Project Number: 902100

Project Start: Jan. 1, 2020 [1] **Project Duration (in years): Year 1 of 2**[1]

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

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

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

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

Project Manager[3]: Eric Martin

Principal Investigator: Kakani Katija

Lead Scientist: Heidi Cullen

Lead Engineer: David Caress

Project Title: Telepresence on MBARI Research Vessels

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

[ ]	[ ]	[ ]	[x]
Ocean biogeochemistry	**Ecosystem dynamics**	**Ocean visualization**	**Exploration & discovery**

1 This date and number should remain the same for the duration of the project. If your project start date for 2021 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.

Please indicate percentage of effort on this project anticipated for 2021 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 transfer[4]
Percentage	80%	10%	10%

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

1) ABSTRACT (if submitted during abstract phase)

A perennial challenge that the oceanographic research community is trying to address is how to effectively engage participation in and expand access to ocean exploration and discovery. While MBARI is fortunate to have a highly regarded marine operations program and consistent access to the sea, scarce seagoing resources are a significant limiting factor for many members of the research community. Additionally, livestreamed outreach capabilities that enable real-time participation and observation of research cruise operations—part of David Packard's original vision for MBARI—have been shown to have measurable impact on public engagement and support for ocean science and conservation (e.g., E/V Nautilus, NOAA's Okeanos Explorer). Therefore, there is a significant value to increasing participation and involvement in research cruises at MBARI through either increased engagement of external collaborators or more broadly through outreach.

Telepresence is a promising modality that can augment both science engagement and public outreach, and has been gaining traction in the oceanographic community in recent years. This project seeks to design, acquire, and implement telepresence on MBARI research vessels for both use cases. Based on recent scoping efforts motivated by addressing science party limitations due to COVID-19, we have identified solutions that address both science operational capability and public outreach. These solutions require minimal resources to implement telepresence on both of MBARI's research vessels, and largely leverages existing hardware and data pathways. This effort is especially timely given global uncertainty around COVID-19, as well as the potential for playing a significant role in the Monterey Bay Aquarium's upcoming exhibit - *Into the Deep: Exploring Our Undiscovered Ocean*, launching in spring of 2022.

This work addresses the grand challenge of increasing access and engagement in ocean sciences, exploration, and discovery, without significantly impacting resources and science and engineering missions while at sea. Telepresence presents a strategic opportunity to engage external science partners while also promoting ocean science and conservation through public audiences and outreach. This effort is relevant in that it can provide the capabilities that facilitate broader science/engineering partnerships, as highlighted in the Technology Roadmap, and enable a persistent presence and sustained involvement in ROV operations.

Our efforts will focus on leveraging existing technologies on MBARI's current research vessels. Surveying the specific science and outreach requirements of MBARI collaborators and users, we will aim to find appropriate tools that we can integrate in each ROV control room. While online streaming has evolved into a ubiquitous consumable for the internet, there remain technical challenges with reducing latencies for operational use. Latencies will inherently compromise collaborator contributions, but initial testing has proven that those can be reduced in exchange of video clarity. Since initial scoping efforts have determined that both ships possess ship-to-shore telecommunication systems capable of meeting requirements, innovation will occur in developing tools to emplace remote users in the control room, providing context, and allowing for remote contributions.

2) PROPOSAL

a) All Projects

Statement of the challenge, why it is important

Providing access to the deepest parts of the Monterey Bay Sanctuary is a core reason MBARI was established in Moss Landing. Few research institutions can claim to reach deep water in only a single day's transit, and this access has driven MBARI as a world leader in deep-ocean research. However, despite access to deep water, MBARI research vessels continue to be limited in at-sea contributions due to personnel restrictions imparted by limitations on accommodations. Also, the remote nature of oceanography serves to restrict participants who have health limitations or physical disabilities. This problem was addressed in recent ship designs for NOAA's latest AGOR class vessels. Both the R/V *Sally Ride* and R/V *Neil Armstrong* were designed with staterooms and limited deck access to accommodate wheelchair access for scientists at sea. However, addressing the accessibility and space limitations of oceanographic vessels is a solution with large capital costs, large facility requirements, and does not scale effectively. We must endeavor to attack this problem from other perspectives, leveraging new technologies from other domains than marine architecture.

Telepresence describes a broad set of technologies that when combined, facilitate interaction with an environment by an individual in a distant location. ROVs are in their own way, a technology of telepresence, and their prevalent use in oceanographic research has almost completely replaced manned submersibles over the last 40 years, extending our reach to the ocean floor and expanding the access to all personnel onboard a research vessel. Telepresence systems for use on ROVs date back to developments against Woods Hole's *Jason* ROV, when Dr. Robert Ballard created the JASON Project in 1988 to bring ROV video directly into classrooms to share the excitement and discovery with classrooms around the world. In this initial incarnation and through the 1990s, the technology needed to bring ROV video and data back to shore was both large, expensive, and required a team of broadcast engineers to maintain and operate, both at-sea and on land. More impactfully, those engineers occupy valuable bunks, making this technology unobtainable to regional class research vessels.

Even today, with advances in both satellite technology and the advent of broadband internet, satellite technologies needed to transmit multiple video feeds and accommodate daily ship internet needs are still too physically large to fit on many vessels, and service costs still remain high. Few vessels carry the budget to maintain a constant telepresence functionality for their at sea operations. However, you will be hard pressed to find a research vessel today that does not possess a consumer grade VSAT system, with dishes sized under 1.5 meter diameter. These systems can provide connection speeds up to 5mbps, just enough for a single feed of high-definition (HD) quality video. There are many vessels, including the R/V *Rachel Carson*, and

R/V *Western Flyer*, which could benefit from a solution designed to meet basic requirements and live within the constraints of the consumer VSAT systems already installed onboard.

Our world has changed rapidly, with the rise of the COVID-19 pandemic, restrictions at sea have grown even larger, challenging the normal operating paradigms that MBARI has developed around its offshore research programs. Restrictions for seagoing participation have restricted access for both MBARI employees and collaborators, and reduced science workforce sizes. Either science goals must be similarly scaled down or new techniques adopted to preserve effectiveness of operations. Recent discussions with other institutes and research operations have reinforced that MBARI is not alone in addressing these concerns.

Telepresence can help by allowing for remote science direction, annotation, and collaborator contribution. In times of great strife such as these, history has taught us to expect a great expansion in technology development in response. We can already see this in recent advances of telecommunications. During this shutdown, the general public has become more broadly literate in teleconferencing and remote work. Daily, new rockets are bringing constellations of new communications satellites to expand the reach of broadband internet to all parts of the world, addressing the digital divide, such as the Starlink system. Heightened competition in these spaces ensure that the future cost estimates of having a persistent telepresence solution onboard marine vessels are shrinking.

We propose to design a system that integrates recent advances in teleconferencing, gaming, broadcast, and cloud technologies into a small turnkey system designed to provide telepresence for the general purpose of expanding access and informing ROV dive operations onboard MBARI's research vessels. The impact of designing such a small and simplistic system will ensure that we can export the knowledge to other at-sea operations that are also meeting these new restrictions. MBARI has also begun pursuing a myriad of new outreach efforts. We would be remiss in not recognizing that this development is also an opportunity to expand outreach from our platforms as an added value proposition.

Relevance

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

The ideas presented here are well aligned with two main objectives of the strategic plan, "Enhancing collaborations", and "Expanding our reach". Specifically, strategy 3.3 establishes that we intend to widen access for our collaborators to MBARI assets. Telepresence efforts aim to allow collaborators access during critical science operations as if they were on board during ROV dives, and will enable a new class of collaborators to be able to work with MBARI researchers to test out new ideas and evolve their employment immediately.

With respect to expanding the institute's reach, we intend to engage with the social media team at the Monterey Bay Aquarium as part of the overall outreach effort proposed under this

project. Live events in collaboration with the Aquarium in 2020 have helped expose MBARI's research to the greater public, and further efforts with ongoing research activities will only inspire the community further.

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

Telepresence, when applied to oceanographic research, is an enabling technology for greater "Exploration and Discovery", a core principle of the Technology Roadmap. Expanding dive access to those unavailable to travel on MBARI research vessels can provide real-time insights to help inform ongoing ROV dive activities from a broader perspective provided by a network of researchers working towards similar goals. Discovery requires the research be directed in the moment, and though MBARI vessels provide unique access to the Monterey Bay Sanctuary, telepresence can help extend that reach even further.

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.)

Telepresence does not directly address the motivations of the Packard Foundation's Ocean Grantmaking program, but holds the promise of becoming a tool in enabling all MBARI researchers to help achieve those goals. Live video is compelling and engaging, and provides viewers an opportunity to understand the immediacy of some of policy and stewardship initiatives, as they listen to researchers comment on what they see on the screen. With the capabilities this system will provide, we could provide science and policy grantees more access in areas of interest to the Foundation.

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

There are few direct research activities for this project, as this is an enabling technology development. We will, however, need to work with a broad range of MBARI PIs to help establish technology solutions to make the telepresence experience as rich and complementary to our researchers as possible. Specifically, this will be addressed through expansion of MBARI's annotation and contextual awareness tools, outlined in the next section. We intend to leverage domain experts to help define these complementary tools, outlined in the 2021 research activities section.

Engineering/Technology Development

In May 2020, a subset of the current project team worked to conduct a scoping and feasibility study to determine if existing telecommunication solutions can provide required bandwidth for a basic telepresence solution. This study involved discussions with leaders in the field of telepresence, service providers, and telepresence researchers. Due to the immediate nature of this problem, we were approved to conduct some experiments on the Western Flyer. We

secured an upgraded service plan from the provider, and set about testing a proxy system on the ship, shown in Figure 1. We were pleased to find that the system was more than capable of sustaining telepresence activities, with stable connections all day, and tests lasting as long as 30 minutes without any significant dropouts. Also, we tested a number of services, evaluating quality across 6 users and latencies to each one.

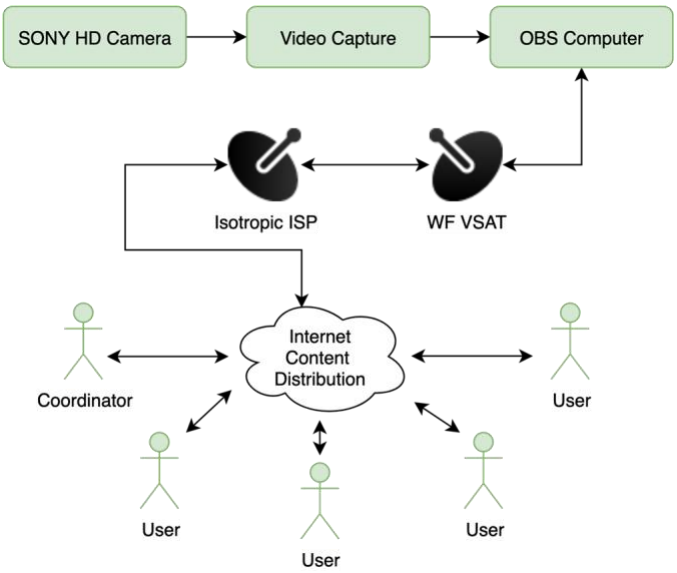

Figure 1: The simplified model of the test system used in the 2020 scoping study.

More than video, a rich experience will be designed to facilitate ROV dive participation. If we expect a scientist to sit at home and take part in these dives we must provide a solution that allows them to make observations so they can participate in discussions that lead to real time decision making. Also, they must have the ability to annotate what's happening, possess contextual understanding and in some cases provide technical support to the smaller team in the field. Put more simply, the product must address the following themes:

- Observation
- Discussion
- Decision making
- Annotation
- Situational Awareness
- Technical Support

In order to provide this functionality, we propose a system that integrates as an ancillary set of equipment to the existing video and audio sources, collecting available contextual data present already in control room networks. This set of broadcast and PC electronics will aim to be a rack-mount "turn-key" system integrated as non-critical and ancillary to existing control room components. This will

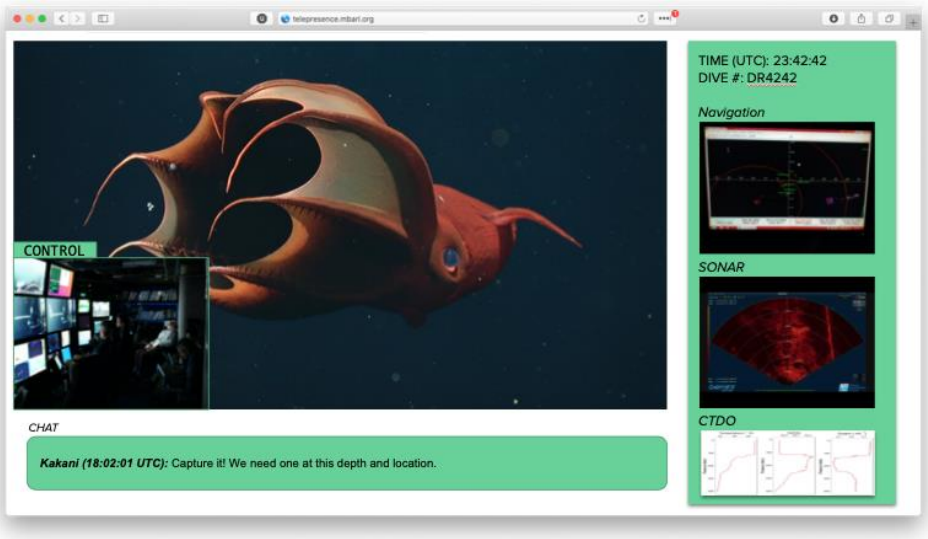

Figure 2: Mockup of the user interface for contextual data presentation with ROV video.

assemble video and data sources and broadcast over the shore link. This system will be operated by science personnel on ship, with video and data feeds maintained eventually by ROV pilots. Dedicated shore-side systems or agile cloud-based solution for content distribution and hosting. Figure 3 presents a vision of all the functional aspects of the final system that will have to be assembled for broadcast.

Along with a hardware solution, we seek to develop more tools to present telepresence users with contextual information to help emplace the remote user into the ROV control room, such as ROV attitude, position, recent waypoints, vehicle track, and environmental sensor data. To that end, we proposed to develop or employ existing software frameworks to provide remote users this necessary perspective to facilitate decision making during participation in remote ROV dives. These tools will be described in more detail in the 2021 efforts section.

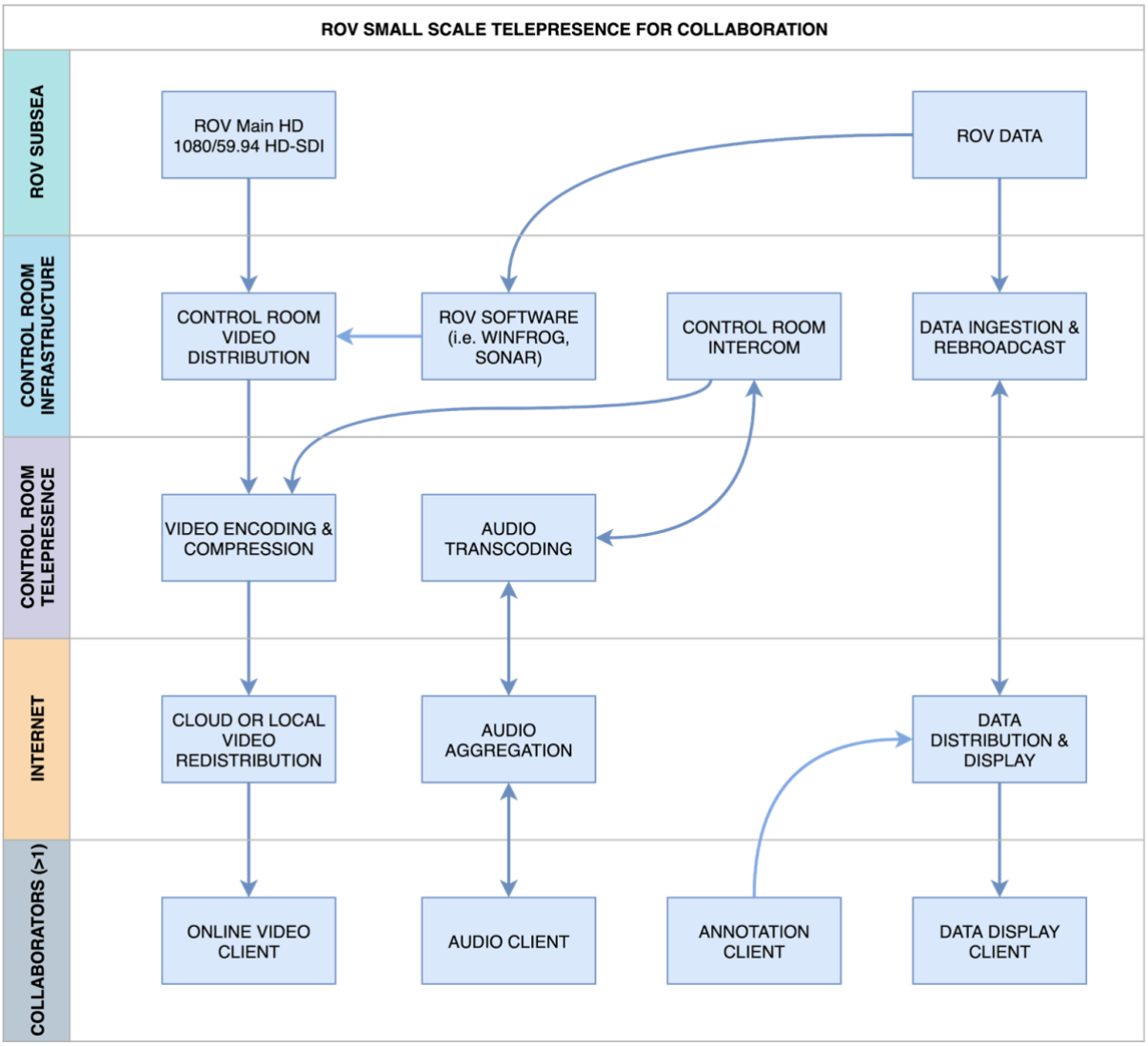

Figure 3: Functional telepresence system diagram.

The final aspect of planned development will address the annotation needs of the telepresence solution. VARS is the natural candidate, and we will aim to improve the system to allow for annotations for remote users. This is not currently supported in the current architecture, but with some modifications this can be accomplished, providing a familiar interface to MBARI personnel.

These developments will be targeted for completion in 2021, reserving the second year of the project for documentation and training, along with outreach components discussed in the Field Programs section. At the end of the project, we expect the system to transition the system from development into an asset allocated as part of cruise planning done during normal proposal cycles to enable appropriate budgeting and shore support.

Marine Operations/Field Programs

Telepresence development and integration will require significant access to both the R/V Western Flyer and R/V Rachel Carson. As part of the development cycle, we do not intend to request any dedicated test days at sea, proposing instead to test solutions thoroughly "at the dock". We expect to complete the prototype system during the 2020 discretionary effort that is currently underway. Extended developments in 2021 contain design risk with network reliability and bandwidth, and will be informed to their data limitations by 2020 efforts. This will limit needs for at sea tests.

However, we would be remiss in not acknowledging that as the system is evolving, ship personnel will be critical collaborators as the system becomes hardened. In the 2020 discretionary efforts, we have already identified key DMO personnel for each vessel that will be part of the development cycle as collaborators and feedback to the design team. The goal of 2021 efforts specifically are to refine the prototype system such that it can be managed from shore by users and coordinators, and develop an operator training program for science personnel onboard to minimize ship personnel labor impacts.

Data

What data products will be generated?

The video experience streamed in real-time is the only uniquely new data product proposed that may need intermittent archiving. All other data products that will be used in contextual display or annotation are already logged under data management software present on both vessels. Core video is already logged.

How will the data products be managed?

These archival video experiences will be stored in the project library, and those archived for outreach will be managed directly by ITD personnel. The livestreams themselves will be

saved to the social media platforms and not archived on MBARI servers.

Describe data availability outside of the project team.

There are no restrictions on data, except for embargoed video identified by telepresence users and their collaborators.

Describe data storage requirements.

We will occasionally require storage for video experiences as a form of documenting progress on the project, and other allocations are covered under telepresence user's projects. Also, the planned ITD outreach components will need to be stored as well. In total we estimate 48 hours of video will be stored, 100GB of video at the bitrates we expect to stream.

Anticipated Impact

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

Any ship user that requires collaborator access can apply to use the tools developed under this project. In 2020, we have already begun working with MBARI PIs that need to move control room roles to shore, as well as engage collaborators that no longer have access to MBARI vessels. These current users include the Katija, Paull, Caress, Smith, and Barry labs, as well as the Aquarium MBARI Partnership (AMP).

Anticipated Outreach

What outreach assets might you need to better reach the audience/consumers you are targeting? Specify how you might like to reach your audience (published paper, seminar, conference, social media, etc.) and what type of assets (graphic, animation, video, etc.) you might need ITD to help generate.

Beyond the development of the system, our outreach team members expect to use the system after its initial development to conduct one-hour long live broadcasts,a coordinated effort between the Aquarium social media team and ITD. We are hoping to broadcast (over MBARI and MBA social media channels) the live feed from our research vessels on 6 - 10 times in 2021 working up monthly after that. . The livestream would be a one-hour long event during selected R/V Western Flyer (or MNV) expedition and once every month or two for the R/V Rachel
Carson expeditions, once developments of the video solution are complete. These events would be planned in advance with the chief scientists of the targeted expeditions.

For each broadcast, the mission is to bring the excitement and joy of deepsea exploration and discovery to a large audience, share MBARI research with classrooms, and the general public, and generate awareness and enthusiasm for deep-sea research. These one-hour

livestreams will be coordinated by ITD and include the ability to respond to comments and provide an abbreviated audio summary of dive activities during the broadcast by onshore researchers and communicators, with some interaction with the researchers at sea. While COVID-19 restrictions remain in place, we expect the broadcast to be primarily coordinated from shore.

In recent discussions with the aquarium team, efforts like these are exactly what they originally envisioned for these livestreams—connecting to MBARI scientists at sea. The COVID-19 quarantine and Aquarium shutdown gave the Aquarium's social media team the motivation to launch this program sooner than they may have otherwise, working with Susan von Thun to coordinate MBARI researchers as guests on a monthly livestream that is broadcast across seven social platforms at once. The reach for these livestreams have been between 25,000 and 60,0000 views pers livestream.. We believe that 720p and 10-20 second latencies (witnessed during scoping studies) will not be a significant deterrent to the Aquarium's original desire to connect with MBARI researchers at sea.

With MBARI outreach experts' interpretation (ITD personnel), along with the scientists at sea and the commentary of the MBA social team, we have the potential to do this livestream in a very different way from what other platforms like E/V *Nautilus* and R/V *Okeanos* are doing. Leveraging the Aquarium's online reach and planning this well in advance, we have the potential to reach an even larger audience, making it one of the Aquarium's premier livestreams that will support the campaign for awareness about *Into the Deep: Exploring Our Undiscovered Ocean*, slated to open in April 2022.The Aquarium's goals for awareness around this exhibit will increase in scope as we approach this opening and will continue during the exhibit's successful launch.

Intellectual Property (IP) Considerations

Do you anticipate a need for a cooperative research and development agreement or licensing arrangement with an external entity?

No

Will novel IP be created, and how might it be disseminated (e.g., open-source, royalty-free license, commercial license agreement)?

No

Will the work potentially result in a patentable product or service?

No

For additional guidance please review MBARI's intellectual property internal web page: https://mww.mbari.org/itd/ip/.

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

This effort was approved under discretionary funding after the abstract presentation in July 2020. We have begun purchasing equipment and expect to begin telepresence operations on July 20th, and have commitments to service cruises through the rest of the year. Prior to the official start of the effort, and during the shutdown, a subset of the team was able to complete a scoping effort that led to a successful test of the VSAT system on the *Western Flyer*, verifying the requirements as we defined them.

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

Not applicable, this project began in July 2020

Will you complete the current year's scheduled work?

Yes.

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

Due to limited resources, the discretionary effort has a greatly reduced scope, planning on providing the bare minimum telepresence required to meet the immediate need.

c) All Projects: Specific Plans for 2021

Research Activities

This is primarily a technology driven project, but we have some research goals as well. We expect to continue to build relationships with individuals interviewed during the scoping effort, and communicate our efforts to the telepresence user community during 2021. Dwight Coleman at URI's Innerspace Center has agreed to continue advising us during developments, and could evolve into a collaborative effort during the second year of the project, once we have compatible hardware requirements established. We also intend to continue discussions with recent seminar speaker, David Lees of NASA Ames, about his developments of xGDS and how those research lessons can inform our telepresence design

Also, we have been in brief discussions with Leila Takayama, associate professor at the University of California, Santa Cruz, who has worked extensively on telepresence robotics for remote collaboration (more info). Some of our team have been working with Leila for improvements in human-robot interactions as part of the research efforts in the LRAUV project and the ROVVR project. There are many commonalities between ongoing efforts in that project and the one proposed here. We intend to apply the ROV-human interaction knowledge that we gain in ROVVR to the telepresence efforts related to contextual data presentation for improved situational awareness. She would like to join the team in 2020 to augment our original scoping efforts through shadowing ongoing activities as the discretionary effort begins, identifying common themes, needs, and pain points for scientists. Those findings would then ground a virtual workshop with participants to deliver UX design goals for 2021's efforts. Leila's contributions during iterative developments in 2021 would then focus on ongoing observations and measures, capturing insights for improving the design of telepresence systems, and benchmarking the improvement made at each version.

Engineering/technology development

By the end of 2020, thanks to discretionary funding, we expect to have a fleshed out prototype of the hardware solution proposed to meet the immediate needs of COVID-19 restrictions. We expect to further prove the telepresence capabilities of the telecommunications systems on both vessels. The Western Flyer will continue to use its 1.5 meter SeaTel VSAT system. After a survey of MBARI PI operating areas, we have determined that the *Rachel Carson* can achieve telepresence using the onboard microwave system. The VSAT system onboard the *Rachel Carson* is not well suited to the demands of telepresence, both from cost and bandwidth limitations. Efforts in 2021 will focus on improving contextual awareness, multi-user annotation, and hardening of the prototype electronics into a well described and easy to operate control room component. We will also endeavor to integrate telepresence components already present on the *Rachel Carson*, and ensure the microwave system is well spared.

The contextual awareness developments will leverage recent developments across a multitude of adjacent projects in data processing. Figure 4 outlines the current concept that will be refined as the software design matures. Many of the components on the boat side are expected to be prototyped in 2020. Video composition will be developed using either open-source or enterprise Open Broadcaster Software (OBS) solutions. These software tools offer a complete solution for collecting video sources and control inputs to replicate a compact version of a tv

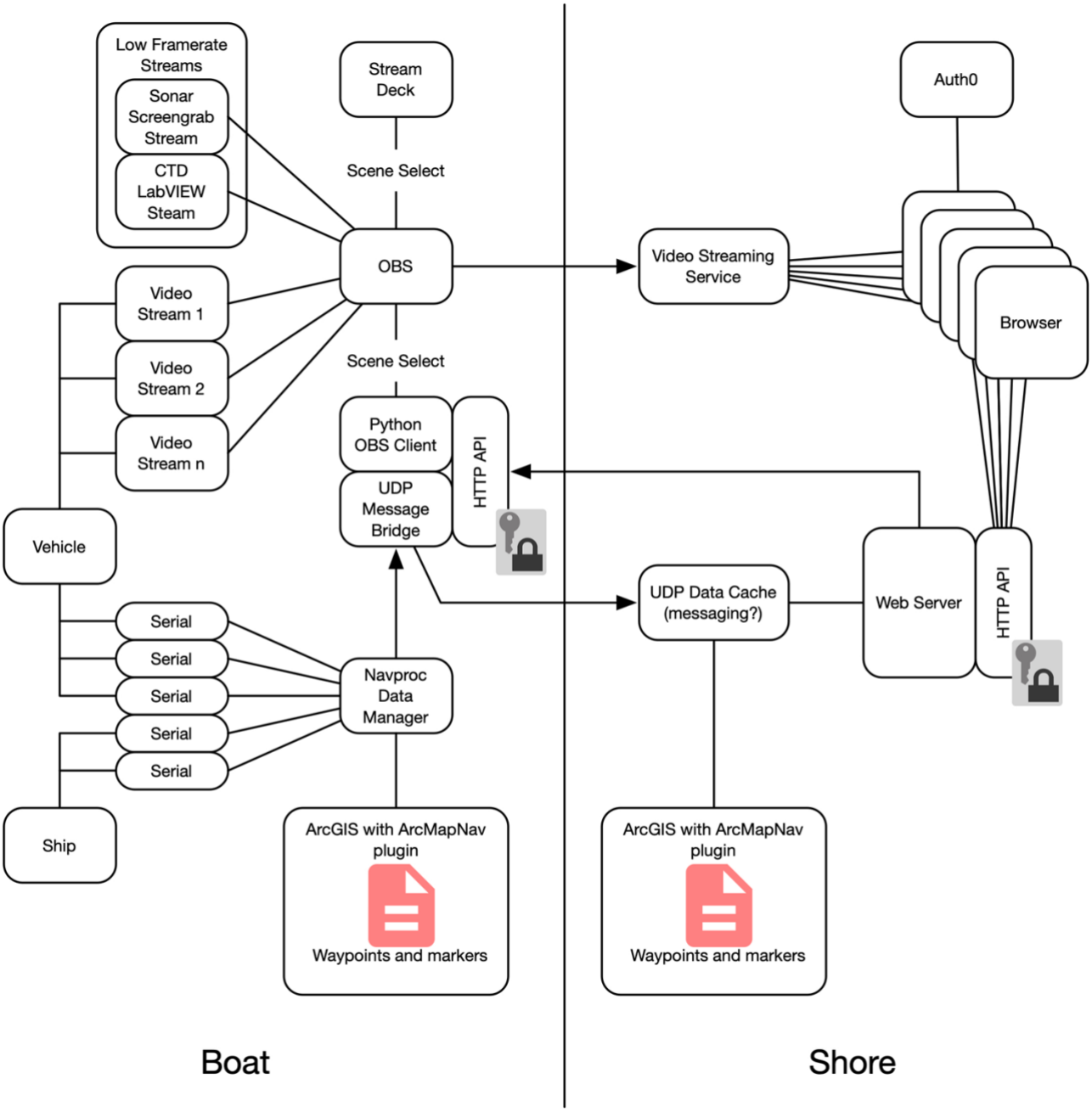

Figure 4: Proposed telepresence web context concept diagram.

production studio, facilitating scene switching, overlay components and direct encoding to source streams to either content distribution networks (CDNs) or social media targets such as Twitch, YouTube Live or Facebook Live.

On both vessels, contextual data of interest are available on the network through the Navproc and Data Manager processes. New developments will be to create a software bridge providing that data to OBS and to a web server that telepresence users can view the data in real-time during dive operations. The shore-side targets will likely leverage cloud based message brokers and web servers to provide accessible and low-latency informational displays to users. Some improvements need to be made to ArcGIS plugins as well to create message pathways. Sub tasks within this development include tools to monitor data streams, authorization interfaces, a client interface to OBS software, and a web application that end users can view the stream and contextual data.

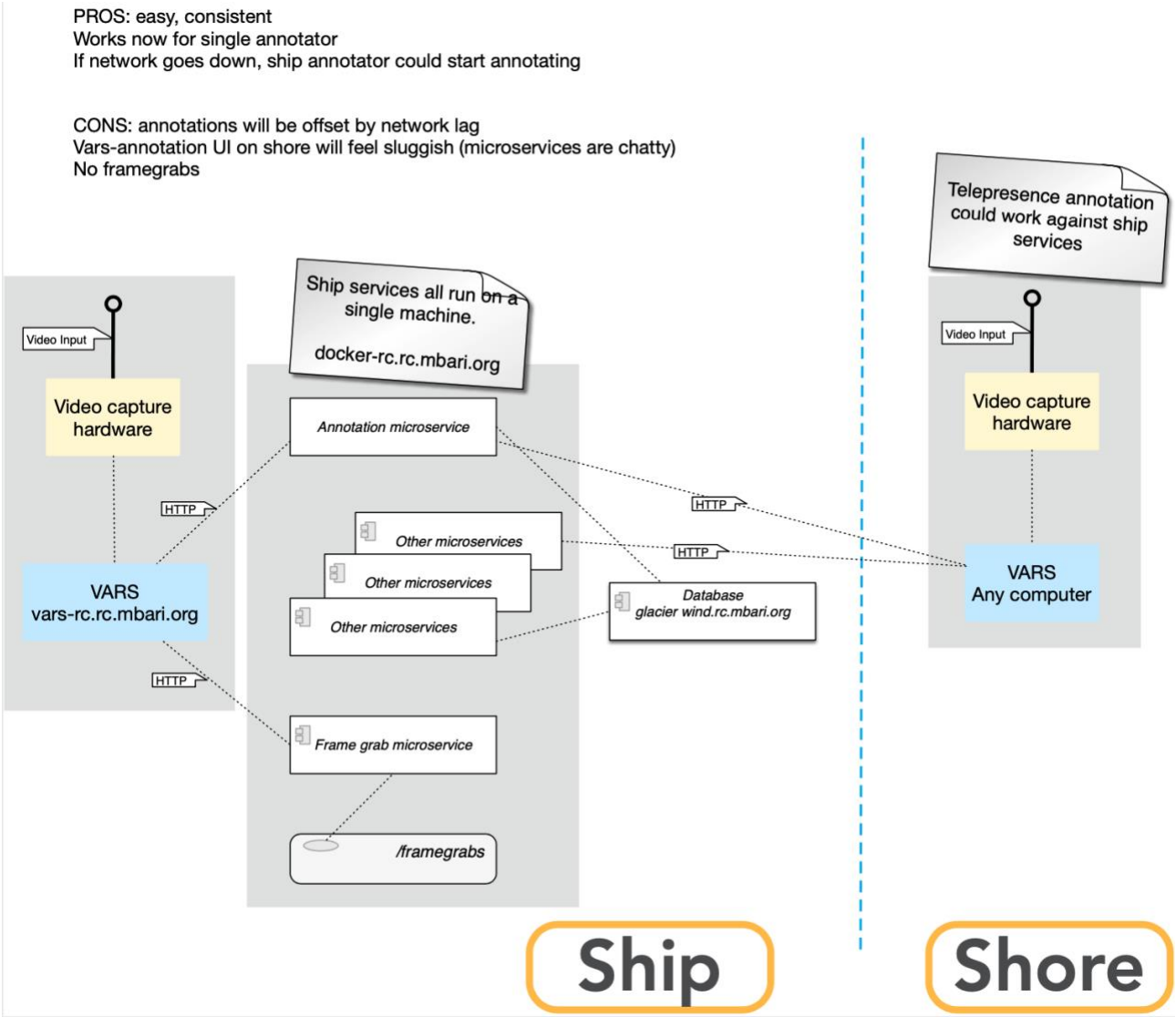

Figure 5: VARS software concept for telepresence users contributing to the shipboard database.

There are also required modifications to VARS as annotators start documenting dives from shore-based locations. It is not practical to expect quality frame grabs be taken of compressed video feeds, and so we advise that shore annotators will still create VARS database entries, but they will not have frame grabs attached to them initially. To aid in this new need for post-dive frame grab attachment, one effort will focus on creating software tools to automatically extract frame-grabs for real-time annotations from telepresence dives when the videos are copied back to shore.

More challenging problems arise from addressing the need for multiple contributors based in disparate locations and networks. For example, we must address the case in which the shore link is broken, and dives will continue on. An initial concept has been developed to address this problem, depicted in Figure 5.

Will novel intellectual property be developed and/or disseminated?
Dissemination includes patenting, licensing, and collaboration agreements.

These technologies will be evolutions of open-source products at MBARI, and no IP will be developed.

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.

Aside from working with individual PIs to provide telepresence to suit their needs. We will plan in 2021 to work with ITD and PIs to select 6 dive days once the schedule is set for the one hour livestreams as described in the outreach section.

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.

This is not applicable to this project.

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.

Not applicable.

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.

Not applicable

Specific deliverables

The deliverables for 2021 are the following:

- A rack-mounted "turn-key" hardware system, refined from the 2020 prototype that meets the requirements to ensemble video, audio, and contextual data.
- A contextual data presentation layer for vehicles aboard the *R/V Western Flyer* and *R/V Rachel Carson*
- VARS for multi user remote contribution.
- Microwave system maintenance and upgrade

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

1. Hardware System Refinement: Eric Martin, Ben Erwin, Craig Okuda
2. Contextual Data Presentation: Kevin Gomes, Rich Schramm, Mike Risi
3. VARS for Remote User Contribution: Brian Schlining
4. Ongoing Coordination of Telepresence Services for 2021: Eric Martin, Ben Erwin, Karen Salamy (precruise form modification), Adriana Sisfontes (QoS)

2021 Project Start Date: 01/01/2021	**Milestone 1**	**Milestone 2**	**Milestone 3**	**Milestone 4**	**Total Resources[5] (in hours)** for each resource category for all milestones listed here
Milestone Date					
Milestone Description	**Hardware Refinement**	**Contextual Data Web**	**VARS for Multiusers**	**Coordination & Training**	
Electrical Engineer	**EM - 160 CO - 120**	**EM - 10**	**EM - 10**	**EM - 80**	**EM - 260 CO - 120**
Software Eng-Embedded		**MR - 16**			
Software Eng-Info Eng		**KG - 220 RS - 124**	**BS - 210**		**KG - 220 RS - 124 BS - 210**
Mechanical Engineer					
Mechanical Eng-Division					
Mechanical Eng-Mfg					
Associate Engineer					
Electrical Tech	**TBD - 20**				**TBD - 20**
Software Tech				**KS - 16**	**KS - 16**
IS				**AS - 16**	**AS - 16**
ROV Technician	**BE - 80**				**BE - 80**

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

Budget justification

Task Group	Function	Item	Unit Cost	Qty	Extended
Hardware Refinement	Video/Audio Ingestion	Decklink Quad HDMI Capture Card	$545	2	$1,090
		Decklink SDI 4K Capture Card	$295	2	$590
	SDI to HDMI Converters	Black Magic SDI to HDMI MiniConverter	$59	2	$118
	Video Cabling		$250	2	$500
	Intercom	Audiocom WM1000 for line tap	$399	2	$798
	Intercom adapter	Focusrite 2x2 Channel USB Audio	$149	2	$298
	Audio Cabling		$250	2	$500
	Rack Mount Hardware		$500	2	$1,000
Microwave System	DVEO DOZER Software update		$500	1	$500
	Stream Configuration Hotkey Controller	Elgato Stream Deck Controller	$150	2	$300
	Broadcast PC	Dell 3930 Rack PC	$3,000	2	$6,000
Web Context	Message Broker	Amazon MQ	$525	1	$525
	Web Hosting	Amazon Web Services	$525	1	$525
Web Services	Cloud Restreaming Services (12 months)	Wowza	$2,400	1	$2,400
	Cloud LiveStream Services (12 months)	Restream.IO	$1,188	1	$1,188
	Teleconferencing Services (12 months)	Zoom	$180	2	$360

Costs:	$16,692
Taxes:	$434
Shipping:	$200
Total:	$17,325

Project team

RDE:

- Kakani Katija, Principal Investigator
- David Caress, Lead Engineer
- Eric Martin, EE, Project Manager
- Kevin Gomes, SE
- Craig Okuda, EE
- Brian Schlining, SE

DMO:

- Ben Erwin, ROV Pilot

ITD:

- Heidi Cullen, Lead Scientist
- George Matsumoto, Senior Education & Research Specialist
- Susan Von Thun, Science Communications and Content Manager

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.

We only require a small amount of lab space for component testing, and we have already been sharing space in the B225 lab assigned to ROVVR and Ocean Imaging.

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		X		
Low	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.

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 (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 https://mww.mbari.org/pco/permits/mbnms-2020-006_exp28feb2025.pdf. Please see Mandy Allen for questions.

Is a permit with MBNMS required for your work?

No

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). If your work will be conducted in one of these areas, please indicate which area by number or name.

None

Anchors
*For activities conducted under MBARI's permit for the Monterey Bay National Marine Sanctuary, Paragraph 16, we are required to recover anchors weighing less than 500 pounds. Project proposals, which involve anchors weighing less than 500 pounds, shall specifically indicate cruise time allocated to anchor recovery. Lack of cruise time is not an acceptable reason for deeming an anchor less than 500 pounds "unrecoverable" under Paragraph 17 of MBNMS permit. Also under Paragraph 17, **ALL** anchors not recovered during the year must be reported detailing location, description of anchor, and reason not recovered. (Mandy Allen will collect this information from project teams to submit as part of the annual report to the Sanctuary.) Each ship will be tracking anchors deployed, duration of attempted anchor recovery, and anchors abandoned on the seafloor with the intent that they be recovered in the future as per MBNMS permit requirements.*

Will you be deploying equipment that will require anchoring? If so, please indicate approximate weight of anchors to be used and recovery plans.

No

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 (MPAs). 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?(See link above for Statewide MPAs or this link for Central California MPAs.)

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 request and provide a copy of the submission to Mandy Allen.

Not Applicable

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.

None

Active Acoustics

We are keeping an inventory of acoustic instrumentation. The current list is posted here: https://mww.mbari.org/resources/2021_Proposal_Process/mbari_acoustic_instruments_updated_may_13_2020_ver_13.xlsx. If you have or plan to use equipment that is not already on this list, please be sure to include that information here.