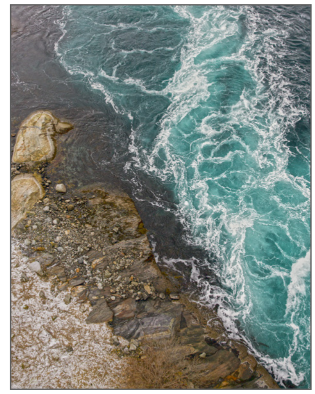
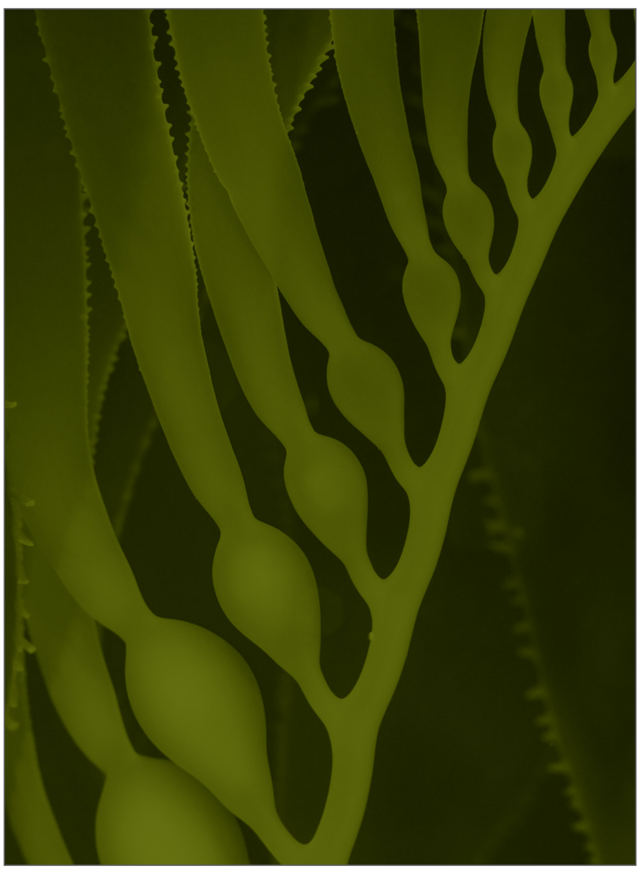
Physical Systems



POTENTIAL CONCERNS

The marine environment comprises physical processes such as tidal circulation and flushing, freshwater input from rivers and streams, heating at the air-surface interface, and the mixing and exchange of sediments, nutrients, and contaminants.

Physical systems act as drivers for the sustainability and health of habitats and the animals they support. The installation of MRE devices and export cables may affect the system by changing natural flow patterns around devices and removing energy from the system. Changes in circulation and flushing can affect sediment transport and distribution, or alter water quality constituents such as nutrients, dissolved gases, and contaminants.



STATUS OF KNOWLEDGE

Decades of reliable oceanographic measurements of tides, currents, waves, nutrient concentrations, and suspended sediment are available around the world. Yet the associated data collection efforts have rarely focused on high-energy sites where wave and tidal energy development is targeted. Examining the physical ocean environment to determine the potential effects of flow changes and energy removal is exceptionally challenging because fast-moving water confounds measurements; meanwhile variability from natural cycles and global changes may not be well known.

Field data are also necessary for validating numerical models, as numerical models are becoming increasingly more capable of predicting the theoretical quantitative changes in physical systems. Simulations can identify changes in the ocean environment caused by the addition of large numbers of MRE devices without the risk and expense of engineering and deployment. Most modeling efforts have focused on the determination of power potential, device survivability, and array optimization; though a few models are beginning to address the question of water constituents. Modeling results indicate that the numbers of MRE devices deployed in an area must be very large to create measurable effects on an oceanographic system.

In general, wave energy converters (WECs) are more difficult to model than tidal turbines because wave energy is variable and less predictable over time, and there are more fundamentally different designs of WECs. Tidal energy devices and their environment are less difficult to model due to the predictability of the tides, extensive hydrodynamics modeling expertise in the oceanographic community, and similarities between tidal turbines and other energy generation gear, including wind turbines and conventional hydro turbines.

OUR UNDERSTANDING OF THE PROBLEM

The magnitude of potential effects of energy removal/ changes in flow from single MRE devices will be too small to measure. Effects might be measurable in future at the large array scale; modeling results could be used to help to guide appropriate monitoring. The scarcity of field data from high-energy environments and the small number of device deployments around the world have slowed the validation of models.

The marine system experiences constant change and adapts to meet new stressors, further confounding the understanding of MRE devices in the water. Flow changes and energy removal have the potential to trigger indirect effects in populations and food webs that could greatly affect organisms not directly influenced by the physical change. Alternatively, change could result in potential positive impacts, such as protection from coastal erosion by the strategic offshore placement of MRE devices.

Significant progress has been made in understanding the potential physical effects, yet some significant challenges remain:

Validation – More data and field measurements around MRE deployments of single devices and arrays are needed to validate existing hydrodynamic models.

Turbulence – The effects of turbulence can introduce uncertainty around model results and requires better understanding.

Device Design – As a relatively new industry, MRE is exploring many different device designs, scales, and operational modes that need to be understood and simulated.

Distance Scales – Effects immediately around the device (nearfield) and on large ocean areas (farfield) are often assessed separately, but animals and ecosystems are not governed by these distinctions and these scales should be assessed jointly.

Cumulative Effects – The present state of the MRE industry has not allowed for the measurement of the cumulative effects of many MRE farms in a region, nor the effects of MRE devices against a background of other anthropogenic effects on the marine environment. These challenges should be addressed with the recognition that the physical system experiences significant spatial and temporal changes due to natural variability, climate change, and other anthropogenic pressures.

FUTURE RECOMMENDATIONS

At the pilot scale, developers should not be required to monitor for changes in physical systems. Coordinated monitoring around array deployments may be needed, once devices are more widely deployed. Monitoring should be coupled with targeted research to improve the validity of models and general understanding of the potential challenges of altering the physical system. Specific research topics should include turbulence, device design, and linkages between distance scales. Removing uncertainty can play an important role in reducing permitting requirements that projects face at this early stage of the industry.

FOR MORE INFORMATION

Annex IV State of the Science full report and executive summary available at: *http://tethys.pnnl.gov/publications/state-of-the-science-2016*

Contact:
Andrea Copping
Pacific Northwest National Laboratory
andrea.copping@pnnl.gov
+1 206.528.3049

Go to *http://tethys.pnnl.gov* for a robust collection of papers, reports, archived presentations, and other media about MRE development.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy
iea Energy Technology Network
OES ANNEX IV
Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965