Changes in Oceanographic Systems

RELEVANCE TO MARINE RENEWABLE ENERGY

The tides, waves, currents, and water circulation make up the oceanographic processes that control the marine environment by determining the concentrations of dissolved gases and nutrients, transporting sediment, and supporting habitats and water quality that allow marine organisms and ecosystems to stay healthy. Harnessing energy from the movement of water with marine renewable energy (MRE) devices has the potential to affect these processes by changing the natural flow patterns around devices, decreasing wave heights, or removing energy from the system.

STATUS OF KNOWLEDGE

It is widely accepted that single MRE devices are unlikely to significantly disrupt the oceanographic system into which they are deployed because any potential changes will be too small to measure. There are likely to be changes in flow close to the MRE devices, but these will fade into the background water movement quickly and are not biologically significant. What we know about changes in oceanographic systems caused by MRE operation comes largely from computer models that have focused on the determination of the potential for power generation and MRE device survivability and efficiency. Only a few models address environmental questions. To date, single MRE devices and small arrays have been deployed around the world and very few have collected oceanographic measurements. Until large

arrays are deployed in the marine environment and oceanographic measurements are collected to determine whether MRE devices are affecting ocean processes, numerical models are the best tools for predicting the future effects of large MRE arrays.

REMAINING UNCERTAINTIES

In preparation for commercial array deployments, changes imposed on the oceanographic systems may be better understood by improving model validation, assessing the cumulative effects of MRE devices, and understanding the related environmental implications.

Numerical models are steadily becoming more detailed, which increases their dependency on high-quality field measurements for model validation. Model realism relies on high-resolution bathymetry and flow measurements that are not readily available in many geographic locations. Field measurements before and after deployments of large arrays are necessary to validate oceanographic models. Models often represent tidal turbines and wave energy converters with simplified equations known as parameterizations, but these parameterizations need to be fine-tuned to represent specific device designs at specific locations, to accurately represent the differing effects they may have on oceanographic systems.

The ocean is a complex environment that has natural seasonal variability, multi-year patterns, and extreme events. Other human activities can also affect oceanographic systems at local and large scales. MRE arrays may cumulatively interact with the natural variability, the effects of other human activities, and oceanographic changes emanating from more than one device. These cumulative interactions may be masked by permanent shifts in the climate, including warming oceans and rising sea levels, which are exacerbated by non-renewable energy sources that could be offset by MRE. In the context of the changing oceans, it becomes very difficult to identify what changes are caused by the energy extraction of MRE devices.

Models predict physical changes, including current speed or wave height, which may affect complex environmental processes such as sediment transport or dissolved gases and nutrients. To provide meaningful information that can inform developers and regulators, studies need to show the connection between physical change and its implications for specific species and habitats. Potential impacts are often site-specific, but trends may be identified that apply across multiple bodies of water, different MRE device designs, and specific communities of organisms.

RECOMMENDATIONS

For small numbers of devices, it is of little value to take oceanographic measurements to determine the potential effects of the devices. However, once larger arrays are deployed, measurements should be taken to determine whether effects are likely. Numerical models will continue to be useful, particularly if they are validated with oceanographic measurements around large-scale MRE developments. Models should also be used to compare oceanographic changes caused by MRE devices with those of other human activities and natural changes. Finally, research studies should seek to understand what effects MRE development might have on specific habitats and marine species, so that any change described by model results can be translated to real-world implications.

REPORT AND MORE INFORMATION

OES-Environmental 2020 State of the Science full report and executive summary available at:
https://tethys.pnnl.gov/publications/state-of-the-science-2020

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

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