Towards an ecosystem-based Underwater Noise Limit Value for the North Sea: A Functional and Risk-Based Framework

Eicher, H; Calonge, A; Krång, AS; Debusschere, E; de Jong, CAF; de Jong, K; McQueen, K; Ainslie, MA; den Held, ME; Rumes, B; Schaffeld, T; Siebert, U; and Schnitzler, JG

Helena Eicher
helena.eicher@tiho-hannover.de
University of Veterinary Medicine Hannover, Germany

Under the Marine Strategy Framework Directive (MSFD), EU Member States must manage continuous underwater noise to achieve or maintain Good Environmental Status, requiring definition of a Level of Onset of Biologically Adverse Effects (LOBE). Current assessments often rely on a single indicator species, missing ecosystem-wide vulnerability. We present a framework from the Interreg North Sea project DEMASK that aims to derive a precautionary, ecologically representative Underwater Noise Limit Value (UNLV) informed by the LOBE concept by integrating evidence across marine mammals, fish and invertebrates, selected via a trait-based vulnerability scoring system. The framework translates fragmented, single-species impact studies, typically reporting responses relative to sound pressure levels (SPL), into a cross-taxa management framework. Rather than aggregating responses by taxonomy, indicator species are grouped by functional hearing characteristics reflecting frequency-dependent vulnerability. SPL values reported across studies are harmonized to a comparative scale and classified along an ordinal severity gradient, ranging from onset of hearing through behavioural and physiological responses to hearing impairment and injury. Knowledge gaps are identified, particularly for masking, effects of particle motion, and limited data. Initial synthesis of harmonized SPL values reveals a consistent severity-prevalence relationship: as SPL increases, both impact severity and the proportion of affected species increase. This relationship is operationalized using cumulative distribution functions, which describe for any SPL the fraction of species expected to experience at least a given impact level. The approach is analogous to Species Sensitivity Distributions used in ecotoxicology, where interspecies variability in sensitivity is statistically represented to derive environmental thresholds. A precautionary UNLV could be derived from a conservative quantile of this distribution, e.g. the SPL at which 10-20% of indicator species are expected to experience at least a given impact level. While this intentionally simplified approach remains under development, it provides a transparent way to integrate heterogeneous evidence across taxa and defines UNLVs near the lower bound of biologically relevant effects. It complements species-specific assessments by supporting ecosystem-based management and provides a reproducible pathway toward UNLV implementation under the MSFD.