Project Number: 901502

Project Start: Jan. 1, 2015[1] **Project Duration (in years): 2**[1]

Please indicate if proposal includes requests for any of the following (mark all that apply).

[ ]	[ ]	[ ]	[ ]	[ ]
Ship Time	**ROV**	**AUV**	**Wave Glider**	**Mini-ROV**

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

[X]	[ ]	[ ]	[ ]	[ ]
Feasibility/Scoping [Less than 100 days effort]	**Development**[2]	**Research**	**Infrastructure**[2]	**Education**
	[ ]	[ ]		
	Time Series	**Institute Initiative**		

Project Manager[3]: John Ryan

Principal Investigator: John Ryan

Lead Scientist: John Ryan

Lead Engineer: Craig Dawe

Project Title: Passive Acoustic Sensing in Foraging Ecology Research

[1] This date and number should remain the same for the duration of the project. If your project start date for 2015 is not January 1, please indicate the start date in the first cell of the milestone chart.
[2] Development and infrastructure projects must complete the risk matrix (see item #5 at the end of the proposal form).
[3] 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)

MBARI's guiding documents motivate advancing capabilities to study foraging ecology – forage species and foragers within their environmental context. Acoustic methods are valuable to this research, with studies of forage populations (small pelagic fish, krill, squid) enabled by active acoustic sensing and studies of some forager populations (marine mammals that vocalize or use echolocation) enabled by passive acoustic sensing. This feasibility / scoping proposal is intended to leverage existing MBARI infrastructure to explore one aspect of this complex research field. Specifically, we propose to apply the power, bandwidth and persistence of MARS to evaluate the potential of passive acoustic sensing at that location, as part of a greater strategy in foraging ecology research. This effort will allow us to (1) determine what marine mammal foragers can be detected from this potentially excellent listening location, (2) relate variations in detections of forager populations to environmental variability observed locally from PhoBOS and regionally from satellites and moorings, (3) inform observing strategies for active acoustic sensing and potential future engineering development, (4) begin building in-house expertise in bioacoustics data analysis and automated detection, with training from regional collaborators, and (5) develop projects to be supported through collaborative external grants. The request for two years of scoping is based on the anticipated start of data collection in mid-2015, as constrained by the schedule of other institutional activities (Gulf of California expedition, PhoBOS servicing). In parallel, work is being proposed as part of AUV Infrastructure (901111) to evaluate the effectiveness of MBARI's existing AUV-borne active acoustic sensors for characterizing pelagic fauna distributions and ecology.

2) PROPOSAL

a) New Projects

Statement of the problem, why it is important

Foraging ecology shapes the structure and function of oceanic food webs – from seabirds that pass across the air-sea interface, to the astounding diversity of pelagic and benthic marine life across shelf, slope and deep-sea habitats. Understanding foraging ecology is essential to effective management of living marine resources, and it is massively challenging. At relatively long time scales MBARI researchers have examined aspects of foraging ecology from bottom-up and top-down perspectives. MBARI's time-series of environmental and phytoplankton data, together with data on forage fish, seabirds, and global sea level, helped us understand how oscillations in the atmosphere-ocean system influence primary productivity and foraging ecology at multidecadal time scales (Chavez et al., 2003). MBARI's long-standing strength in ROV technology allowed unique long-term observations of Humboldt squid and examination of the potential roles of environmental and biological variability in the range expansion of this top predator (Zeidberg and Robison, 2007). These insights into low-frequency ecosystem variability are important, and at shorter time scales, where the processes of foraging ecology play out, there are tremendous opportunities to advance our understanding. This project aims to explore opportunities for MBARI to leverage infrastructure and capabilities toward advancing this challenging and important research. This would be the first effort of its kind in the Monterey Bay region, leveraging the persistence enabled by MARS and the ecological insights that are possible from the effective contextual environmental sensing.

How does it relate/contribute to MBARI's mission and strategic plan?

In alignment with MBARI's mission, this project will promote development of better systems and methods for marine research through science – engineering partnerships. It will build upon MBARI's capabilities represented in infrastructure (MARS) and knowledge of signal processing (Zhang, McGill, Ryan). This project addresses multiple research themes of our strategic plan: exploration and discovery, ocean visualization, and ecosystem dynamics. Taking advantage of the relative transparency of the sea to sound, as compared to light, acoustics are an important means of discovery and visualization for research not only of the seafloor, but also of the pelagic ecosystem. In light of the metrics of success defined in our Strategic Plan, this project may foster research contributions to raising public awareness about the health and future of the ocean.

How does it relate/contribute to the Packard Foundation's Ocean Visions Grantmaking policies?

The Packard Foundation's oceans grantmaking focuses on three interrelated objectives: restoration of ecologically important fisheries, improved coastal management, and enhanced scientific understanding of the functioning of marine ecosystems. This proposal relates to the third objective, and the proposed local work in the heart of the MBNMS is aligned with the Foundation's long-term commitment to research along the North American west coast.

Does it relate to the Technology Roadmap? If so, please describe how.

This proposal relates to the focal topic of forage species in the MBARI Technology Roadmap. Resonant with this theme within our Roadmap is the Packard Foundation West Coast Strategic Plan emphasis on forage species and their support of broader ecosystem needs. Foraging ecology, through which forage species support broader ecosystem needs, shapes the structure and function of marine food webs and associated consequences for the cycling of productivity. Among the institutional priorities defined in the Technology Roadmap for addressing engineering challenges and opportunities, this project relates to advancing a persistent presence and enabling targeted sampling. Primary limitations of the use acoustic recording devices in marine research is limited data storage and power supply. These limitations force the use of partial duty cycles, which produces data sets with gaps that can never be filled to address research questions (J. Joseph, NPS, personal communication). MARS' power and bandwidth can overcome this primary limitation and enable persistent presence. Automated identification of marine mammal foragers is an active research frontier (Baumgartner and Mussoline, 2011; Mellinger et al., 2011; Hussein et al., 2012). Advancing these capabilities will support more effective targeting of ecosystem observations in time and space. For example, increased detection of beaked whales near MARS could temporally target deployment of AUV-borne active acoustic sensing (event response), which in turn could spatially target faunal sampling in the water column. Passive acoustic monitoring (PAM) from MARS represents a path to examining the potential of more advanced technology developments and observing strategies.

Approach to the problem

MT feedback on the original project abstract was clear. A key statement was this: "Starting small with just a passive sensor at MARS might be a better approach, but it must include a data handling and analysis plan and a clear reason for conducting the research."

Focusing first on the reason for conducting this research: Passive acoustic monitoring (PAM) is the primary method used to estimate the abundance and distribution of marine mammals (Marques et al. 2013). Because we have never deployed PAM on MARS, we don't know what marine mammal foragers can be effectively detected there. A single hydrophone (PAM device) on MARS would inform not only understanding of the local abundance and variability of marine mammal foragers, but also observing strategies that employ collocated active acoustic sensing of forage species, from fixed and/or mobile platforms. Beyond the first important question of what marine mammal foragers can be detected at MARS, this exploratory deployment would allow us to examine variability in detection of different species relative to environmental variability. At what time scales does the activity of different foragers, as indicated by echolocations or vocalizations, covary with environmental variability within different frequency bands: diurnal, episodic (upwelling / relaxation cycles), seasonal?

We know that Smooth Ridge is a good location for detecting acoustic scattering layers (forage species) with active acoustic sensing, and that MARS is an effective platform for supporting acoustics research that requires persistence (Urmy et al., 2012). However, we don't know if MARS is a good location for the passive acoustic sensing side of foraging ecology research. MARS is theoretically a good location to listen. Because mammal vocalizations refract downward, a deep hydrophone is better able to receive vocalizations from a greater depth range than a shallow hydrophone (e.g. the hydrophone being proposed for a mooring off Año Nuevo by F. Chavez in collaboration with B. Block). Also, compared to shallow water closer to the coast, the deep location of MARS is less impacted by noise from human activities. Observed distributions of the largest marine mammals, blue whales, reveals favored foraging habitat off the Monterey Bay shelf break (Croll et al., 2005). The MARS site is within the range of effective listening for Blue whale vocalizations from this foraging hotspot, as well as humpback vocalizations in the region, however Gray whales may only be audible when traversing the canyon and not when foraging in benthic habitat on the shelf (J. Joseph, NPS, personal communication). Beaked whales, which feed on squid in relatively deep water, have been detected with hydrophones off Pt. Sur, but we do not yet know about their presence or detectability in the region around Smooth Ridge. Based on this first PAM effort on MARS, extension into integrated research on forage species and foragers from MARS would be pursued through externally funded collaborative research (with Hopkins, NPS, MLML, UCSC, MBNMS). The only deployment of a scientific echosounder on MARS to date was successful, and a key conclusion was that future studies would benefit from multi-frequency active acoustics and direct sampling to support discrimination of scattering layer fauna (Urmy et al., 2012). While MARS is a potentially excellent location from which to deploy integrated passive and active sensing, the dependence of sounding range on acoustic frequency introduces the need to carefully scope such a system. Stationary systems deployed near-bottom at MARS would face inadequate range for the higher frequency sensing, which could not reach sufficiently shallow into the water column to distinguish squid, fish and krill across the required depth range. Further, such systems would be limited to the small spatial footprint of the echosounder directly above MARS. In contrast, multifrequency acoustic sensing from an AUV would permit surveying over larger areas relevant to understanding forage species distributions and ecology, and at multiple depths to cover the required depth range. The passive acoustic research proposed here will provide critical information for evaluating what forager/forage species relationships we may best target, and the associated engineering development required.

We propose to connect the hydrophone to PhoBOS, which has a spare connector allowing ready access to power and Ethernet connections and would provide the benefit of local environmental contextual data for hydrophone-based time series research. The hydrophone would be deployed in a float collar approximately 30 m from PhoBOS (farther north along the cable line), to reduce potential for noise from PhoBOS and the MARS node. Connection to PhoBOS will require cables and a pressure-housed power converter that can be assembled in-house.

We have defined data handling requirements, following the data path from the hydrophone, through PhoBOS / MARS, to data logging software on shore, to storage on Atlas. Atlas was chosen based on access requirements and manageable data volume (T. Ruston). The data analysis plan includes training of MBARI personnel (Ryan, Zhang, McGill) by regional collaborators at NPS and MLML, which will allow us to conduct analyses of forager detection data relative to local and regional environmental data. While autonomous detection of some forager species is well established, it yet requires development for other species known to inhabit this region (J. Joseph, NPS, personal communication). Zhang and McGill have experience with spectral analysis of acoustic data, and Ryan has applied spectral techniques to other data types (Fourier and Wavelet transforms applied to climate data). There is thus some relevant expertise in-house upon which we will build for PAM data analysis. The full frequency spectrum includes ranges within which mammal vocalizations are relatively simple to detect from a low-noise background, for example the echolocations of beaked whales. It also includes frequency ranges within which mammal vocalizations are difficult to extract from background, for example low frequency calls of Blue and Fin whales. We propose to divide the data set among internal (Ryan, Zhang, McGill) and external (NPS, MLML, and Hopkins) participants to accelerate data processing and synthesis for the full frequency range. Contributions to this effort will come from a student (D. Cade, former student of K. Benoit Bird at OSU and now a student of J. Goldbogen at Hopkins). The goal is a thorough characterization of variability in acoustically detectable marine mammal foragers in relation to environmental variability, as a basis to inform subsequent research strategies and programs.

References cited:

Baumgartner, MF, SE Mussoline, 2011. A generalized baleen whale call detection and classification system. J. Acoust. Soc. Am. 129: 2889-2902.

Chavez, FP, J Ryan, SE Lluch-Cota, M Ñiquen, 2003. From Anchovies to Sardines and Back: Multidecadal Change in the Pacific Ocean. Science 299:217-221. doi:10.1126/science.1075880

Croll, DA, B Marinovic, S Benson, FP Chavez, N Black, R Ternullo, BR Tershy, 2005. From wind to whales: trophic links in a coastal upwelling system. Mar. Ecol. Prog. Ser. 289:117-130. doi:10.3354/meps289117

Hussein, WB, MA Hussein, T Becker, 2012. Spectrogram enhancement by edge detection approach applied to bioacoustics calls classification. Signal and Image Processing 3: 1-20.

Marques, T. A., Thomas, L., Martin, S. W., Mellinger, D. K., Ward, J. A., Moretti, D. J., Harris, D. and Tyack, P. L. (2013), Estimating animal population density using passive acoustics. Biological Reviews, 88: 287–309. doi: 10.1111/brv.12001

Mellinger, DK, SW Martin, RP Morrissey, L Thomas, JJ Yosco, 2011. A method for detecting whistles, moans, and other frequency contour sounds. J. Acoust. Soc. Am. 129: 4055-4061.
Urmy, SS, JK Horne, DH Barbee, 2012. Measuring the vertical distributional variability of pelagic fauna in Monterey Bay. ICES J. Mar. Sci. 69:184–196. doi:10.1093/icesjms/fsr205
Zeidberg, LD and BH Robison, 2007. Invasive range expansion by the Humboldt squid, *Dosidicus gigas*, in the eastern North Pacific. PNAS 104 (31):12948-12950. doi:10.1073/pnas.0702043104

Publications (from other projects over the last 5 years)

Peer-reviewed publications listed below reflect work co/authored by Ryan and Zhang.

2014
Berdalet, E, MA McManus, ON Ross, H Burchard, FP Chavez, JS Jaffe, IR Jenkinson, R Kudela, I Lips, U Lips, A Lucas, D Rivas, MC Ruiz-de la Torre, J Ryan, JM Sullivan, H Yamazaki. 2014. Understanding harmful algae in stratified systems: Review of progress and future directions. *Deep Sea Research II* 101: 4-20. doi: 10.1016/j.dsr2.2013.09.042.
Fischer, AM, JP Ryan, C Levesque, N Welschmeyer. 2014. Characterizing estuarine plume discharge into the coastal ocean using fatty acid biomarkers and pigment analysis. *Marine Environmental Research*, doi: 10.1016/j.marenvres.2014.04.006.
Robidart JC, MJ Church, JP Ryan, F Ascani, ST Wilson, D Bombar, R Marin III, KJ Richards, DM Karl, CA Scholin, JP Zehr. 2014. Ecogenomic sensor reveals controls on N_2-fixing microorganisms in the North Pacific Ocean. *The ISME Journal*, doi:10.1038/ismej.2013.244.
Ryan, JP, MA McManus, RM Kudela, M Lara Artigas, JG Bellingham, FP Chavez, G Doucette, D Foley, M Godin, JBJ Harvey, R Marin III, M Messié, C Mikulski, T Pennington, F Py, K Rajan, I Shulman, Z Wang, Y Zhang. 2014a. Boundary influences on HAB phytoplankton ecology in a stratification-enhanced upwelling shadow, *Deep Sea Research II* 101: 63-79. doi: 10.1016/j.dsr2.2013.01.017.
Ryan, JP, JBJ Harvey, Y Zhang, B Woodson. 2014b. Distributions of invertebrate larvae and phytoplankton in a coastal upwelling system retention zone and peripheral front. *J. Exp. Mar. Biol. Ecol*. 459:51-60.
Ryan, JP, CO Davis, NB Tufillaro, RM Kudela, BC Gao. 2014c. Application of the Hyperspectral Imager for the Coastal Ocean to Phytoplankton Ecology Studies in Monterey Bay, CA, USA. *Remote Sens*. 6: 1007-1025.
Sevadjian, JC, MA McManus, JP Ryan, AT Greer, RK Cowen, CB Woodson. 2014. Across-shore variability in plankton layering and abundance associated with physical forcing in Monterey Bay, California. *Cont. Shelf Res.* 72: 138-151.
2013
Ottesen, EA, CR Young , JM Eppley, JP Ryan, FP Chavez , CA Scholin, EF DeLong. 2013. Pattern and synchrony of gene expression among sympatric marine microbial populations, *PNAS*, doi:10.1073/pnas.1222099110.
Y. Zhang, 2013. Adaptive Ocean Observation, *Advances in Earth Sciences* 28(5): 537-541.
2012
Das, J, F Py, T Maughan, T O'Reilly, M Messié, J Ryan, G Sukhatme, K Rajan. 2012. Coordinated sampling of dynamic oceanographic features with underwater vehicles and drifters. *International Journal of Robotics Research* 31:626-646. doi: 10.1177/0278364912440736

Frolov, S, J Ryan, F Chavez. 2012. Predicting euphotic-depth-integrated chlorophyll-a from discrete depth and satellite-observable chlorophyll-a off central California. *J. Geophys. Res.*, 117 (C5) DOI: 10.1029/2011JC007322

Harvey, JBJ, JP Ryan, R Marin III, CM Preston, N Alvarado, CA Scholin, RC Vrijenhoek. 2012. Robotic sampling, in situ monitoring and molecular detection of marine zooplankton. *J. Exp. Mar. Biol. Ecol.* 413: 60-70.

Mackey, KRM, CE Mioni, JP Ryan, A Paytan. 2012. Phosphorus cycling in the red tide incubator region of Monterey Bay in response to upwelling. *Frontiers in Microbiology* 3:33. doi: 10.3389/fmicb.2012.00033

Weiss-Penzias, PS, C Ortiz Jr., RP Acosta, W Heim, JP Ryan, D Fernandez, JL Collett Jr., AR Flegal. 2012. Total and monomethyl mercury in fog water from the central California coast, *Geophys. Res. Lett*. 39: L03804, doi:10.1029/2011GL050324

Zhang, Y, JG Bellingham, MA Godin, JP Ryan. 2012a. Using an autonomous underwater vehicle to track the thermocline based on peak-gradient detection. *IEEE Journal of Oceanic Engineering* 37: 544-553, doi: 10.1109/JOE.2012.2192340

Zhang, Y, MA Godin, JG Bellingham, JP Ryan. 2012b. Using an Autonomous Underwater Vehicle to Track a Coastal Upwelling Front. *IEEE Journal of Oceanic Engineering* 37: 338-347, doi: 10.1109/JOE.2012.2197272.

Zhang, Y, JP Ryan, JG Bellingham, JBJ Harvey, RS McEwen. 2012c. Autonomous detection and sampling of water types and fronts in a coastal upwelling system by an autonomous underwater vehicle. *Limnol. Oceanogr. Methods*, 10: 934-951, doi: 10.4319/lom.2012.10.934.

2011

Mazzillo, FFM, JP Ryan, MW Silver. 2011. Parasitism as a biological control agent of dinoflagellate blooms in the California Current System. *Harmful Algae*, doi:10.1016/j.hal.2011.06.009.

Ottesen, EA, R Marin, CM Preston, CR Young, JP Ryan, CA Scholin, EF DeLong. 2011. Metatranscriptomic analysis of autonomously collected and preserved marine bacterioplankton. *The ISME Journal*, doi:10.1038/ismej.2011.70.

Preston CM, A Harris, JP Ryan, B Roman, R Marin III, S Jensen, C Everlove, J Birch, JM Dzenitis, D Pargett, M Adachi, K Turk, JP Zehr, CA Scholin. 2011. Underwater application of quantitative PCR on an ocean mooring. *PLoS ONE*, doi:10.1371/journal.pone.0022522.

Ryan, J, D Greenfield, R Marin III, C Preston, B Roman, S Jensen, D Pargett, J Birch, C Mikulski, G Doucette, C Scholin. 2011a. Harmful phytoplankton ecology studies using an autonomous molecular analytical and ocean observing network. *Limnol. Oceanogr.*, doi:10.4319/lo.2011.56.4.1255.

Ryan, JP, Y Zhang, H Thomas, EV Rienecker, RK Nelson, SR Cummings. 2011b. A high-resolution survey of a deep hydrocarbon plume in the Gulf of Mexico during the 2010 Macondo blowout. In: Monitoring and Modeling the Deepwater Horizon Oil Spill: a Record-Breaking Enterprise, *Geophys. Monogr. Ser.*, Vol. 195, edited by Y. Liu et al. AGU, doi:10.1029/2011GM001106.

Tkacik, DS, Y Luna-Cruz, N Clinton, S Spak, J Ryan. 2011. Atmospheric correction for MASTER image data using localized modelled and observed meteorology and trace gases. *Remote Sensing Letters*, doi:10.1080/01431161.2010.551550.

Zhang, Y, RS McEwen, JP Ryan, JG Bellingham, H Thomas, CH Thompson, E Rienecker. 2011. A Peak-Capture Algorithm Used on an Autonomous Underwater Vehicle in the 2010 Gulf of Mexico Oil Spill Response Scientific Survey. *Journal of Field Robotics*, doi:10.1002/rob.20399.

Woodson, CB, JA Barth, OM Cheriton, MA McManus, JP Ryan, L Washburn, and 18 others. 2011. Observations of internal wave packets propagating along-shelf in northern Monterey Bay. *Geophys. Res. Lett*. 38: L01605, doi:10.1029/2010GL045453

Cazenave, F, Y Zhang, E McPhee-Shaw, JG Bellingham, TP Stanton, 2011. High-resolution surveys of internal tidal waves in Monterey Bay, California, using an autonomous underwater vehicle. *Limnol. Oceanogr.: Methods*, 9: 571-581, 2011, DOI: 10.4319/lom.2011.9.571.

2010

Mackey, KRM, GL van Dijken, S Mazloom, AM Erhardt, J Ryan, KR Arrigo, A Paytan. 2010. Influence of atmospheric nutrients on primary productivity in a coastal upwelling region. *Global Biogeochem. Cycles* 24: GB4027, doi:10.1029/2009GB003737.

Ryan, JP, SB Johnson, A Sherman, K Rajan, F Py, H Thomas, JBJ Harvey, L Bird, JD Paduan, RC Vrijenhoek. 2010a. Mobile autonomous process sampling within coastal ocean observing systems. *Limnol. Oceanogr. Methods* 8: 394–402.

Ryan, JP, AM Fischer, RM Kudela, MA McManus, JS Myers, JD Paduan, CM Ruhsam, CB Woodson, Y Zhang. 2010b. Recurrent frontal slicks of a coastal ocean upwelling shadow. *J. Geophys. Res*. 115: C12070, doi:10.1029/2010JC006398

Ryan, JP, MA McManus, JM Sullivan. 2010c. Interacting physical, chemical and biological forcing of phytoplankton thin-layer variability in Monterey Bay, California. *Cont. Shelf Res.* 30: 7-16.

Sullivan, JM, MA McManus, OM Cheriton, KJ Benoit-Bird, L Goodman, Z Wang, JP Ryan, M Stacey, DV Holliday, C Greenlaw, MA Moline, M McFarland. 2010. Layered organization in the coastal ocean: An introduction to planktonic thin layers and the LOCO project. *Cont. Shelf Res*. 30: 1-6.

Zhang, Y, RS McEwen, JP Ryan, JG Bellingham. 2010. Design and Tests of an Adaptive Triggering Method for Capturing Peak Samples in a Thin Phytoplankton Layer by an Autonomous Underwater Vehicle. *IEEE Journal of Oceanic Engineering* 35: 785-796, dio:10.1109/JOE.2010.2081031

Zhang, Y, JG Bellingham, Y Chao, 2010. Error Analysis and Sampling Strategy Design for Using Fixed or Mobile Platforms to Estimate Ocean Flux. *Journal of Atmospheric and Oceanic Technology* 27: 481-506, doi: 10.1175/2009JTECHO700.1

2009

Jessup, DA, MA Miller, JP Ryan, HM Nevins, HA Kerkering, A Mekebri, DB Crane, TA Johnson, RM Kudela. 2009. Mass Stranding of Marine Birds Caused by a Surfactant-Producing Red Tide, *PLoS ONE* 4: e4550. doi:10.1371/journal.pone.0004550.

Ryan, JP, AM Fischer, RM Kudela, JFR Gower, SA King, R Marin III, FP Chavez. 2009. Influences of upwelling and downwelling winds on red tide bloom dynamics in Monterey Bay, California, *Cont. Shelf Res*. 29: 785–795.

Steinbuck, J, MT Stacey, MA McManus, OM Cheriton, JP Ryan. 2009. Observations of turbulent mixing in a phytoplankton thin layer: Implications for formation, maintenance, and breakdown. *Limnol. Oceanogr*. 54: 1353–1368.

Woodson, CB, L Washburn, JA Barth, DJ Hoover, AR Kirincich, MA McManus, JP Ryan, J Tyburczy. 2009. The northern Monterey Bay upwelling shadow front: Observations of a coastally- and surface-trapped buoyant plume. *J. Geophys. Res*. 114: C12013, doi:10.1029/2009JC005623.

b) Continuing Projects

-

c) New and Continuing Projects: Plans for 2015

Research Activities

Research activities are planned both before and after connection of the hydrophone to MARS/PhoBOS and the associated start of science data collection in June 2015. Before deployment, Ryan, Zhang and McGill will train with regional PAM experts from NPS and MLML who are part of the project team. We will use existing PAM data from collaborators to become familiar with the signal processing methods, and explore extension of these methods toward advancing automated detection of echolocations and vocalizations from species inhabiting the region around Smooth Ridge. Immediately following deployment, we will monitor the data to ensure quality and test automated detection methods on the new data. As the time series builds during the third and fourth quarters of 2015, and assuming MARS proves to be an effective listening location, we will examine PAM and environmental data to relate variability in marine mammal foragers to environmental variability.

Engineering/technology development

The primary engineering development is in the area of signal processing: to apply and advance automated detection of vocalization and echolocation signals, and this is where the effort of Zhang, Ryan and McGill will focus. The hardware and data collection software are off-the-shelf. The hydrophone package already contains the circuitry necessary to digitize the audio and send it back to shore over Ethernet for monitoring and storage with the vendor's software. We'll have to build a power converter in a small housing to convert MARS 375 VDC to 24 VDC, but such a converter has already been designed for the MOBB seismometer currently deployed on Smooth Ridge.

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

No field programs are required, only installation of the hydrophone at MARS during a PhoBOS servicing cruise in June 2015.

Specific deliverables

This project will deliver (1) the first passive acoustic data from MARS, allowing us to evaluate the potential for use of this sensing method in the midwater for research on foraging ecology, (2) cultivation of in-house expertise in the analysis of marine bioacoustics data that are essential to successful research in foraging ecology, and (3) experience and results to inform future projects and development efforts, including externally funded collaborative research projects.

Milestones (see personnel classification list)

The project milestones are PAM data analysis training and development for Zhang, McGill and Ryan (Q1), installation of the hydrophone by Dawe and French (Q2), PAM / environmental data analysis by Zhang, Ryan and McGill (Q3-Q4), and consideration of an EARTH project by Matsumoto and Ryan (Q4).

2015 Project Start Date: 01/01/2015	**Milestone 1**	**Milestone 2**	**Total Resources**[4] for each resource category for all milestones listed here
Milestone Date	**June 1**	**December 15**	
Milestone Description	**PAM data analysis training and methods development; design of hydrophone power supply and cabling**	**Analysis of PAM data from MARS**	
EE (McGill)	**40**	**40**	**80**

Budget justification

Supplies: The potential loan of a hydrophone was found to be of insufficient duration for the goals of this project. Therefore, we propose to purchase a hydrophone ($13,700). Having been used in both OOI and Ocean Networks Canada, the hydrophone is proven for this application. Also off-the-shelf components include a quiet float collar for deployment of the hydrophone near PhoBOS ($1,800), and software required for hydrophone set up and data acquisition ($4,500). We will also require purchase of connectors ($200), a power converter ($100), and a cable to connect the hydrophone to PhoBOS ($300). Data logging will be achieved using a Windows virtual machine, for which we request a license ($200). Data storage on Atlas will be covered under IS operational budget.

Ship time: We propose piggybacking on a PhoBOS servicing cruise in June 2015 to deploy and connect the hydrophone and thus do not request ship time for deployment in this project.

Port fees: As defined in the PhoBOS project, port fees are to be covered by MBA.

Labor: We request 60 hours each for C. Dawe and D. French to prepare and conduct connection of the hydrophone to PhoBOS. We request four weeks each for Y. Zhang and J. Ryan, and two weeks for P. McGill. This time will be split between training with existing hydrophone data provided by NPS to apply and further develop automated detection of marine mammal foragers (Q1-2), and analysis of hydrophone data collected at the MARS location and environmental data (Q3-4).

Project team

MBARI personnel and roles

- Craig Dawe and David French: hydrophone installation and connection to PhoBOS
- John Ryan, Yanwu Zhang and Paul McGill: training and work in PAM data analysis
- George Matsumoto: work with Ryan to develop an EARTH (2016) project from PAM and environmental data analysis

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

External collaborators and roles

- John Joseph and Tetyana Margolina (NPS) and Alison Stimpert (MLML): training of MBARI personnel in PAM data analysis; work on MARS PAM data analysis
- Brandon Southall (SEA Inc. and UCSC): advisor for research and analysis methods
- Jeremy Goldbogen and Dave Cade (Hopkins): data analysis for PhD thesis of D. Cade; integrate mammal tag data with MARS PAM / environmental data analysis
- Andrew DeVogelaere and Lisa Uttal: discussion of connecting PAM / environmental data and analysis results to goals of the MBNMS in exploring the "Sanctuary Soundscape" (as Andrew described at DOEST), management concerns about noise in the marine environment, and public outreach

Through research-focused external collaborators we will entrain expertise, training, and processing horsepower that are all valuable to acoustics data analysis.

Project lab space

Preparation of the hydrophone assembly (power converter, cabling and float collar) for deployment will occur in DMO space of Dawe / French.

Data availability outside project team, uniqueness

In addition to being stored on Atlas at MBARI, the hydrophone data will be copied to storage at NPS, so that collaborators can readily work on the data.

Export Regulation
Does the project team anticipate any foreign collaborations or international travel? If so, please identify collaborators by name, institution, and country.
No.

Does the project team plan or anticipate export controlled purchases, shipments, or transfers of items (e.g., research instruments, proprietary data, hand-carried tools or samples) outside the U.S. temporarily or permanently? If yes, please identify country or countries and indicate whether these items will remain under MBARI control while abroad or controlled by others. Will the items be exported to more than one country? Please include foreign collaborator information as described above.
No.

Monterey Bay National Marine Sanctuary SESAs (General map)
Projects will need to indicate whether or not work will be conducted within one of the Monterey Bay National Marine Sanctuary's Ecologically Significant Areas (SESAs). An interactive map can be found on the Sanctuary's SIMoN webpages at http://sanctuarysimon.org/maps/sesa/. (*Note: It may take a moment for the page to load, so please be patient.*) To determine if your work will occur in a SESA, specific coordinates can be entered using the locator function (click on the red "target" button in the toolbar at the top of the map). If your work will be conducted in one of these areas, please indicate which area, by number.

SESA #7.