DEMASK: Vulnerability of North Sea fish species to underwater noise

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Under the European Union's (EU) Marine Strategy Framework Directive (MSFD), the introduction of energy, including underwater noise, must be at levels that do not adversely affect the marine environment. The North Sea is one of the busiest seas in the world, with anthropogenic activities, such as vessel traffic, construction and seismic surveys, becoming more prevalent every year. To achieve Good Environmental Status (GES), regional threshold values of noise levels need to be defined (European Commission, 2017). This includes defining the Level of Onset of Biological adverse Effects (LOBE) for indicator species, or the noise level at which the fitness, survival and vital functions of individual animals are compromised (Borsani *et al.*, 2023). Defining indicator species across different animal taxa is therefore crucial in the evaluation of the effects of underwater noise. As part of the Interreg North Sea project DEMASK (Development and evaluation of noise management strategies to keep the North Sea healthy), a trait-based scoring system to assess the vulnerability to underwater noise was developed for marine mammals, fish and invertebrates. The scoring system defines several factors related to the animal's hearing and sound production, reported impacts of impulsive and continuous noise, and the socio-ecological status of species, to compare their relative vulnerability to underwater noise. Based on an extensive literature review and an expert consultation survey, each species was assigned a score (0 to 3) for each vulnerability factor. The quality of information on which the vulnerability score was based was also assessed, resulting in a data quality score for each species. With this scoring system, we highlight species with a good evidence base of vulnerability to underwater noise and therefore could be selected as indicator species for the North Sea. The scoring system also highlights species that may be vulnerable to underwater noise but could not be selected as indicator species due to the lack of information on their vulnerability to noise. Among the 55 North Sea fish species assessed, Atlantic cod, haddock, Atlantic herring, ling and Atlantic salmon were those that fell within the 90th percentile of both vulnerability and data quality scores. These species have sufficient evidence of vulnerability to underwater noise and/or are commercially and ecologically important. Masking of communication signals vital for reproductive success (Stanley *et al.*, 2017), negative effects on foraging (Løkkeborg *et al.*, 2012), and reduced heart rate related to stress (Davidsen *et al.*, 2019) were some of the reported impacts of underwater noise to these fish species. As the selection is based on the most present knowledge, these species may not necessarily be the most sensitive species to underwater noise. Rather, as potential indicator species, degradation of ecosystems due to underwater noise may be assessed through known impacts of noise on their populations. Using habitat suitability models and distribution maps of the selected indicator species, overlayed with noise level maps from different policy scenarios, the effects of underwater noise can be mitigated through adaptive management strategies. The scoring system presented here serves as a framework, and new indicator species could therefore evolve over time as more research studies on the impacts of noise across different taxa develop.

Keywords

Underwater Noise Vulnerability; MSFD; DEMASK; Masking; Noise Sensitivity; Indicator Species; Impacts of Anthropogenic Noise