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Editorial: Novel technologies for assessing the environmental and ecological impacts of marine renewable energy systems

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Editorial on the Research Topic

Novel technologies for assessing the environmental and ecological impacts of marine renewable energy systems

The continued expansion and worldwide adoption of renewable energy systems, including marine renewable energy (MRE) technologies, is essential for addressing climate change (IPCC, 2019; IRENA, 2020; IPCC, 2022). Globally, the amount of potentially harvestable tidal stream and wave energy from nearshore areas is sufficient to meet current worldwide energy demand (Mørk et al., 2010; IRENA, 2020). However, the share of MRE in global electricity generation falls far short of this potential due to the current small scale of deployments; typically, single devices or small-scale arrays. MRE expansion to larger, commercial scales may contribute to addressing the climate crisis, but is hampered by a variety of factors, including uncertainty about their environmental effects (Neill et al., 2012; Kempener & Neumann, 2014a; Kempener & Neumann, 2014b; Copping et al., 2016).

Environmental monitoring around MRE devices has typically relied on standard oceanographic and remote-sensing instruments not intended for use in the complex hydrodyna0mic conditions typical of tidal channels and the nearshore regions where MRE development is planned (Hasselman et al., 2020). Exposure of environmental monitoring instruments to dynamic marine conditions has revealed challenges that have stimulated pioneering research and innovations in the technologies and approaches for understanding the effects of MRE devices on marine ecosystems. This Research Topic has compiled contributions from authors leading cutting-edge research advancing our understanding of the environmental and ecological effects of MRE development, thereby facilitating the expansion of the sector and accelerating progress in addressing the climate crisis.

Advances in machine learning are enhancing our understanding of the environmental effects of MRE devices. Multibeam imaging sonars and optical cameras are frequently used to monitor for interactions of marine animals with MRE devices, but post-processing is laborious, and the accurate identification of species remains challenging. Using convolutional neural networks and Kalman filters, Kandimalla et al. (2022) developed an automated real-time deep-learning framework for the accurate detection, tracking, species identification, and enumeration of fish recorded using a DIDSON imaging sonar and optical cameras. This achieved relatively high performance, though results were highly dependent on the quality of training data. Although the method was developed using data collected from a river and hydroelectric facility, it could be applied to monitoring MRE devices with site-specific retraining.

Machine learning is also enhancing the application of echosounders for monitoring fish in tidal channels. Turbulent hydrodynamics can entrain air in the water column that must be excluded before analyses, but the boundary of entrained air is porous, and its penetration depth can vary, complicating its identification and removal. Using echosounder data from tidal channels in Nova Scotia, Lowe et al. (2022) applied a deep learning approach to develop 'Echofilter' – a new model that accurately (>95%) identifies the boundary of entrained air, and reduces the post-processing time for raw echosounder data by 50%. Echofilter improves the standardization and repeatability of this process by removing the subjectivity inherent to manual post-processing.

It is also important to understand the implications of removing data contaminated by entrained air on estimates of fish abundance and distribution at MRE sites. Using echosounder data from Nova Scotia, Viehman et al. (2022) found little influence of entrained air on estimates of fish abundance and vertical distribution from the lower 70% of the water column and during current speeds < 3 m/s. However, the upper water column and faster current speeds were under-sampled, limiting accurate quantification of fish abundance and distribution at those times. These results highlight the value of complementary technologies that monitor animal movements for understanding potential environmental effects of MRE devices.

One of these technologies is acoustic telemetry. Bangley et al. (2022) demonstrate an approach to develop a predictive species distribution model for migratory fish species using fish implanted with acoustic tags that can be detected at various monitored locations. The authors matched physical oceanographic variables with tag detections of the species at receiver stations and used boosted regression tree analyses to generate a predictive species distribution model for striped bass in the Bay of Fundy. This framework can be applied to other fish telemetry datasets, and turbine specific parameters can be integrated to generate encounter rate models for quantifying the risk of MRE devices.

The integration of complementary monitoring technologies into subsea monitoring packages to facilitate continuous operation over extended periods and provide monitoring data in real-time is a noteworthy advance in facilitating the expansion of the MRE sector. Gillespie et al. (2022) describe the development of a cabled subsea monitoring platform equipped with high-frequency multibeam sonars and a tetrahedral array of high-frequency hydrophones for monitoring the fine-scale movements of marine mammals around operational tidal stream turbines. The results proved the system to be highly reliable, and the platform will be deployed close to an operational turbine in 2022.

Work from tidal channels has improved our understanding of how hydrodynamics can influence species distributions (e.g., turbulent features may increase the availability of prey to predators). Knowledge of these associations is important for understanding potential environmental effects of MRE development. Slingsby et al. (2022) used drone imagery to quantify associations of diving seabirds (auks) with turbulence features. They found that auks primarily oriented themselves across the flow, and that density distribution was influenced by current velocity and tide phase, frequently coinciding with kolk-boils at the sea surface. This work highlights the value of drones for environmental monitoring and collection of seabird data that is difficult using conventional survey methods.

Cost-effective and practical monitoring approaches are needed to advance the MRE sector. Fraser and Waggitt (2022) describe an approach for providing site-specific data on diving seabird behavior and prey assemblages using shore-based observation and baited fish traps. The information gathered using this approach provides metrics that inform environmental impact assessments and collision risk models for seabirds and site-specific data on prey assemblages in a cost-effective manner that will facilitate the responsible development of the MRE sector.

The studies compiled herein highlight recent advances for understanding the environmental and ecological effects of MRE development. Additional innovations will be needed to help facilitate the deployment of MRE devices at scales that can help address climate change, and this should include social science research on social, cultural and economic impacts.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflictof interest

Author JJ was employed by MarineSitu Inc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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