Changes in Oceanographic Systems

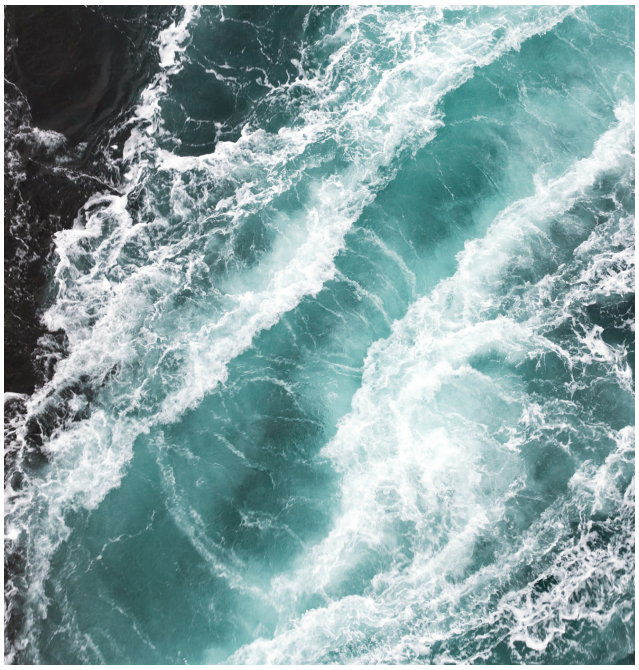
RELEVANCE TO MARINE RENEWABLE ENERGY

Physical processes such as tides, waves, and ocean currents shape the marine ecosystem through the mixing of water masses and exchange of dissolved gases and nutrients, providing support for marine organisms and habitats. Marine renewable energy (MRE) devices that harness energy from tides, waves, and ocean currents may affect these oceanographic systems. Potential changes include altered water flow patterns around devices, changes in circulation, decreased wave heights, and energy removal from the system, both in the nearfield (close to the device) and farfield (at the scale of a water body).

These potential changes can affect organisms and habitats through secondary effects such as sediment transport, water quality changes, nutrient availability, and effects on coastlines either by erosion or coastal protection. Ocean thermal energy conversion (OTEC), another form of MRE, also has the potential to affect oceanographic systems. OTEC uses the temperature differential between warm tropical surface water and cold deep ocean water to create energy; this process returns large volumes of cold water to the surface, which can cause temperature shock to organisms and potentially destabilize the localized water column.

STATUS OF KNOWLEDGE

Changes in oceanographic systems associated with the presence of MRE devices have not been observed. It is expected that flow patterns around devices will be slightly altered but the natural flows will quickly resume at a short distance from the device. The natural variability of oceanographic systems remains more influential than changes introduced by the small tidal and wave energy devices deployed to date.



Currently, numerical models predicting the effects from large MRE arrays, often with 30 or more devices, have informed much of our understanding of potential oceanographic changes. Environmental concerns are not often the focus of these models, which mainly concentrate on potential power generation and wake effects of MRE devices. Some modeling studies show wave energy converter arrays may provide localized protection against coastal erosion and flooding; however, significant uncertainties remain. For the small number of tidal and wave energy devices presently deployed, no changes are expected. While only a few OTEC plants have been operational worldwide resulting in limited knowledge of potential effects, OTEC systems can be designed with cold water return pipes and operated at rates that allow the cold water to be returned to depth, avoiding potential adverse environmental effects.

Scientific literature indicates that changes to oceanographic systems from properly sited small tidal and wave deployments will be lower than those within the natural variability of the system, allowing the risk posed to the marine environment to be retired for small numbers of devices (one to six devices).

REMAINING UNCERTAINTIES

Potential impacts on oceanographic systems will need to be resolved as the MRE industry moves toward larger wave and tidal commercial arrays, including improving the realism of numerical models and providing field data for validation. For OTEC, there is a need to study the efficacy of cold water return pipes and models that drive the design of larger OTEC plants.

As the industry moves forward, potential secondary effects of oceanographic changes on marine habitats and organisms due to MRE arrays will require investigation. Changes to dynamic marine environments from MRE development should be considered in the context of natural variability, as well as the cumulative effects of present and future human activities. Interactions are further complicated by the shifting baseline of climate change, resulting in sea level rise, ocean temperatures, and ocean acidification.

RECOMMENDATIONS

Data collection around deployed wave and tidal energy devices will inform the operation of devices and serve to better validate numerical models to be used in future environmental assessments around arrays. Studies of environmental effects from OTEC systems, including cold water return and other possible effects, need to be developed to assure that operational plants are doing no large-scale harm to oceanographic systems.

Understanding the relative effects of MRE on oceanographic systems should be informed by research studies that place these changes in context with other anthropogenic activities and the natural variability of the system. Addressing secondary effects of MRE developments on habitats and marine organisms will require the development of consistent methodologies to ensure comparable data are generated for interpretation. Collaboration between researchers in more established oceanographic fields and MRE experts should be used to inform field data collection and research investigations into potential ecosystem effects.

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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