2004 Implementation Plan of the MBARI Strategic Plan

Overview

Each year, MBARI prepares a summary for the Board of Directors of projects that the institute proposes to undertake for the following year and discusses how these projects contribute to realizing the goals of the strategic plan. It should be recognized as well that there are a number of ongoing activities covered under divisional budgets that also contribute to the strategic plan.

For 2004, MBARI's management team considered a total of 92 abstracts submitted in late June briefly describing plans for new, continuing, and externally funded projects. At that point in the process, the projects were evaluated on the basis of consistency with MBARI's strategic plan, likelihood of manpower being available to complete the project, and timing with respect to other dependent efforts. Some projects were discouraged from submitting full proposals while others with similar objectives were encouraged to combine into one effort. A total of 69 projects submitted full proposals for Phase I in early August. Twenty of them are at least partially funded externally. In mid-August, the management team evaluated these full proposals, concentrating on the feasibility of the full project plan and the level of staff and financial resources that could be devoted to the effort. Only four projects had to be declined entirely after preparing full proposals. Of the remaining proposals, about half of the Phase I submissions were approved as scoped, while the other half required significant revision during Phase II to bring the resources into line. After the Phase II review, two additional efforts were dropped or postponed. We believe that this proposal process is quite efficient, in that PIs receive plenty of guidance before preparing proposals as to what sort of project is likely to be approved, and few full proposals go unsupported.

The sixty-three projects selected for 2004, all listed in Table 1, may seem like too many for an institution of MBARI's size. However, these projects include seven proposals to be undertaken by MBARI adjuncts (Steve Rock – Stanford, Edie Widder -HBOI, Larry Madin - WHOI, Ken Smith – SIO, Bill Hamner – UCLA, Barbara Romanowicz – Berkeley, and Geoff Wheat – NOAA-NURP). Rather than being treated as independent projects, the various components of MOOS are centrally managed by Keith Raybould as one integrated project. In addition, seven smaller efforts support MBARI's data streams and other infrastructure. MBARI management has made the conscious decision to treat as projects any activity that uses shared resources, such as ship time, engineering time, the video lab, the Information Applications Group (IAG), etc., in order to track the use of those resources and budget efficiently.

One aspect that MBARI management tracks carefully is whether we are creating enough opportunities to pursue creative ideas. Two of the five feasibility studies initiated in 2002, the underwater mass spectrometer and the automated event detection (AVED), continue in full development. Of the three feasibility studies begun in 2003, only the AUV payload

to acquire unattended midwater video and bioluminescence transects generated enough interest from science to move forward into development. However, there will be a one-year delay in transitioning this project to development while we complete other AUV payload projects. Three new feasibility studies were approved for 2003, led by Bellingham, Kolber, and Brewer. Bellingham will be investigating the propagation of electromagnetic signals along the seawater-seafloor interface as a possible mechanism for communicating with stand-along instruments clustered in seafloor observatories. Kolber will be developing the *in situ* instrumentation and experimental protocols for monitoring the effect of anticipated changes in pH in the upper ocean on primary and secondary producers. Brewer's project is also aimed at quantifying the effect of a lower pH ocean, but with emphasis on the deep-sea ecosystems. He proposes to explore the planning, design, permitting, funding, and execution of a national, undersea, CO_2 observatory as a complement to land-based observatories currently in operation.

Some highlights from projects for 2004 are summarized below. Emphasis here is given to the new projects rather than continuing efforts that were called out in previous implementation plans. The full abstracts for all projects are appended to this document.

Benthic Processes

In addition to ongoing work with the new laser raman tool, Peter Brewer has proposed to investigate whether energy can be obtained from methane hydrates along the continental margin in the process of releasing liquid CO_2. Because the free energy of formation of CO_2 hydrate is greater than that for methane hydrate, injecting liquid CO_2 into a methane hydrate zone should release methane into the gas phase in a controlled manner.

In anticipation of a major MOOS experiment in 2005 at Shepard Meander, Jim Barry's group is monitoring the lateral and vertical flux of carbon to the deep sea. Oxygen consumption by the sediment community can be used to estimate its carbon demand. Currently measuring oxygen consumption is a challenge using respirometers. Barry, with Ken Johnson, will be investigating whether eddy correlation techniques can be used instead. By measuring the correlation between oxygen concentration and the vertical component of current velocity, it should be possible to estimate the oxygen flux.

Debra Stakes will be wrapping up her work on the Cleft segment of the Juan de Fuca ridge, using geochemical data from samples to be acquired from *Tiburon* transects to distinguish between two models for the relationship between the present location of axial melt bodies and magmatism. She will also be completing the analytical work on an exciting sequence of sulfide-carbonate samples that recorded the growth of a hydrothermal chimney in the Guaymas Basin.

Dave Clague's group has nearly completed the work on the Hawaiian samples. They will turn their attention to seamounts of the California Borderlands, which appear to be examples of a new kind of oceanic intraplate volcanism. Similar to the volcanoes

offshore Monterey Bay but likely younger in age, submersible observations will allow the team to evaluate various tectonic models (e.g., passage of a triple junction, subduction of a ridge, presence of a microplate, etc.) for the formation and geologic history of the borderlands region.

Charlie Paull and Gary Greene are leading the effort to collect the site survey data necessary for placing and permitting the MARS cable and the associated ODP drill holes. Charlie will also begin instrumenting Shepard's Meander in the Monterey Canyon to quantify the flux of material to the deep sea along the axis of the canyon. Benthic Instrument Nodes (BINs) and benthic vertical profilers will be deployed and serviced. Previous work by Jim Barry suggests that the canyon delivers 20 times more carbon to the deep sea than off-canyon sites. This project will test out some of the higher-risk elements of the 2005 MOOS science experiment, including laying cable in 3800 meters of water along the slopes of the canyon from *Tiburon*.

Bob Vrijenhoek's lab is examining the problem of how to use the genetic variability within as opposed to between populations of deep-sea vent and seep communities to understand their geographic mobility. Target species for 2004-2006 are the symbiotic microbes that infect deep-sea hydrothermal vent and cold-seep animals.

In support of the Keck program headed by John Delaney at the University of Washington, Debra Stakes and Paul McGill will be leading an expedition on the *Western Flyer* to recover the first deployment of seismometers on the Endeavour segment of the ridge. They will also deploy a new suite of instruments on the Nootka segment. These experiments are providing important experience for siting and servicing seismometers and other instruments that will be part of the NEPTUNE observatory.

Midwater Research

Bruce Robison's group has now perfected the technique for using *Tiburon* to conduct quantitative video transects at bathypelagic (>1000 m) depths. They will be continuing their surveys to determine the differences in midwater communities as a function of depth. They will also be completing the analysis of data from the Gulf of California, including a study of the effect of the prominent oxygen minimum layer on the vertical distribution of midwater animals.

Steve Haddock will be applying molecular tools to sort out evolutionary relationships in the midwater that cannot be deduced from morphology alone. His group will also continue their highly successful work on the origins of photoproteins in Cnidarians. The discovery of these proteins in non-luminous species living far below the depth of light penetration suggests that they have other functions than bioluminescence.

In addition, MBARI adjuncts Madin and Widder will be using ROV time for projects on salps and the effect of thruster noise on midwater observations, respectively. Bill Hamner

from UCLA will be using the video archives to document behaviors of shrimp and lobate ctenophores.

Upper Ocean Biogeochemistry

Ken Johnson's group will continue their time series investigating regulation of oceanic ecosystems by iron. A new aspect is the potential for using OsmoSamplers to collect high-resolution iron samples from moorings and other unattended platforms. In recognition of MBARI's leadership in this area, the National Science Foundation has asked Johnson to conduct an international iron intercalibration exercise to try to determine the cause of and remove offsets in the absolute concentrations of iron when collected by different research groups.

The program to transition the routine CTD runs from the *Point Lobos* to the *Dorado* AUVs is making rapid progress. The DMO vehicle has been running the transects at 3-week intervals since April. The data are automatically transferred to the shore-side data system. In 2004, the length of the runs will be increased, data retrieval will be enhanced, and data products will be defined. The mooring time series will also continue under the direction of Francisco Chavez for the purpose of better understanding biogeochemical processes in the upper ocean.

Ed DeLong will continue to explore water column and benthic microbial processes, with a focus on the role of planktonic Archaea in CO_2 fixation. Field programs will examine the microbial methane cycle at cold seeps and processes associated with hydrothermal vents on the Juan de Fuca.

John Ryan has proposed to study the impact of the Elkhorn Slough plume in carrying sediment, chemical and biological species, and pollutants into Monterey Bay. The AUV *Dorado* will be used to sample the plume, and be equipped with the ability to determine real-time magnitudes and gradients of the signals. This information will be used as feedback to the vehicle control such that it continues to survey the interior of the plume without external guidance.

Chris Scholin's lab has been improving DNA probe array technology for use in ESPs. So far, reagents have been stabilized for long-term deployments, and improvements have been made in methods for automating array printing. New probes will be designed and deployed to support the research efforts of Scholin (harmful algae), DeLong (planktonic microbes), Vrijenhoek (larvae of benthic invertebrates), Chavez (phytoplankton), and Robison (siphonophores, krill, jellyfish).

With external funding from DARPA, Ed DeLong and Paul Chandler will be conducting experiments to determine the level of electrical power production that can be sustained by a biofuel cell as particulate organic matter is oxidized. Such a fuel cell could conceivably power a glider cycling up and down through the upper 200 m of the ocean by filtering biomass from the seawater and converting it to energy.

MOOS Observatory

MBARI held a large workshop in June 2003, to help guide the next phase of development for MBARI's ocean observing system. The MOOS project for 2004 strongly reflects the priorities established at that meeting.

Much of the cost for the next phase of development of the OEM (Optical-Electrical-Mechanical) cable is now being borne by the National Science Foundation in collaboration with Woods Hole Oceanographic Institution. The next test of cable design will occur in 2004, with two different cable configurations being evaluated side-by-side. The best cable design will be selected for the 2005 MOOS science experiment at Shepard's Meader.

Three important MOOS subsystems are the controller, the instrument interface software, and the shore-side data system. These three systems will all be showcased in an operational environment in support of the CIMT (Center for Integrated Marine Technology) science project in 2004. The CIMT project will deploy a mooring to examine the formation of blooms inside Monterey Bay in real time in response to oceanographic triggers. This project is collaborative with UCSC with funding from NOAA. Following that deployment, there will be evaluations of the performance of the systems in order to determine what additional development is necessary to meet the MOOS goals.

AUV docking and vertical profiling emerged as high priorities from workshop participants. In 2004, the *Dorado* team will focus on demonstration of autonomous homing in on a dock. The vertical profiler team will be testing commercially-available vertical profilers for both upper water column and benthic environments to determine whether there already are systems that come close to meeting the MOOS science requirements and are compatible with the MOOS OEM cable configuration.

MBARI scientists and engineers will also begin working with Dr. Ken Smith from SIO on how to design an interface for his benthic rover so that it can communicate with the MARS cabled observatory. At this point, many options are being evaluated, ranging from a tethered system to a simple acoustic modem.

Work on the MARS project will be ramping up towards the close of 2003 with site and permit surveys. The shore crossing is still the high-risk portion of the route, with two different options being evaluated for cost and maintainability.

ROV / AUV Enhancements and Upgrades

The ROV *Tiburon* is now more than 5 years in operation, and some of its specialty parts are either no longer available or completely outdated. DMO and the Support Engineering

group will begin in 2004 an assessment of *Tiburon*'s aging components to determine their affect on functionality and reliability. The outcome of this assessment will be a plan for cost and manpower required to update the vehicle. At the same time, the ROVUC (ROV Users Committee) will be assessing whether additional upgrades to the vehicle are desirable to meet new science needs and to remain competitive with newer systems being fielded by other oceanographic institutions. Towards the end of 2004, depending on the outcome of the assessments above, the institute may modify the power system for *Tiburon* to boost its delivery by 50% as power seems to be a limiting factor for many operations, especially in high current environments.

An interesting problem has surfaced with the operation of the ROV *Ventana* as the scientists desire to carry larger payloads to the seafloor. On account of the lack of a variable ballasting system, once heavy payloads are deployed, the vehicle is too buoyant to remain at depth to install or operate the payload. Furthermore, the lack of variable buoyancy limits the payload that the vehicle can bring to the surface. A new project for 2004 will develop a variable buoyancy system for *Ventana*, which will be an important feature as this vehicle begins to service instruments to the MARS observatory. This system will also reduce ascent and descent rates for the vehicle, maximizing time at the target depth.

Another recommendation that came out of the June MOOS workshop was the need for the ability to take a water sample aboard the AUV. A team led by Drew Gashler, John Ryan, and Farley Shane will define science uses and engineering functional requirements for such a system to determine whether MBARI needs can be met by modification of an off-the-shelf system, or whether a new build is required. We also hope to see finally in 2004 the delivery of the seafloor mapping vehicle. As of October 2003, the sonar vendor, Reson, had yet to deliver the payload!

Bioluminescence measurements in support of Steve Haddock's programs can be routinely collected during the AUV-CTD missions, but the current sensor is not depth rated to the same maximum depth as the other sensors. Furthermore, it is not easily reintegrated into the vehicle if it has to be removed in order to conduct deeper missions. In 2004, MBARI will investigate improvements to the bioluminescent detector to address these problems.

New *In-Situ* Instruments

Goals for Ken Johnson's chemical sensors lab for 2004 are to expand the use of ISUS and DigiSCAN to more chemical species and to extend the endurance and reliability of their deployments in the field to a year or more. With funding from the National Science Foundation, these chemical systems will be deployed on a prototype nutrient-observing network in Elkhorn Slough.

DORISS (Deep Ocean Raman *In Situ* Spectrometer) will be entering the last year of this phase of development in 2004. The PUP (Precision Underwater Positioning) system will be completed, allowing the laser to be precisely pointed at solid targets underwater. The

probe head will also be redesigned for a smaller package, thus making the system easier to handle and to port to other ROV systems.

The *in-situ* mass spectrometer development is focusing on the high-risk element: an inlet system suitable for use at high pressures without degrading sensitivity or reliability. The team has so far demonstrated that the membrane system they designed can sustain 6500 PSI for at least 5 hours and measure a suite of dissolved gases in both oceanic and hydrothermal vent seawater. The system is depth rated to 4500 m. The goal for 2004 is a full science deployment.

With substantial co-funding from the National Ocean Partnership Program, the design of the second generation ESP is now underway. The goal is to make a system that can be routinely deployed and maintained by a team of technicians (as opposed to an engineering department). The new design has reduced the size, complexity, and power consumption of the original prototype. Testing of the new system is planned for August 2004. A deep-water version is also being developed in support of Ed DeLong's involvement in the Keck project.

MBARI's newest researcher, Zbigniew Kolber, is initiating a program to develop a family of instruments based on novel optical, electrochemical, and MEMs technology, capable of operating in a distributed network environment. These instrument packages will be used to study photosynthetic activity, bacterial respiration, and patterns of primary production and export. The ultimate goal of BiOSA (Biophysical Oceanographic Sensor Array) is a compact instrument frame carrying a wide range of sensors to measure the biological and chemical state of the ocean. BiOSA will have low power consumption and be capable of deployment on a variety of existing and emerging platforms, including moorings, AUVs, and cabled observatories.

Data Management and Information Outreach

The VARS (Video Annotation and Reference System) will be for the most part completed in 2003. The query system has already been opened up to outside users. For 2004, the goals will be to update both ships to the latest system to allow for real-time annotation at sea, create training manuals for users of the new software, and address all of the bugs and usability issues that will surface as the software goes into operational mode.

George Matsumoto, with help from the staff of the Monterey Bay Aquarium, will continue the EARTH (Education and Research: Testing Hypotheses) near-real-time workshops. The purpose is to develop with teachers the tools to enable observatory data to be used in the classroom. Through the auspices of the MBARI/MBA joint projects, MBARI will also be providing scientists and engineers to mentor and judge students competing in ROV contests. MBARI will also help in the redesign of the live link program at the Aquarium. As the Mysteries of the Deep exhibit has closed at the Aquarium, the live animals will be returned to the deep sea and periodically revisited to monitor their health and re-adaptation to the wild.

MBARI adjunct Geoff Wheat will act as host for teams of young engineers from Santa Clara University who will be using MBARI's test tank to "field" the instruments and platforms they have developed as part of their training in ocean engineering. On the final visit to MBARI, the students will make presentations to the MBARI staff and demonstrate their inventions.

Table 1: 2004 MBARI Projects

Benthic Processes

Project No.	Associate External Projects	Title	Project Manager	Lead Scientist	Lead Engineer
200001	705001, 705002	Ocean Chemistry of the Greenhouse Gases II	Peltzer	Brewer	Kirkwood
200002		Benthic Biology and Ecology	Barry	Barry	Roman
200006		Ocean Crust Geochemistry: Construction and Hydrothermal Alteration of Oceanic Crust	Stakes	Stakes	
200007		Submarine Volcanism	Davis	Clague	
200009		Long Term Broadband Seismic Observatory in Monterey Bay	Stakes	Stakes, Romanowicz	McGill
200010	701010, 706010, 708010	Continental Margin Processes	Ussler	Paull	
200101		Canyon Dynamics	Ussler	Paull	Massion
200104	701104	Molecular Ecology of Marine and Aquatic Organisms	Vrijenhoek	Vrijenhoek	
900237	800237	Keck Proposal: Seismology and microbial linkages	Stakes	Stakes, Delong	
900405		Beyond Climate: Planning the Science of a Low pH, High CO_2 Ocean	Peltzer	Brewer, Barry	Kirkwood
900421		Electromagnetism in the Ocean	Bellingham		Bellingham

Midwater Research

Project No.	Associate External Projects	Title	Project Manager	Lead Scientist	Lead Engineer
200108	701451	Midwater Ecology	Robison	Robison	
900206	704084	Bioluminescence and Molecular Biology of Zooplankton	Haddock	Haddock, Schnitzler, Herren	
900209		Deep-water Salps in Monterey Bay	Madin	Madin	
900430		Video Archives to Investigate Behavior of Midwater Invertebrates	Hamner, Hamner	Hamner, Robison, Matsumoto	
900432		Investigation of Unobtrusive Observational Techniques		Widder	Massion

Upper Ocean Biogeochemistry

Project No.	Associate External Projects	Title	Project Manager	Lead Scientist	Lead Engineer
200018	702018, 702336, 703018,	Equatorial Pacific Mooring	Chavez, Mahoney	Chavez	Headley
200021	701021	Iron Regulation of Ocean Ecosystems	Fitzwater, Johnson	Johnson	
200023		Southern Ocean Iron Fertilization Experiment	Chavez	Chavez, Johnson	
	704270	AOSN II: Integration and Demonstration of Observation and Modeling	Chandler		
900200		AUV CTD Time Series Measurements	Gashler	Chavez	O'Reilly
900204	708086	Biogeochemical Responses to Climate variability	Chavez, Pennington	Chavez	
900240	701334	Molecular Microbial Oceanography	DeLong	DeLong	
900246	703326	Observing Complexity Coastal Ocean	Ryan	Ryan	
900326	703089	Observations of Open Ocean and Coastal Upwelling Systems in Ocean Process and Climate Research	Ryan	Ryan	
900327		Probe Array Development	Scholin	Scholin	
900329	703329	Studies of Biogeochemical Dynamics of Upwelling Systems Using Drifters	Chavez, Harlan	Chavez	Friederich
900386	703086, 708386,	Simulation of Coastal Ocean Physics and Ecosystems (SCOPE)	Chavez	Chavez/Ryan	
900406		Biofuel Cells	Chandler	Reimers, DeLong	Chandler, Shane
900412		Feasibility Study of Small-Scale pH Perturbation Experiments in the Upper Ocean	Kolber	Kolber	Klimov
900417		Layered Organization of the Coastal Ocean (LOCO)	Ryan	Ryan, Scholin	

MOOS Observatory

Project No.	Associate External Projects	Title	Project Manager	Lead Scientist	Lead Engineer
600026 (600125)		Software Infrastructure and Applications for MOOS (SIAM) (formerly ISI)	O'Reilly	Ryan	O'Reilly
600027 (600125)	701027	MOOS Mooring	Chaffey	Ryan	Chaffey
600031 (600125)		Shore Side Data System (formerly MOOS Data Management)	Graybeal	Ryan	
600125		MOOS Program	Raybould	Ryan	Chaffey
	700125	MARS (NSF)	Raybould		Massion
	708125	NEPTUNE Project (UW Subaward))	Massion		
900313		ATOC Cable Survey	Paull	Paull	
900389 (600125)		*Tiburon* Cable Laying Toolsled	Bird		
900393 (600125)		AUV Docking	Sibenac		Kirkwood
900409		Communication Interface for SIO Benthic Rover - MARS Cable Connection	Barry	Barry, Smith	Roman
900434 (600125)		MOOS Vertical Profiler	Hamilton	Ryan	
900303	708303	MBARI-CIMT	Chavez	Chavez	O'Reilley
900026	701026	SENSORS: Ocean Observing System Instrument Network Infrastructure	Edgington (PI)/Davis (PM)		Edgington

ROV / AUV Enhancements and Upgrades

Project No.	Associate External Projects	Title	Project Manager	Lead Scientist	Lead Engineer
600034		Precision Control Technologies for ROVs and Intervention AUVs	Rock	Robison	McEwen, Risi
	708024	Autonomous Underwater Vehicle Measurements of Arctic Change Due to Atlantic Inflow	Bellingham, Kirkwood		Bellingham
900261		Benthic Respirometer Upgrade	Barry	Barry	
900267		AUV Bioluminescence	Haddock	Haddock, Herren	Thomas
900402		AUV Guidance, Navigation and Control Improvements	McEwen	Ryan	McEwen
900403		AUV Gulper	Gashler	Ryan	Shane
900423		ROVUC - GIS Migration	Graybeal	Barry	Schlining
900424		Seafloor Mapping	Caress	Caress	Kirkwood
900427		*Tiburon* Reliability Refit	Grech	Barry	Au, Graves, Mellinger
900431		*Tiburon* Power Boost	Grech		Mellinger
900433		*Ventana* Variable Buoyancy	Dawe		

New In-Situ Instruments

Project No.	Associate External Projects	Title	Project Manager	Lead Scientist	Lead Engineer
600144	701144, 701452	Chemical Sensor Program (MBARI)	Coletti, Johnson	Johnson	Coletti
600045		DORISS - Deep Ocean Raman In-Situ Spectrometer	Brewer	Brewer	Kirkwood
900213		Characterization, construction, and deployment of a prototype in situ mass spectrometer	Johnson	Girguis, Friederich	Erickson
900238	701238	Costa Rica Osmosamplers (Long Term Continuous Monitoring of Hydrogeologic Properties in Instrumented Boreholes)	Jannasch	Jannasch, Wheat	
900312	701312, 708312	Environmental Sample Processor (ESP)	Jensen	Scholin	Jensen
900392	701450	Biophysical Oceanographic Sensor Array (BiOSA): a New Tool for Assessing Global Trends	Kolber	Kolber	Klimov

Data Management and Information Outreach

Project No.	Associate External Projects	Title	Project Manager	Lead Scientist	Lead Engineer
200103		Core CTD Data - MDUC	Burczynski	Caress	
200105		Core Navigation Data – MDUC	Caress	Caress	Schramm
200109		Core Mooring Data - MDUC	Schlining	Caress	
500049		Video Annotation and Reference System (VARS)	Jacobsen-Stout	Paull	Schlining
500055		ROV Video Outline Annotation - MDUC	Jacobsen-Stout	Caress	
500056		Joint Projects - MBA/MBARI	Matsumoto	Matsumoto	
900245 (600125)		NEPTUNE: Educational Outreach:Testing Hypothesis (EARTH)	Matsumoto	Matsumoto	
900255		Student-Developed Instrumentation	Wheat	Wheat	Kirkwood
900260		Automated Visual Event Detection (AVED)	Edgington	Robison	Edgington
900306		Data Stream Support	Gomes	Johnson	Gomes

Infrastructure Support

Project No.	Associate External Projects	Title	Project Manager	Lead Scientist	Lead Engineer
300057		Mooring Maintenance 2003	Kelley	Chavez	Headley
300058		DMO Divisional Support	Grech		