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Putting Anthropogenic Submerged Noise in Ecological Context: Evaluating how Marine Mammals' Listening Spaces are Affected by Tidal Energy Devices

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Abstract

Anthropogenic underwater noise is a pervasive environmental stressor with significant implications for marine ecosystems, particularly concerning the acoustic habitat of marine mammals. Amidst the growing interest in renewable energy sources, tidal energy devices have emerged as a potential solution to mitigate climate change impacts. However, the deployment of such devices introduces underwater noise that may disrupt marine mammal communication, foraging, and navigation. This study aims to evaluate the ecological context of anthropogenic submerged noise by examining its effects on marine mammals' listening spaces in proximity to tidal energy installations. These findings highlight the importance of assessing masking over seasons, as masking effects are highly influenced by ambient noise conditions. Understanding the natural variation within seasons is also particularly relevant for tidal turbine noise assessments as devices are typically situated in highly dynamic environments. Since masking effects occur at the lower level of behavioural impacts in marine mammals, assessing the spatial extent of masking as part of environmental impact assessments is recommended. The listening space formula, which is largely based on measurable environmental factors is transferable to any MRE device, or arrays, for any species and therefore provides an effective method to better inform MRE pre- and post-consenting processes. Using acoustic monitoring techniques and ecological modeling, we assess the spatial extent and temporal patterns of noise propagation, alongside its potential impacts on marine mammal behavior and habitat use. By integrating ecological and engineering perspectives, this research contributes to a comprehensive understanding of the ecological consequences of tidal energy development and informs sustainable management practices for marine renewable energy projects.

Keywords: Anthropogenic submerged noise; Tidal energy devices; Marine mammals; Listening spaces; Ecological context

Introduction

Anthropogenic activities in the marine environment, such as shipping, construction, and resource extraction, have led to a significant increase in underwater noise levels over recent decades. This noise pollution poses a threat to the sensitive auditory systems of marine mammals, which rely heavily on sound for communication, navigation, and foraging. With the urgent need to transition towards renewable energy sources, tidal energy has gained traction as a promising alternative to fossil fuels. Tidal energy devices harness the kinetic energy of tides to generate electricity, offering a clean and reliable source of power. However, the installation and operation of these devices introduce anthropogenic noise into marine ecosystems, potentially disrupting the acoustic habitats of marine mammals. Understanding the ecological context of this submerged noise is crucial for assessing its impacts on marine mammal populations and informing sustainable energy development strategies. This study investigates the effects of tidal energy devices on marine mammal listening spaces, focusing on the spatial and temporal dynamics of noise propagation and its implications for animal behavior and habitat use. By elucidating the ecological consequences of anthropogenic submerged noise, this research aims to facilitate the integration of renewable energy technologies with marine conservation efforts. The listening space concept differs from communication space in that it extends beyond intra-specific communication and also includes the detection of acoustic signatures from conspecifics, prey, predators and/or danger. It also differs from the communication space metric by its computation, whereby prior knowledge of the species-specific auditory filter, gain, detection threshold, signal directivity and duration are not needed indeed; the only species-specific data requirement is an audiogram. Even in the absence of anthropogenic sources, the ocean is not silent. There are both physically and biologically derived sounds, such as breaking waves and marine life that together form what is referred to as the soundscape. Furthermore, daily and seasonal fluctuations in noise levels will occur due to changes in current speeds, sea state as well as spawning and migration patterns of many marine species [1-5].

Discussion

The findings of this study shed light on the potential impact of anthropogenic submerged noise, specifically from tidal energy devices, on marine mammal listening spaces. Through a combination of field observations, acoustic monitoring, and ecological modeling, we were able to assess the extent to which marine mammals' acoustic environments are altered by the presence of these devices. Our results indicate that tidal energy devices introduce significant levels of underwater noise, which has the potential to encroach upon marine mammals' listening spaces. This can disrupt crucial communication and echolocation behaviors, leading to potential impacts on their ability to navigate, forage, and communicate effectively within their habitats.

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Furthermore, our study highlights the importance of considering the ecological context when evaluating the impacts of anthropogenic noise on marine mammals. By integrating acoustic data with habitat characteristics and species distribution models, we were able to elucidate how changes in noise levels may intersect with the spatial distribution and ecological requirements of different marine mammal species. It is important to note that the effects of tidal energy devices on marine mammal listening spaces are likely to vary depending on factors such as device location, deployment depth, and species-specific sensitivities to noise. Future research should aim to further refine our understanding of these dynamics, incorporating long-term monitoring data and experimental studies to assess the cumulative effects of noise exposure on marine mammal populations. In addition, proactive measures should be taken to mitigate the potential impacts of anthropogenic noise on marine mammal habitats. This may include implementing noise reduction technologies on tidal energy devices, establishing marine protected areas in key habitats, and incorporating noise considerations into marine spatial planning processes [6-10].

Conclusion

In conclusion, our study underscores the importance of considering the ecological context when evaluating the impacts of anthropogenic submerged noise on marine mammal habitats. By integrating acoustic monitoring with ecological modeling techniques, we have provided valuable insights into how tidal energy devices may affect marine mammals' listening spaces. Moving forward, it is essential that policymakers, industry stakeholders, and conservation practitioners work together to develop strategies that minimize the potential impacts of underwater noise pollution on marine mammal populations. By adopting a proactive and collaborative approach, we can strive to ensure the long-term health and resilience of marine ecosystems in the face of increasing anthropogenic pressures.

Acknowledgment

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Conflict of Interest

None

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