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Editorial: Marine invertebrates and sound

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Editorial on the Research Topic
Marine invertebrates and sound

The growing pressure from anthropogenic activities impacts organisms at their communities and ecosystems levels. Among these stressors, the recent introduction of artificial noises in the oceans affects their inhabitants, altering their metabolism, deriving in malfunctions of physiological processes, or in behavioural disruptions. These dramatic changes may lead to significant transformations at population levels and negatively influence the whole oceanic ecosystem.

Sound is an important sensory modality for marine organisms, especially because other senses (vision, smell or taste) may be limited due to information loss in aquatic habitats. While marine mammals and fishes have received a great scientific attention in the last three decades, our knowledge of the biological significance of sound perception and production in marine invertebrates is scarce. Most of them are able either to produce and/or detect sounds through specialised hearing organs, or mechanoreceptors, which respond to the kinetic component of the sound. In some species, sounds can have various ecological functions (e.g. communication, territorial, social and sexual behaviour, species recognition), but it is generally considered that they are produced as a reaction to environmental stressors (predators – prey, alarm or stress reactions). Similarly, hearing sensitivity and its related behavioural patterns are little known.

Marine invertebrates play a central role in food webs and ecosystem services, as well as represent an important economical resource. Recent findings have shown that invertebrates are sensitive to anthropogenic noise. Noise can cause physical injuries, physiological stress, alterations of embryonic and larval development, changes in behaviour, reduction of growth and reproduction, increase of mortality and decrease of ecological success. These effects can have long-term consequences for the survival and adaptation of marine invertebrates in an increasingly noisy ocean, and indicate that this sensitivity may have a direct consequence on ocean biodiversity, placing them as direct indicators of ocean health. There is a clear need for more research to progressively assess the risks generated by noise exposure and to identify the gaps in knowledge on the potential effects that noise exposure may trigger in marine invertebrates.

This Research Topic aims at contributing to the advancement of our scientific knowledge on marine invertebrate bioacoustics and their implications for biodiversity and the functioning of marine ecosystems. The papers under this Research Topic show the

complexity of effects caused by acoustic pollution on these understudied taxa. The results indicate the importance of multi-level research on the effects of noise as stressor on marine invertebrates and identify the existing gaps, proposing future lines of research that will allow improving the assessment and mitigation of the impacts of anthropogenic noise on marine invertebrates and on the whole oceanic ecosystem.

This Research Topic collects a series of studies regarding marine invertebrate bioacoustics. Solé et al. summarise the current scientific knowledge on sound production, reception and sensitivity and review how marine invertebrates are affected by anthropogenic noises, identifying gaps that will frame future research for the assessment of the tolerance to noise of marine ecosystems.

Another review (Pysanczyn et al.) analyses the role of acoustics in the sensory landscape of coral larval settlement, to first provide an updated overview of the abiotic and biotic cues used by coral larvae to guide settlement, highlighting the potential for incorporation of acoustic enrichment techniques in coral reef conservation and restoration interventions. The snapping shrimp contribution on the Southern China coastal soundscape is analysed in Song et al., indicating that snaps are important communication means in light-limited conditions, which improves our understanding on the correlation of snapping behaviour and ecological environments.

This Research Topic on Marine Invertebrates and Sound also includes the response of invertebrates to sound as an anthropogenic stressor. In that context, a wide range of physiological, behavioural and ultrastructural responses from invertebrates to noise pollution are introduced. These studies deal with (i) the most representative groups of invertebrates: bivalves (Ledoux et al.; Gigot et al.), crustaceans (Sal et al.; McCloskey et al.) and cephalopods (Cones et al.) and (ii) a wide range of effects: feeding behaviour (Aspirault et al., Kühn et al.), metabolism (Gigot et al.; Ledoux et al.), development (Aspirault et al.; Cervello et al.), reproduction (Sal et al.), locomotion (Cones et al.), survival and community structure (McCloskey et al.; Kühn et al.).

Ledoux et al. assess the valve gape velocity and the physiology effects under pile driving, drilling and boat sound exposure. The study of Sal et al. is the first to contribute to assess the effect of different sound sources on the maternal care behaviour of a crustacean species. The results of Cones et al. demonstrate that pile driving disrupts squid fine-scale movements, but these impacts are short-lived, suggesting that offshore windfarm construction may minimally affect the energetics of this ecologically key taxon. McCloskey et al. experimentally demonstrate that SCUBA noise can have at least some negative impacts on reef organisms at community level, confirming this sound source as an ecologically relevant pollutant.

Interestingly, a high proportion of the articles in the Research Topic are dedicated to the study of the noise impact on planktonic species. Aspirault et al. assess the vessel noise impact on the feeding behaviour of blue mussel (*Mytilus edulis*) veligers and of the copepod *Eurytemora herdmani* as well as on the growth of the rotifer *Brachionus plicatilis* determining different results depending on the species. In a similar way, Kühn et al. show decreasing feeding rates of copepod *Acartia tonsa* exposed to harbour traffic noise. *Venus verrucose* larvae response to pile driving and drilling is modulated by their physiological condition and the noise could reduce compensatory mechanisms to balance the temperature increase (Gigot et al.). Also pile driving, drilling and vessel sounds are used in Cervello et al. to assess their effects on larvae of model species involved in marine biofouling. The results of these works suggest that effects of noise on plankton are complex and more research needs to be devoted to these initial live stadia.

We thank all the authors and reviewers who have participated in this Research Topic for their valuable contribution to this emerging field of marine acoustic ecology and we hope that this Research Topic will stimulate further investigation and innovation.

Author contributions

MS: Writing – original draft, Writing – review & editing. MA: Writing – review & editing.

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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