Extended abstract

Brilliant Marine Research Idea 2025

This extended abstract is part of the full report submitted to VLIZ philanthropy. Data of this specific final report are under embargo and are therefore not yet published online.

1. General information

Title of the idea	When the ocean gets loud: Noise pollution disrupts macrofaunal bioturbation-
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2. Brilliant Marine Research Idea

Extended abstract

Anthropogenic low-frequency noise (LFN) is rapidly transforming coastal soundscapes, yet its consequences for sediment microbial communities and the ecosystem processes they underpin remain largely unexplored. Microbial assemblages in marine sediments drive key biogeochemical functions, including carbon mineralization and nutrient cycling, and are strongly structured by bioturbating macrofauna. However, it is unknown how LFN interacts with ecosystem engineers to influence the structure and activity of active sediment microbiomes.

Here, we investigated the combined effects of continuous low-frequency noise (~110 Hz) and the presence of the bioturbating polychaete *Hediste diversicolor* on active microbial communities in intertidal mud. We conducted a fully factorial laboratory experiment with four treatments: sediment with and without noise, crossed with the presence or absence of *Hediste*. After one week of exposure, metatranscriptomic sequencing was used to characterize both taxonomic composition (rRNA fraction) and functional activity (mRNA fraction) of the active microbial community.

Microbial alpha and beta diversity were strongly driven by *Hediste* presence, with bioturbated sediments exhibiting higher diversity and clear shifts in community composition. In contrast, LFN alone did not significantly alter microbial richness or genus-level structure. However, functional analyses revealed pronounced effects of noise. In the absence of bioturbation, LFN induced substantial reorganization of microbial activity, characterized by increased expression of stress-related and regulatory pathways and reduced expression of nutrient transport, biosynthesis, and central metabolic functions. These patterns indicate a shift from growth-related processes toward maintenance and stress responses.

Bioturbation by *Hediste diversicolor* markedly enhanced microbial metabolic capacity, with increased expression of pathways involved in carbon degradation, nitrogen and sulfur cycling, and biosynthesis. Importantly, *Hediste* partially buffered noise-induced functional disruptions: while many core metabolic functions remained elevated under noise, stress-related responses persisted and some nutrient-cycling and biosynthetic pathways were still reduced.

These findings demonstrate that anthropogenic low-frequency noise acts primarily as a functional, rather than taxonomic, stressor in coastal sediments. Moreover, they highlight the critical role of bioturbating macrofauna in enhancing microbial diversity and stabilizing ecosystem functioning under disturbance, while also showing that this buffering capacity is

incomplete. Integrating microbial functional responses with macrofauna-mediated processes is therefore essential for predicting the impacts of expanding underwater noise on benthic biogeochemistry and ecosystem resilience.