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Editorial: Hearing research in cetaceans

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Editorial on the Research Topic
Hearing research in cetaceans

Whales, dolphins, and porpoises serve as crucial indicators of the well-being of marine ecosystems. These animals, with unique acoustic adaptations, prioritize sound production and underwater hearing as crucial aspects of their sensory capabilities. Within the realm of cetaceans, the prevailing sensory modality is hearing, which enables vital life functions, including communication, navigation, and locating prey (Supin et al., 2001). Consequently, the mounting presence of anthropogenic noise pollution has emerged as a significant environmental stressor for these creatures (Slabbekoorn, 2019; Wang et al., 2021a). Efforts to regulate human activities and alleviate the detrimental impacts of human-made noise on marine animals are on the rise. Understanding the impact of noise on marine mammals necessitates a comprehensive grasp of their auditory abilities and adaptability.

Audiograms, which show the sensitivity to sound across the frequency range of hearing, provide the most fundamental piece of information necessary for addressing the potential impact of ocean noise on marine mammals. Even though there are more than 90 cetacean species worldwide, studies have only investigated the audiograms of fewer than a third of these species (Wang et al., 2020; Wang et al., 2021b). In this Reseacrh Topic, audiograms of six novel odontocetes, (i.e. the dwarf sperm whale (*Kogia sima*), pygmy sperm whale (*Kogia breviceps*), northern right whale dolphin (*Lissodelphis borealis*), melon-headed whale (*Peponocephala electra*), long-beaked common dolphin (*Delphinus capensis*), and Atlantic spotted dolphin (*Stenella frontalis*)) and a seldom-tested odontocete, the pygmy killer whale (*Feresa attenuata*), were presented (Houser et al). The audiograms were obtained using auditory evoked potential (AEP) methods, but due to a mismatch between the frequency specificity of the stimulus and the cochlear place specificity of the auditory brainstem response at lower frequencies of hearing (ANSI, 2018; Finneran et al., 2016), carrier frequency at frequencies ≤ 10 kHz were not reported or attempted. Determining hearing sensitivity within the low-frequency range of hearing in marine mammals remains a challenge, and additional research needs to be performed to determine the low-frequency limits to AEP utilization across a broad range of species. The AEP method remains the most promising approach to obtaining population-level audiometry among free-ranging animals, although it has been attempted in only a few species (Houser and Finneran, 2006; Houser et al., 2008; Mooney et al., 2018; Popov et al., 2007; Wang et al., 2020).

The potential impact of anthropogenic noise on the hearing of cetaceans has sparked significant interest into auditory fatigue and the potential for noise-induced hearing loss (Finneran, 2015). In this Research Topic, the potential for a temporary loss of hearing, or temporary threshold shift (TTS), was modeled for the harbor porpoise (*Phocoena phocoena*) exposed to noise emitted from acoustic flowmeters (Schaffeld et al). The team modeled the possible exposure of a harbor porpoise swimming through a region in which an acoustic flowmeter emitted 28 kHz pulses at regular intervals to measure water flow velocity into the port of Hamburg. The modeling was made possible by a significant amount of work into the levels of sound required to cause TTS in this species. Unfortunately, TTS has been studied in few marine mammal species, and much knowledge about it remains to be realized given the diversity of species and noise sources present within the world's oceans.

Anatomical studies can unravel the intricate connections between the physical structures of cetacean auditory systems and their sensory capabilities. Indeed, anatomical modeling of the auditory system has been used to predict hearing sensitivity in whales that have not been subject to hearing tests, particularly mysticete whales. Anatomical analyses have also been used to demonstrate impacts to the auditory system, including potential impacts from noise. This Research Topic reported evidence of low-frequency hearing impairment with focal loss of outer hair cells in the cochlea of a stranded harbor porpoise from the German Baltic Sea (Rohner et al). The inner ear of this animal showed tissue damage that was compatible with noise-induced hearing loss during post-mortem investigations. Such techniques will continue to be important in determining causes of stranding and mortality in some cetaceans, and may be critical to establishing linkages between noise exposure and hearing loss in wild cetaceans.

Many unknowns remain regarding cetacean hearing. Assessing what the mysticete (baleen) whales hear remains an urgent task in need of a solution. This will likely require collaboration across disciplines, including behavioral research (e.g. playback studies), anatomical modeling, and neurophysiological studies. It is unlikely that any one research approach will address the challenges caused by the vast differences in body mass, behaviour, and ecology of these massive creatures. Urgency also exists to further understand auditory adaptation, auditory temporal windows and forward masking within cetaceans (Finneran et al., 2020; Nachtigall et al., 2018; Popov et al., 2022; Popov et al., 2021), as well as the ability of certain cetaceans to consciously control hearing sensitivity to predictable high-level noise exposures (Finneran et al., 2023; Nachtigall et al., 2016a; Nachtigall et al., 2016b; Nachtigall et al., 2016c). In addition, advancements in hearing research methodologies, including the integration of technologies like artificial intelligence have yet to be fully explored (Lesica et al., 2021). Furthermore, there is a compelling need for continued interdisciplinary collaboration within the realm of whale auditory research (Mulsow et al., 2020). Integrating insights from various fields such as marine biology, acoustics, neurology, and ecology will not only enrich our understanding but also provide a more comprehensive perspective on how whales perceive and interact with their acoustic environment, and ultimately bolsters broader conservation and management initiatives aimed at safeguarding cetaceans.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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