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TITLE: Marine mammals and sonar: Dose-response studies, the risk-disturbance hypothesis and the role of exposure context

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ABSTRACT:

Abstract Marine mammals may be negatively affected by anthropogenic noise. Behavioural response studies (BRS) aim to establish a relationship between noise exposure conditions (dose) from a potential stressor and associated behavioural responses of animals. A recent series of BRS have focused on the effects of naval sonar sounds on cetaceans. Here, we review the current state of understanding of naval sonar impact on marine mammals and highlight knowledge gaps and future research priorities. Many marine mammal species exhibit responses to naval sonar sounds. However, responses vary between and within individuals and populations, highlighting the importance of exposure context in modulating dose-response relationships. There is increasing support from both terrestrial and marine systems for the risk-disturbance hypothesis as an explanation for underlying response processes. This proposes that sonar sounds may be perceived by animals as a threat, evoking a response shaped by the underlying species-specific risk of predation and anti-predator strategy. An understanding of responses within both the dose-response and risk-disturbance frameworks may enhance our ability to predict responsiveness for unstudied species and populations. Many observed behavioural responses are energetically costly, but the way that these responses may lead to long-term individual and population-level impacts is poorly understood. Synthesis and applications . Behavioural response studies have greatly improved our understanding of the potential effects of naval sonar on marine mammals. Despite data gaps, we believe a dose-response approach within a risk-disturbance framework will enhance our ability to predict responsiveness for unstudied species and populations. We advocate for (1) regulatory frameworks to utilize peer-reviewed research findings when making predictions of impact, (2) regulatory frameworks to account for the inherent uncertainty in predictions of impact and (3) investment in monitoring programmes that are both directed by recent research and offer opportunities for validation of predictions at the individual and population level.

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