

# PNNL Support to Marine and Hydrokinetic Ocean Energy Development

## Marine and Hydrokinetic Energy Generation

Energy generated from the world's oceans and rivers offers the potential to make substantial contributions to the domestic and global renewable energy supply. The U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Wind and Water Power Program, supports the emerging marine and hydrokinetic (MHK) energy industry. The emerging MHK industry in the U.S. requires that MHK developers face challenges related to siting, permitting, installation, and operation of pilot- and commercial-scale facilities, as well as the need to develop robust technologies, secure financing, and gain public acceptance.

In many cases, little is known about the potential effects of MHK energy generation on the aquatic environment from a small number of devices or a large-scale commercial array. Nor do we understand potential effects that may occur after years or decades of operation. This lack of knowledge affects the solvency of the industry, the actions of regulatory agencies, the opinions and concerns of stakeholder groups, and the commitment of energy project developers and investors.

To unravel and address the complexity of environmental issues associated with MHK energy, Pacific Northwest National Laboratory (PNNL) is developing a program of research and development that draws on the knowledge of the industry, regulators, and stakeholders and builds on investments made by the EERE Wind and Water Power Program. The PNNL program of research and development—together with complementary efforts of other national laboratories, national marine renewable energy centers, universities, and industry—supports DOE's market acceleration activities through focused research and development on environmental effects and siting issues.

## U.S. Department of Energy Directives to PNNL for Ocean Energy Research

The Department of Energy's Office of Energy Efficiency and Renewable Energy has directed PNNL to support the responsible development of offshore wind and marine and hydrokinetic energy through several multi-year tasks focused on assessing environmental effects.

## Pacific Northwest National Laboratory— Marine Sciences Laboratory

Pacific Northwest National Laboratory's (PNNL) Marine Sciences Laboratory (MSL) is located in Sequim on Washington State's Olympic Peninsula. MSL is the Department of Energy's only marine research laboratory. This unique facility and the capabilities of its researchers to deliver science and technology that is critical to the nation's energy, environmental and security future.



**PNNL is addressing the following research areas:**

- **Categorizing and evaluating effects of stressors** – Information on the environmental risks from MHK devices, including data obtained from *in situ* testing and laboratory experiments (see other tasks below) will be compiled in a knowledge management system known as *Tethys* to facilitate the creation, annotation, and exchange of information on environmental effects of MHK technologies. *Tethys* will support the Environmental Risk Evaluation System (ERES) that can be used by developers, regulators, and other stakeholders to assess relative risks associated with MHK technologies, site characteristics, water body characteristics, and receptors (i.e., habitat, marine mammals, and fish). Development of *Tethys* and the ERES will require focused input from various stakeholders to ensure accuracy and alignment with other needs.
- **Effects on physical systems** – Computational numerical modeling will be used to understand the effects of energy removal on water bodies from the short- and long-term operation of MHK devices and arrays. Initially, PNNL's three-dimensional coastal circulation and transport model of Puget Sound will be adapted to test and optimize simulated tidal technologies that resemble those currently in proposal, laboratory trial, or pilot study test stages. This task includes assessing changes to the physical environment (currents, waves, sediments, and water quality) and the potential effects of these changes on the aquatic food webs) resulting from operation of MHK devices at both pilot- and commercial-scale in river and ocean settings.
- **Effects on aquatic organisms** – Testing protocols and laboratory exposure experiments will be developed and implemented to evaluate the potential for adverse effects from operation of MHK devices in the aquatic environment.

Initial studies will focus on electromagnetic field effects, noise associated with construction and operation of MHK devices, and assessment of the potential risk of physical interaction of aquatic organisms with devices. A variety of fish species and invertebrates will be used as test animals, chosen due to their proximity to and potential susceptibility to MHK devices.

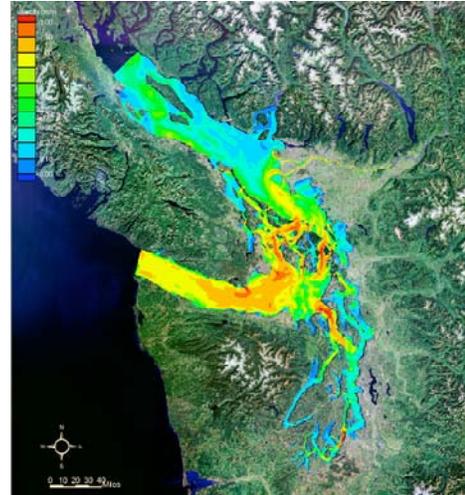
- **Permitting and planning** – Structured stakeholder communication and outreach activities will provide critical information to the project team to support execution of other project tasks. Input from MHK technology and project developers, regulators and natural resource management agencies, environmental groups, and other stakeholder groups will be used to develop the user interface of *Tethys*, populate the database, define the risk attributes of the ERES, and communicate results of numerical modeling and laboratory studies of exposure of test animals to MHK stressors. This task will also include activities to promote consideration of renewable ocean energy in national and local Coastal and Marine Spatial Planning activities.



*Ocean Power Technology's Power Buoy (left), installed off the Oregon Coast at Reedsport and Verdant Power tidal turbines (right), slated for installation in Puget Sound, WA.*

The team for the Environmental Effects of Marine and Hydrokinetic Energy Development project is made up of staff, faculty, and students from:

- Pacific Northwest National Laboratory
  - Marine Sciences Laboratory (Sequim and Seattle, Washington)
  - Risk and Decision Sciences (Richland, Washington)
  - Knowledge Systems (Richland, Washington)
- Oak Ridge National Laboratory (Oak Ridge, Tennessee)
- Sandia National Laboratories (Albuquerque, New Mexico; Carlsbad, California)
- Oregon State University, Northwest National Marine Renewable Energy Center (Newport, Oregon)
- University of Washington, Northwest National Marine Renewable Energy Center (Seattle, Washington)
- Pacific Energy Ventures (Portland, Oregon)



*Plot from PNNL Puget Sound Hydrodynamic Model, showing maximum tidal velocities in Puget Sound. Warmer colors show higher velocities. This tool can be used for tidal energy site planning*

### About Pacific Northwest National Laboratory

The Pacific Northwest National Laboratory, located in southeastern Washington State, is a U.S. Department of Energy Office of Science laboratory that solves complex problems in energy, national security and the environment, and advances scientific frontiers in the chemical, biological, materials, environmental and computational sciences. PNNL currently has approximately 4,900 staff members and a business volume of more than \$1.1 billion. The Laboratory has been managed by Ohio-based Battelle since 1965.

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