

The importance and challenges of an ecosystem-based, multi-taxa approach to underwater noise risk assessment and management

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Without regulatory measures, underwater radiated noise (URN) from human activities poses risks to marine life. To mitigate these hazards, a shift towards an ecosystem-oriented, risk-based URN assessment and management is essential. Fundamental steps for this approach include selecting indicator species across various taxa and establishing ecologically relevant underwater noise limit values (UNLV). Previous URN risk assessments focused primarily on marine mammals, while ecologically vital taxa like fishes and invertebrates are often overlooked. A multi-taxa approach was adopted for assessment of URN impacts at ecosystem level. For this, a trait-based vulnerability scoring system was developed to select indicator species for marine mammals, fishes and invertebrates, estimating the relative URN vulnerability across species by quantifying sound production and detection abilities, documented URN impacts, general susceptibility related to intrinsic life-history traits and socio-ecological status, while also accounting for data quality. The assessment identified a set of multi-taxa indicator species backed by robust evidence. It also highlighted potentially vulnerable species that currently lack sufficient data for selection. A primary limitation is the system's reliance on existing data; high vulnerability scores often correlate with how well a species has been studied. Especially for invertebrates and fishes, the species studied only represent a small fraction of those potentially vulnerable to URN, and data gaps regarding bioacoustics and noise impacts - including effects of particle motion - remain substantial. Other challenges include only a few sound sources tested, a general lack of dose-effect relationships, inconsistent methodologies and metrics that impede comparative analyses, and unknown mechanisms behind demonstrated effects and their impact on populations. Despite these challenges, the establishment of regional UNLVs to protect vulnerable species should not be delayed. Identifying data gaps helps prioritise future research in the emerging field of bioacoustics, allowing the vulnerability assessment framework to be refined iteratively as research progresses. By integrating indicator species' distribution and key habitats with regional UNLV and the spatiotemporal overlap of URN exposure from sound maps for current and future policy scenarios, this multi-taxa approach facilitates an ecosystem-based URN management applicable across different regions.