

# Path Forward

Ocean Energy Systems (OES) continues to collect, organize, and disseminate information on environmental effects of marine renewable energy (MRE), as well as pursuing processes for applying data and information to support consenting for new projects through risk retirement and data transferability processes. These efforts will continue in collaboration with experts from the OES-Environmental countries.

In addition, four new areas will become the focus of future efforts:

1. Using the accumulated knowledge acquired on stressor-receptor interactions to advise on environmental acceptability;
2. Examining potential environmental effects of off-grid MRE applications;
3. Diving deeper into methods for collection and analysis of social and economic data that affect consenting; and
4. Analyzing potential system-wide effects of MRE as the industry scales up.

## ENVIRONMENTAL ACCEPTABILITY

Key factors that will support the MRE industry include assuring that MRE devices are efficient, durable, manufacturable, and meet established standards. Of equal importance is the need to minimize damage and perturbations to the marine environment. This project will develop science-directed guidance, based on the past 14 years of OES-Environmental work, assuring that device developers will have access to information that can limit harm to the environment.



This information will be based on the examination of stressor-receptor interactions that have been measured for small numbers of devices (one to six) and for increasingly larger-scale arrays, and will be directed at the design, deployment, operation, maintenance, and decommissioning of MRE devices. Each major archetype of wave energy converter (WEC), turbine, and other MRE devices will be examined by stressor-receptor interaction to parse potential effects, and advice tailored accordingly. This same information will be made available to regulators, advisors, developers, and consultants so that they will gain confidence in applying data from already consented MRE projects, research studies, and appropriate surrogates for consenting new MRE projects as well as for designing post-installation monitoring programs.

### ENVIRONMENTAL EFFECTS OF OFF-GRID MARINE RENEWABLE ENERGY APPLICATIONS

Most research and monitoring efforts that have examined potential effects of MRE devices and arrays on the marine environment have been focused on grid-scale devices designed to provide power for national grids. Smaller-scale uses for MRE are becoming of great interest, particularly for remote coastal locations and islands that are often powered by imported diesel fuel. These remote or islanded areas generally have limited power needs that could be satisfied by a mix of renewable energy sources including MRE, micro-grids, and energy storage. In addition, generating and using power at sea is another viable option for MRE, including powering offshore aquaculture operations or ocean observation and navigation platforms. Most of these applications will use smaller devices than those planned for national grid applications. While there is a general assumption that these smaller devices are likely to cause less environmental risk, this has not been shown. Environmental effects information will be tailored to small-scale deployments through a series of case studies, and a framework developed for consenting off-grid MRE devices. This information will be made available to regulators, advisors, developers, and consultants to accelerate siting and consenting processes of smaller-scale devices.

### SYSTEM-WIDE EFFECTS

As the MRE industry scales up, it is vital to understand how the knowledge collected around early small deployments will apply to larger arrays, how those larger projects might affect marine ecosystems, and how they might interact with other human uses of the oceans. This system-wide approach will be expanded to include information from new research studies and monitoring around early arrays, and will be supported by numerical modeling and assessment tools. New MRE environments like tropical ecosystems will be examined to see if new approaches to examining effects are needed. Projecting future potential environmental effects will assist planners and funders of projects in determining the likely outcomes of larger projects, smoothing the way for a thriving MRE industry.

### SOCIAL AND ECONOMIC EFFECTS OF MARINE RENEWABLE ENERGY

As part of consenting processes, information on social and economic effects of MRE projects is required, yet there is limited guidance for collecting these types of data. Often environmental effects of MRE are strongly associated with social and economic effects of concern to stakeholders. The different scales, locations, and end uses of MRE will be examined to better understand how these factors might affect coastal communities and other stakeholders. Best management practices will be developed that applies this information to a range of MRE projects and will be made available to developers, regulators, advisors, and stakeholders.



OES-Environmental 2024 State of the Science report and executive summary available at:  
<https://tethys.pnnl.gov/publications/state-of-the-science-2024>

Go to <https://tethys.pnnl.gov> for a collection of papers, reports, presentations, and other media about environmental effects of MRE.

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