Dear Member of the Marine Renewable Energy Community:

I would like to request your assistance in gathering information on current efforts that investigate environmental effects of marine renewable energy projects (principally tidal, wave, and ocean current energy). The [OES-Environmental initiative](https://tethys.pnnl.gov/about-oes-environmental) collects and distributes information, or metadata, on site-specific projects and research studies that investigate potential environmental effects of marine renewable energy on marine animals, habitats, and ecosystem processes. In collecting and distributing metadata, OES-Environmental strives to increase understanding of these impacts, mobilize practitioners, and coordinate research that can progress the industry in an environmentally responsible manner.

**The following form seeks information about** **projects (or test sites) and research studies associated with environmental effects of marine renewable energy**, including a brief summary of the project, methods, and results of research or monitoring. We are interested in collecting information from completed, in-progress, and planned projects and research studies.

By choosing to participate in the OES-Environmental metadata collection process, you will assist the marine renewable energy industry, government agencies, and stakeholders by contributing to the compilation of environmental effects information in a single location to allow for:

* **Increased awareness** amongst developers and regulators about new and current research efforts, which may inform new investments into monitoring methods and mitigation strategies;
* **Increased efficiency** of the permitting/consenting process by precluding studies shown to yield few results (under certain conditions), allowing for shorter and less costly processes;
* **Reduced uncertainty** for targeted investments of environmental effects by government agencies and other funding sources, further clarifying the permitting/consenting process; and
* **Value added interpretation and knowledge** through the examination of key research findings in conjunction with project monitoring data, informing optimal siting and permitting.

Please provide information about your project or research study on the following pages. An example form is provided at the end of the blank form to demonstrate the type of information requested.

Thank you in advance for your consideration and contribution to this valuable effort!

Dr. Andrea Copping
Coastal Sciences Division
Pacific Northwest National Laboratory
andrea.copping@pnnl.gov

Please email the form and any associated files to Cailene Gunn (cailene.gunn@pnnl.gov).





#  **Research Study metadatA survey form**

Name of person updating the form Date submitted

*Title of Research:*

Status: [ ]  Planned [ ]  In-Progress [ ]  Completed

*Researchers:*

Principal Investigator Contact Information

*Name:*

*Affiliation:*

*Phone:*

*Email:*

Technology Types

[ ]  Wave

[ ]  Tidal

[ ]  Ocean Current

[ ]  Salinity Gradient

[ ]  OTEC

[ ]  Riverine

[ ]  Technology Neutral

Stressors

|  |  |
| --- | --- |
| [ ]  Attraction | [ ]  EMF |
| [ ]  Avoidance | [ ]  Entrapment |
| [ ]  Changes in Flow | [ ]  Habitat Change |
| [ ]  Chemicals | [ ]  Lighting |
| [ ]  Collision | [ ]  Noise |
| [ ]  Displacement |  |

Receptors

|  |  |  |
| --- | --- | --- |
| [ ]  **Fish** | [ ]  **Bats** | [ ]  **Birds** |
|  [ ]  Demersal | [ ]  **Reptiles** |  [ ]  Ground-Nesting Birds |
|  [ ]  Pelagic | [ ]  **Terrestrial Mammals** |  [ ]  Passerines |
| [ ]  **Marine Mammals** | [ ]  **Ecosystems Process** |  [ ]  Raptors |
|  [ ]  Cetaceans | [ ]  **Physical Environment** |  [ ]  Seabirds |
|  [ ]  Pinnipeds |  [ ]  Sediment Transport |  [ ]  Shorebirds |
| [ ]  **Invertebrates** |  [ ]  Water Quality |  [ ]  Waterfowl |

|  |
| --- |
| [ ]  **Human Dimensions** |
|  [ ]  Climate Change | [ ]  Legal & Policy | [ ]  Recreation & Tourism |
|  [ ]  Environmental Impact Assessment | [ ]  Life Cycle Assessment | [ ]  Social & Economic Data |
|  [ ]  Environmental Justice | [ ]  Marine Spatial Planning | [ ]  Stakeholder Engagement |
|  [ ]  Fisheries | [ ]  Navigation | [ ]  Visual Impacts |

*Project Description:*

*Project Website:*

*Funding Source:*

*Funding Contact:*

*Institutions Involved:*

*Location of Research:*

*Start of Research:*

*End of Research:*

*Project Aims:*

*Project Progress:*

*Key Findings:*

*Publications:*

# **EXAMPLE Research Study metadatA survey form**

Name of person updating the form Date submitted

January 18, 2022

Levy Tugade

*Title of Research:* **Adaptable Monitoring Package (AMP)**

[ ]  Planned [x]  In-Progress [ ] Completed

*Researchers:* Brian Polagye, Andy Stewart, James Joslin, Steve Brunton, Emma Cotter, Paul Murphy, Paul Gibbs, Shari Matzner, Sarah Henkel, Pat Cross, Mitchell Scott, Chris Bassett

Principal Investigator Contact Information

*Name:* Chris Bassett

*Address:* Senior Mechanical Engineering, University of Washington Applied Physics Laboratory

*Email:* cbassett@uw.edu

For commercial inquiries, please contact James Joslin at MarineSitu (james@marinesitu.com).

For scientific or regulatory inquiries, contact Brian Polagye (bpolagye@uw.edu) or Chris Bassett (cbassett@uw.edu).

Technology Types

[ ]  Wave

[ ]  Tidal

[ ]  Ocean Current

[ ]  Salinity Gradient

[ ]  OTEC

[ ]  Riverine

[x]  Technology Neutral

Stressors

|  |  |
| --- | --- |
| [x]  Attraction | [ ]  EMF |
| [x]  Avoidance | [ ]  Entrapment |
| [ ]  Changes in Flow | [ ]  Habitat Change |
| [ ]  Chemicals | [ ]  Lightning |
| [x]  Collision | [ ]  Noise |
| [x]  Displacement |  |

Receptors

|  |  |  |
| --- | --- | --- |
| [x]  **Fish** | [ ]  **Bats** | [x]  **Birds** |
|  [ ]  Demersal | [ ]  **Reptiles** |  [ ]  Ground-Nesting Birds |
|  [ ]  Pelagic | [ ]  **Terrestrial Mammals** |  [ ]  Passerines |
| [x]  **Marine Mammals** | [ ]  **Ecosystems Process** |  [ ]  Raptors |
|  [ ]  Cetaceans | [x]  **Physical Environment** |  [ ]  Seabirds |
|  [ ]  Pinnipeds |  [ ]  Sediment Transport |  [ ]  Shorebirds |
| [x]  **Invertebrates** |  [ ]  Water Quality |  [ ]  Waterfowl |

|  |
| --- |
| [ ]  **Human Dimensions** |
|  [ ]  Climate Change | [ ]  Legal & Policy | [ ]  Recreation & Tourism |
|  [ ]  Environmental Impact Assessment | [ ]  Life Cycle Assessment | [ ]  Social & Economic Data |
|  [ ]  Environmental Justice | [ ]  Marine Spatial Planning | [ ]  Stakeholder Engagement |
|  [ ]  Fisheries | [ ]  Navigation | [ ]  Visual Impacts |

*Project Description:* The project is developing and demonstrating variants of the Adaptable Monitoring Package (AMP). The AMP integrates active acoustic, passive acoustic, and optical sensors into a single instrumentation package that can be cabled to shore or operated autonomously. By simultaneously observing rare, but potentially significant, interactions between marine life and marine energy converters with multiple sensor modalities, detection and interpretation of such events is likely to be improved. Automatic detection and classification algorithms now allow the system to make continuous observations without incurring a “data mortgage” and automatic sensor control allows such observations to occur without biasing marine animal behaviour.

*Project Website:* “Interesting” video archive: https://www.youtube.com/channel/UCqR-J-6LOLjsHCjO285jBbA/

*Funding Source:* US Department of Energy (Water Power Technologies Office), US Department of Defence (Naval Facilities Engineering Command)

*Institutions Involved:* University of Washington, Oregon State University, Pacific Northwest National Laboratory, Sea Mammal Research Unit, LLC, University of Hawai’i

*Location of Research:* Multiple: cabled system testing has been conducted at the University of Washington and Pacific Northwest National Laboratory’s Marine Science Lab in Sequim, WA, while autonomous system testing has been conducted at PMEC-SETS off Newport, OR and at the Wave Energy Test Site in Kaneohe, HI.

*Start of Research:* January, 2015

*End of Research:* June, 2023 (planned)

*Project Aims:*

* Develop and demonstrate an integrated instrumentation package that can be used in cabled or autonomous modes to study the interactions between marine life and marine energy converters.

*Project Progress:*

* Endurance trial completed for cabled system in May 2016 (> 90% uptime over four month period for prototype cabled system), with subsequent improvements over three month deployment in 2017.
* Automatic real-time detection and classification of “rare” targets (seals, diving birds, fish schools) in multibeam sonar data with high true positive rates (> 80%) and low false positive rates (< 20%).
* Post-processing identification of fish in optical camera data with acceptable true positive and false positive rates.
* Integration of PAMGuard with the system to automatically detect fish tags and simulated marine mammal vocalizations.
* Development and initial deployment of autonomous lander with duty cycle and ability to “wake up” in response to the presence of Vemco fish tags.
* Integration of an AMP with a wave energy converter. The “WAMP” draws power from the WEC to operate the sensor package and achieved an 84% uptime over a 3.5 month deployment, with an average power draw of 600 W.

*Key Findings:*

* Cooperative target testing with drifting or towed objects at known position is effective at establishing sensor ranges and diagnosing sensor functionality.
* Passive acoustic detection of fish tags is likely to occur within the range of active acoustic instruments (e.g., multi-beam sonar, acoustic camera).
* Multibeam sonars capable of detecting marine mammals, fish schools, and individual fish to a range of 10 m. Different sonars have different detection capabilities and some are more easily interpretable by human reviewers, but machine learning classification outcomes are similar (i.e., computers perceive objects differently than humans).
* Sensor fusion across instruments on the platform helpful to improve manual and automatic classification.
* Without real-time target detection, it is unlikely that sufficient training could be collected for automatic tracking and classification algorithms without incurring a large data mortgage.
* Active sonars can produce sound at lower frequencies than their characteristic operating frequencies. This is unlikely to cause harm to marine animals, but could be detectable by animals and should be considered in study design.

*Publications:*

* Cotter, E. and Polagye, B. (2020), Detection and classification capabilities of two multibeam sonars. Limnol Oceanogr Methods. <https://doi.org/10.1002/lom3.10393>
* Cotter, E. and Polagye, B. (2020), Automatic Classification of Biological Targets in a Tidal Channel Using a Multibeam Sonar, *Journal of Atmospheric and Oceanic Technology*, 37(8), 1437–1455, 2020. doi:10.1175/JTECH-D-19-0222.1.
* Polagye, B.; Joslin, J.; Murphy, P.; Cotter, E.; Scott, M.; Gibbs, P.; Bassett, C.; Stewart, A. Adaptable Monitoring Package Development and Deployment: Lessons Learned for Integrated Instrumentation at Marine Energy Sites. J. Mar. Sci. Eng. **2020**, 8, 553.
* Cotter, E., Murphy P., Basset, C., Williamson, B., and Polagye, B. (2019) Acoustic characterization of sensors used for marine environmental monitoring, Marine Pollution Bulletin. 144, doi: 10.1016/j.marpolbul.2019.04.079.
* Joslin, J., Cotter, E., Murphy, P., Gibbs, P., Cavagnaro, R., Crisp, C., Stewart, A., Polagye, B., Cross, P., Hjetland, E., Rocheleau, A., and Waters, B. (2019) The wave-powered Adaptable Monitoring Package: Hardware design, installation, and deployment, 12th European Wave and Tidal Energy Conference, Cork, Ireland, August 28-31.
* Cotter, E., Murphy, P., and Polagye, B. (2017) Benchmarking sensor fusion capabilities of an integrated instrumentation package, International Journal of Marine Energy.
* Cotter, E. and Polagye, B. (2017) Advancing environmental monitoring through integrated instrumentation, Proceedings for the 12th European Wave and Tidal Energy Conference, Cork, Ireland, August 26-31.
* Cotter, E., Matnzer, S., Horne, J., Murphy, P., and Polagye, B. (2016) Benchmarking sensor fusion capabilities of an integrated monitoring package, Proceedings of the 4th Marine Energy Technology Symposium, Washington, D.C., April 25-27.
* Cotter, E., Williamson, B., and Polagye, B. (2015) Challenges to integrating active acoustic sensors, Proceedings of the 3rd Marine Energy Technology Symposium, Washington.