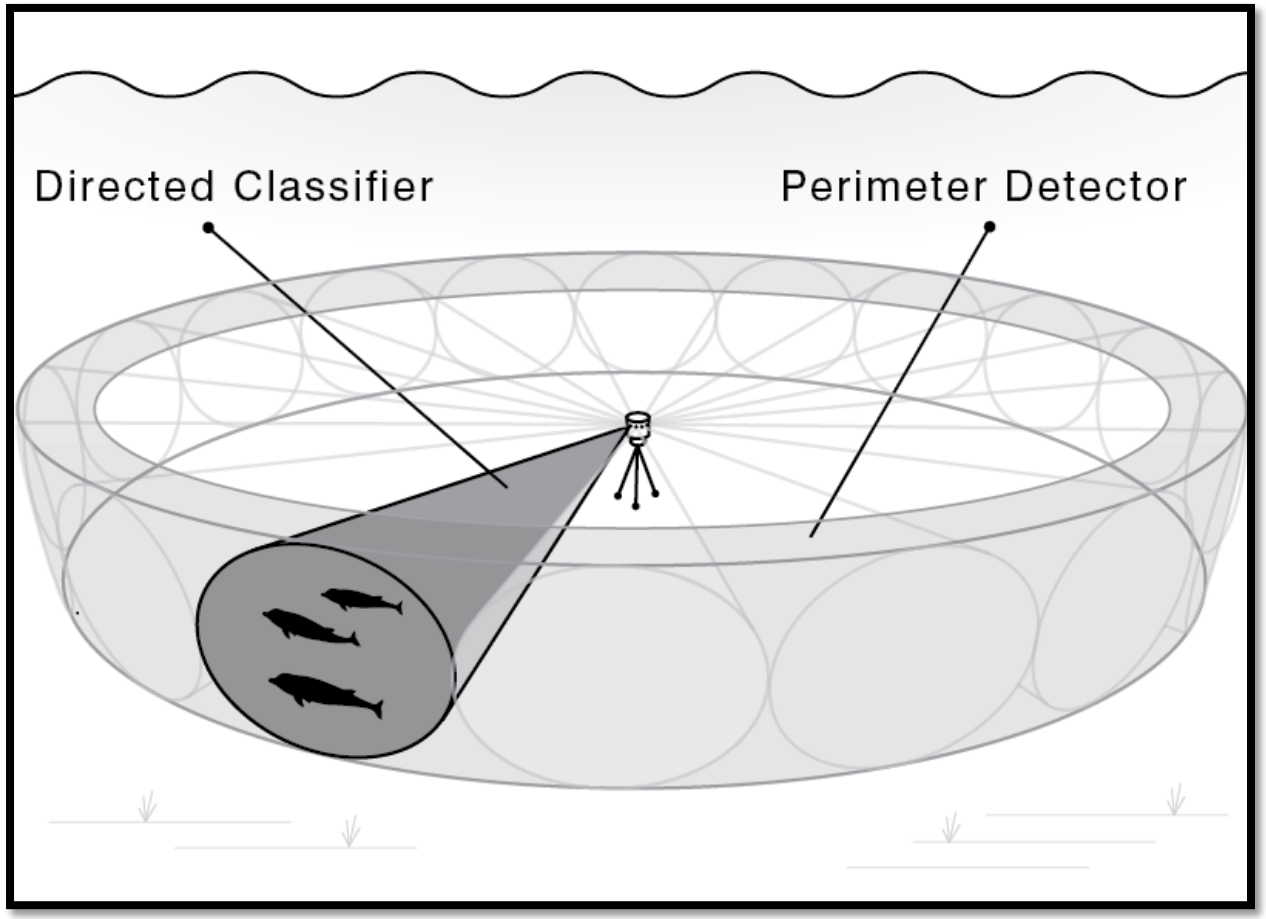
Project Title: Long-Range Target Detection and Classification System for Environmental Monitoring at Marine Energy Sites



Presenter: Tim Acker
Organization: BioSonics, Inc.

Email: tacker@biosonicsinc.com
Presentation Date: July 20, 2022

Project Overview

Project Summary

Deliver a practical, robust and cost-effective long range (200 – 300 meters) active acoustic monitoring system, with innovative shaped pulse and Chirp capabilities to suppress off-frequency sound energy within the hearing range of marine mammals, to automatically assess marine life behavior at Marine Energy sites. The one-of-a-kind sonar system successfully integrates a 360-degree Perimeter Detector to automatically detect and geolocate targets at range, and a focused split beam Directed Classifier to track and classify target types.

Intended Outcomes

Marine Energy (ME) developers, regulators and the public need to understand how candidate ME devices affect the behavior of fish, marine mammals and other marine life for responsible project permitting decision making and to provide an early warning of anomalous or dangerous marine life activity. This automated target detection, localization and classification system will help answer key questions, such as:

- Does the presence of a ME device alter the natural migratory and/or foraging behavior of marine mammals and other migratory species by repelling or attracting these animals?
- Do marine mammals become entangled in ME device mooring cables?

By unobtrusively monitoring marine life behavior before, during and after ME device installation, this technology helps to further understand the potential environmental risks to marine organisms from ME devices.

Project Information

Principal Investigator(s)

James J. Dawson, MSc

Project Partners/Subs

- Airmar Technology Corp.
- Dr. Orest Diachok

Project Status

Ongoing

Project Duration

Project Start Date: January 1, 2017
Current Project End Date: June 30, 2022;
Modification to Extend End Date to:
June 30, 2023 (in progress)

Total Costed (FY19 – FY21)

$147,018

****DRAFT TEMPLATE FOR REVIEW AND FEEDBACK****

Project Objectives: Relevance and Approach

Relevance to Program Goals:

- The BioSonics Long-Range Target Detection and Classification System for Environmental Monitoring at Marine Energy Sites contributes to WPTO's Marine Energy Program mission of reducing barriers to testing of marine energy devices in these ways:
  - Deployment of the BioSonics environmental monitoring technology alongside marine energy devices provides unbiased, scientifically defensible data on the presence, behavior and possible interactions of the biological community with the device itself and has the added benefit of providing automated alerts and early warning of anomalies.
  - The real-time automated reports generated by the BioSonics device when simultaneously deployed with the marine energy device reduces barriers to permitting by providing key insights about the site, the device and the marine life, keeping key stakeholders informed, reducing environmental and asset risk, while reducing the cost and complexity of environmental monitoring.

Project Objectives: Relevance and Approach

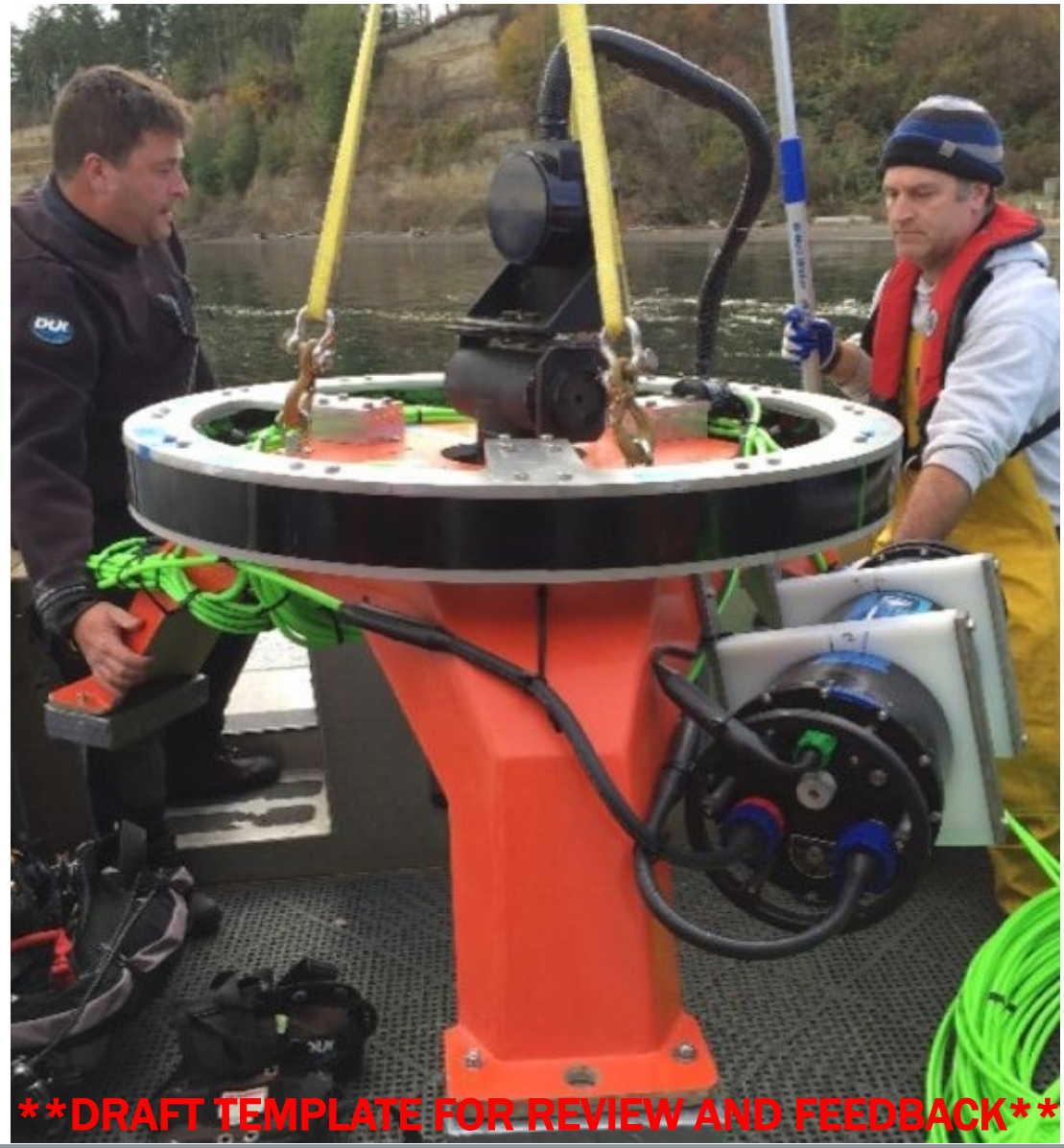
Approach

- Assemble a team of the best researchers in the field;
  BioSonics, Inc., Airmar Technology Corp., Dr. Orest Diachok (NRL).
- Transition similar technological accomplishments previously achieved by the project team for US Navy waterside security applications to the Marine Energy application.
- Develop and implement shaped transmit pulse and chirp technology to minimize monitoring system detectability by marine mammals.
- Take an incremental approach by first developing and testing a subsector 120-degree perimeter detection array.

Project Objectives: Relevance and Approach

Approach (continued)

- Work closely with Pacific Northwest National Laboratory's Marine Sciences Lab to field test and optimize the subsector array.
- Apply lessons learned and build out a full prototype system with 360-degree perimeter detector array and slew-to-cue directed classifier.
- Transition previously developed background clutter mapping and biological species classification capabilities to the prototype system.



Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Develop novel 200kHz omni-directional target detection sonar system.
- Develop 200kHz split beam target classification sonar system triggered by omni-directional detections
- Develop a shaped transmit pulse that reduces sonar frequency transmissions in the hearing range of marine mammals.
- Develop background environmental clutter removal software.
- Develop biological target tracking and classification software.
- Develop a cloud-based data processing and web-based dashboard reporting software.
- Co-locate all technology on a robust seabed platform with power and connectivity capability.

Outcomes:

- The first of its kind, an omni-directional long-range target detection and classification and monitoring system for Marine Energy sites reduces barriers to marine energy device testing and permitting by providing key insights for all stakeholders;
- This system to will have been fully tested on the seabed at a high energy test site;
- This system can be powered by a Marine Energy device and programmed to run continuously for long-term deployments;
- The system generates real-time Marine Energy site-specific biological target detections, geolocation, behavior, site anomalies and system status, and can display tracked targets in real-time on a web-based dashboard;
- The system can be remotely programmed via an intuitive real-time user interface.

****DRAFT TEMPLATE FOR REVIEW AND FEEDBACK****

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$750K	$187.5K	$937.5K

FY17	FY18	FY19 AND FY20 (EXTENDED)	Total Actual Costs FY17–FY20**
Costed	Costed	Costed	Total Costed
$199.2K	$562.5K	$165.9K	$927.6K

**Project cost performance goals have been achieved with actual costs in line with proposed budget costs, however, due to delays in the final in-water tests planned for Budget Period 3 (2019), the project Period of Performance has been extended through 2022, and the remaining milestones related to this final in-water testing at WETS, Hawaii, have not yet been achieved or costed.

Project Timeline

FY 2017-FY2018

Go/No-Go 1 Milestones <u>Achieved</u>:

NOAA/NMFS approved in-water test plan

Range and angular position of towed targets detected by the radial array test section successfully calculated, PNNL tested (Task 1)

Shaped Pulse transmission reduced sound pressure in the hearing range of selected marine mammals by 20 dB over baseline (Task 2)

Go/No-Go 2 Milestones <u>Achieved</u>:

Shaped pulse transmission fully integrated into Perimeter Detector and Directed Classifier (Tasks 1, 5)

Target Handoff from Full Perimeter Detector to Directed Classifier tested and verified (Tasks 1, 5)

Reduction in frequencies heard by selected marine mammals maximized by pulse shaping and power adjustments (Task 2)

FY 2019

- Continued development of noise removal and target classification algorithms
- Perimeter Detector background clutter removal and target detection algorithm development
- Directed Classifier targeted tracking and classification algorithm development

FY 2020

- Conducted extensive bench and tank testing for optimization
- Robust packaging and platform improvement
- Integrated, pitch, roll and bearing sensor testing

FY 2021

- Continued system testing at BioSonics facility, hardware and software modifications and improvements
- Internal data analysis and reporting optimization
- 100-meter seabed power and communication cable.

****DRAFT TEMPLATE FOR REVIEW AND FEEDBACK****

End-User Engagement and Dissemination

Strategy

- BioSonics team members have attended and presented information on the project at a variety of domestic and international conferences attended by developers, public and private stakeholders, and regulators. Project presentations at technical conferences are the most effective way to engage with members of the Marine Energy community, disseminate information and receive valuable feedback.

- BioSonics President, Tim Acker, serves on the National Hydropower Association's Marine Energy Council and is leader of the Regulatory Affairs Working Group. In this capacity, BioSonics maintains an on–going dialog with Marine Energy developers and decision makers from a variety of Federal Agencies. A key focus of the Regulatory Affairs Working Group is to simplify the permitting process for Marine Energy device deployment. Actively educating the community on BioSonics project achievements along with presenting similar achievements made by other WPTO Triton Initiative environmental monitoring technology developers is helping provide a pathway toward permitting simplification and stakeholder buy-in.

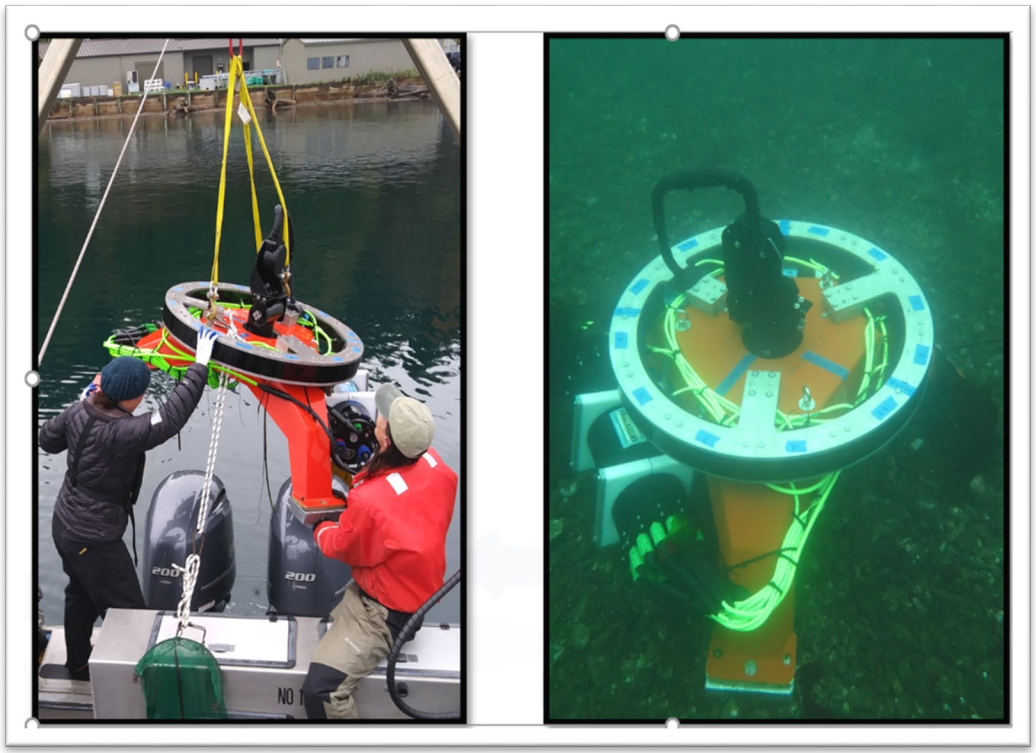
Recent Highlights

- In April 2022, BioSonics President Tim Acker, presented project updates at Waterpower Week in Washington DC. In addition, in cooperation with PNNL and WPTO, Tim Acker set up and managed an information table disusing all of the Triton Initiative technologies, along with other WPTO initiatives that are helping move the industry forward.

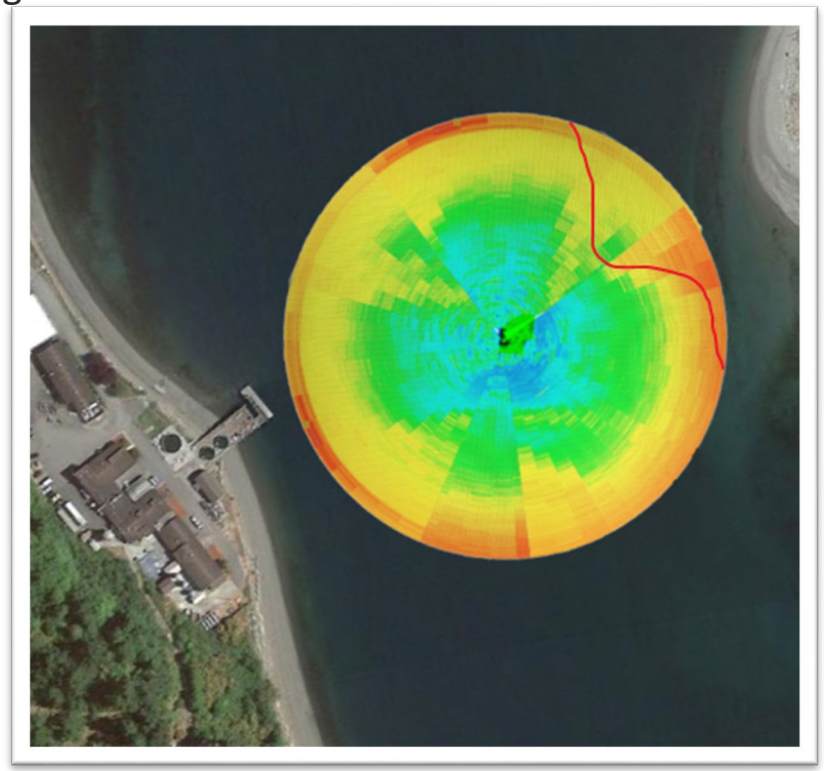
Performance: Accomplishments and Progress

2017 -2018 Prototype System Development and Field Testing

- Successfully designed, developed and operated the prototype system on the seabed in at high energy test site.
- Successfully tracked man-made targets as they were towed through the monitoring site.
- Demonstrated an intuitive real-time user interface displaying tracked targets in real-time



Test Site: Pacific Northwest National Laboratory Marine Sciences Laboratory - Sequim, WA, October 28-29, 2018



User interface – real time, omni direction display of system coverage area and target track

Performance: Accomplishments and Progress (cont.)

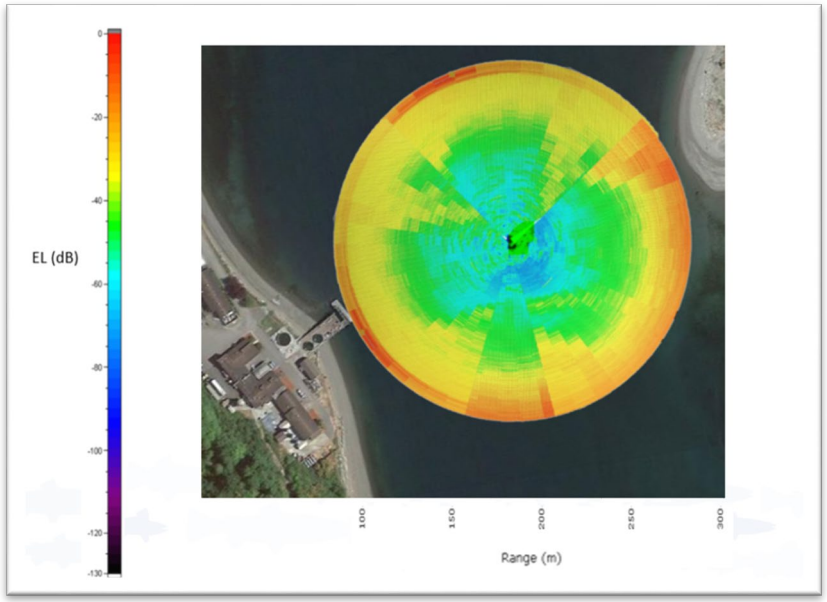
2017 – 2018 Suppression of Low Frequency Sound Energy Within the Hearing Range of Marine Mammals

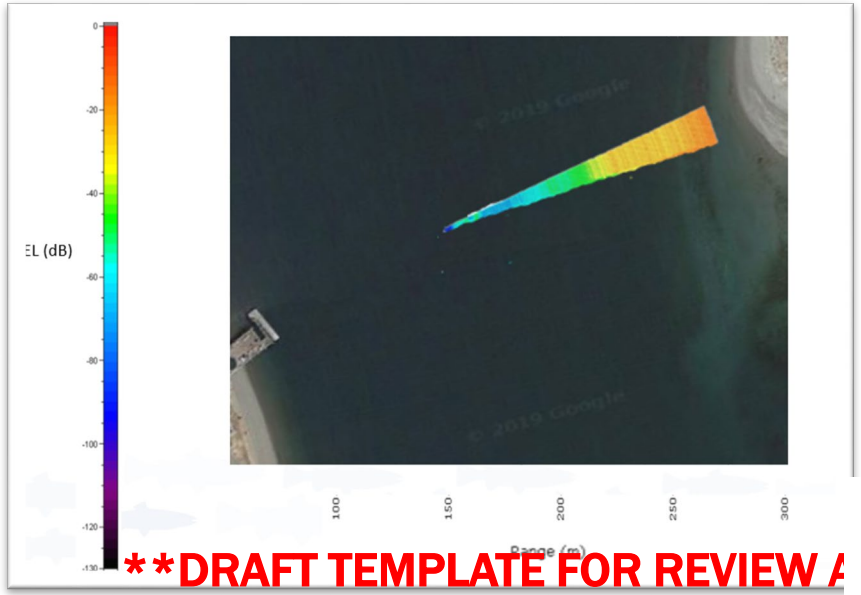
Minimizing the possibility that marine mammals can “hear” the monitoring system is critical to its permitting and credible application

Solution #1 – Minimize the total amount of sonar energy transmitted into the environment, while still covering a large omni-directional sector

- 48 individually operational overlapping 9° conical 200kHz transducers = omni-directional coverage.
- Electronically scanned in synchronized groups to maximize ping repetition rate and minimize crosstalk
- For a typical 400-meter omni-directional coverage sector, each transducer transmits an active ping lasting 3 milliseconds once every 2 seconds

Sonar is active only 0.15 % of the time in any given direction



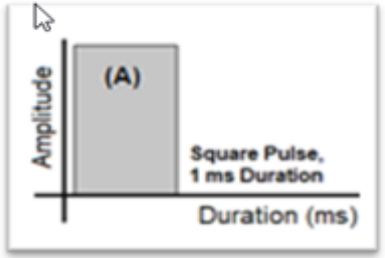


**DRAFT TEMPLATE FOR REVIEW A

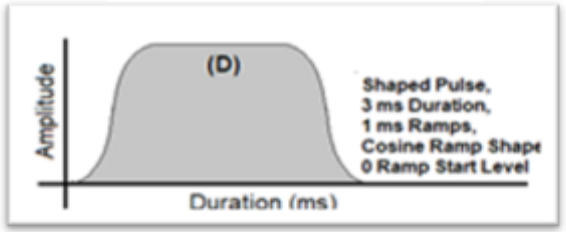
Performance: Accomplishments and Progress (cont.)

2017-2018 Suppression of Low Frequency Sound Energy Within the Hearing Range of Marine Mammals

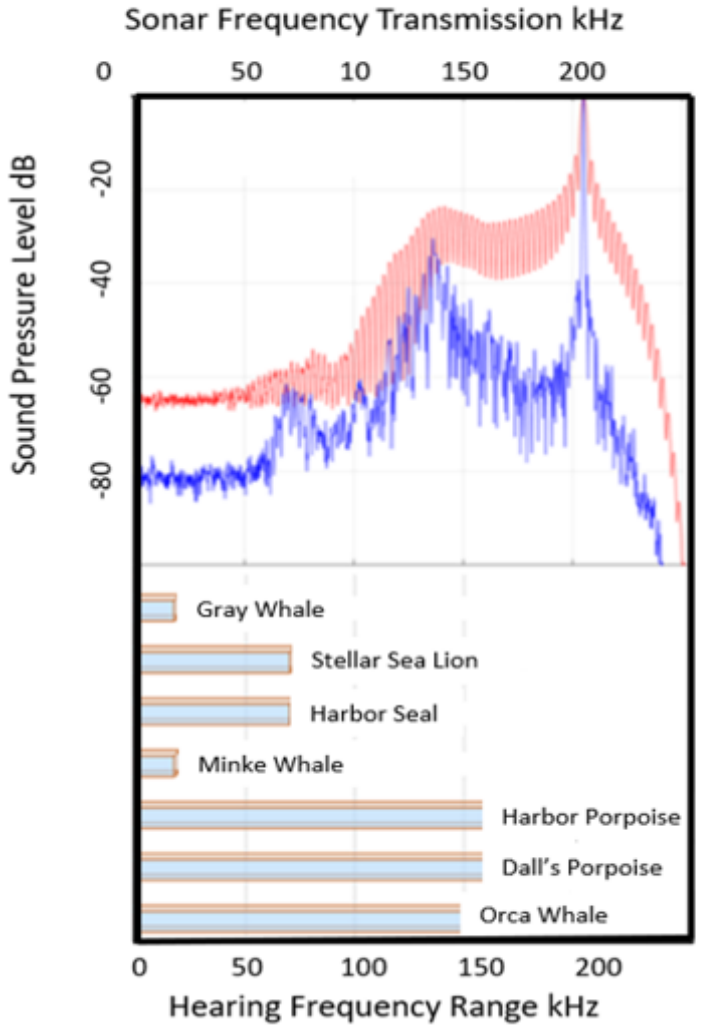
Solution #2 – Decrease intensity of low frequency sound (<200kHz) transmissions by implementing shaped transmit pulse



Default / Baseline square shaped transmit pulse



Custom low frequency sound suppressing shaped transmit pulse



- Pulse shaping techniques decreased low frequency Sound Pressure Levels (SPL) by 10-30 dB depending on frequency and pulse shaping technique, without affecting the main 200 kHz transmission
- Each 10 dB decrease in SPL results in a 10-fold decrease in sound intensity of that frequency
- SPL reductions can be manipulated over different frequency domains by using different pulse shaping techniques, for site specific / species specific optimization.

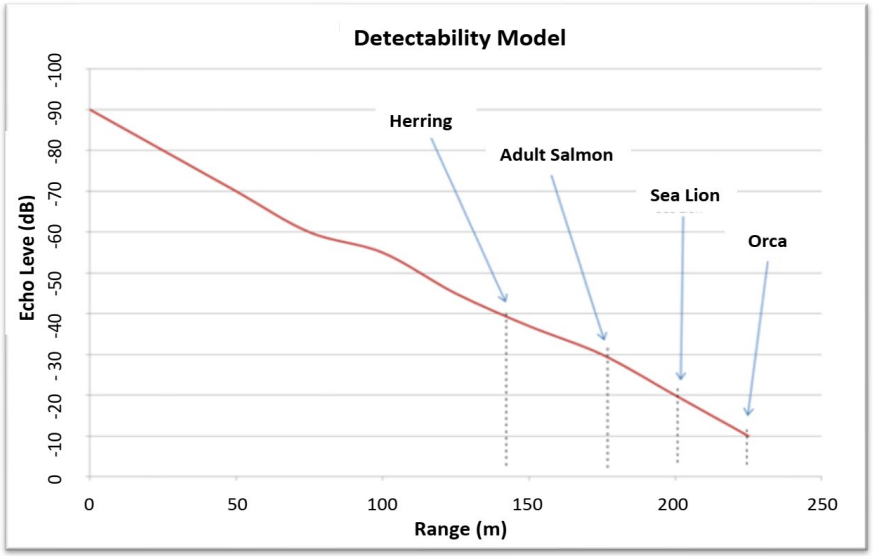
Sound intensity reductions achieved in the hearing range of selected marine mammal species:

Gray Whale: 15 dB = 30-fold decrease in sound intensity
Stellar Sea Lion: 10 dB = 10-fold decrease in sound intensity
Harbor Seal: 10 dB = 10-fold decrease in sound intensity
Minke Whale: 15 dB = 30-fold decrease in sound intensity
Harbor Porpoise: 20 dB = 100-fold decrease in sound intensity
Dall's Porpoise: 20 dB = 100-fold decrease in sound intensity
Orca Whale: 15 dB = 30-fold decrease in sound intensity

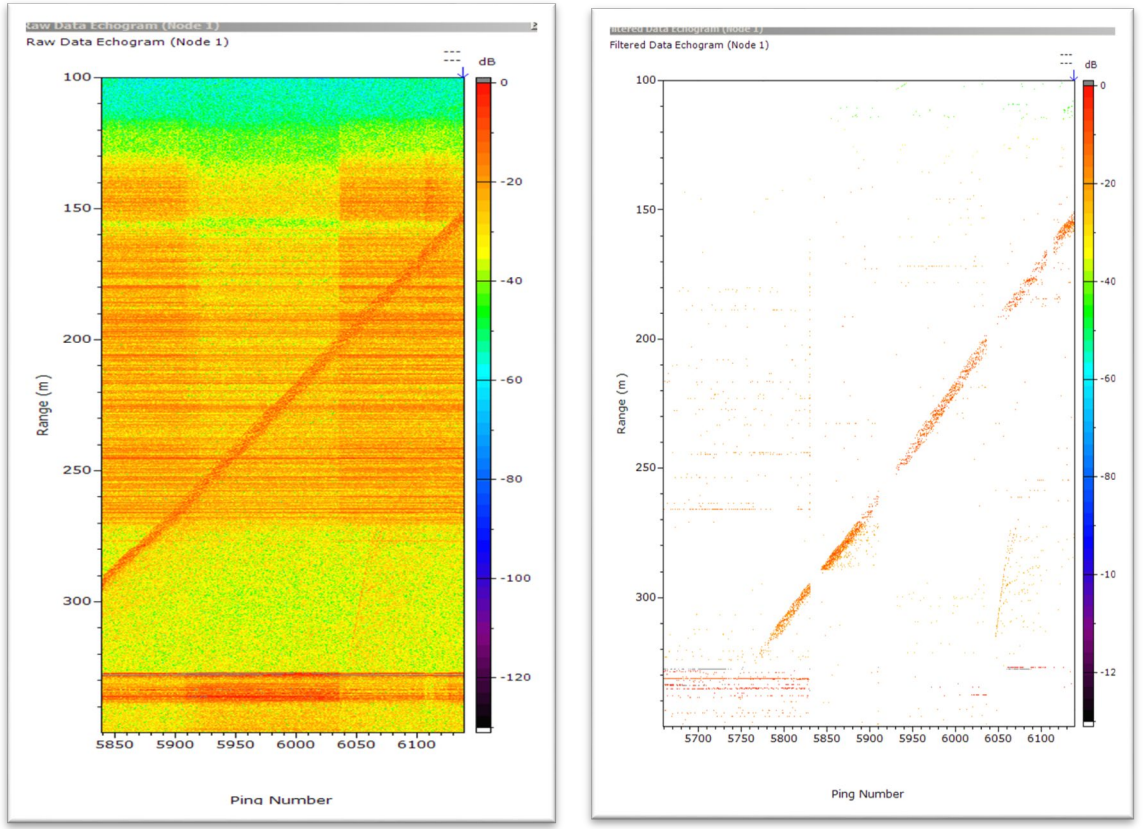
Performance: Accomplishments and Progress (cont.)

2019 -2021 Continued Development of Noise Removal and Target Classification Algorithms

- Perimeter Detector background clutter removal and target detection algorithm development
- Directed Classifier targeted tracking and classification algorithm development



Detectability modeling to estimate maximum detection ranges for species of interest



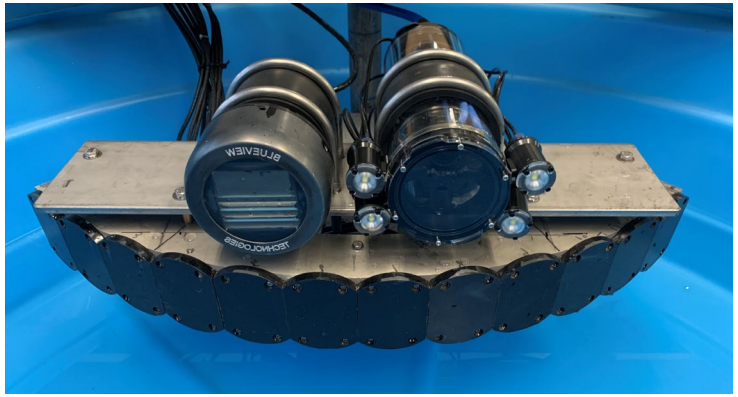
Time series echogram data with target approaching before and after natural cluttered background removal

Performance: Accomplishments and Progress (cont.)

2019 - 2021 Continued System Testing at BioSonics Facility, Hardware and Software Modifications and Improvements

- Extensive bench and tank testing & optimization
- Robust packaging and platform improvement
- Integrated, pitch, roll and bearing sensor testing
- Internal data analysis and reporting optimization
- 100-meter seabed power and communication cable

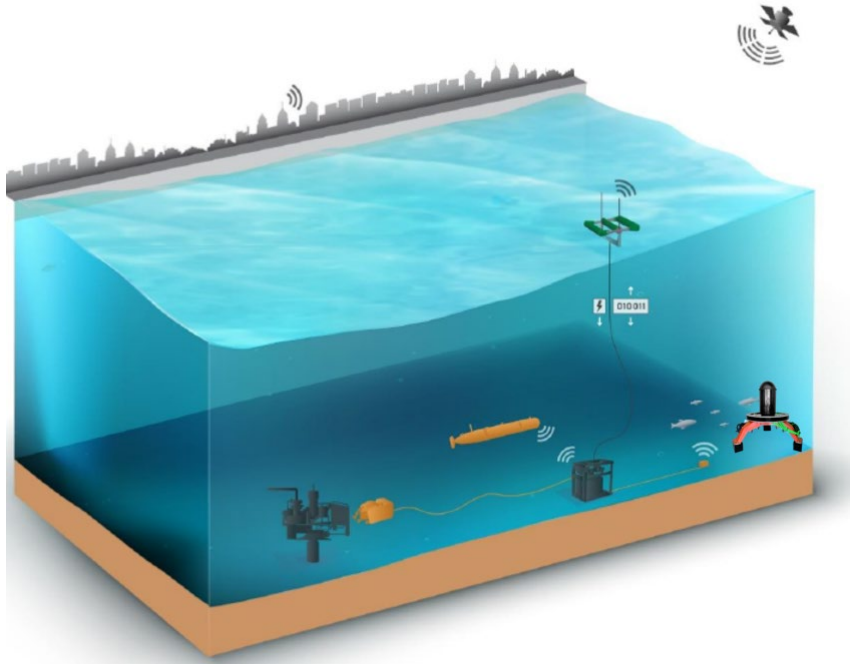
- Enabling related new product development

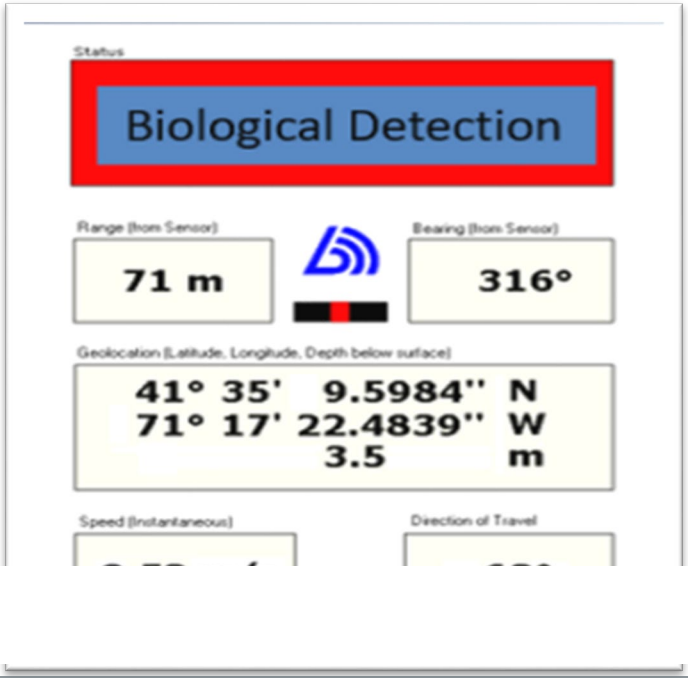


Future Work

Deployment at the Wave Energy Test Site (WETS) - Marine Corps Base Hawaii, Fall 2022

- Wave Energy Test Site (WETS) - Marine Corps Base Hawaii
- Six Month Deployment Adjacent to C-Power SeaRAY and SAAB UUV docking station
- Monitor general Marine Life / Mammal Behavior out to Hundreds of Meters in all Directions
- Monitor near field Marine Life Behavior Around SeaRAY and SAAB Seafloor Components
- Cabled to C-Power SeaRAY seafloor hub for continuous Power and Communications
- Deliverable - Cloud Processing and Real-Time Web-Based Reporting Dashboard
- All raw scientific sonar data stored and archived to servers in Seattle. Available for research application.





Q&A