Project Number: 906017

Project Start: Jan. 1, **2006** **Project Duration (in years):** **2**

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
	X				

Project Manager/PI:
Kim Reisenbichler, Bruce Robison (co-PI)

Project Title:

Midwater Respirometry System (MRS)

[1] Development and infrastructure projects must complete the risk matrix (see item #5 at the end of the proposal form).

1) ABSTRACT

In order to accurately determine the flux of carbon within the intricate meso-and bathypelagic food webs, researchers need to accurately measure the metabolic rates of the major constituents of these communities. The primary method used to determine metabolic rates is the measurement of oxygen consumption. While several researchers have published oxygen consumption rates for a variety of zooplankton and micronekton species, most measurements have been made in shipboard labs, at surface pressure and on robust animals collected by nets or suction sampler. These measurements have shown that deep living pelagic fish and crustaceans have much lower metabolic rates than do shallow living species.

Measurements of deep living gelatinous animals have been more problematic due to their fragile structure, which makes collection and transfer of specimens tenuous, at best. Also, the activity levels of many gelatinous organisms has been observed to be lower at the surface than what has been observed at depth, bringing into question whether experiments conducted at surface pressures truly represent natural respiration rates. The only experiment to directly compare in situ respiration vs. laboratory respirometry measurements of three gelatinous phyla, showed a 2 to 5- fold higher rate of oxygen consumption at depth than what was observed at surface pressure. Should the findings of this experiment prove valid, the role of mesopelagic gelatinous zooplankton in the deep-sea carbon cycle is being greatly underestimated.

We are proposing to build an ROV deployed midwater respiration system (MRS) to: 1) conduct respirometry measurements on animals that do not survive capture and transport to the surface and, 2) determine the effects of pressure on the respiration rates of those organisms that can also be respired at the surface. Animals will be collected into individual respirometry chambers and then the whole package will be left in situ for 24 to 48 hours for incubation. This system will be the only functioning midwater system of this type in the world and will allow us to gather experimental metabolic data on a variety of meso- and bathypelagic animals under natural conditions.

The MRS is a low-risk system. It will use many of the sensor, control, and data logging components previously developed at MBARI for the Benthic Respirometry System (BRS). Modifications will be made to our existing detritus samplers so that they can be used as respirometry chambers. We envision that the deployment at depth will be done by one or more of the following methods: 1) leave the package on the seafloor at the desired depth and retrieve it with an ROV; 2) attach the MRS package to an existing mooring or observatory cable and retrieve with an ROV; 3) deploy a midwater elevator assembly that the MRS package can be offloaded to from the ROV and then recovered using an acoustic release or; 4) incorporate the MRS into a midwater drogue that would drift at depth and then surface after 24 to 48 hrs.

2) PROPOSAL

a) The problem addressed (new projects only)

Statement of the problem

Over the last three decades, a relatively small group of researchers have been measuring the metabolism of deep-sea organism in an effort to understand their physiology and, more recently, their role in oceanic carbon transport. Unfortunately, the majority of the animals were collected by dragging a net through the water, generally bringing the animal to the surface abraded and decompressed. The least damaged animals were then used to measure oxygen consumption rates. Relatively recent access to research submersibles has allowed for the more gentle collection of animals via suction and detritus samplers, minimizing abrasive damage to the animal, but they still undergo decompression as they are brought to the surface and in most cases are subject to surface pressure while oxygen consumption rates are measured. Furthermore, many deeper living organisms (>1000m minimum depth of occurrence) do not survive decompression for respirometry measurements at the surface and the gelatinous animals throughout the water column can be difficult to respire do to their delicate nature.

The question of the validity of oxygen consumption measurement made on deep-sea organisms at surface pressure has always been of concern and has been addressed in a number of laboratory experiments where the animals were recompressed prior to respiration measurements. For the most part, these experiments have shown that there is little affect of pressure on the metabolic rates of the animals studied, primarily fish, crustaceans and molluscs found in the upper 1000m and that the general metabolic trend is for the rate to decrease with depth at a higher rate than can be explained by the associated temperature drop. Childress and Thuesen (1992 and 1993) reached a similar conclusion on the affects of hyperbaric pressure on six, relatively robust gelatinous midwater species. However, they also showed that these species exhibited higher metabolic rates than one might expect based on the decline with depth in metabolic rates found in fish and crustaceans.

The observation that deep living gelatinous organism may have higher metabolic rates than expected was taken further by Bailey, et al. (1994) who made *in situ* vs. laboratory comparisons of the respiration rates of four gelatinous species representing three phyla. There data showed a 2 to 5 fold higher rate of oxygen consumption at depth than what was observed at surface pressure. These latter findings indicate that the role of gelatinous zooplankton in the deep-sea carbon cycle is being greatly underestimated.

We propose to address this question by developing an ROV deployed midwater respiration system (MRS). The purpose of this system will be to: 1) conduct respirometry measurements on animals that do not survive capture at depth and transport to the surface and, 2) determine the effects of pressure on the respiration rates of those organisms that can also be respired at the surface. Animals will be collected into individual respirometry chambers and then the whole package will be left *in situ* for 24 to 48 hours for incubation. This system will be the only functioning midwater system of this type in the world and will allow us to gather experimental metabolic data on a variety of meso- and bathypelagic animals under natural conditions that cannot be duplicated in the lab.

Why it is important

The emphasis of the Midwater Ecology Project has shifted towards quantifying the transfer of energy, or carbon flux, between the different legs of the pelagic “Jelly Web”. In order to accurately quantify the contribution that jellies, as well as hard-bodied animals make to the nutrient flux within these communities, it is critical to have a means to accurately measure metabolic rates at depth and the MRS is a practical, low risk solution.

Present state of art/understanding

MBARI has already invested in the development of the Benthic Respirometry System (BRS) that is now operational. The BRS utilizes Aanderaa optodes to measure dissolved oxygen and temperature. These sensors have proven to be incredibly stable and trouble-free as compared to traditional polarographic electrodes used in most labs and in the field. We will use the same optode sensors and modify four of our existing detritus samplers so that they can serve as respirometry chambers.. We envision that the deployment at depth will be done by one or more of the following methods: 1) leave the package on the seafloor at the desired depth and retrieve it with an ROV; 2) attach the MRS package to an existing mooring or observatory cable and retrieve with an ROV; 3) deploy a midwater elevator assembly that the MRS package can be offloaded to from the ROV and then recovered using an acoustic release or; 4) incorporate the MRS into a midwater drogue that would drift at depth and then surface after 24 to 48 hrs.

How it relates/contributes to MBARI’s mission and strategic plan

The development and regular deployment of the MRS utilizes MBARI’s unique assets (ships, ROV’s, technology development capabilities and access to deep water) to answer an ecological question not readily addressed elsewhere. It also capitalizes on the investment that MBARI has already made in the BSR.

b) Approach to the problem (new and continuing projects)

Status of project

New

Plans for 2006

Engineering/technology development

The MRS project will use many of the sensor, control, and data logging components previously developed at MBARI for the Benthic Respirometry System (BRS). Modifications will be made to our existing detritus samplers so that they can be used as respirometry chambers and will primarily require the purchase, fabrication and adaptation of components during the first year. Our task outline is as follows:

- Design, modify and/or fabricate the electronics, software, housings, cabling and adapters required to interface and control COT Aanderaa optodes onto four Harbor Branch Oceanographic Institution Detritus Samplers.
- Design and construct MRS benthic deployment package that is compatible with both MBARI ROVs and test.
- Develop concept design for MRS midwater deployment package and hold a Concept Design Review.
- Final design and construct MRS midwater deployment package (2007)

Field programs

The field program is set up in two stages in order to: 1) allow us to identify any unanticipated problems at an early stage and 2) to allow us to begin to collect scientifically relevant data prior to the completion of project.

- Test respirometer assembly in laboratory and short-term in situ incubation experiments. The latter will be performed using an ROV (either *Ventana* or *Tiburon)* on Midwater Ecology dives and will be conducted within the normal timeframe of the dives.
- Conduct in situ respirometry measurements using the MRS and benthic deployment package in the latter half of 2006 in conjunction with Midwater Ecology cruises. Midwater animals will be collected at an approximate depth to that of a predetermined, readily available shelf, plateau or flat area. The ROV will reposition to the deployment site and the package will be off-loaded to incubate at depth and be recovered on the following day by the ROV and brought back to the surface.

Data (availability outside project team, uniqueness)

The oxygen consumption data collected with the MRS will be integral to quantifying the flow of energy, or organic carbon, within the meso- and bathypelagic food webs. The data will be used in publication and posters produced by the Midwater Ecology Group and those of MBARI collaborators that can benefit from using this system.

The data collected with the regular usage of the MRS will be unique and will allow us to measure the metabolic rates of meso- and bathypelagic animals that heretofore have only been measured after decompression and recompression or, not at all because they cannot survive the initial decompression experienced when brought to the surface from depth.

c) Specific deliverables (new and continuing projects)

Year 1: - A four-channel midwater respirometry system/benthic deployment package.
Year 2: - A four-channel midwater respirometry system/midwater deployment package.
- Presentation at a science conference highlighting the technology and early results.
- A peer reviewed publication that utilizes the data collected with this system.

d) Project team (new and continuing projects)

PI/Project Manager:	Kim Reisenbichler
Co-PI:	Bruce Robison
Lead/Mechanical Engineer:	Brett Hobson
Electrical Engineer:	YTD
Support Engineer:	Craig Okuda

e) Project lab space (new and continuing projects)

We are requesting approximately 8 feet of counter space in one of the engineering labs for component/system assembly and testing.

3) BUDGET JUSTIFICATION (new and continuing projects)

a) Supplies
   i) Equipment <$5000
      (1) Aanderaa optodes (4 X $4500=$18K). Four optodes are required for this system; one for a control sampler and three to respire specimens.
      (2) Homer Pro beacon - $4.5K. Required to relocate system after the end of a deployment (24 to 48 hrs). May not be required if we can borrow a unit from DMO for these short deployments.
      (3) HBOI detritus sampler mounting brackets (2 X $2000=$4K). Required to mount modified detritus samplers on MRS assembly.
   ii) Supplies – General
      (1) Parts and materials for optode adapter assemblies - $2930. Used to adapt bulkhead penetrating optode to a standard underwater connector configuration.
      (2) Materials for 4 km aluminum electronics housing - $550. Used to house the control and data log boards, as well as the batteries.
      (3) Alkaline battery packs (4 ea. X $175=$700. Used to power the controller, optodes and stirrers.
      (4) Electronics boards (Oasis board stack and CF2 + card) - $3600. Used to control the optodes and stirrers, as well as log data.
      (5) Parts and materials for the stirrer assemblies - $2150. Used to slowly circulate the water within the respirometry chamber during the experiment.
      (6) Parts and materials for hydraulic decoupler - $2100. Used to allow the hydraulic function used to open and close the detritus samplers to be disconnected upon deployment of the system.
      (7) Misc. spare (connectors, cables, etc…) - $500

4) MILESTONES (new and continuing projects)

	Milestone 1	Milestone 2	Milestone 3	Milestone 4	Milestone 5	**Total Resources**[2] for each resource category for all milestones listed here
Milestone Date	**2/15/06**	**3/15/06**	**6/25/06**	**8/2/06**		
Milestone Description	PDR	CDR	Lab test	Field deployment 1		
EE	**1**	**1**	**3**			**5**
SE			**6**	**5**		**11**
ME	**10**	**8**	**5**	**1**		**24**
Machine Shop			**21**			**21**

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

5) RISK MATRIX (development and infrastructure projects only)

Please carefully read Section 5.2.3 in the instructions for internal proposals for an explanation regarding the risk matrix. This table must be completed for **ALL** development and infrastructure proposals (new and continuing). The instructions can be found at http://mww.mbari.org/resources/2006_Proposal_Process/Internal-only_Instructions_2006.htm.

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

Bibliography

Bailey, T.G., J.J. Torres, M.J. Youngbluth and G.P. Owen. 1994. Effect of decompression on mesopelagic gelatinous zooplankton: a comparison of in situ and shipboard measurements of metabolism. Mar. Ecol. Prog. Ser. Vol. 113:13-27.

Childress, J.J. and E.V. Thuesen. 1992. Metabolic potential of deep-sea animals: regional and global scales. In: Rowe, G.and V. Pariente (eds.) Deep-sea food chains and the global carbon cycle. Kluwer, New York, p. 217-236.

Childress, J.J. and E.V. Thuesen. 1993. Effects of hydrostatic pressure on metabolic rates of six species of deep-sea gelatinous zooplankton. Limnol. Oceanogr. 38:665-670