**Project Number:** 901012

**Project Start: Jan. 1, 2010** **Project Duration (in years): 2**

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

| | | | | |
|---|---|---|---|---|
| [ ] | [x] | [ ] | [ ] | [ ] |
| **Feasibility/Scoping** [Less than 100 days effort] | **Development**[1] | **Research** | **Infrastructure**[1] | **Education** |
| | [ ] | [ ] | | |
| | **Time Series** | **Institute Initiative** | | |

Project Manager[2]: Brett Hobson

Principal Investigator: Brett Hobson

Lead Scientist: Jim Barry and Ken Smith

Lead Engineer:

# Project Title: Imaging AUV

[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.

# a) <u>Continuing Projects</u>

### Current status of project and results to date

This proposal is for the second year of a two year effort to refine the Imaging AUV (IAUV) for operations by DMO in support of both benthic and midwater science. So far this year, the IAUV has been operated by DMO for Steve Rock and Jim Barry and the video lab is getting ready to begin annotating benthic transect data for entry into VARS. To smooth-out resource scheduling this year, this poject was asked to phase most of the development work to the second half of the year so we are just now getting started on the tasks for this year.

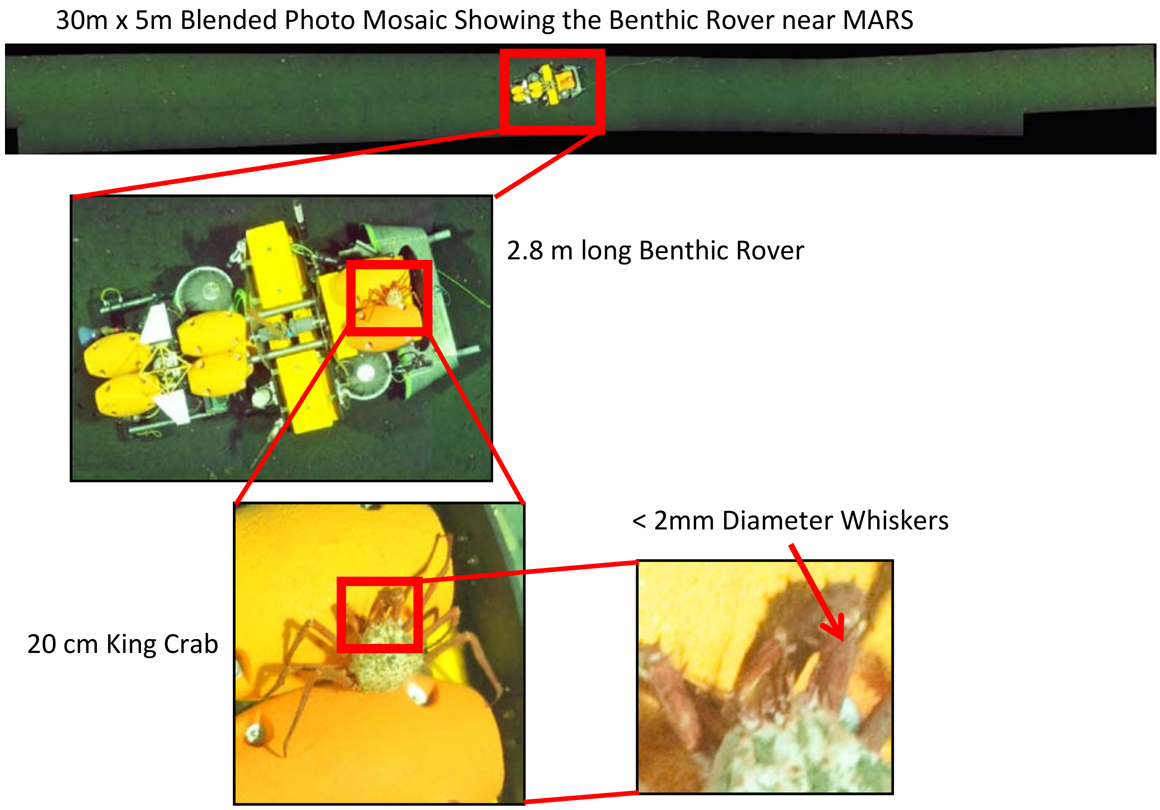


**Figure 1: Sample of IAUV data showing linear mosaic and high resolution capabilities**

### Significant changes from previous project proposal

There was a delay in delivery of the 4-km depth rated camera housing from an outside vendor so we were forced to postpone dives for Ken Smith at Station M until his November cruise.

### Publications based on the results of this project only

No publications for this project yet.

## b) New and Continuing Projects: Plans for 2011

We propose to work on three main tasks in 2011: (1) Refine the existing capability of benthic imaging and support ongoing operations; (2) develop a new capability of imaging in the Midwater, and (3) finish the data infrastructure for the IAUV. The most difficult tasks are to improve the agility of the AUV to allow safe, controlled flight at altitudes low enough for color imaging over rough terrain. Collaboration with the proposed Ocean Imaging project has also identified that low altitude AUV flight is required for high resolution acoustic imaging. Ongoing collaboration with Steve Rock's precision control project is beginning to provide innovative techniques to improve our navigation and provide a predictive element to the terrain following algorithims developed by Rob McEwen so we are optimistic we will be able to perform many of the missions proposed by MBARI's scientists.

In parallel with the benthic work we feel it is a good time to figure out how to perform routine midwater transcects with an autonomous system, and free up valuable ROV deployments for interactive tasks. This will require a change in the experimental protocol for midwater transects, but we feel confident we can find a technique that will produce comparable results and are interested to see if the quiter AUV may even image animals that currently avoid the ROV. While benthic imaging with the AUV requires the Zephyr to follow the AUV to perform surface aiding navigation updates, midwater tansects could be performed without surface ship support. The AUV must accuratly control its depth, but the precise X-Y navigation is not necessary in the midwater. When the AUV is operated without suface ship support, the full potential operational cost reductions of un-manned vehicles are realized.

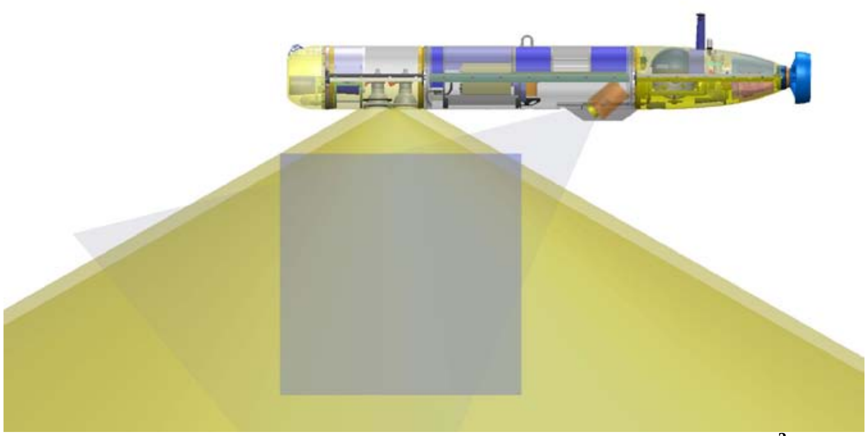

**Figure 2: IAUV configured for Midwater Mode, showing the 2m$^3$ sample box**

The Midwater group at MBARI has been very successful identifying animals with a forward looking high definition camera and several kW of light. While the AUV can be configured to image in a forward-looking mode, the geometry of the camera and lights are sub-optimal and will cause strong backscatter unless something like range gating is used. Our approach is to use the AUV's length to our advantage by placing the strobes in the nose to illuminate a ~ 2m cube, then tilt the existing downward-looking high resolution still camera slightly forward. The still camera captures images at twice the resolution of the HD video, though at only 1 frame every 1.5 seconds. We can temporarily move the tail strobe up to the nose and either fire both strobes together for more light, or alternate firing to increase the lighting duty cycle. More light is needed for midwater imaging for two reasons: First, the animals are small and many are translucent so very little light is reflected back to the camera, and also, we need a much greater depth of field in the midwater to ensure animals close and in the background are all in focus, which requires a small lens aperture, which limits light reaching the imaging chip.

During the final year of this effort we will streamline the data flow of images and their related metadata from the AUV into data within VARS. We'll be creating a dedicated portal for the IAUV that is similar to what was developed for the CTD AUV. For each high resolution photograph, a separate data file will be created that contains information relevent to the image, e.g. lat/long and heading of the image and the width and height of imaged area. We hope to also add information about the over-lying water: salinity, temperature and amount of disolved oxygen. All of this data will be easily accessible by the scientists who are analyzing the data.

This project is coordinating with the following projects and project proposals:

1. Barry's Benthic Biology and Ecology
2. Smith's Palegic Bentic Coupling
3. Robison's Midwater Time Series
4. Paull's Canyon processes
5. Deep Sea Guide
6. Carress' Ocean Imaging
7. Haddock's Plankton Imaging

**Research Activities**

[Click here to enter text]

**Engineering/technology development**

**Task 1** is to finish up the development of the Benthic Imaging mode. The first set of tasks is to support ongoing operations of the IAUV. **Task 1.1.1** is to upgrading the scaling lasers to green wavelengths that will be useful for operations above 3-m altitude. The current red lasers are only visable in the images at altitudes below 3m. **Task 1.1.2** is to add a CTD and DO sensor to provide contextual environmental information to the image metadata that is valuable for helping to explain change in the images at a given location over time. The final task of this group is to provide technical support to DMO for IAUV operations.

**Task 2** is to develop a Midwater Mode for the IAUV. **Task 2.1** is to deploy the IAUV camera system on the MBARI ROVs and capture AUV-like images at the same time as the Midwater Group is collecting their routine midwater trascect data. We plan to integrate the equipment in the first month of the year and collect data on 6 of the 12 midwater trascect missions. For the first two missions, the IAUV team will collect the data and train the Midwater Group to operate the camera system, who will then collect data during the following four missions. **Task 2.2** is to deploy the IAUV along the same midwater transects as the ROV collected data. We hope to perform these surveys as close in time to the ROV surveys as possible. We plan to run at least two of these missions without ship support, but are still requesting four days of Zephyr time.

**Task 3** is to refine the Data Flow from the IAUV. **Task 3.1** is to develop a copy of the existing data portal for the CTD AUV. **Task 3.2** will be to modify BIAUV portal to also offload the images from the AUV to the shared drive on Tornado. **Task 3.**3 will setup a process to execute the existing matlab code that generates a metadata file for each image when a portal publishes a new mission. **Task 3.4** will be to setup a process to load images and metadata into the VARS-imaging database when the Matlab process completes. All of these tasks require either Brian Schlining or Mike McCann.

The remaining subtasks of the Data Flow task are for AVED procesing of the AUOV's Midwater Time Series images. After the AUV image sequences in digital format are uploaded and post-processed on shore they are then ready to be sent to the *AVED Process* where events of interest are detected and tracked. Following AVED processing, event images (cropped images of events) are then sent to the *AVED Classification Process* to be classified into the lowest possible taxonomic category. Classifier results are then merged with the AVED detection results. The final AVED detection results are then sent back to the Science Annotator in its raw XML format to preview and edit the results. If integration with an existing data management system were desired, the data management system would ingest the AVED XML data. Four sub-tasks needed for these data flows are: **Subtask 3.5.1: Create a training database.** In order to classify images into the lowest possible taxonomic category, first a training database is needed. This training database consists of images that represent the classes desired (e.g. Three steps are needed to create a image training database for the IAUV 1) Identify the best images to generate the representative training database from. This can be a random sampling of images, but these are typically the images highly populated with representative animals of interest. 2) Process these images through *AVED Process* with the option to generate a cropped, event-centered image of all detections. 3) Sort these event-centered images using the AVED sorting graphical interface. Most of these steps are automated and reuse the existing AVED software, except step 3 that requires an expert science user to verify the images are in fact representative of the target category. We know from previous classifier work that creating a training library requires many days of effort; therefore, a fair amount of time should be devoted to this task to create the training library. This task will be performed by the video lab, and time for this work is budgeted under Robison's proposal. **Subtask 3.5.2: Tune AVED algorithm for benthic and midwater imagery.** There are many tunable parameters in AVED to improve the detection results. Danelle will create processing options optimized for each image type (e.g. benthic versus midwater). Preliminary work started on this task in 2010 on the IAUV benthic images; the work in 2011 will be to further optimize benthic as well as add midwater. Because the AVED software has existing optimized processing parameters for both midwater and benthic images from the Doc Rickets and Ventana ROV's, we expect this work to be similar to these parameters and straightforward.

**Table 1: Labor request, by task**

| IAUV 2011 | Task Time (hrs) | Subtask Time (hrs) |
|---|---|---|
| **Task 1: Benthic Imaging** | 963 | |
| Task 1.1: Support Benthic Imaging | | |
| Task 1.1.1 Upgrade scaling lasers - 3 green | | 77 |
| Task 1.1.2: Integrate contextual sensors | | 235 |
| Task 1.1.3: Provide technical support to Dmo | | 219 |
| Task 1.2: Terrain and trackline following | | |
| Task 1.2.1: Stanford precision control | | 120 |
| Task 1.2.2: Continue to improve Dorado control | | 400 |
| *Milestone 1: Canyon axis dive* | | |
| **Task 2 Midwater Imaging** | 255 | |
| Task 2.1 ROV deployments | | 89 |
| Task 2.2: IAUV deployements in the midwater | | 165 |
| *Milestone 2: Compare 3 collection modes* | | |
| **Task 3: Data Flow** | 700 | |
| Task 3.1-3.4: Refine data flow into VARS | | 200 |
| Task 3.5 Refine AVED processing | | 500 |
| *Milestone 3: Compare AVED to annotater* | | |
| Project management | 75 | |
| **Total Hours** | **1993** | |

**Table 2: Labor request, by engineer**

| Engineer | Task | Time req. (hrs) | Task time (hrs) |
|---|---|---|---|
| **Brett** | | 495 | |
| | Task 1.1.1 Upgrade scaling lasers - 3 green | | 9 |

| | | | |
|---|---|---|---|
| | Specify and order | | 9 |
| | design brackets | | 10 |
| | Task 1.1.2: Integrate contextual sensors | | 67 |
| | specify and order | | 9 |
| | design bracketry | | 45 |
| | Task 1.1.3: Provide technical support to Dmo | | 3 |
| | Ride the boat on IAUV day trips | | 60 |
| | Integrate camera, strobe and controller on Ventana | | 40 |
| | Ride Pt. Lobos with midwater grouop for two days | | 20 |
| | Set up IAUV for midwater | | 28 |
| | Collect data within days of ROV | | 120 |
| | Project Management | | 75 |
| **Rob** | | 583 | |
| | Task 1.1.3: Provide technical support to Dmo | | 3 |
| | Ride the boat on IAUV day trips | | 60 |
| | Support integration of TRN | | 120 |
| | Develop a navigation position filter for surface aiding | | 200 |
| | Develop a predictive system to improve bottom following | | 200 |
| **Brian** | | 200 | |
| | Develop an automated image upload and support file tool | | 100 |
| | Refine Still image annotation for VARS | | 100 |
| **Danelle** | | 500 | |
| | Refine AVED for Benthic | | 250 |
| | Refine AVED for Midwater | | 250 |
| **Alana** | | 80 | |
| | Electrical support | | 40 |
| | Electrical support | | 40 |
| **Rich** | | 80 | |
| | develop drivers and test | | 40 |
| | Software support | | 40 |

**Field programs (detail ship requirements/deployments)**

Six days of Zephyr (plus AUV) are requested to improve the terrain following performance of the IAUV and validate the midwater imaging capabilities.

**Specific deliverables**

The engineering development phase of the IAUV will be completed with a yet to be determined maximum slope the AUV can follow across the seafloor. A comparison of three midwater animal survey techniques will be compared: Legacy ROV, downward-looking still camera below the ROV and AUV. A comparison will also be generated that compares AVED processing verses the existing annotation process for still images from the IAUV.

**Milestones (see last page for personnel classification list)**

| | **Milestone 1** | **Milestone 2** | **Milestone 3** | **Milestone 4** | **Milestone 5** | **Total Resources**[3] for each resource category for all milestones listed here |
|---|---|---|---|---|---|---|
| **Milestone Date** | **15 Sept** | **15 Nov** | **15 Dec** | | | |
| **Milestone Description** | **Canyon Axis dive** | **Compare Midwater methods** | **Compare AVED to Legacy** | | | |
| **EE** | **60** | **20** | | | | **80** |
| **SE** | **588** | | **775** | | | **1363** |
| **ME** | **225** | **225** | **25** | | | **475** |
| **EE Tech** | **20** | | | | | **20** |
| **SE Tech** | | | | | | |
| **ME Tech** | **50** | **50** | | | | **100** |
| **Machine Shop** | **75** | **25** | | | | **100** |

## Budget justification

We propose to purchase three green lasers to replace the two red lasers we've been using that are only visable from a maximum of 3m. The three green lasers cost $6500. We have been asked to provide a CTD and DO sensor for contextual environmental data. The Seabird 19 Plus V2 CTD and Seabird 43 DO sensors have been specified and cost $11,700 and $4900 respectively.

## Project team

Brett Hobson
Rob McEwen
Brian Schlining, or Mike McCann

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

Alana Sherman
Danielle Cline

**Project lab space**

None required

**Data availability outside project team, uniqueness**

All data is archeived on a Tornado Share and annotations loaded into VARS. There are no restrictions on the data collected under this project

**Risk matrix (development and infrastructure projects only)**

| | Technical Risk | Organizational Risk | Tech Transfer Risk | Labor Estimate Risk |
|---|---|---|---|---|
| High | | | | |
| Medium | x | x | x | x |
| Low | | | | |

## Personnel Classifications

| **Engineer - Mechanical Engineer** (Reg) | **Engineer - Electrical Engineer** (Reg) | **Engineer - Software Engineer** (Reg) | **Engineer - Mechanical Tech** (Reg) | **Engineer - Electrical Tech** (Reg) | **Engineer - Software Tech** (Reg) | **Observ Support Technician** (Reg) | **Research – Software Engineer** (Reg) |
|---|---|---|---|---|---|---|---|
| Jim Birch | Mark Chaffey | Dave Caress | John Ferreira | Paul Coenen | Karen S | Mike Kelley | Mike Godin |
| Larry Bird | Scott Jensen | Danelle Cline | Mike Parker | Tom Marion | | Erich Rienecker | Frederic Py |
| Jon Erickson | Chad Kecy | Duane Edgington(2/3) | Jim Schofield | Jim Montgomery | | | |
| Andy Hamilton | Denis Klimov | Kevin Gomes (2/3) | | Jose Rosal | | | |
| Brett Hobson | Paul McGill | Kent Headley (2/3) | | | | | |
| Bill Kirkwood | Ed Mellinger | Rich Henthorn | | | | | |
| Gene Massion | Craig Okuda | Bob Herlien | | | | | |
| Doug Pargett | Alana Sherman | Brian Kieft | | | | | |
| Farley Shane | | Thom Maughan | | | | | |
| | | Mike McCann | | | | | |
| | | Rob McEwen | | | | | |
| | | Tom O'Reilly | | | | | |
| | | Wayne Radochonski | | | | | |
| | | Mike Risi | | | | | |
| | | Brent Roman | | | | | |
| | | Carlos Rueda-Velasquez | | | | | |
| | | Brian Schlining | | | | | |
| | | Rich Schramm | | | | | |