Project Number: 900827

Project Start: Jan. 1, 2008 **Project Duration (in years): 3**

Please indicate what type of project is being proposed (mark only one).

☐	☒	☐	☐	☐
Feasibility/Scoping [Less than 100 days effort]	**Development**[1]	**Research**	**Infrastructure**[1]	**Education**

☐	☐
Time Series	**Institute Initiative**

Project Manager[2]: Bob Herlien

Principal Investigator: Kurt Buck, Kim Reisenbichler

Lead Scientist: Jim Barry, Bruce Robison

Lead Engineer: Craig Okuda

Project Title:

Modification of in situ respirometers for ocean acidification studies

[1] Development and infrastructure projects must complete the risk matrix (see item #5 at the end of the proposal form).
[2] Not all projects will require all four titles to be filled in. Please indicate individuals only for those titles that are appropriate for your project.

1) ABSTRACT (new projects only)

[Paste abstract here]

2) PROPOSAL

a) Continuing Projects

Current status of project and results to date

- The goal of Project 900827 is to modify the benthic and midwater respirometry systems for ocean acidification studies through a revision of the hardware, software, and mechanical systems that address several issues. The major objectives are to:
- Increase the number of chambers to 6 (MRS) and 8 (BRS).
- Modify the controller hardware and software to accommodate the increased number of sensors, pumps, and stirrers.
- Use gas impermeable materials for chamber construction to reduce oxygen influx into chambers from wall material.
- Add the capability to inject & withdraw samples during incubations.

The project has made important progress this year, in spite of the delay in its start date from January 1 to July 1, 2008.

A preliminary design for the control system was developed during a series of discussions throughout the year, leading to a preliminary design review of the electronics and mechanical architecture of the system held just this week (late July 2008). The current control system is a modified "Oasis" controller that is limited to 3-4 chambers and far more limited I/O capabilities. The new control system is a significant element of the project that will enable control of 8+ chambers (each chamber is an add-on module) for either the midwater or benthic respirometer. Progress on the mechanical design has centered on resolving the oxygen efflux problems from chamber materials (oxygen stored in the acrylic chamber walls effluxes into the contained water during incubations) that currently plague both the midwater and benthic respiration systems. For at least the benthic respiration system chambers, we plan to use glass chambers (a vendor has been identified) that will be protected by a shielding of other materials.

Through this project, we will merge the technology used for respiration studies by the midwater and benthic research groups. The new system will be sufficiently generic that it could be applied is several projects (benthic studies, benthic rover, midwater, other).

Progress during the remainder of 2007 is expected to lead quickly to a final engineering design, but development of prototype control boards and other preliminary production activities may be limited by funds. It appears that sufficient engineering time is available to make progress on the control system, but that funds (<$15 K) to produce prototypes may hinder progress beyond the drawings stage.

Significant changes from previous project proposal

None

Publications based on the results of this project only
None

b) New and Continuing Projects: Plans for 2009

Research Activities
This project is a sub-project of the MBARI Ocean Acidification Initiative. Research related to the respirometer modification project is centered largely on the metabolic rates and physiological capabilities of deep-sea animals of all sorts, and particularly their sensitivity to ocean acidification. Modifications to the respirometers will enable more detailed examination of these aspects of benthic and midwater animals.

Engineering/technology development
We plan during 2009 to implement the engineering design that we expect will be finalized during the latter half of 2008.

The preliminary controller design uses a modular organization to allow expansion of the number of incubation chambers to 5-10 (Figure 1). The new controller will continue to use Persistor CF2, but the I/O system will be modified to allow the greater flexibility required for the increased number of sensors, pumps, and stirrers used on the more capable system. Software has always been a problem for the old system, which required engineering time to configure the controller for nearly every deployment. Modifications planned for the new system will provide users a fairly straightforward interface for controller operation, system deployment, and data download.

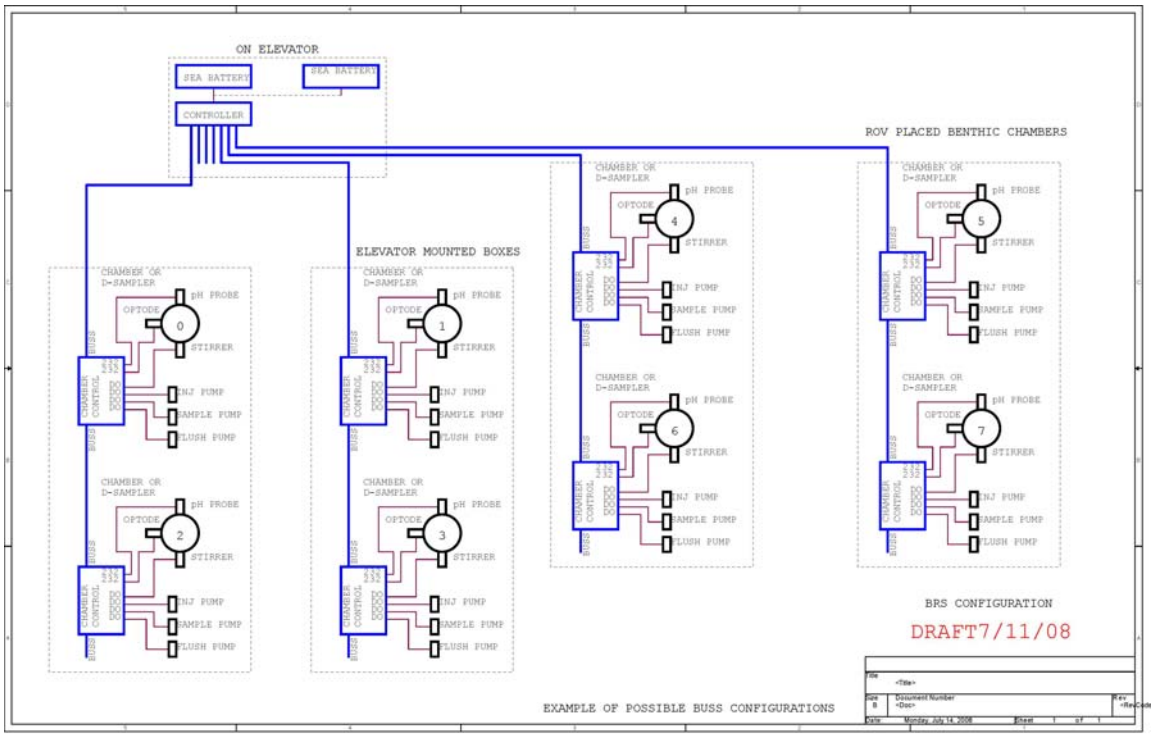

Figure 1. BRS/MRS system layout. Note the modular design of individual chambers.

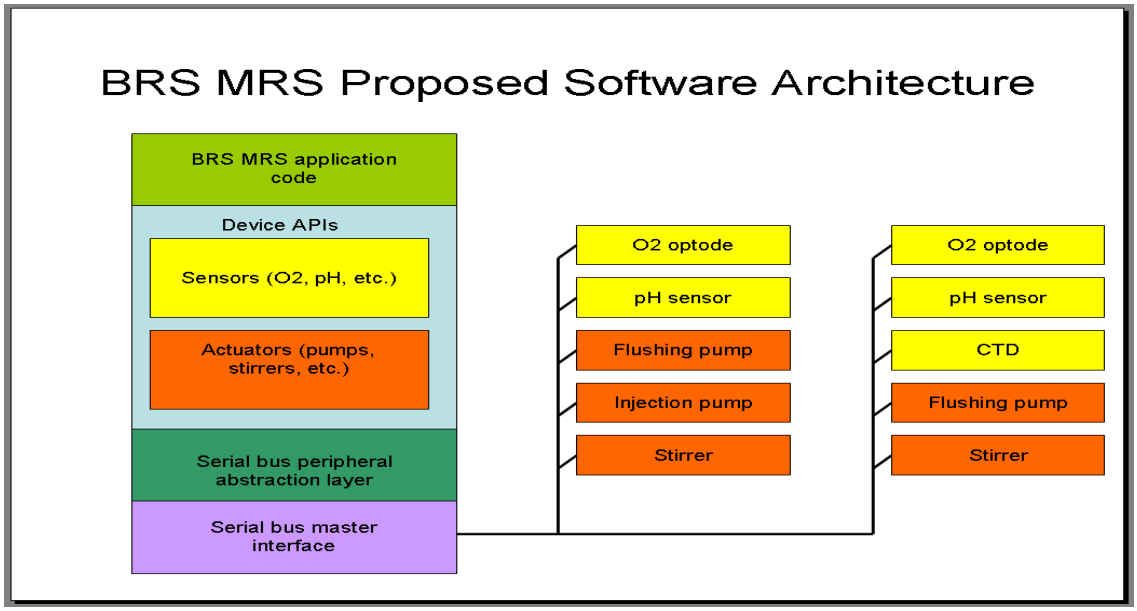

Figure 2. Overview of software architecture for BRS / MRS.

Increasing the number of chambers reduces the ship-time required for a complete dataset. Eight chambers is a reasonable compromise between the costs of shiptime and the number of replicate measurements per deployment of the system (Figure 3). Although we plan to implement 8 chambers for the benthic respiration system, constraints on battery power and weight will limit the MRS to 6 chambers. The benthic respiration system will be mounted on an elevator and deployed as a free-vehicle, allowing for the higher system weight (driven mainly by batteries).

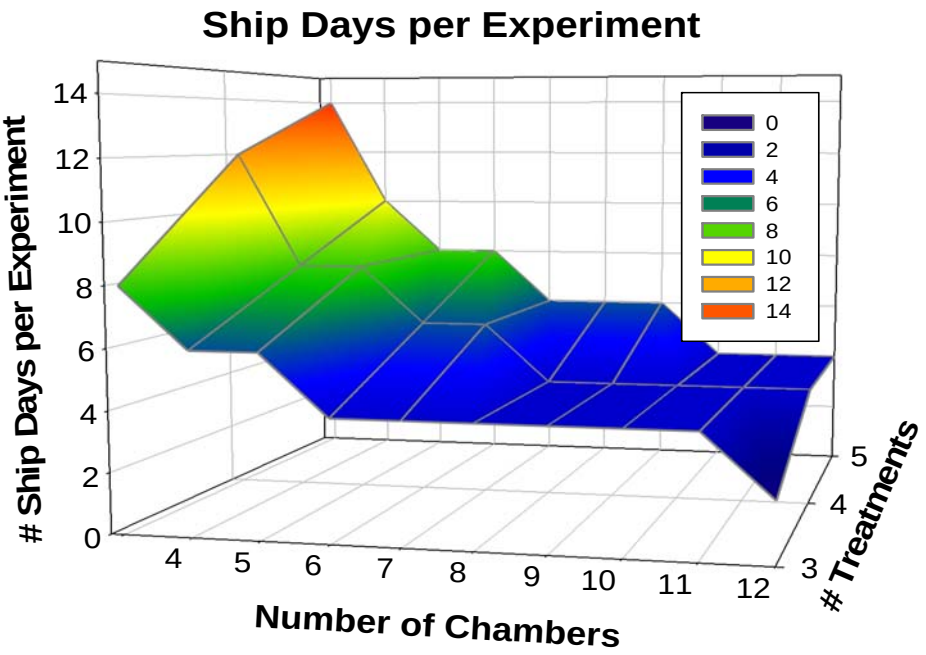

Figure 3. Number of ship-days versus the number of respirometer chambers and treatments (e.g. low, medium, high CO2). Note that the greatest benefit is gained by reaching ~8 chambers.

Field programs (detail ship requirements/deployments)
Field tests of the new systems (BRS, MRS) are planned for the second quarter of 2009, with further testing and operations later in the year. We request 4 days of Pt. Lobos / Ventana to support testing (2 days each for MRS & BRS).

Specific deliverables
Hardware: upgraded midwater and benthic respiration systems.
Peer-review publications on the development and data collected from the respiration systems.

Milestones
Critical Design Review (1/31/09)
System Development (3/30/09)
System development and fabrication (6/1/09)
Initial deployment and testing (8/30/09)

Budget justification
Although the budget request is substantial ($211K, including a 25% margin for uncertainty), the project supports 2 research groups (benthic and midwater). Our estimate for the cost of the control system for both systems is $27 K. To produce 8 chamber modules each for the BRS and MRS will cost $93K and $91K, respectively. The cost of a single electronics module for each chamber is expected to be near $1217, plus sensors. Modest cost reduction for 2009 could be achieved, if necessary, through a reduction in the number of chamber modules produced in 2009. It is more efficient, however to produce all units at the same time. For both the MRS and BRS, any existing sensors (oxygen optodes), motors, and pumps will be transferred to the new system, thereby decreasing overall costs. Twenty-five percent ($42K) of the above estimates represent the margin included for uncertainty. This relates to potential changes to the now preliminary design and likely increases in the cost of goods over the next several months. Our request for this project originally split most of these costs over 2 years, but the funds allocated for 2008 were reduced to near zero.

Labor requests were developed by the engineering team, based on experience with earlier respirometer development. We also request 2 days of marine technician support for help with integration of the respirometers with the ROVs.

Ship-time requests are for at-sea testing of the systems. We are requesting 2 days each for the midwater and benthic respiration systems. Concurrent testing of both systems at sea is not possible.

Project team
Science:
Jim Barry, Bruce Robison (lead scientists)
Kurt Buck, Kim Reisenbichler (Principal Investigators)

Engineering:
Mike Risi
Craig Okuda (lead engineer)
Bob Herlien (project manager)

Project lab space
We are presently using a small amount of lab space in building B for the benthic respiration system, but this space is too small to complete the development of the larger BRS and MRS. We can continue to us this space for some of the development, but request additional space in an area suitable for the assembly of these larger respiration systems – perhaps some space in the bay area of building D (ROV area).

Data availability outside project team, uniqueness
Data from the BRS and MRS will be available in publications arising from its use.

The electronic and software upgrades to both respirometry systems will better enable MBARI to transfer this technology to the outside research community, should the publications that result from these systems create sufficient interest. Hypothetically, if another institution showed interest in duplicating one of these systems, MBARI could either supply them with the plans and software or build a replica system(s) under contract.

Risk matrix (development and infrastructure projects only)

	Technical Risk	Organizational Risk	Tech Transfer Risk	Labor Estimate Risk
High				
Medium			X	
Low	X	X		X

3) MILESTONES (new and continuing projects)

	Milestone 1	Milestone 2	Milestone 3	Milestone 4	Milestone 5	**Total Resources**[3] for each resource category for all milestones listed here
	Milestone 1	**Milestone 2**	**Milestone 3**	**Milestone 4**		
Milestone Date	**Jan 30**	**Mar 30**	**June 30**	**Aug 30**		
Milestone Description	**CDR**	**System Development**	**Sys Dev and Fabrication**	**Initial Deployment**		
EE						
SE	**10 (Risi)** **10 (Herlien)**	**260 (Risi)** **185 (Herlien)**	**210 (Risi)** **145 (Herlien)**	**80 (Risi)** **60 (Herlien)**		**560 (Risi)** **400 (Herlien)**
ME						
Support Engineering	**10 (Okuda)**	**314 (Okuda)**	**32 (Okuda)**	**16 (Okuda)**		**364 (Okuda)**
EE Tech		**44**	**44**	**8**		**96**
SE Tech						
ME Tech			**124**	**8**		**132**

(See next page for personnel classification information.)

[3] This number should be the same number you entered on the resource requests for this particular resource.

Personnel Classifications

Mechanical Engineers (regular)	**Electrical Engineers** (regular)	**Software Engineers** (regular)	**Support Engineers** (regular)	**Mech Technician** (regular)	**Mechatronics Engineer** (regular)	**Electrical Technician** (regular)	**Software Technician** (regular)	**Observ Support Technician** (regular)
Gene	Mark	Tom	Craig	John F		Carolyn (2/3)	Karen	Mike K
Jon	Ed	Brian	Thom	Jim Sch		Dick L		Paul
Farley	Paul	Rich H	Mike McC	Mike Parker		Tom		Zorba
Brett	Alana	Rob	Rick Schr			Jose		
Doug P	Scott	Brent	Brian Sc			Jim M.		
Bill K (2/3)	Chad	John G	Mark Brown (1/2)					
Jim Birch (2/3)		Kevin						
Andy		Danelle						
Larry Bird		Bob H						
		Mike R						
		Wayne R						
		Duane (2/3)						
		Kent (2/3)						

Mechanical Engineers (term)	**Electrical Engineers** (term)	**Software Engineers** (term)		**Mech Technician (term)** (term)	**Mechatronics Engineer** (term)	**Electrical Technician** (term)	**Software Technician** (term)	**Observ Support Technician** (term)
					Adeline			
					Cheri			

Proposed WBS for Project 900827 (Modification of in situ respirometers for ocean acidification studies)

		Jan - Mar 2009						Apr - Jun 2009						Jul - Sep 2009					
Task Description	**Hours**	**Risi**	**Okuda**	**Herlien**	**E-Tech**	**M-Tech**	**M-Shop**	**Risi**	**Okuda**	**Herlien**	**E-Tech**	**M-Tech**	**M-Shop**	**Risi**	**Okuda**	**Herlien**	**E-Tech**	**M-Tech**	**M-Shop**
Reviews																			
Critical Design Review	30	10	10	10															
Management																			
Project Management	60			20						20						20			
Technician Oversight	20		8						8						4				
Development																			
Software Development																			
I/O expander firmware development	130	90						40											
Common application development	90	40						40						10					
BRS application development	50	20						20						10					
MRS application development	50	20						20						10					
Mission downloader and configurator	45	20						20						5					
OASIS kernel mods	80			40						40									
Application configuration definition	80	20		40				20											
Application configuration implementation	80			40						40									
Electrical Development																			
System Electronics			16		20				16		20				20			8	
System Controller	60		30		20				10										
Chamber Controller	60		30						10			20							
Junction box and connectors	12				4						8								
Sensor modification	40		40																
MRS system cabling	8		8																
BRS system cabling	8		8																
Mechanical Development																			
Controller housing MRS/BRS	20						20												
Chamber Controller							16												
Sea Battery	16		8									8							
Junction box																			
Hydraulic Decupler	40		20				20												
Flushing pump modification																			
Aanderaa adapters	80												80						
Glass work	156								60		16	80							
MRS system frame	20								20										
BRS system frame	38								20			8	10						
Testing																			
Testing and deployments	311	50		45				50		45		8	10	45	18	40			
Totals (hours)	**1584**	**270**	**178**	**195**	**44**	**0**	**56**	**210**	**144**	**145**	**44**	**124**	**100**	**80**	**42**	**60**	**0**	**8**	**0**

Totals hours by resource	
Risi	**560**
Okuda	**364**
Herlien	**400**
E-Tech	**88**
M-Tech	**132**
Machine Shop	**156**

Note: Unless specified with BRS or MRS all task are common to both instruments.

8/4/2008
Rev 0