



Long-term intra-site variability of ecoacoustic recordings

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ABSTRACT

Passive acoustic monitoring is being increasingly explored as a scalable, inexpensive tool for ocean monitoring, with proposed use-cases such as identifying ecosystem changes over the long-term to inform management and policy. While recent meta-analyses have shown a moderate positive correlation between acoustic indices and biodiversity, generalised, accurate biodiversity metrics are difficult to obtain from soundscapes (Alcocer et al., 2022; Pan et al., 2024). Understanding the factors driving soundscapes and the outcomes from derived metrics is important to be able to effectively utilise acoustic indices for environmental monitoring (Azofeifa-Solano et al., 2025; Kemp et al., 2025). Few studies have explored multi-site monitoring over longer periods with marine soundscapes. Short-term recordings may not contain enough information to overcome potential variability, such as could be found between sites, lunar phase, times of day, tide height, or sea-surface temperature. Many studies are designed to examine sound characteristics based on inter-site variability with short-term recordings, leading to potentially spurious results if ecological drivers are not included. Using recordings collected from 11 sites over 2 months, we apply generalised additive models to examine the effects of the environmental factors on ecoacoustic outputs, and demonstrate that intra-site variability can be greater than inter-site variability, even when some factors are accounted for. We also propose a novel diel representation that can be utilised in machine learning models. We compare dimension reduction and clustering techniques with traditional representations to our representation, and find that incorporating diel patterns produces better cluster separation. Our study highlights the need for long-term datasets to better describe baseline patterns in passive acoustic monitoring, and the importance of incorporating additional sources of information, such as environmental information, which can influence noise-producing species.

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