2.3.2.601 – Triton

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Project Overview

TRITON

Project Summary

Triton is focused on reducing barriers to testing marine energy (ME) devices through research and development of technologies and approaches that improve our understanding of potential environmental effects.

- **FOA Support** provided technical, permitting, and logistical support for DOE funded environmental monitoring technology developers
- **Triton Field Trials (TFiT)** explored and field-tested and made recommendations for commercially available technologies used to monitor collision risk, underwater noise, electromagnetic fields, and changes in habitat at diverse marine energy sites.
- **Environmental Technology Development (EMTD)** improves the efficiency of collecting and processing large datasets from underwater video and acoustic cameras used to study collision risk around turbines and mitigate potential impacts during collision events with turbine sensors and controls.
- **Researching Stressor Receptor Interactions (RSRI)** researches receptor (fish or mammal) response to ME stressors and develops mitigation strategies for interactions.

Intended Outcomes

Recent outcomes from Triton are:

- Increased TRLs of DOE supported technology developers for commercial use at ME sites
- Published open access peer-reviewed TFiT recommendations for field tested cost-effective monitoring technologies and methodologies available to the ME community
- Application of the peer-reviewed TFiT recommendations to improve data transferability between ME device types and sites and build evidence-based data supporting regulatory decisions

Project Information

Principal Investigator(s)

Joe Haxel (PI)
Michael Richlen (PM)

Project Partners/Subs

BioSonics Inc., University of Washington, Integral Consulting, Inc., Aquacoustics, LLC., Woods Hole Oceanographic Institution, Solid State Lighting Systems, Sea Engineering, Inc., University of Alaska Fairbanks, University of New Hampshire, CalWave Power Technologies Inc., Scripps Institution of Oceanography, Sandia National Laboratory

Project Status

Ongoing

Project Duration

Project Start Date: 1 October 2018
Project End Date: 30 September 2024

Total Costed (FY19–FY21)

$5,147,176.00

Project Objectives: Relevance

Relevance to Program Goals:

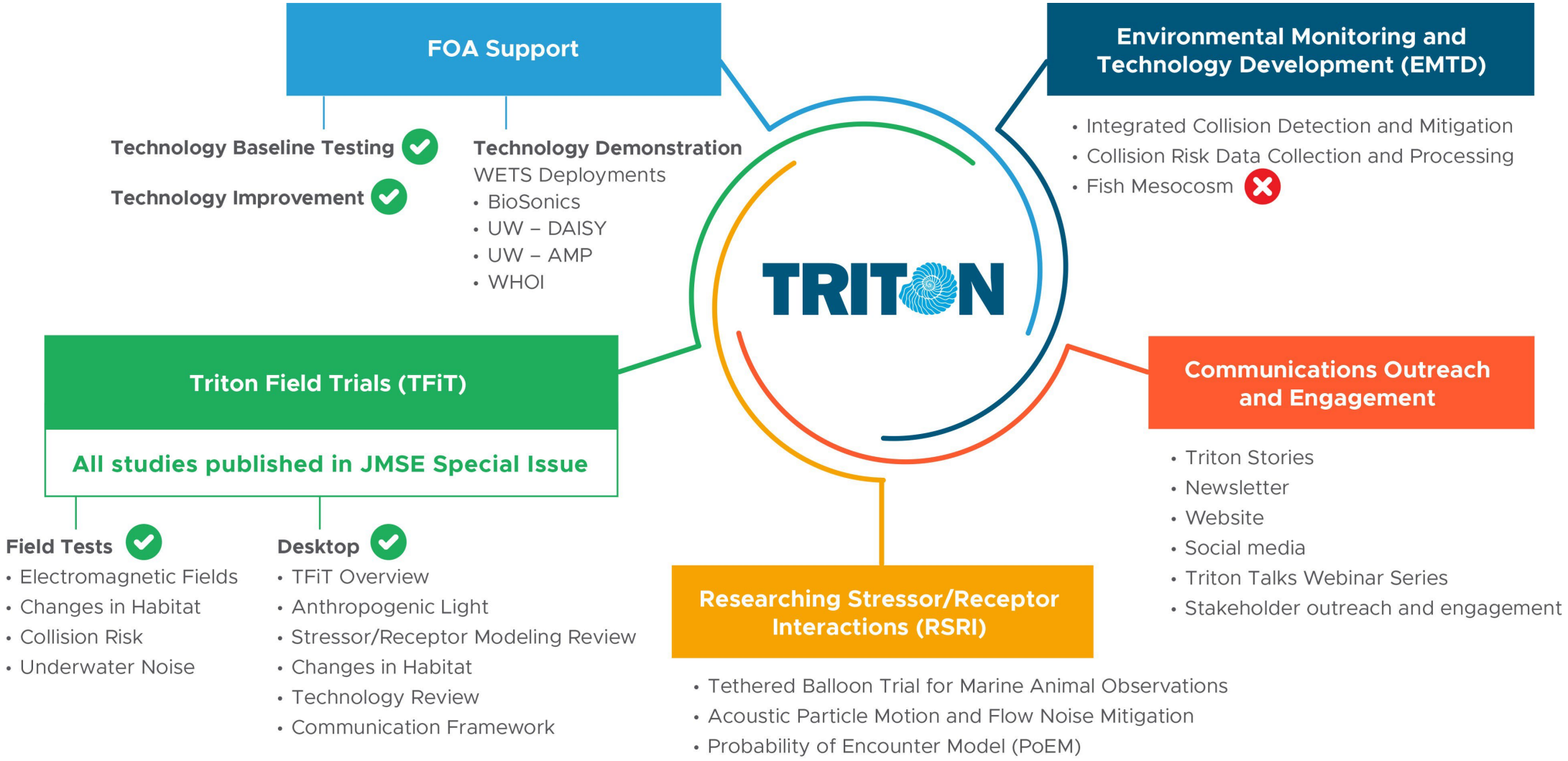
- DOE WPTO's Multi-year Program Plan calls for **improved technical performance and adoption of best practices of environmental monitoring technologies.** This will result in more consistent data collection and greater confidence in results about the risks of specific environmental concerns in alignment with WPTO's Marine Energy Program Activity 3, Reducing Barriers to Testing and Sub-activity 3, Environmental Research and Instrumentation Development.

Triton has addressed this by:

1. Supporting environmental monitoring technology developers (FOA Support).
2. Developing peer-reviewed, open access best practices for environmental monitoring around ME installations (TFiT).
3. In-house technology development and partnering with commercial technology developers (EMTD)

In the future, Triton will continue with a focus on technologies for monitoring stressor receptor interactions and implementing cost effective, consistent, and transferable data collection and analysis at marine energy sites. (RSRI)

Project Objectives: Approach



Triton FOA Support Project Objectives: Expected Outputs and Intended Outcomes

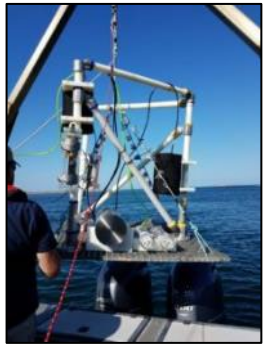
Outputs:

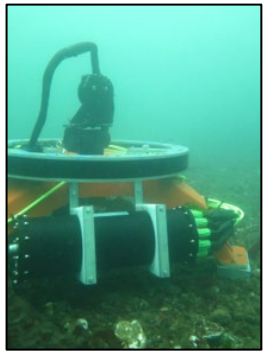
- **Technology Baseline Testing:** Provided pre-permitted testing location and logistical support for Awardees to test baseline performance of their technology
- **Technology Improvement:** Continued testing location and logistical support as well as provided technical support for technology advancement
- **Technology Demonstration:** Secured two testing locations (including permitting and contracting) for Awardees to demonstrate technologies in an energetic location around ME devices.
- Two Awardees have completed Baseline Testing, Improvement, and Demonstration. Four are anticipated to complete final testing in 2022.

Outcomes:

FOA Awardee support increased the technology readiness levels of devices, advancing their progression toward commercial use for environmental monitoring by the ME community (Performance Goal in MYPP).

Triton FOA Support Project Timeline





FY 2019

Successful technology comparison with permitting and logistical on-water support to characterize underwater noise with **UW-DAISY**, **Integral NoiseSpotter**, and a technology developer from Oregon State University. (Chang et al., 2021)

FY 2020

Supported **UW-DAISY** at PNNL Sequim with permitting, logistical and technical support for Technology Improvement field test.

Collaborated with CalWave Power and Scripps Institution of Oceanography planning and permitting for **Integral NoiseSpotter** Technology Demonstration testing.

FY 2021

Completed support of FOA Awardee **Integral NoiseSpotter** for their Technology Demonstration at Scripps Institution of Oceanography around the CalWave device.

Triton FOA Support Performance: Accomplishments and Progress

Project	Technology Baseline Testing	Technology Improvement	Technology Demonstration
Integral NoiseSpotter	✓	✓	✓
	✓	✓	✓
	✓	✓	
	✓	✓	
	✓	✓	
	✓	✓	

* All permitting and on-water support contracts in place for demonstration testing at the Wave Energy Test Site (WETS) in Hawaii in FY22/23 around operational WECs. Waiting for WEC deployments.

Triton TFiT Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Triton focused Special Issue in the Journal of Marine Science and Engineering detailing TFiT activities and results including ten peer-reviewed, research articles describing:

  1. Field testing and validation of commercially available environmental monitoring technologies
  2. Development and evaluation of data collection methods

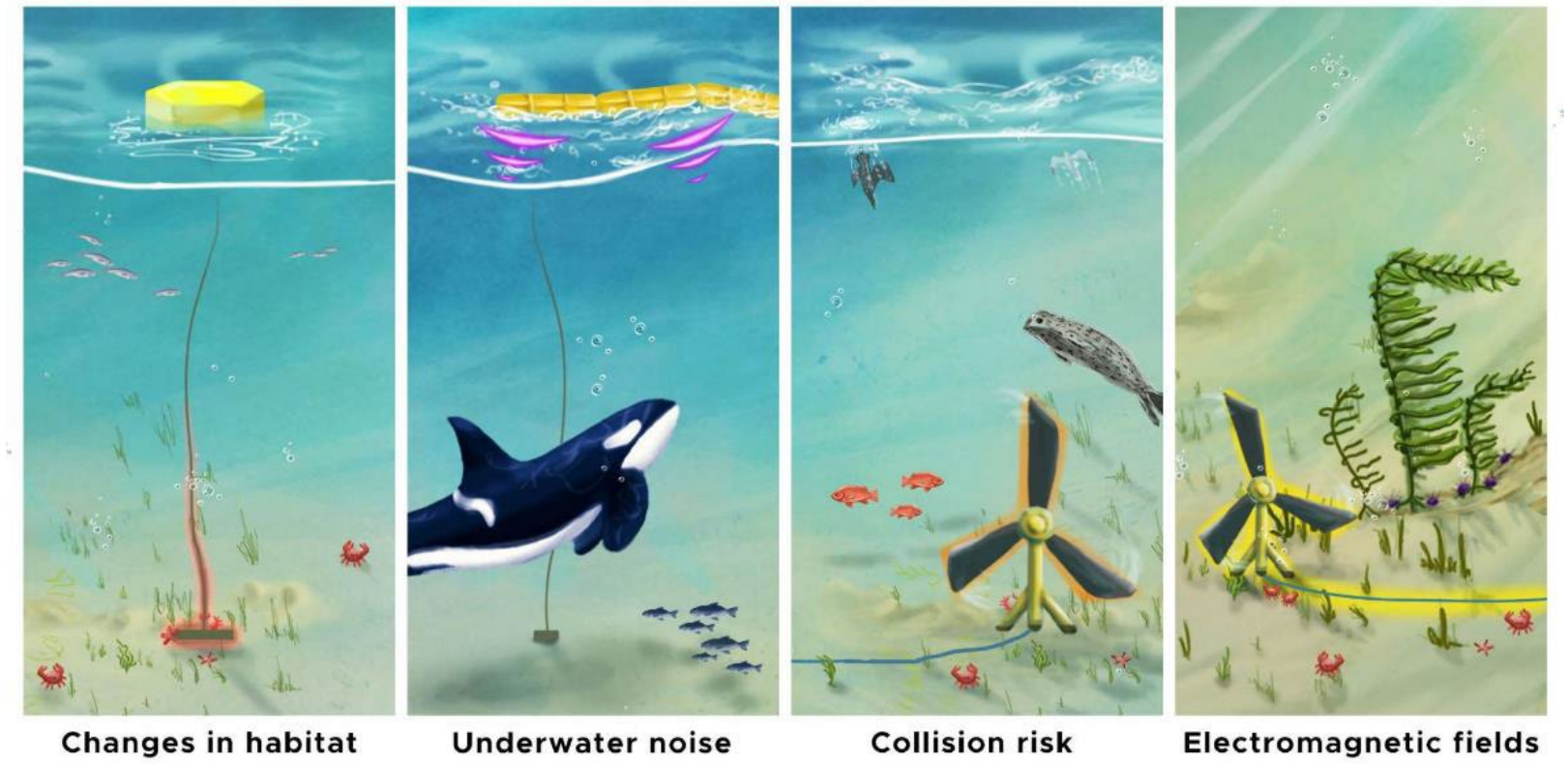
Outcomes:

- Open access, best practices special issue, promotes data transferability between ME projects with recommendations for consistent and standardized technologies as well as methods for environmental monitoring data collection and analysis.

Triton TFiT Project Timeline

2019

- Site selections for testing
- Acquired commercially available technologies and finalized methodologies for data collection
- Permitting/authorization requirements for field testing



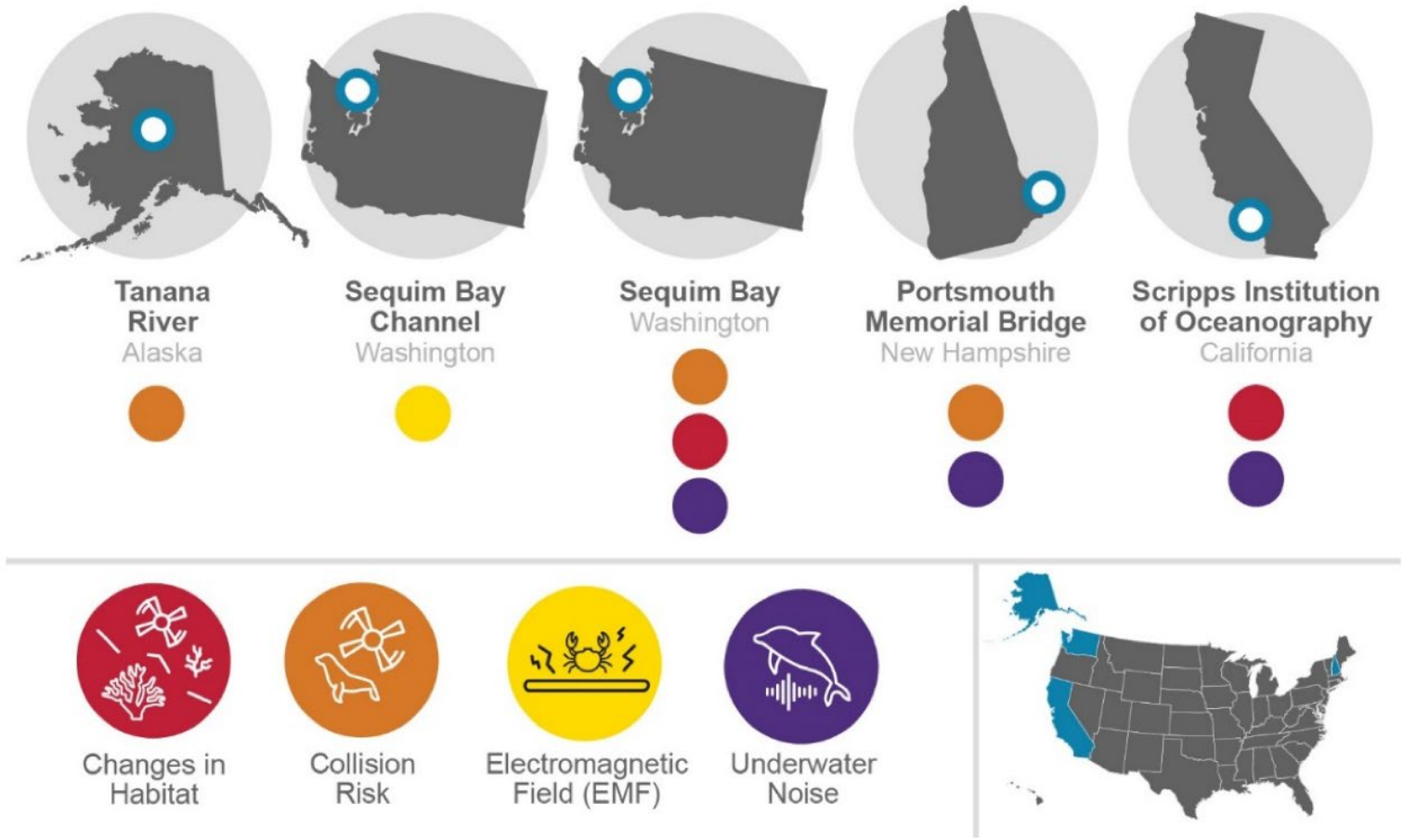
Triton TFiT Project Timeline

2020

- Finalized test plans
- **Electromagnetic Field** sensor tests in Sequim Bay

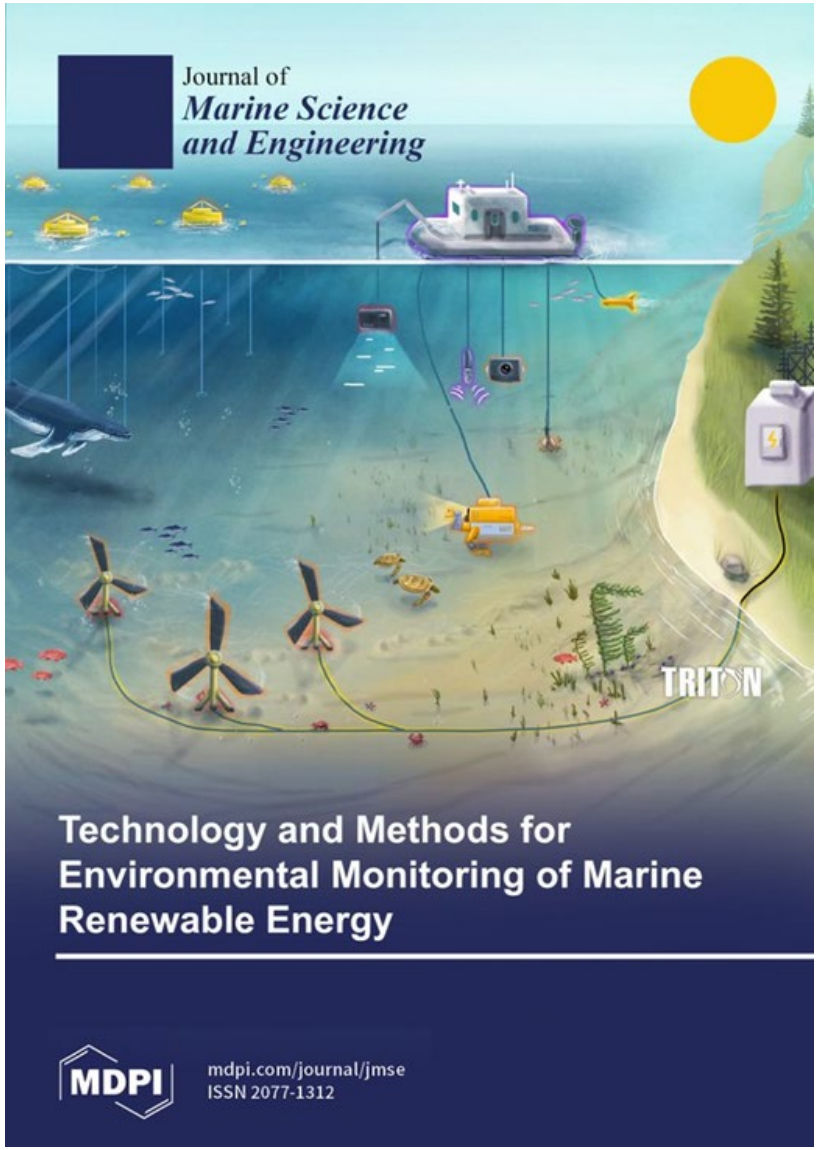
2021

- Turbine **Collision Risk** tests at the Portsmouth Memorial Bridge and Tanana River
- **Underwater Noise** hydrophone testing in Sequim Bay channel, Portsmouth Memorial Bridge and Scripps
- **Changes in Habitat** testing in Sequim Bay and Scripps Institution of Oceanography



Eaves et al., 2022

Triton TFiT Performance: Accomplishments and Progress



- Successful technology field testing and validation
- Four field test papers
- Six literature reviews
- Culminating in 10-paper special issue in the open access Journal of Marine Science and Engineering

Special Issue: **Technology and Methods for Environmental Monitoring of Marine Renewable Energy**

https://bit.ly/JMSE-Triton-Special-Issue
or scan to view the special issue.

Triton FMS/EMTD Project Objectives: Expected Outputs and Intended Outcomes

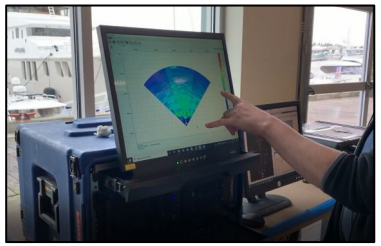
Outputs:

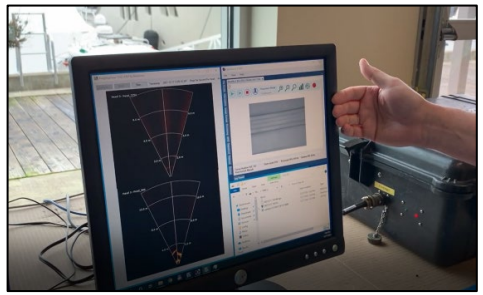
Fish Mesocosm (FMS)

- Juvenile Salmon Acoustic Telemetry System (JSATS) technology successfully 3D tracked juvenile sablefish in Sequim Bay tidal channel
- Marine Technology Society/Institute of Electrical and Electronics Engineers (MTS/IEEE) presentation and conference paper

Environmental Monitoring Technology Development (EMTD)

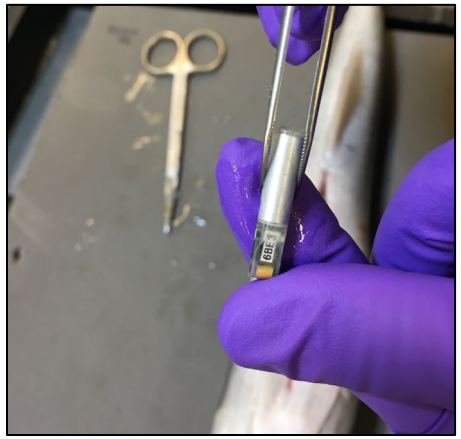
- Advanced data collection sensor package: sonar, acoustic camera, and video camera (Collision Risk Data Collection – CRDC)
- Improved commercially available acoustic camera software for data processing (Collision Risk Data Processing – CRDP)





Outcomes:

- JSATS tracking technology demonstrated fine-scale fish movement that informs collision risk at ME project sites reducing uncertainty for fish interactions
- Sensor suite package ready for field testing that will reduce data accumulation while monitoring for collision risk – reducing data storage, analysis requirements, and associated costs
- Acoustic camera data software improvements will reduce time for processing of large volumes of data, improving efficiency and reducing costs



Triton FMS/EMTD Project Timeline

FY 2019

FMS pilot study completed

Successful JSATS fish tagging/tracking

MTS/IEEE paper and presentation

FY 2020

FMS was discontinued due to lack of installed turbine, Remaining funds were rescoped to CRDC/DP

Collision Risk data collection and processing (CRDC & CRDP) aimed to reduce large data volume accumulation and improve efficiency for processing methods

FY 2021

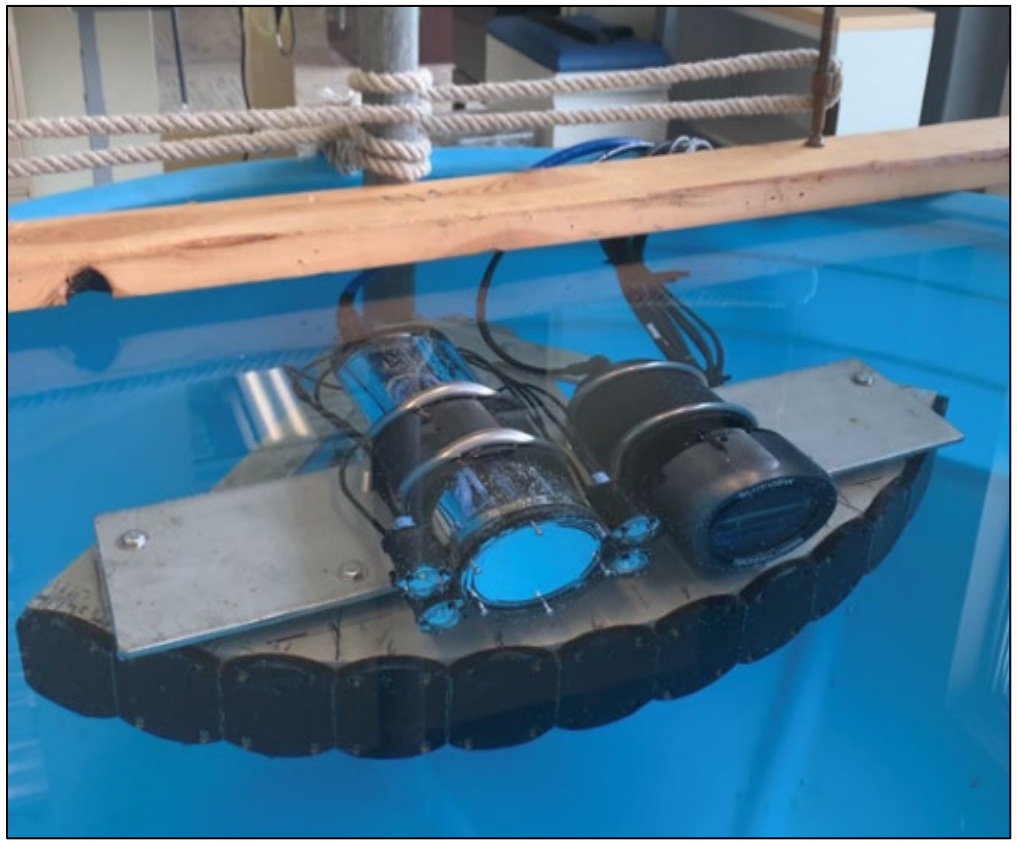
Successful sensor suite bench and tank testing and preparation for in-water field testing in 2022.

Improved available acoustic camera data processing software to inform **Collision Risk**

Triton EMTD Performance: Accomplishments and Progress

- FMS pilot study in-water testing complete
  - Demonstrated that individual fish movements in an energetic tidal channel can be observed using JSATS tagging technology and can inform collision risk around tidal turbines.

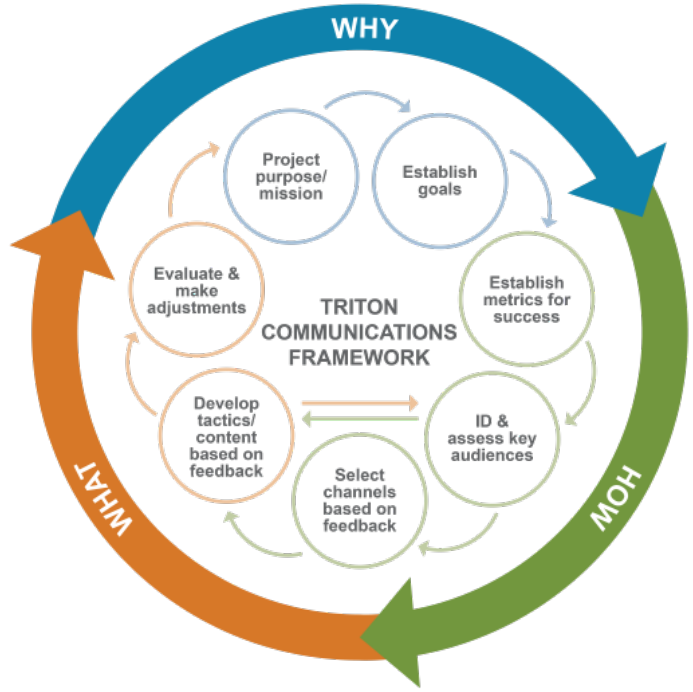
- EMTD
  - Successful proof of concept testing of sensor suite and data archiving software leading to in-water field testing in 2022
  - Enhanced functionality of commercial software that reduced large acoustic camera data volumes by an average of 35% compared to the original method



End-User Engagement and Dissemination

- Multi-pronged approach to communication, outreach, and engagement to target audiences
- Target audiences were mapped in collaboration with the WPTO, Triton team, and OES-Environmental, to include:
  - ME Stakeholders
  - Research Partners
  - General Audiences
  - Stakeholders are engaged directly via workshops/webinars, newsletter, and surveys; feedback is used to refine communications efforts and inform research decisions
- Project information and results are strategically disseminated on multiple channels to reach each target, including peer-reviewed journals, monthly newsletter, website, social media, Triton Stories blog, and webinars
- Channels and content are refined on an ongoing basis based on metrics and feedback

https://www.pnnl.gov/projects/triton



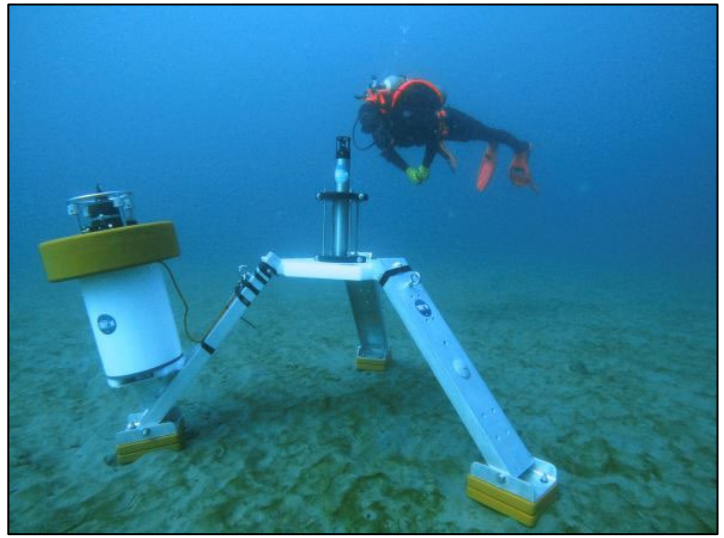
Project Budget

FY19		FY20		FY21		Total Actual Costs FY19–FY21
FOA Support	$972,626	FOA Support	$452,432	FOA Support	$536,068	$1,961,126
TFiT	$322,110	TFiT	$928,646	TFiT	$1,136,241	$2,386,997
FMS/EMTD	$406,811	FMS/EMTD	$106,181	FMS/EMTD	$146,021	$659,013
				Comms	$123,480	$123,480
				RSRI Scoping	$16,560	$16,560
	$1,701,547		$1,487,259		$1,958,370	$5,147,176

Future Work – Researching Stressor Receptor Interactions (RSRI)

Research focused on animal interactions with ME devices and associated stressors

Dari Dexheimer, Sandia National Lab



Credit: Richard Marsh, SIO

Tethered Balloon System (TBS): partnership with Sandia NL to monitor wildlife interactions with ME devices using a diverse optical and thermal payload

Probability of Encounter Model (PoEM): collect smolt outmigration data to develop a probability model that informs collision risk for fish with current energy converters

Acoustic Particle Motion (PM): researching underwater noise effects for fish and invertebrates

Flow Noise (FN): research flow noise mitigation strategies to improve acoustic sensor measurements in energetic ME environments

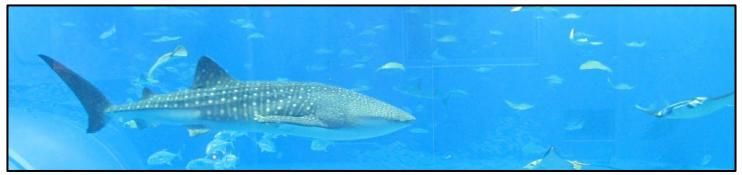
Triton RSRI Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Filling data gaps around animal interactions with ME devices and associated stressors
  - **TBS:** a non-invasive, aerial, optical and thermal sensor package for use with tethered balloon systems (or other aerial platforms) to track and monitor wildlife behavior around ME devices
  - **PM:** experimental results of behavioral and physiological effects of acoustic particle motion from ME devices on fish and invertebrates
  - **FN:** an evaluation of several materials and flow shield designs including recommendations for performance in high flow environments
  - **PoEM:** a probability model that informs collision risk for fish with current energy converters made available to the ME community

Outcomes:

- **TBS:** new aerial technology methods and sensor applications will improve understanding of animal interactions with ME devices
- **PM:** research will improve understanding of underwater noise effects from ME projects for fish and invertebrates.
- **FN:** mitigation research will enable high quality, longer-term, fixed station acoustic time series data collection in high current environments for improved characterization of underwater noise coupled with short-term measurements of drifting systems
- **PoEM:** will advance understanding of collision risk for fish with current energy converters through data driven modeling tools available to the ME community



Triton RSRI Project Timeline

FY 2021 included development of the scope and planning of the RSRI projects and tasks

FY 2022

TBS - sensor validation and initial flight from land, over water in a coastal area

PM - subject matter expert and regulator workshop to identify data gaps and research needs; sensor procurement

FN – design and test several flow shields and materials in the tidal channel at PNNL-Sequim

PoEM - data collection of smolt outmigration at a CEC site for model development and validation

FY 2023

TBS - operational flights in open water from the Scripps Institution of Oceanography pier and a vessel offshore San Diego, California targeting free-ranging animals (whales, dolphins, pinnipeds, fish, and seabirds).

PM - data collection at two ME sites to gather baseline and operational measurements of particle motion around ME devices

FN - application of the best performing flow shield design from the FY22 experiment at a more energetic ME site to validate performance in higher currents

PoEM - model development and data integration complete and model released for use by the ME community

FY 2024

TBS - transition the winch system and balloon to an autonomous buoy platform for testing in the bay at PNNL-Sequim

PM - tank experiments – dose response exposures of ME recorded particle motion (FY23) with measurements of physiological stress and behavioral observations of fish and/or crabs to evaluate effects of PM on animals

Q&A