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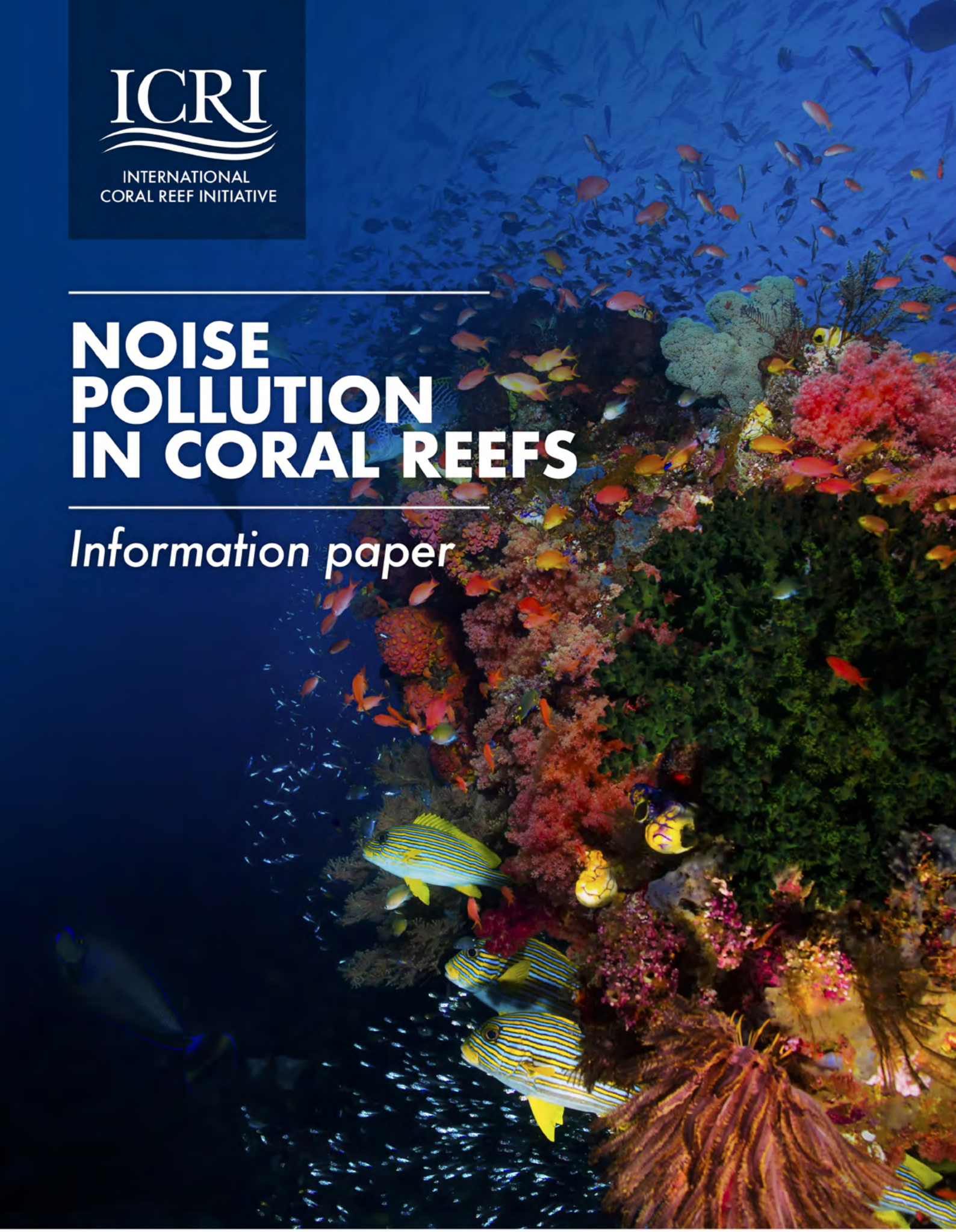
INTERNATIONAL CORAL REEF INITIATIVE

NOISE POLLUTION IN CORAL REEFS

Information paper



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Government Offices of Sweden
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NOISE POLLUTION IN CORAL REEFS INFORMATION PAPER

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Coral reefs are among the most biologically diverse and structurally complex ecosystems worldwide, but also one of the most endangered natural ecosystems. While climate change, ocean acidification, and human-driven activities such as agriculture and industry are identified as strong contributing factors to reef deterioration, noise pollution (anthropogenic noise) has been increasingly acknowledged for its negative impact on coral reef ecosystems.

As the use of acoustic data increases for assessing how coral reef organisms sense, and use sound, it also provides mounting evidence on the negative impacts of underwater noise pollution. Policy initiatives are thus urgently needed to implement effective legislation that addresses this global, and growing, issue. This is an issue which can be tackled more easily than other global stressors, such as global warming and ocean acidification, which respond very slowly to mitigating action.

THE SOUND OF A HEALTHY REEF

Coral reefs are naturally noisy as, in addition to the sounds of breaking waves, water and wind currents, organisms produce, and use, a multitude of sounds for a variety of purposes. These include: navigation, location of suitable settlement habitats (e.g. as shown by coral larvae), foraging, communication, recognition of species, groups and even individuals (e.g. shown by marine mammals), nestling, territorial fights (e.g. seen with shrimps), competition for food, and courtship interactions (e.g. by reef fish), and others. These all make up the reef soundscape (Figure 1).

In addition, this soundscape is an indicator of the health of the reef as a habitat. A recent study comparing the pre- and post-degradation soundscapes of Australia's Great Barrier Reef (GBR) revealed that after severe damage the reef soundscape[1] became 15dB quieter, significantly less complex and less rich, and thus 8% less attractive with a 40% reduction in juvenile fish settlement.

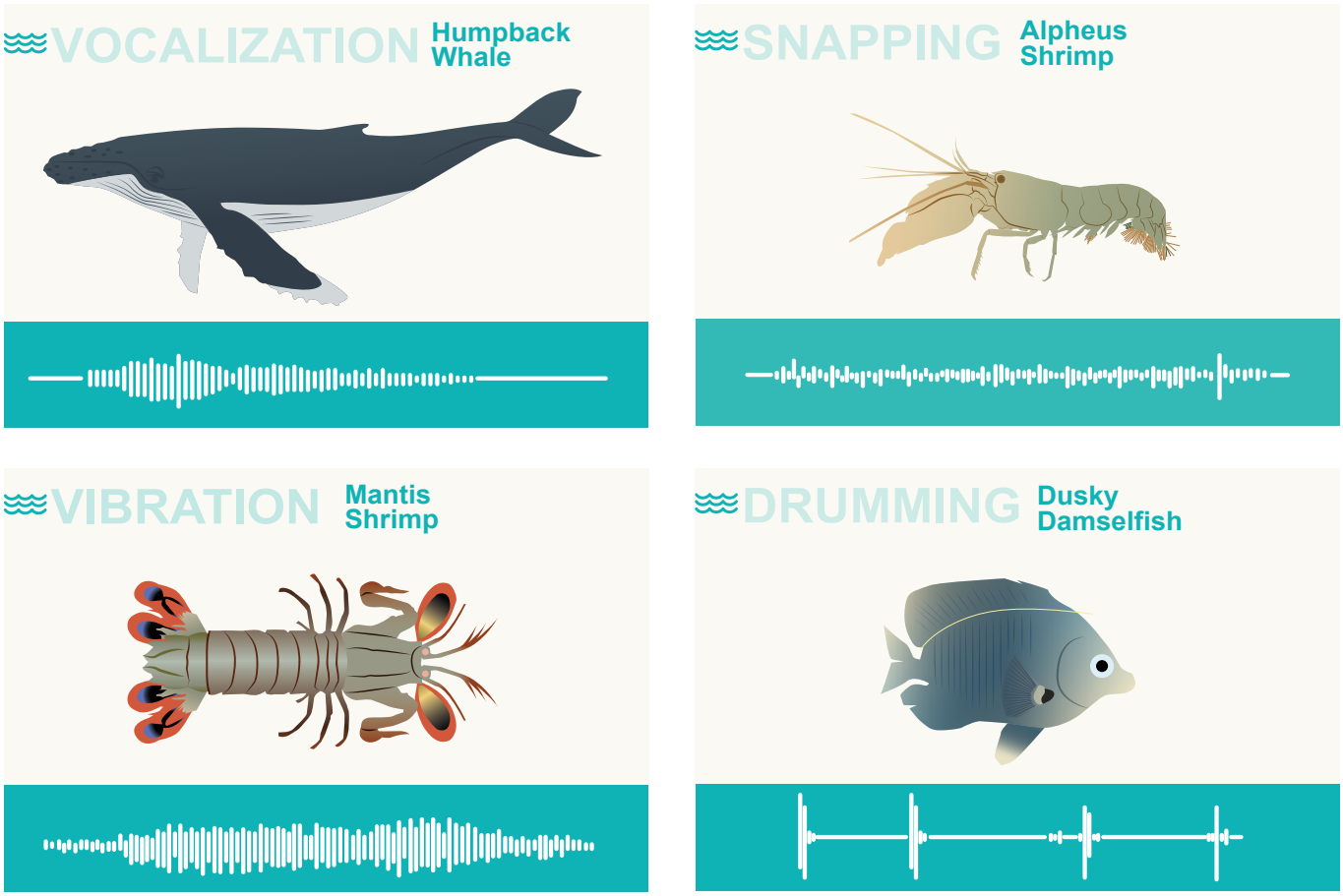

Figure 1. Sounds produced by coral reef organisms

1. GORDON, T. A. C., HARDING, H. R., WONG, K. E., MERCHANT, N. D., MEEKAN, M. G., MCCORMICK, M. I., RADFORD, A. N. & SIMPSON, S. D. (2018). Habitat degradation negatively affects auditory settlement behavior of coral reef fishes. Proc Natl Acad Sci United States of America 115, 5193–5198.

NOISE POLLUTION
A NOT SO NEW STRESSOR

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Anthropogenic noise has been classified as a form of pollution since 1970 (US National Environment Policy Act) and several international guidelines have been enacted in recent years, (e.g. the Marine Strategy Framework, Descriptor 11 of Directive 2008/56/EC; Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life, MEPC.1/Circ.833 and Monitoring Guidance for Underwater Noise in European Seas 2014). Multiple human activities related to marine installations contribute to enhanced underwater noise pollution in coastal environments, such as wind turbines; oil platforms; use of airgun-arrays; pile driving and explosives; petroleum and mineral exploration and extraction; high resolution imaging; and defence operations. Nevertheless, the most prevalent sources of anthropogenic noise are commercial and recreational boat/ship activities. Of particular concern are the high numbers of small motorboats as they operate near organisms in shallow areas, particularly in coral reef areas. For instance, 11.85 million recreational boats were registered in 2018 in the United States, and 6 million recreational boats were registered in 2015 in Europe. On the Great Barrier Reef alone, over 90,000 recreational motorboats were registered in 2014 and these numbers are predicted to increase to 0.5 million by 2040.

HOW ARE CORAL REEFS AFFECTED BY SOUND?

As anthropogenic noise usually overlaps the sound production and detection ranges of marine organisms (Figure 2), it can interfere with the biological processes of coral reef organisms. This severely compromises their ability to sense and use sound in a wide array of functions. Indeed, both acute and chronic effects have been observed, from the reduced number of coral larvae reaching their settlement areas on coralline crustose algae to increased heart rate, opercular beat rate, blood cortisol and sheltering of reef fish; all of which indicate increased stress levels in the presence of boat noise. In addition to physiological and distributional changes, noise pollution (particularly boat noise) has been shown to disrupt feeding behaviour, swimming patterns, anti-predator responses, and parental care. Moreover, under continuous noise pollution, response thresholds and response times may be modified and may lead to permanent changes at the population and ecosystem levels, such as altered distributional and behavioural patterns and auditory thresholds (Figure 3).

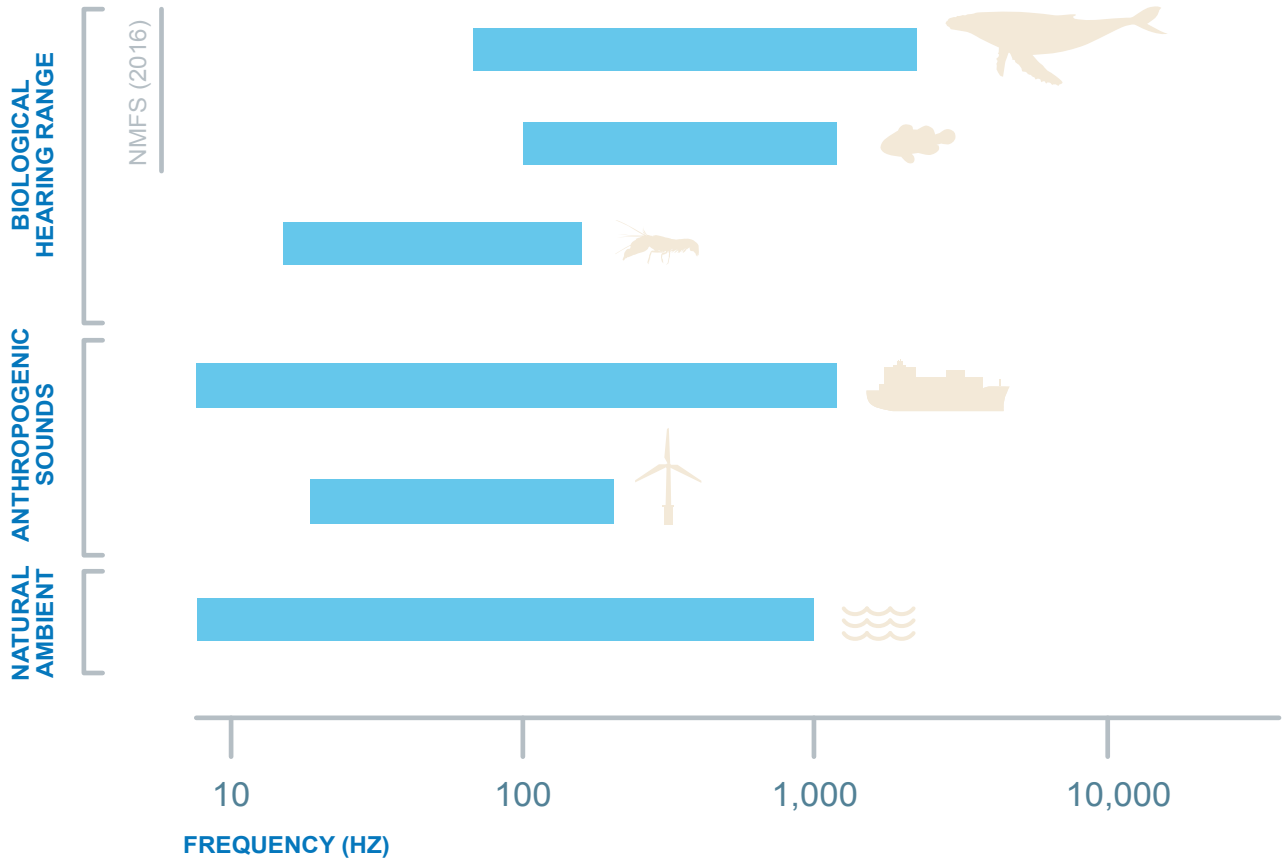
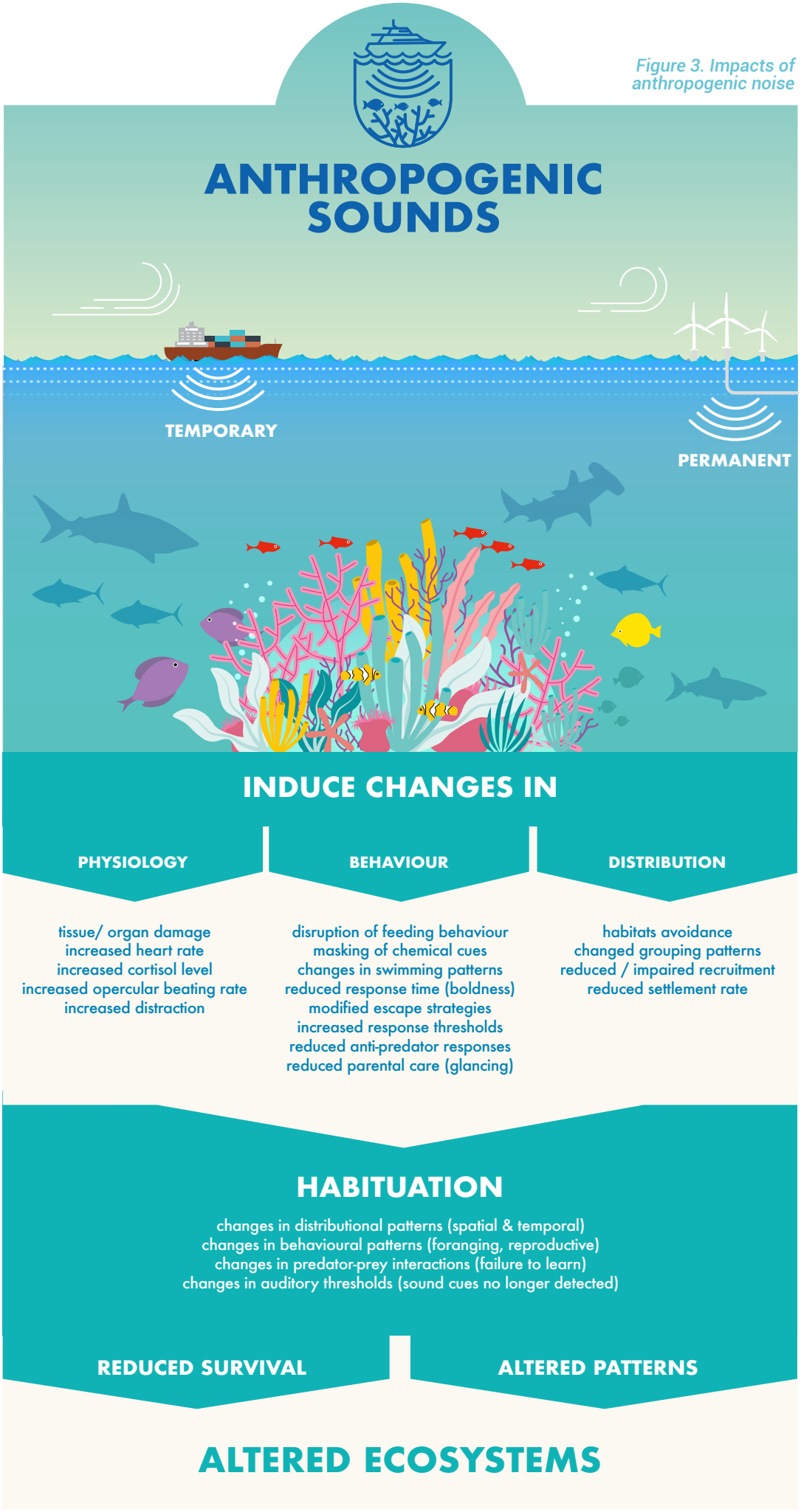


Figure 2. Frequency of sounds emitted by natural and anthropogenic sounds, and its overlap with biological hearing range.

Figure 3. Impacts of anthropogenic noise



TACKLING NOISE POLLUTION IN CORAL REEFS POLICY APPROACHES

As evidenced by the already known impacts of noise pollution, it is crucial to identify the species and/or life stages most vulnerable to noise pollution, to establish measures that mitigate the known effects, and to enforce practices that prevent further damage to coral reefs. International organizations such as the **International Maritime Organization (IMO)**, the **European Union (EU)**, and the **United Nations (UN)**, as well as individual countries and local authorities, have been demonstrating a growing interest in the negative effects of noise pollution and have identified key points of action that can translate into policy approaches. These include but are not limited to:

Stimulating the establishment of policies that improve knowledge on ocean noise pollution, as highlighted by the UN through the encouragement of studies on the impacts of noise pollution on marine living resources, and by the EU through the Technical Group on Underwater Noise established in 2010 (this aims to identify knowledge gaps on underwater noise). These will include the spatiotemporal extent of the problem, the identification of the noise types that affect marine organisms the most, and the development of trigger values against which the stressor can be monitored and managed.

Identifying the need for a coordinated international response to reduce ocean noise pollution generated by shipping, as approved in IMO guidelines in 2014.

Classifying underwater noise pollution as a stressor that can adversely affect marine life, as stated in the Marine Environment Protection Committee Guidelines in 2014.

Recognizing 'Particularly Sensitive Sea Areas' as marine areas that deserve special protection, as defined by the IMO.

Providing economic incentives that encourage the reduction of noise pollution, such as reduced tax and subsidies for technological innovations, incentivizing vessels to travel in convoy to reduce cumulative noise levels, using specially designed propellers to reduce cavitation and the use of electrical engines

Regulating noise-generating activities by imposing pollution limits for noise-generating activities, defining limits on the intensity and duration of the activity itself, such as forbidding the use of the most damaging boat engine types, introducing spatiotemporal restrictions on noise-generating activities close to coral reefs, such as imposing limits on the permanence of vessels in these areas during spawning, recruitment and feeding times of key species.

Ensuring that the noise emission of sonars, echosounders and multibeams occurs at frequencies that do not interfere with coral reef organisms and with their sound detection and emission frequencies.

Reducing the noise generated by offshore windfarms and surveying activities for oil, gas and tectonics.

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Some of these policies have already been implemented with success in reducing noise pollution and its impacts on marine mammals. In 2002, the IMO amended the traffic separation scheme (TSS) in the Bay of Fundy and the east coast of Canada to avoid the likelihood of commercial vessels coming into close contact with whales. Ten years later (November 2012), the IMO amended the TSSs off the west coast of United States for the same reason. As of 2018, the Canadian Government established a minimum approach distance of 100m for most whales, dolphins and porpoises; 200m was set as the limit for all killer whale populations along the west coast. These regulations apply to both commercial and recreational boaters, and contravention is charged as an offence under the Fisheries Act. During the summer of 2018, a voluntary vessel slowdown in Haro Strait was established to reduce underwater noise affecting resident killer whales and the next year this voluntary slowdown was expanded to lower noise in a wider area and as soon as whales were spotted. To protect North Atlantic Right whales, a speed restriction to a maximum of 10 knots was reinstated for vessels larger than 20m travelling in the western Gulf of St Lawrence.

Although international decision makers and individual countries are increasingly aware of the impacts of underwater noise pollution, an improved effort is needed to implement policies that effectively address its negative impacts within marine ecosystems, particularly within coral reefs. The following roadmap is suggested for an effective mitigation of anthropogenic noise pollution in the marine environment and to restore natural sound levels in coral reefs:

1. Gather scientific data for a better understanding of natural sound levels and how changes of such levels due to anthropogenic sources affect
2. coral reef organisms;
3. Knowledge on natural soundscapes will allow the development of guidelines for stakeholders;
4. Development and implementation of legal frameworks and mitigation measures supported by solid scientific evidence.

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BIBLIOGRAPHY

- Elise, S. et al. (2019) 'Assessing key ecosystem functions through soundscapes: A new perspective from coral reefs', Ecological Indicators, 107.
- European Commission (2009) 'Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC', Official Journal of the European Union, 5, p. 2009.
- Ferrari, M. C. O. et al. (2018) 'School is out on noisy reefs: the effect of boat noise on predator learning and survival of juvenile coral reef fishes', Proceedings Royal Society B. 2018/02/02, 285(1871).
- Graham, N. A. J. and Nash, K. L. (2013) 'The importance of structural complexity in coral reef ecosystems', Coral Reefs, 32(2), pp. 315–326.
- Hughes, T. P. et al. (2017) 'Coral reefs in the Anthropocene', Nature, 546(7656), p. 82.
- IMO (2014) Guidelines for the Reduction of Underwater Noise From Commercial Shipping to Address Adverse Impacts on Marine Life. Edited by I. M. Organisation. London, UK.
- Jain-Schlaepfer, S. et al. (2018) 'Impact of motorboats on fish embryos depends on engine type', Conservation Physiology. 2018/03/30, 6(1), p. coy014.
- Jones, N. (2019) 'The quest for quieter seas', Nature, 568, pp. 158–161.
- Kunc, H. P., McLaughlin, K. E. and Schmidt, R. (2016) 'Aquatic noise pollution: implications for individuals, populations, and ecosystems', Proceedings Royal Society B. 2016/08/19, 283(1836).
- Lecchini, D. et al. (2018) 'Boat noise prevents soundscape-based habitat selection by coral planulae', Scientific Reports. 2018/06/20, 8(1), p. 9283.
- Lillis, A. and Mooney, T. A. (2018) 'Snapping shrimp sound production patterns on Caribbean coral reefs: relationships with celestial cycles and environmental variables', Coral Reefs, 37(2), pp. 597–607.
- McCormick, M. I. et al. (2019) 'Effects of boat noise on fish fast-start escape response depend on engine type', Scientific Reports. 2019/04/27, 9(1), p. 6554.
- Merchant, N. D. (2019) 'Underwater noise abatement: Economic factors and policy options', Environmental Science & Policy, 92, pp. 116–123.
- Slabbekoorn, H. et al. (2010) 'A noisy spring: the impact of globally rising underwater sound levels on fish', Trends Ecol Evol. 2010/05/21, 25(7), pp. 419–427.
- UN (2018) Nineteenth Meeting of the United Nations Open-Ended Informal Consultative Process on Oceans and the Law of the Sea: Anthropogenic Underwater Noise. 18–22 June 2018, New York.

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