

2020 Proposal Process – Internal-Only Projects
Submission Deadlines: Phase I – July 17th at 8:00 a.m., Phase II – September 5th

Project Number:	901807
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Project Start: Jan. 1,	2018 ¹	Project Duration (in years):	Year 3 of 3
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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).

☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Feasibility/Scoping [Less than 100 days effort]		Development²		Research		Infrastructure²		Education		Time Series		Institute Initiative					

Project Manager³: Eric Martin

Principal Investigator: Kelly Benoit-Bird

Lead Scientist: Bruce Robison, Kelly Benoit-Bird

Lead Engineer: Eric Martin

Project Title: Next Generation Bioacoustics on Dorado

Please indicate which category best describes the project theme (mark only one).

☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐
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¹ This date and number should remain the same for the duration of the project. If your project start date for 2020 is not January 1, please indicate the start date in the first cell of the milestone chart. Format for duration example: "Year 2 of 5".

² Development and infrastructure projects must complete the risk matrix (see 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.

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Ocean biogeochemistry	Ecosystem dynamics	Ocean visualization	Exploration & discovery
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Please indicate percentage of effort on this project anticipated for 2020 toward these three highest institutional goals (percentage total should equal 100%).

Goal	Developing/adapting innovative technologies	Utilizing developments to explore and understand ocean systems	Technology/knowledge transfer⁴
Percentage	30%	50%	20%

⁴ This category includes transfer of hardware, know-how, publications, presentations, etc.

1) ABSTRACT (new projects only)

2) PROPOSAL

a) All Projects

Statement of the challenge, why it is important

Responses of animals to platforms and lights have been well documented. Addressing this question for ROVs and Dorado class AUVs is particularly timely for MBARI as the Midwater Time Series shifts from decades of video sampling using ROVs to utilizing an AUV as the primary platform. Ongoing work with the ROV Ventana has already demonstrated both avoidance and attraction of animals to the platform and its lights. Determining how platforms differ in their effects on the animals sampled is critical to providing a seamless, calibrated transition for the Midwater Time Series. The unification of acoustical and imaging tools has been a goal of the community at least since the first descriptions of the deep scattering layer were made in the 1940s. These two approaches have complementary strengths, providing measurements with different resolution, coverage, and scale. Combined, these tools have the potential to answer challenging questions about life in the ocean's interior. This integrated view, however, has largely remained a challenge, one that recent developments leave MBARI uniquely poised to address. By integrating acoustics into the i2MAP AUV payload, we will:

- Quantify the behavioural responses of animals to the survey platform (avoidance/attraction) and compare them to responses to Ventana as the midwater time series shifts platforms
- Obtain broadband backscatter measurements from individuals identified and sized with the camera system to improve acoustic classification.
- Measure the spatial distribution of organisms in midwater to address at what scales animals are aggregated, if those aggregations are organized by taxonomy size or other features, and what role variation in the habitat plays in structuring the biota.

Relevance

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

The proposed research will address several themes of the MBARI strategic plan including exploring the deep sea as well as providing a new, integrated approach to visualizing the variability in the abundance, distribution, and activity of biota in the water column by leveraging and building upon existing MBARI investments in order to enhance understanding of the fluctuations and fate of forage species from the surface to the upper bathypelagic and the populations of larger marine animals for whom they are a primary food source.

Does it relate to the Technology Roadmap? If so, please describe how. (See <http://mwww.mbari.org/oed/TechnologyRoadmap.pdf>.)

The toolset proposed here will provide critical support for the goal of ‘taking the laboratory to the ocean’ as we seek to understand how the presence of the laboratory affects the subjects of study. This work to understand how animals behave in response to platforms has implications far beyond the midwater time series that will serve as the backbone of the first observations, potentially influencing all studies of mobile animals from AUVs and ROVs. This understanding of platform effects will become increasingly important as MBARI continues to make progress in enabling a persistent presence in the ocean, largely through the application of underwater vehicles. To support the goal of enabling targeted sampling, this effort explicitly includes a system architecture capable of supporting on board data processing and communication for future efforts which could include control of lights and cameras, vehicle location, water sampling, and more.

How does it relate/contribute to the Packard Foundation’s Ocean Grantmaking Program? (See <https://www.packard.org/what-we-fund/ocean/> and documents therein.)

The technology development proposed here will facilitate the discovery of biological patterns and processes in midwater as well as an understanding of our sampling capabilities. The mesopelagic is understudied region that is critically important for the success of a wide range of species including many important food fish and, through decreasing oxygen and shallowing of the oxygen minimum layer, is being dramatically impacted by climate change. In order to meet the PF’s plan to provide information for the sound management of biological resources in the ocean, the animals in this critical yet undersampled region must be brought to light.

Overall approach to the challenge: Over the complete term of the project, what is needed to address the challenge (e.g., sensors, platforms, marine operations, de novo R & D, etc.)

Research

We propose to further the integration of imaging and acoustics at MBARI by developing an acoustics payload for the Dorado class vehicles that can be deployed within the existing i2MAP imaging vehicle. While acoustics and imaging can be used in a coordinated fashion from independent platforms, this kind of true integration provides resolution at depth not possible with surface vessels, allowing the observation of behavior in response to the platform, identification of targets and measurement of their sizes, and independent, simultaneous assessments of animal density at sub-patch scales. This approach parallels efforts undertaken with the ROV Ventana, allowing an increase in the sample size of visual-acoustic data. More importantly, this development provides the opportunity to quantitatively compare the responses of animals to these two sampling platforms to permit appropriate integration of the data from the ROV and AUV surveys as the midwater time series changes its core sampling approach. As the midwater group has observed, there are differences in some types of animals observed and the frequency of observation of others. This is not

surprising given the differences in the size of the two platforms the differences in their radiated noise, the number, intensity, and range of the lights on each, and the factor of 2 in their survey speeds. Observation of the behavior of animals in response to the platforms provides a direct approach to quantifying these effects and developing correction factors to scale the data sets for comparison.

Engineering/Technology Development

We will integrate a dual-frequency Simrad EK80 Mini scientific echosounder into a Dorado payload with two transducers (one at 200 kHz and one at 333 kHz) looking forward to align with the video data and two looking downward to provide context across the water column.

Marine Operations/Field Programs

Field operations are required for testing the newly integrated vehicle's flight and sensor capabilities. Comparison dives with ROV surveys will also be conducted. Finally, we envision experimental dives where identified avoidance/attraction is manipulated by turning systems on/off and changing vehicle drive characteristics.

Data

What data products will be generated?

During 2020, we expect to continue taking part in i2MAP dives as we have in 2019. In addition, we propose several dives where the lighting is experimentally manipulated to explore vehicle avoidance.

How will the data products be managed?

Video data will follow existing protocols within the video lab and midwater group. A working copy of the raw acoustic data will be kept on a local hard drive and backed up in an archive on Atlas following existing protocols for multibeam mapping data. Acoustic survey data will be quality controlled (noise removed, seafloor detected and marked, geographic data corrected, etc.) before echograms are produced. These quality controlled echograms will be available for other MBARI groups in a shared folder.

Describe data availability outside of the project team.

Data will be available to all interested MBARI personnel and data products will be shared with external collaborators. The data being collected from Ventana and i2MAP will provide an unprecedented database of acoustic scattering characteristics that is being provided to the community through both publications and software analysis tools.

Describe data storage requirements.

Operations in 2019 have given us firm grasp of the storage requirements. For single day deployments, data averages 70-GB/day, and overnight 24-hour deployment average 450-GB total.

Anticipated Impact

Who are the consumers of the instruments, methods, systems, and data that will be generated?

- Data on behavioral responses to the platforms will be used by the Midwater Time Series team as they work to integrate data across platforms.
- Behavioral response data will be useful for other imaging groups at MBARI and beyond to design more effective visual sampling tools.
- The unique in situ broadband data we are collected with matched video will be used by other acousticians to understand biological scattering processes and applied acoustics scientists to improve acoustic classification.

b) Continuing Projects

If the proposed project includes multiple individual projects, please list each of these projects as a subheading in the proposal. For each subheading, please address the following:

Current status of project and results to date

The project, as proposed, has spent the first half of 2019 focused on removing electrical and acoustic noise sources observed during initial testing in 2018. There has been marked progress as major sources from the LED lights and cameras have been removed, and a solution for noise in the AUV Main Vehicle Controller has also seen significant reduction. We have completed concurrent operations as part of the midwater time series experiments, expanding transect data into overnight operations. These operations have highlighted behavioural limitations in the Dorado software that we are hoping to improve upon moving forward. Also a lighter weight aluminum housing for the camera system has been manufactured and fit, ready for final integration onto the i2Map platform.



Figure 1. *Pre-dive operations on the assembled i2MAP+A vehicle, the forward transducers are the red cylinders below the camera dome.*

Acoustic measurements from i2MAP have shown striking avoidance of the vehicle, particularly its lights. For example, the downward looking transducer from a nighttime transect at 50 m shows remarkable behavioral changes, with many animals descending nearly 100 m in the 10 minute duration of the transect. Other animals form discrete schools that are absent in the period before the lights were turned on. Similar effects were observed in the forward-looking transducer, with avoidance of the area imaged by the camera system by some animals and intense aggregation by others.

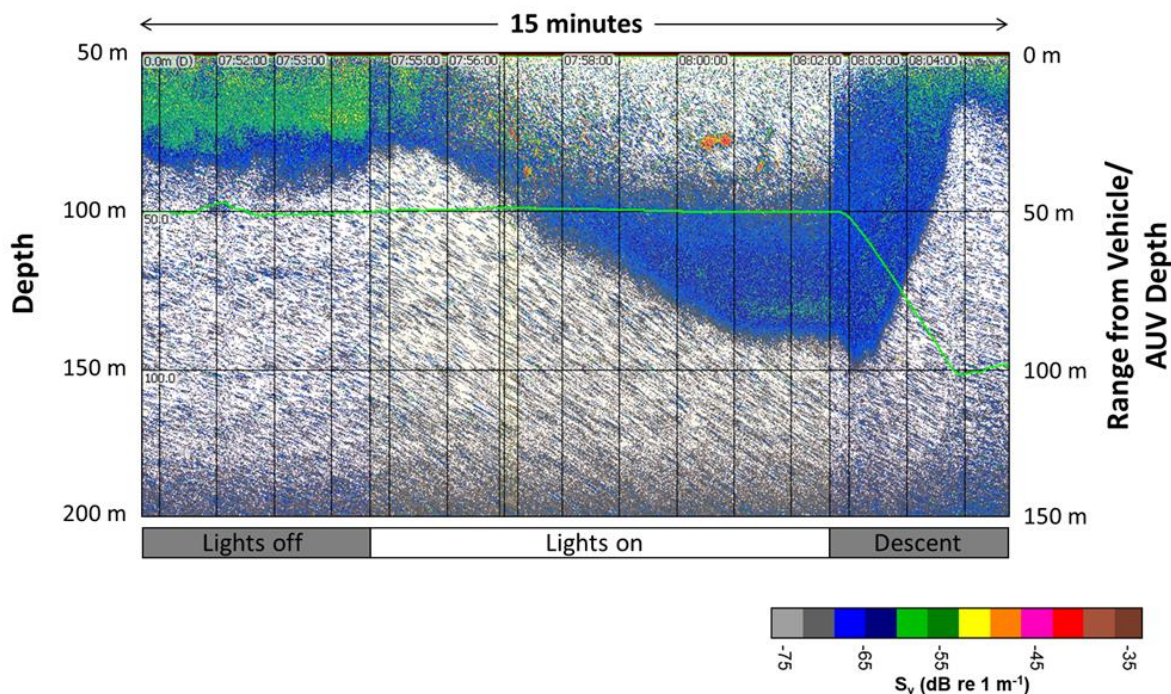


Figure 2. An echogram of 200 kHz data from the downward looking transducer on i2MAP shows a strong response of animals below the vehicle to the artificial light used by the video imaging system. The green line shows the depth of the AUV throughout the mission. When the lights were turned on approximately 5 minutes into this view, many animals swim down, with both individual tracks and a mass of animals showing a displacement of nearly 100 m. Other animals used an alternative tactic, forming dense, discrete schools in response to the vehicle and its lights.

During 2019, we have developed a rigorous protocol for comparable data processing of the acoustic data from i2MAP and a similar system on the ROV Ventana. While our sample size remains too small for robust statistical comparisons, largely as the result of unexpected AUV mission failures, the results suggest large differences in the way animals respond to the two platforms. In the coming year, we will work to obtain more matched data sets and robustly quantify these differences to support the integration of the time series data across the change in sampling platform.

What percentage of labor and budget have been used through the 1st half of year?

For shared resource labor hours, we have used 623 hours from 1,052 budgeted, approximately 60%. Fiscally, we have spend \$18,000 of near \$45,000 budget, roughly 40%.

Will you complete the current year's scheduled work?

As the noise reduction efforts continue to narrow, we will begin to continue onto efforts as proposed that require resources as requested in 2018. We should be well positioned to carry

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into more innovative efforts aligned with data visualization and synthesis with the video. We have also proposed to attempt some real-time processing for target identification. There is further vehicle integration work for the current year, as we attempt to complete new dorado behaviors that are not based on durations that allow us to conduct transects at predetermined times.

If you are at less than 50% resource usage, what is the plan to complete, or what work won't be done this year?

We are only behind resource use fiscally at this point, but expect to finish within budget and address planned milestones for the remained of the year.

Significant changes from previous project proposal

None

Over the past two years, what peer-reviewed publications, education and/or outreach activities have resulted directly from this project? Please be brief.

Benoit-Bird will give two presentations at the Acoustical Society of America Meeting in San Diego in December of 2019. The first, an invited talk, discusses the contributions of robotic technology to bioacoustical oceanography. The second is a data driven talk, introducing the broadband acoustic database being produced by the ROV and AUV. Additional efforts are planned as part of 2020, see below.

c) All Projects: Specific Plans for 2020

Research Activities

2020 will be a continuation of the efforts in 2019, seeking to collect relevant data samples to augment the time-series data and services overall program goals of acoustic target classification and behavioral observation. See in the following technology development section for characterization of the task to help study the avoidance behavior that was highlighted in Figure 2. We expect that in 2019 and 2020 more behaviors or unique targets will be observed, and some agile mission adjustments will allow for further study. The field program described below targets the continued efforts to characterize the comparability of AUV and ROV collected data as well as the other goals already described.

We also intend to collaborate on a system description paper publication, which will be a minimum of 1 technical write-up in a TBD peer-reviewed journal.

Engineering/technology development

Goals for 2020 will be to test and refine efforts scheduled in the latter half of 2019. Given some level of real-time processing is possible, software needs to be created that would allow

for acoustics system control of the camera systems, specifically the ability to turn on the lights upon target identification. This requires multiple developments, including a construction of a novel detector on the real-time data, driver modifications to allow for remote control of the lamps (power and brightness) from the detector, and appropriate logging of these data.

Broadband echoes are complex spectra, affected by not only species but size, orientation, and body condition. Relatively straightforward statistical tools have revealed significant potential for species classification using video ground-truthed echoes but they have also revealed shortcomings as the echoes are often spectrally compressed and altered in ways that human eyes are able to generalize but are challenging for statistical classification. We plan to incorporate machine learning to increase our classification success, experiment with data handling effects on classification, and increase our number of classes. While this will begin as a post-processing tool, transition to real time classification is a long-term goal.

Since this is the final year of the project, we intend to collect and document the system design as-built, and finish the process of transition into DMO operation that is already well-underway. We also would like to develop automated logging and data processing across the whole i2MAP package now including the acoustic systems, much like how data-flow works across the Gulper Dorado vehicle.

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

In addition to describing anticipated field programs, please be sure to include requirements for specific platforms and equipment (Dorado AUVs, LRAUVs, Wave Glider, mini ROV, etc.) for each proposed field program so that expectations are clear. Requests must also be entered in the budget entry system.

- 3 ROV/AUV Comparison Dives: These are days in which concurrent transects are completed using the i2MAP Dorado and ROV Ventana, Running transects from both vehicles. These days will precede Robison 2-day sequences from the Carson to leverage the time-series and provide comparable results. These are overnight deployments of the AUV.
- 9 Days of operation during the Midwater Time Series surveys (no additional effort/ship time). These are overnight deployments of the AUV.
- 4 Days using i2MAP+A for testing the new driver modifications and run test transects intent on “surprising” targets by reactively turning on/off the lamps and to measure the reaction and recovery times of animals to the lights. As we explore data gathered in 2019, we expect other novel use experiments of the system to help characterize behaviors will be conceived and will be slated for tests on these days as well.

Isotope Usage

Project teams must provide details regarding any planned isotope use on shore, on ships, in the Sanctuary, etc. Please review the guidance on isotope usage at <http://www.mbari.org/at-sea/cruise-planning/hazardous-materials/> and policy at

http://mww.mbari.org/safety/SafetyManual/Isotope_Use_Policy.pdf, and then provide details on plans below.

N/A

Safety Disposal Needs

So the Safety office can plan and budget accordingly, please respond to the questions below regarding any anticipated safety disposal needs for the coming year. Budget for cost of such removal will be captured by the safety office based on responses received.

Will this project generate more than 1 gallon (4 liters) of battery waste per year?

No

If yes, please indicate the type of batteries (alkaline, NiCad, NiMH, lithium ion or lithium metal) and the approximate amount of each to be generated.

N/A

Will this project generate more than 15 gallons (60 liters) of hazardous liquid waste per year?

No

If yes, please indicate the composition of the waste(s) and the quantity of each to be generated.

N/A

Specific deliverables

- Samples from identified animals for the broadband acoustic database.
- Animal response metrics for both the ROV and AUV.
- Improved bioacoustics payload for I2Map configurations of the Dorado AUVs.
- At least one presentation at a national meeting and one peer-reviewed publication..
- Data archival and automated analysis for the i2MAP mission data.

Milestones and required personnel (see [personnel classification list](#) for staff classifications)

1. System description publication (All), final system documentation (E. Martin)
2. Acoustic system control over i2MAP lamps (R. Henthorn, E. Martin)
3. Machine Learning for target classification (P. McGill)
4. Data processing and archival (M. McCann)
5. Field Efforts: Continued use of the system for time-series and ROV/AUV Comparison work to increase sample size for statistical power.

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2020 Project Start Date: MM/DD/2020	Milestone 1	Milestone 2	Milestone 3	Milestone 4	Milestone 5	Total Resources ⁵ (in hours) for each resource category for all milestones listed here
Milestone Date	12/1/20	4/1/20	8/1/20	10/1/20	12/1/20	
Milestone Description	Publication/Pre sentation	Acoustic System Lamp Ctl	Machine Learning on Data	Data Archival	Field Efforts	
Electrical Engineer	EJM – 140 PM – 40 MC – 40	EJM – 60	EJM – 40 PM – 210	EJM – 40	EJM – 40	EJM – 300 PM – 250 MC – 40
Software Eng- Embedded		RH – 140			RH – 20	RH – 160
Software Eng- Info Eng				MM – 160		MM – 160
Mechanical Engineer	FC – 20					
Mechanical Eng-Division						
Mechanical Eng-Mfg						
Associate Engineer						
Electrical Tech						JM – 20
Software Tech						
Mechanical Tech						
Machinist						TBD – 20
DMO		HT – 80			HT – 80	HT – 160
ITD					TBD – 55	TBD – 55

⁵ This number should be the same number you entered on the resource requests for this particular resource.

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Budget justification

Item	Estimated Cost	Tax	Shipping	Total
Simrad license	\$ 26,100.00	\$ -	\$ -	\$ 26,100.00
WBT Electronics	\$ 17,400.00	\$ 1,348.50	\$ 200.00	\$ 19,000.00
Oxygen Sensor Service	\$ 1,040.00	\$ 80.60	\$ 100.00	\$ 1,300.00
Electronic Components	\$ 1,000.00	\$ 77.50	\$ 200.00	\$ 1,300.00
Spare cabling	\$ 2,000.00	\$ 155.00	\$ 200.00	\$ 2,400.00
Bracketry	\$ 500.00	\$ 38.75	\$ -	\$ 600.00
Journal Submissions	\$ 1,000.00	\$ 77.50	\$ -	\$ 1,100.00
Conference Attendance Fees/Travel	\$ 3,000.00	\$ 232.50	\$ -	\$ 3,300.00
Total:				\$ 55,100.00

- Items 1 and 2, Simrad transceivers are requested because Simrad has been unable to make their single system performed on 4 sonar channels as well as the two parallel systems of two channels that we integrated in 2018. As such one of these two systems has been on loan to us through this year, but we feel like it would be prudent to buy the loaned system as it is currently critical to our operation.
- The oxygen sensor service (Item 3) can be removed or transferred if this maintenance would be covered under the core CTD proposal.

Project team

RDS:

Kelly Benoit-Bird
Bruce Robison
Kim Reisenbechler
Chad Waluk

RDE:

Eric Martin, EE
Paul McGill, EE
Mark Chaffer, EE
Rich Henthorn, SE
François Cazenave, ME

DMO:

Hans Thomas, AUV Supervisor

Project lab and office space requirements

In addition to any changes to current space usage, please also include anticipated office and lab needs for students, postdocs, collaborators, etc.

No further needs

R/V Paragon Requests

If the project team will be requesting time for the R/V Paragon, please specify the operators in the group and provide estimates of their availability to operate the vessel. DMO staff have extremely limited availability to be operators and only with advanced budgeting and planning.

Not applicable

Risk matrix (development and infrastructure projects only)

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

d) Compliance Considerations

Export Regulation

Does the project team anticipate any foreign collaborations or international travel? If so, please identify collaborators by name, institution, and country.

None at this time.

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.

The data from the bioacoustics system is open format.

Monterey Bay National Marine Sanctuary (MBNMS)

General Permit

Projects teams need to indicate if any work will be performed that is either: (1) currently authorized under our general permit; or (2) will require that we obtain authorization. The current permit can be viewed at http://mwww.mbari.org/pco/permits/mbnms-2015-002_feb2015.pdf. Please see Mandy Allen for questions.

Is a permit with MBNMS required for your work?

No

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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 https://sanctuarysimon.org/regional_sections/maps/mpaviewer/. If your work will be conducted in one of these areas, please indicate which area by number or name (zoom in to see names of MPAs).

None

California Department of Fish & Wildlife

A Scientific Collecting Permit will be required for biological and geological sample collections offshore California (even in Federal waters and beyond), and for many activities in State Marine Protected Areas. Please see Mandy Allen for questions.

Will you be collecting samples that require a permit?

No

Will you be working in a [State Marine Protected Area](#)?

No

United States Coast Guard

If your project will deploy or maintain moorings, the project team must ensure proper compliance and notification of these activities to the US Coast Guard. DMO does not automatically do these notifications on behalf of projects. Two common types of permits and notifications that may apply to your project are [Private Aid to Navigation \(PATON\)](#) authorizations (required for buoys deployed for six (6) months or longer) and Notice to Mariners, which must be submitted for temporary PATONs (less than 6-month deployments). Other science operations may submit a request for a [Local Notice to Mariners](#) and are useful for missions or deployments with risk of 3rd Party Liability such as the Wave Glider.

Will your project require a PATON?

No

If yes, have you obtained a PATON? (Please provide a copy to Mandy Allen.)

No

Will your project require submission of a Local Notice to Mariners?

No

If yes, please indicate who will be submitting requests and provide a copy of the submission to Mandy Allen.

N/A

Authorizations/Permits from other Agencies or Organizations

Is the project team aware of any other permits or authorizations that will be necessary to perform the proposed work? If so, please list below along with status of authorizations (obtained, pending, need to apply, etc.). Please see Mandy Allen if you have questions.

No

Active Acoustics

We are keeping an inventory of acoustic instrumentation. The current list is posted here: https://mwww.mbari.org/resources/2019_Proposal_Process/documents/mbari_acoustic_instruments_updated_july_2018_ver_12.xlsx. If you have or plan to use equipment that is not already on this list, please be sure to include that information here.

This system is listed under the current spreadsheet, and as developed is categorized as “No Issue”.