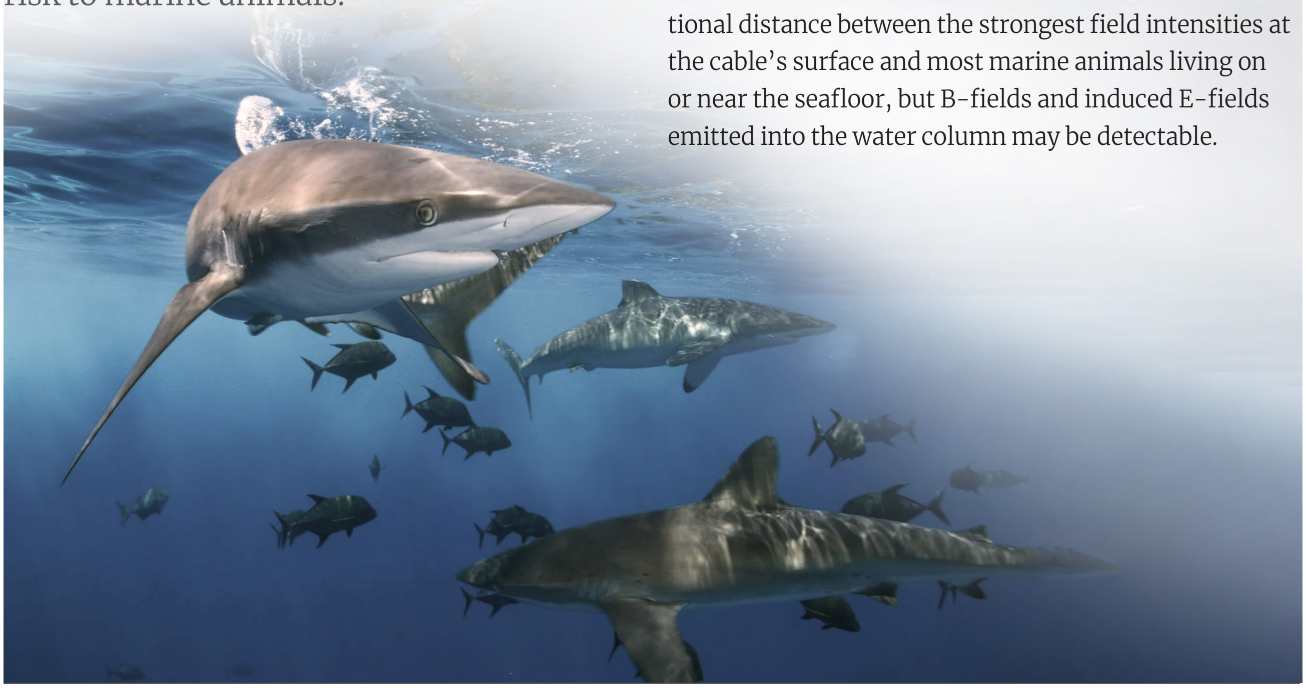
Electromagnetic Fields

RELEVANCE TO MARINE RENEWABLE ENERGY

Electromagnetic fields (EMFs) occur naturally in the environment and consist of electric fields (E-fields) and magnetic fields (B-fields). Natural E- and B-fields provide important cues to electro-receptive and magneto-receptive species, including some species of bony fish (e.g., salmon), crustaceans (e.g., crabs), and elasmobranchs (e.g., sharks, rays). As the marine renewable energy (MRE) industry expands around the world, the addition of human-caused EMFs emitted by subsea power cables and other project infrastructure may mask or modify these existing fields. However, the evidence base to date suggests that EMFs from small-scale MRE developments, such as those currently under development, are not harmful and do not pose a risk to marine animals.

STATUS OF KNOWLEDGE

The primary sources of anthropogenic EMFs associated with MRE systems are the subsea power cables used to transmit the electricity produced to shore. The characteristics and strength of EMFs emitted from these cables depend on the cable design, number of cables, type of current (alternating current [AC] or direct current [DC]), power transmitted, local fields, and other environmental factors. In general, the stronger the electrical current, the stronger the emitted B-field and induced E-fields (E-fields are contained by cable shielding but induced E-fields are produced by the movement of water and animals through the B-field, and by the rotating nature of the B-field in AC cables). Cable burial can create additional distance between the strongest field intensities at the cable's surface and most marine animals living on or near the seafloor, but B-fields and induced E-fields emitted into the water column may be detectable.



Research to better understand the potential effects of EMFs on marine animals has primarily involved controlled laboratory-based studies of anthropogenic B-fields, field-based surveys of EMF-emitting subsea cables, and a few numerical modeling studies. Overall, these studies have shown measurable behavioral, physiological, developmental, and genetic effects and responses to relatively high levels of E- and/or B-fields on a small number of fish and invertebrate species; however, these experimental EMF intensities are much higher than those associated with small-scale MRE development. Based on existing evidence, there is consensus among the scientific community that MRE-related EMF effects on marine animals are likely very weak for single devices or small arrays, and therefore should not inhibit projects or require extensive environmental monitoring. The risk of EMFs for new MRE projects with small numbers of devices (one to six devices) can be retired.

REMAINING UNCERTAINTIES

While EMFs from small MRE developments are unlikely to cause harm, the evidence base is still limited with substantial uncertainties. Several recent laboratory studies use much higher-intensity EMF levels than those expected from the subsea cables associated with small-scale MRE developments, so applying their conclusions should be approached with caution. Very little research has been conducted on the effect of changes at a scale relevant to MRE. Numerical modeling has been used to complement field and laboratory measurements, but the data needed for model validation are lacking.

RECOMMENDATIONS

Although resolving remaining knowledge gaps is not likely necessary for MRE consenting processes to move forward, additional research and monitoring are needed to further advance understanding of MRE and EMFs. For example, future research should focus on improving understanding of species' responses to EMFs at more realistic intensities and temporal patterns associated with MRE devices; determining thresholds for species-specific and life stage-specific dose responses; and increasing the understanding of the interaction of some species (e.g., sharks, marine mammals, fish) with dynamic inter-array cables (i.e., cables draped in the water column).

Additionally, EMF modelling for MRE is not well developed for array layouts and requires field validation as well as the incorporation of species-response data from controlled laboratory studies to assess potential long-term effects. MRE developers and the cable industry should make cable properties and energy transmission data available to improve modeling and enable realistic assessments. Developing environmental standards or guidelines for subsea cable deployment and the measurement of EMFs would assure that data are transferable and can inform future developments.

Finally, as larger MRE projects are planned alongside additional offshore energy development such as wind, the cumulative EMFs from multiple subsea cables and associated infrastructure must be measured and these levels evaluated relative to what is known about marine animal sensitivities.

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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