUNE collaboration is to host, with NSF funding, a cabled test bed in Monterey Bay called MARS. In addition to providing year-around accessibility to the cable node for instrument developers, the MARS observatory will begin to entrain the research community in cable observatory science, test out operations, management, and outreach methods and costs, and test some aspects of NEPTUNE technology. Plans are underway to incorporate docking stations for AUVs or benthic rovers to the MARS node, for recharging batteries, downloading data, and uploading new mission commands. Charlie Paull has also submitted a proposal to the Integrated Ocean Drilling Program (IODP) to drill a borehole in Monterey Bay to accelerate the use development of borehole observatories using cable power and communications. Involvement of MBARI in NEPTUNE through MARS will aid in the transfer of some MBARI technology (pucks, data systems) to the external community. Because MARS is intended for the entire community, it will not be solely the purview of MBARI to determine what science experiments will go forward using this facility. However, MBARI internal funds can indeed be used to jump-start some first experiments for the cable, especially if the experiments are quite unique using equipment not available elsewhere. For example, MBARI would not encourage its own investigators to propose an acoustic array for MARS, as this interest and expertise is widely available outside of MBARI.

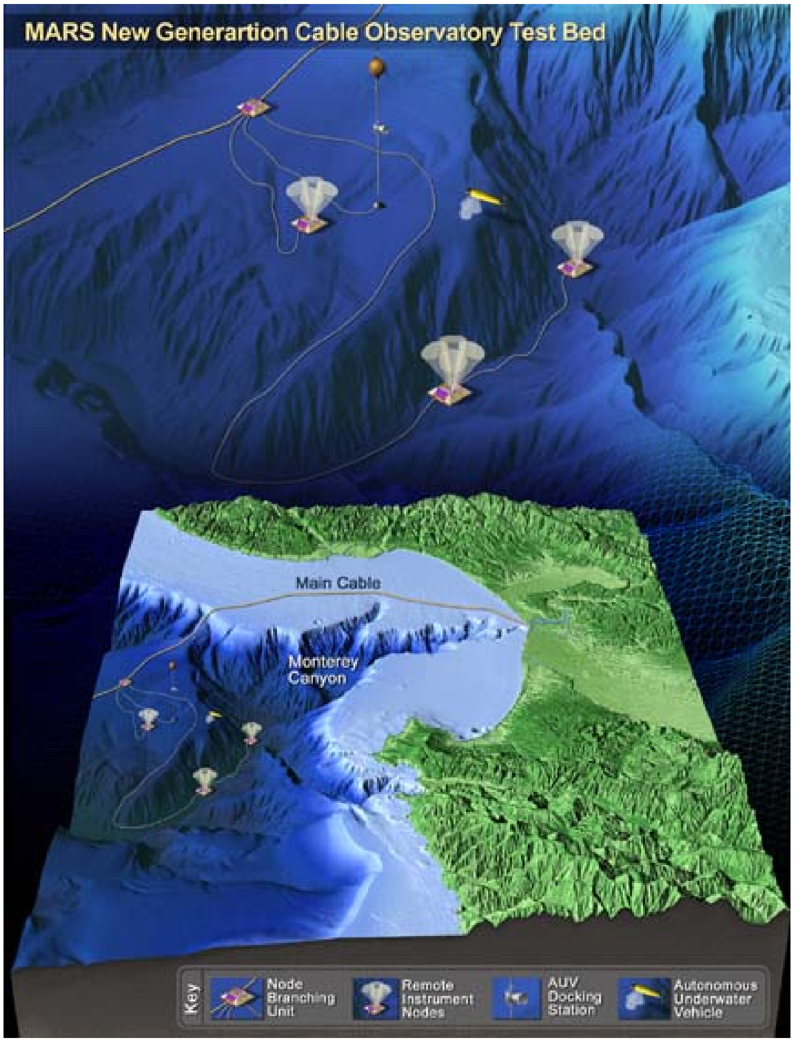

Figure 4 - MARS cabled observatory.

MBARI has been designing small devices, called pucks, to enable automatic and spontaneous integration of instruments into observing systems. Each puck is designed to integrate to a specific type of instrument, and contains the instrument service code and metadata. The host system (e.g., mooring, cable node, etc.) retrieves information from the puck when the instrument and puck are plugged into the host serial port. This concept simplifies system integration and maintenance, addresses critical problems of data traceability and context, can be retrofitted to any serial instrument, and is scalable from small moorings to large observatories. By keeping the puck simple, small, and cheap, the goal is to encourage adoption by the oceanographic community and commercial instrument vendors. Seabird Electronics, Satlantic, Wetlabs, Hobilabs, and RD Instruments have all shown some interest in the MBARI concept. The puck concept is also being considered as a standard for NEPTUNE and for JAMSTEC cabled observatories.

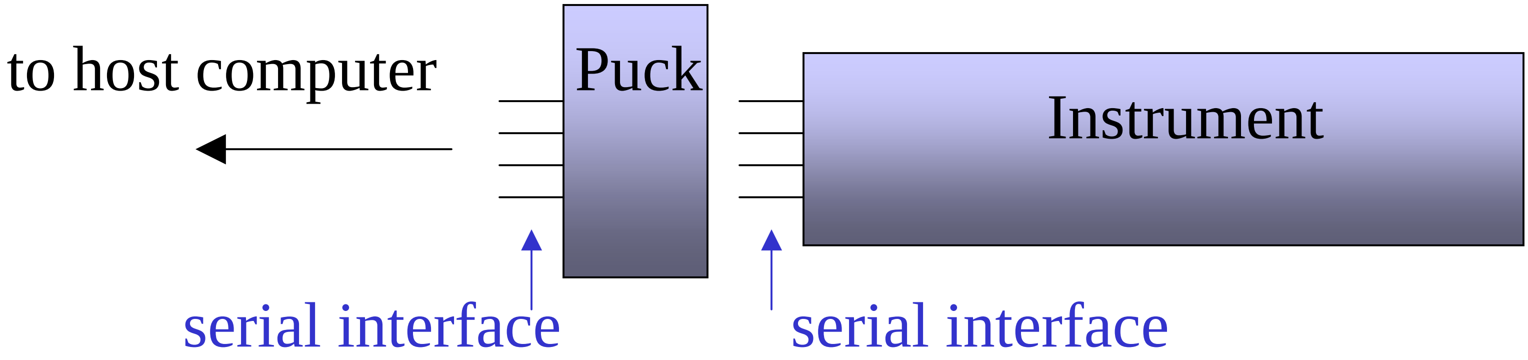

Figure 5 - Puck forms an interface between an instrument and the network.

MBARI's Shore Side Data System (SSDS) developers have also been connecting with other observatory efforts. Because many of these systems are slow to develop, whereas MBARI has an immediate need to manage data from its moorings, MOOS, MARS, and AOSN-type experiments, the goal has been to make the SSDS design compatible with the directions that others are taking. However, it is unlikely that MBARI's SSDS software will be useable by these other groups "as is". The Canadian partners in NEPTUNE are responsible for creating the data system for that observatory, but exactly who will take on the task is yet to be defined. MBARI is a partner in an NSF proposal, IOOP (Interoperable Ocean Observatory Portal), along with WHOI and Rutgers, to build a single portal to multiple observatories and instruments. The project will establish standard interface protocols and advance the infrastructure for the existing simpler systems.

The external oceanographic community has also been making plans for moored coastal observatories. The Ocean.US office was established by the National Ocean Partnership Program to create an integrated, sustained ocean observing system for the US. The concept is to create a federation of regionally-coordinated observing systems that will primarily have an operational, as opposed to a research, mandate to measure climate change, improve marine safety and operations, monitor ocean health, aid in fisheries management, ensure national security, and mitigate damage from natural disasters. MBARI is likely to become a leader in the central and northern California observing region. MBARI's goal is to be a technology instigator, as opposed to a large-scale observatory operator.

MOOS Mooring Costs

In response to some concerns at MBARI on the cost of the MOOS mooring system, Keith Raybould compiled a table (Table 1) showing the cost of various system components in comparison to other designs. Both the Upper Water Column (UWC – or MOOS Light) design and the full benthic configuration were considered. Labor, ship time, and a basic instrument suite were included in the calculations for all systems. Although the MOOS UWC configuration is slightly more expensive than the current OASIS mooring (6% more), the MOOS system includes the following additional capabilities:

- automated metadata capture and delivery with the data packets to archive, thus reducing the cost of data analysis and making data mining more effective;

- plug and work instrumentation for automated mooring network configuration, which is important for arrays of moorings and data integrity;
- 30W-50W power, as opposed to only 6W for OASIS;
- extendable architecture;
- satellite communications for over-the-horizon deployments.

For both of these systems, instrument and labor costs dominate the bottom line. In the full benthic configuration, the MOOS system is less expensive than the DEOS version. Ship costs for deployment in remote locations are likely to be a major cost driver for those installations.

TABLE 1. Comparison of MOOS Mooring costs to those of other systems.

	OASIS Mooring	MOOS Mooring	DEOS mooring
			(based on MOOS mooring)
a) UWC Configuration			
Surface float, solar panels, tower bridle	$ 10,000	$ 33,000	
Mooring controller, conectors, wireless comms	$ 9,000	$ 20,000	
Instrumentation	$ 225,000	$ 225,000	($225k)
Labor (fabricate and deploy)	$ 175,000	$ 165,000	
Installation UWC (Point Sur 1d)	$ 11,000	$ 11,000	
Sub total (UWC configuration)	***$ 430,000***	***$ 454,000***	
b) Benthic Network			
OEM cable 4km depth, snubber, floats, terminations		$ 265,000	
Step up, step down power convertors		$ 28,000	
3 BIN's, 4 pairs opt conectors, 2*4km cable		$ 280,000	
Benthic Instruments ($100k for each of 2 nodes)		$ 200,000	($200k)
Sub Total Benthic config (excl installation)		***$ 773,000***	
Total Benthic + UWC (excl installation)		***$ 1,227,000***	***$ 1,700,000***
Installation		$ 125,000	$ 1,139,000
		(Shephard Meander)	(NAZCA)
Total UWC + Benthic network		**$ 1,352,000**	**$ 2,839,000**

New Capabilities

Presentations by Mark Sibenac and Andy Hamilton updated the staff on two feasibility studies under the MOOS project that would provide the capability for AUV docking and vertical profiling. After a one-year feasibility study, each is a candidate for development under the MOOS project.

Docking has the promise of extending the interactive survey capability of AUVs from a time scale of a day to the time scale of a year, while minimizing the need for attending ships, decreasing the response time for events, and increasing the weather window for operations. AUV docking has been demonstrated in several one-off experiments, but the goal is to be able to routinely dock vehicles with the MARS cable or the MOOS mooring. To implement docking, Mark is looking at candidate technical solutions to the problems of homing in on the dock, creating a robust mechanical dock, and effecting power and communications transfer once the vehicle is docked. A number of functional requirements have been determined for both the docking AUV and the dock itself on terms of reliability, maintenance, deployment, and number of dockings.

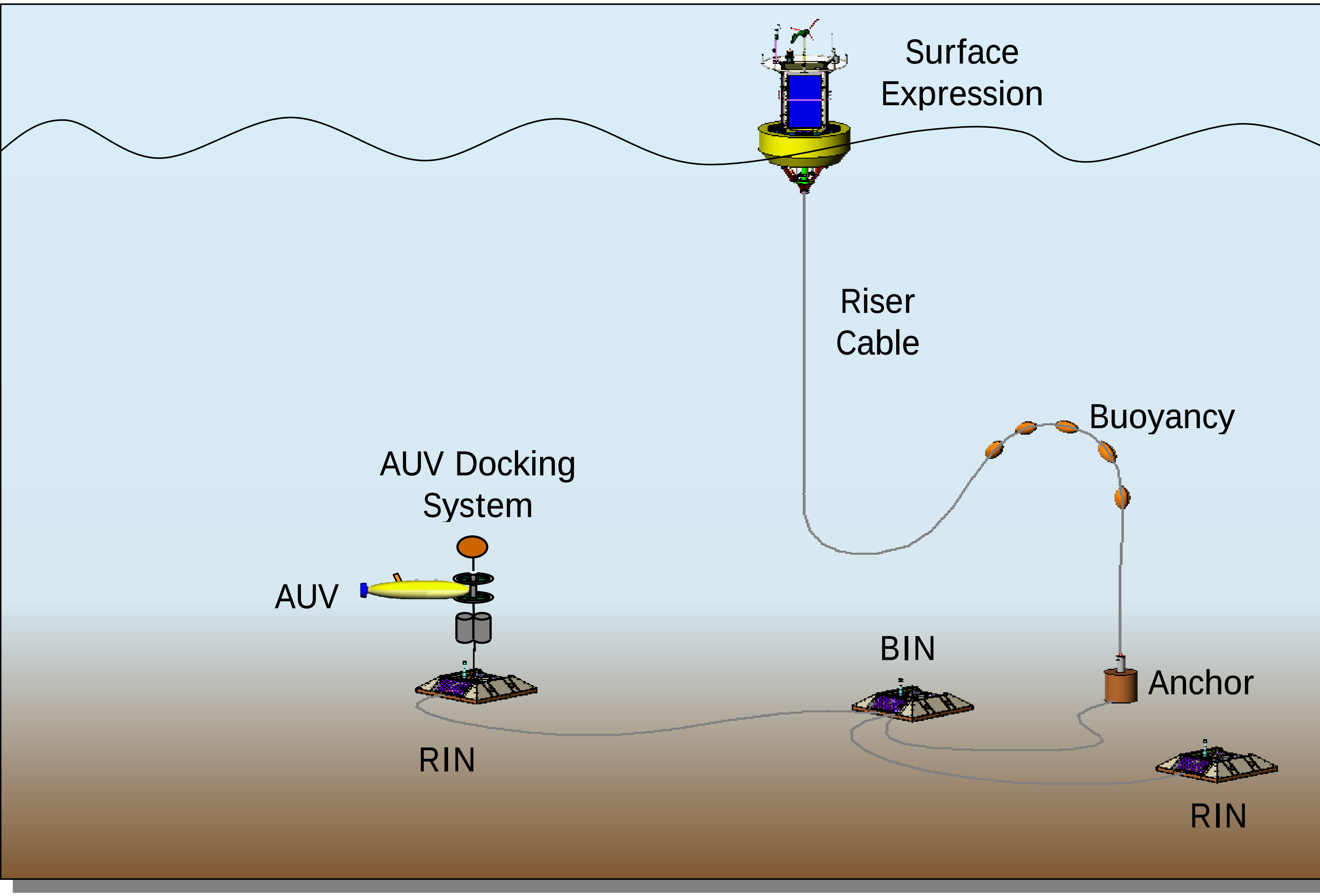

Figure 6 - Basic MOOS Use Scenario.

Vertical profiling has the goal of enabling near-synoptic measurements of many quantities of interest in all regions of the water column. Although vertical profilers exist for both the near surface and benthic environments, it is important to understand what design changes will be required to use them on the MOOS mooring, either MOOS Light or with the full benthic configuration. For deployments of a year or more, power and durability are important considerations. Functional requirements have been derived (Table 2), and tests of some existing systems (SeaHorse and McLane MMP) will be undertaken shortly to determine to what extent they can be modified to meet the requirements.

	Depth Range	Profile Frequency	Deployment Duration	Real-Time Data Requirements	Instrument Requirements
Carbon Production	0-300 m	4/day	> 1 Yr	H	C+P+S
Carbon Export	0-500 m	2/day	> 1 Yr	H	C+P+S
Layer Phenomena (UWC)	0-200m	6/day	1mo-1yr	H+R	C+B+P+S
physical and biological phenom.					
Mixing Phenomena	0-200m/3300-3700m	6/day	1mo-1yr	H+R	C+B+P+S+Currents
Lateral Material Flux in Canyon	3300-3700 m	6/day	> 1 Yr	H	C+B+P+Currents
Pelagic-Benthic Coupling	0-500/3300-3700	4/day	1mo-1yr	H+R	C+B+P+S
- Upwelling on fortnight tide cycles			3wk		
- Spring transition to upwelling			3mo		
- Annual cycle due to upwelling			1yr		

Table 2 - Science requirements for depth, period, instrumentation, duration, and communication for vertical profiling.

Technology Transfer

Given the high premium that MBARI now places on passing on its technology to the external community, Jim Bellingham briefly reviewed some case histories at MBARI as to how that handoff was or was not accomplished. For example, ROV *Tiburon* was built in house to internal science specifications with no external funding and no external involvement. To date, there has been very little hand-off, except for sharing some design features with WHOI for the *Jason II* vehicle. The In Situ Ultraviolet Spectrophotometer (ISUS) very smoothly transitioned to a private company and is now commercially available, despite the fact that the device was developed in Ken Johnson's lab with little external involvement. The Environmental Sample Processor (ESP), although begun with internal MBARI funds, has now attracted substantial grant funding on account of external demand for this unique instrument. The development of the *Dorado* AUV was supported externally to a large part and has enjoyed external demand. A commercial partner was identified early on, and this AUV is now available commercially as well. The ISI/SIAM project is also gaining external interest, but it remains to be seen whether it will attract external funding.

Although from these few case histories it is difficult to generalize, external involvement (users, potential manufacturers) early on in projects, even if externally funded, is likely to smooth the transition to the external community. This approach allows MBARI to gauge whether the development is unique, and external demand is a pre-requisite to attracting external funding.

Educational Outreach Through Observatory Science

George Matsumoto reviewed plans for using observatory information to promote higher levels of ocean literacy. One current problem is that there is simply too much ocean information, of variable quality and suitability for educators, available on the web. A NOPP-funded effort, called the BRIDGE, has created a peer-reviewed web site to help educators select content for their students (http://www.vims.edu/bridge/). George has been holding EARTH (Education and Research: Testing Hypotheses) workshops for educators to determine what teachers would like/need in the classrooms with regard to real-time data (http://www.mbari.org/education/earthwksp.htm). Two of the messages have been that the world-wide web is the most effective method of interaction, that material should not be set up by grades, but rather by complexity such that teachers can determine what level is appropriate for each student. It is clear that educators are excited about the potential of integrating real data into the classroom but will be satisfied with near-real-time data that has undergone quality control and that comes complete with a story (why the data is being collected, how it is being used) as well as some inquiry based activities/lesson plans that are tied to national science standards. And finally, the educators would like to see our efforts designed with an eye towards including data from ships, ROVs, and AUVs, as well as observatories..

Summary of Workshop Discussions and Conclusions

During the two-day meeting, the workshop participants broke off into smaller discussion groups to consider future directions in technology development, instrument development, data management and archiving, and science experiments. The recommendations of the workshop participants can be summarized as follows:

Technology Development

- MOOS Mooring
    1. Solve the various issues with the OEM cable;
    2. Develop the MOOS light mooring for work in the upper water column;
    3. Implement vertical profiling;
    4. Incorporate some of the successful projects (e.g. NMC, SIAM, SSDS) onto CIMT, M1 and M2 platforms;

5. Perform a reality check – make sure that things that seem straightforward really are easy (e.g. *Tiburon* cable laying, routine AUV operations, and ROV dives near cables);
6. Prepare an exit strategy for MOOS that includes transfer to the community.

- MARS
  1. Implement AUV docking on MARS first, since it will probably be easier than the mooring dock;
  2. Develop tethered platforms (e.g. Ken Smith's ROVER);
  3. Use as a test bed for instruments (e.g. ESP);
  4. Plan borehole experiments and instruments;
  5. Engage external partners;
  6. Transfer technology (hardware, software) to external partners (e.g. VENUS and NEPTUNE)
  7. Prepare back-up plan for providing MARS-critical technology in the event that external partners fail to deliver system components in a timely fashion.

Sensor Development

1. Improve existing sensors for long-term, unattended deployment;
2. Evaluate to what extent vertical profiling can extend the operations of existing sensors;
3. Complete development of promising sensors, e.g. oxygen optrodes, that can be ready for MOOS;
4. Initiate development of new instruments to monitor the rates of processes and collect fluid samples.

Data Management/Visualization

1. Develop smart methods of quality control using models;
2. Investigate methods for data skimming to winnow out the interesting information, potentially using information from several sensors simultaneously;
3. Improve methods for data access (quickly) for internal and external use;
4. Formulate a basic timeline for sensors that are to be deployed to insure sufficient advance notice for the data system to accommodate the information;
5. Disseminate data from published scientific papers for educational use (e.g. domoic acid and sea lions; anchovies and sardines).

Science Experiments

1. Use "Ocean Margin Processes" as a general theme for MOOS experiments;
2. Demonstrate adaptive event response (detection from one sensor dictates response from another sensor);
3. Create experiments that integrate the capabilities of the cable with the capabilities of other platforms;
4. Investigate the creation of artificial cold seeps, perhaps using the borehole;
5. Formulate other kinds of bore hole experiments with external collaborators;
6. Deploy MOOS light arrays;
7. Plan ahead for scaling observatories to reasonable human and financial resource levels;

8. Scale science experiments such that they are worth doing even if the risky part fails;
9. Develop wall-mounted experiments for Monterey Canyon;
10. Continue CO_2 perturbation experiments in observatory mode.

APPENDIX 1. Workshop Participants

The following individuals attended either all or part of the MOOS2 Workshop. All are staff members at MBARI unless otherwise noted.

1. Allen, Mandy
2. Au, Doug;
3. Barry, Jim
4. Bellingham, James
5. Brekke, Knute
6. Brewer, Peter
7. Caress, David
8. Chaffey, Mark
9. Chavez, Francisco
10. Connor, Judith
11. Davis, Dan
12. Delong, Ed
13. Edgington, Duane
14. Erickson, Jon
15. Etchemendy, Steve
16. Friederich, Gernot
17. Gomes, Kevin
18. Graybeal, John
19. Greene, Gary
20. Haddock, Steve
21. Hamilton, Andrew
22. Johnson, Ken
23. Kelley, Mike
24. Kirkwood, Bill
25. Kolber, Zbigniew
26. Massion, Gene
27. Matsumoto, George
28. McCann, Mike
29. McNutt, Marcia
30. Mellinger, Ed
31. Meyer, Debbie
32. O'Reilly, Tom
33. Parker, Mike
34. Paull, Charles
35. Peltzer, Edward
36. Pinto, Mike
37. Podder, Tarun
38. Raybould, Keith
39. Robison, Bruce
40. Rosenfeld, Leslie (Naval Postgraduate School)
41. Ryan, John

42. Scholin, Chris
43. Shane, Farley
44. Sibenac, Mark
45. Stakes, Debra
46. Ussler, Bill

APPENDIX 2. Workshop Agenda

Wednesday June 4th

8.00- 8.30 Breakfast

8.30-8.45 Introduction and Aims of the Workshop (Marcia)

8.45- 9.00 Current Status Overview: where we are compared to the plan presented to the Board in 1999 (Keith)

9.00-10.15 Lessons Learned: Engineering and Science
9.00-9.15 MUSE/AUV's: Jim Bellingham
9.15-9.30 OEM Cable Mooring: Mark Chaffey
9.30-9.45 NMC: Duane Edgington
9.45-10.00 Instrumenting the Canyon: Charlie Paull/Gene
10.00-10.15 Cable Laying, ROV servicing of Benthic Nodes: DMO (Knute Brekke)

1015-1030 Break

10.30-12.00 Connection of MOOS to Outside Community Programs
10.30-10.45 DEOS (Mark)
10.45-11.00 MARS (connection to NEPTUNE, technology test bed for community) (Jim)
11.00-11.15 ISI/PUCKs (instrument manufacturer involvement/tech transfer to ocean community) (Tom)
11.15-11.30 Data Management (WHOI/Rutgers/MBARI proposal, local DM workshop, DMAS) (John Graybeal)
11.30-11.45 Oceans.us, CIMT and AOSN (Francisco)
11.45-12.00 Discussion

12.00-1.00 Lunch

1.00- 1.20 MOOS Costs
1.00-1.15 Mooring configuration costs compared to OASIS and DEOS systems. Options for more affordable systems (Keith)
1.15-1.20 Discussion

1.20-2.00 New Capabilities
1.20-1.40 AUV presentation (Mark Sibenac)
1.40-2.00 Vertical profiling presentation (Andy Hamilton)

2.00-5.00 Breakout Sessions (non-cabled observatory programs)

<u>2.00-3.15 Session 1</u>

- Group A. Sensor Developments (Ken)
- Group B: Technology Development Projects (Jim)
- Group C. Data Management and Data Visualization/Presentation (John Graybeal)

<u>3.15-3.30 Summary of Breakout Sessions</u>

<u>3.30-5.00 Session 2 (split into 2 groups that include both engineers and scientists)</u>

Future MOOS technology development efforts and candidates for future MOOS science experiments (groups led by Marcia and John Ryan)

<u>5.00-5.30 Summary of Breakout Sessions 2</u>

Thursday June 5th

8.00- 8.30 Breakfast

8.30-10.00 MARS (Jim)
- what opportunities does this test bed offer to MBARI
- what collaborations should we be looking for developing now
- how MBARI staff can get involved in MARS
- science planning for MARS

10.00-10.15 Break

10.15-12.00 Open Discussion and Summaries of Future Plans (Marcia moderator)

10.30-11.00 What external efforts should we be connecting to as part of the MOOS development? (Jim)
11.00-12.00 Goals for the next 3 years, Technology Development, Sensor Development and Science Experiments (Marcia)

12.00-1.00 Lunch