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Joint monitoring programme of ambient noise North Sea (Jomopans): Opinion paper on continuous noise pollution

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ABSTRACT

Sound is omnipresent in the underwater environment and can be produced by natural (waves, weather, animals) and man-made (shipping, wind farms, oil and gas activities) sources. For marine animals, such as whales, fish and even invertebrates, the auditory senses are very important. To evaluate the soundscape and to manage the marine environment with respect to underwater noise monitoring is very important. For management the impact of noise some options are available. These options need further consideration to be implemented effectively.

1. Introduction

Sound is a major element of the underwater environment and originates from natural sources (waves, weather, animals) and man-made sources (shipping, wind farms, oil and gas activities). With a low to very low visibility sound is the major sense for communication, food detection and navigation. Sound also works as a warning against various threats. Man-made noise can disturb one or more of the conditions essential for animal survival. Although the last decade the knowledge of various effects of underwater noise has hugely increased, the integrated impact of noise is largely unknown (Duarte et al., 2021; Popper et al., 2020).

In 2008 the European Union adopted the Marine Strategy Framework Directive, MSFD (European Union (EU), 2008). In this directive underwater noise was for the first time recognised as a pollutant. Member states of the European Union have to address underwater noise through monitoring and measures. Transnational co-operation for this transnational phenomenon is strongly encouraged by the MSFD.

The effects of underwater noise on marine animals range from death and injury for very high noise levels, through displacement and disturbance for medium high levels and masking for low continuous noise. The effects vary dependent on the species and the frequency content and character of the noise. For this paper we will focus on the less pronounced effects, that can be caused by low-frequency continuous noise. Erbe et al. (2019) describe various effects of ship noise on marine mammals, but concludes that many problems exist and need attention. For other species than marine mammals even less is known.

The principle of masking is relatively well-understood and it interferes directly with the communication of marine animals. It can be described in terms of the signal-to-noise ratio, which is based on physical principles only. However for most marine species masking has not been thoroughly investigated. But the role of communication for individual animals and populations is unknown for most species.

For most species we don't know how noise affects them, what the consequences are on the short and the long term and how the animals react to an increased exposure to noise. Also many species depend on particle motion, for which masking issues will be different. Knowledge on the biological aspects of underwater noise is essential and scientific research in this field should be intensified.

The MSFD describes underwater noise with two criteria, impulsive noise (D11C1) and continuous low frequency noise (D11C2). Because of the increasing human activities at sea, like offshore wind development and seismic surveying, the focus of marine management was primarily on impulsive noise and less on continuous noise. This paper will focus on continuous noise from shipping.

The two major elements, which are needed for environmental management, are the knowledge on the effects of noise on marine life (biological knowledge) and the amount of noise and the spatial and temporal distribution of it (monitoring).

This paper will use the results of the Jomopans (Joint Monitoring Programme of Ambient Noise North Sea) project for monitoring of ambient sound in the North Sea to discuss some options for marine managers.

2. What is Jomopans?

The aim of monitoring of underwater sound is to quantify the pressure on the environment. Acoustic monitoring should focus on sea basin

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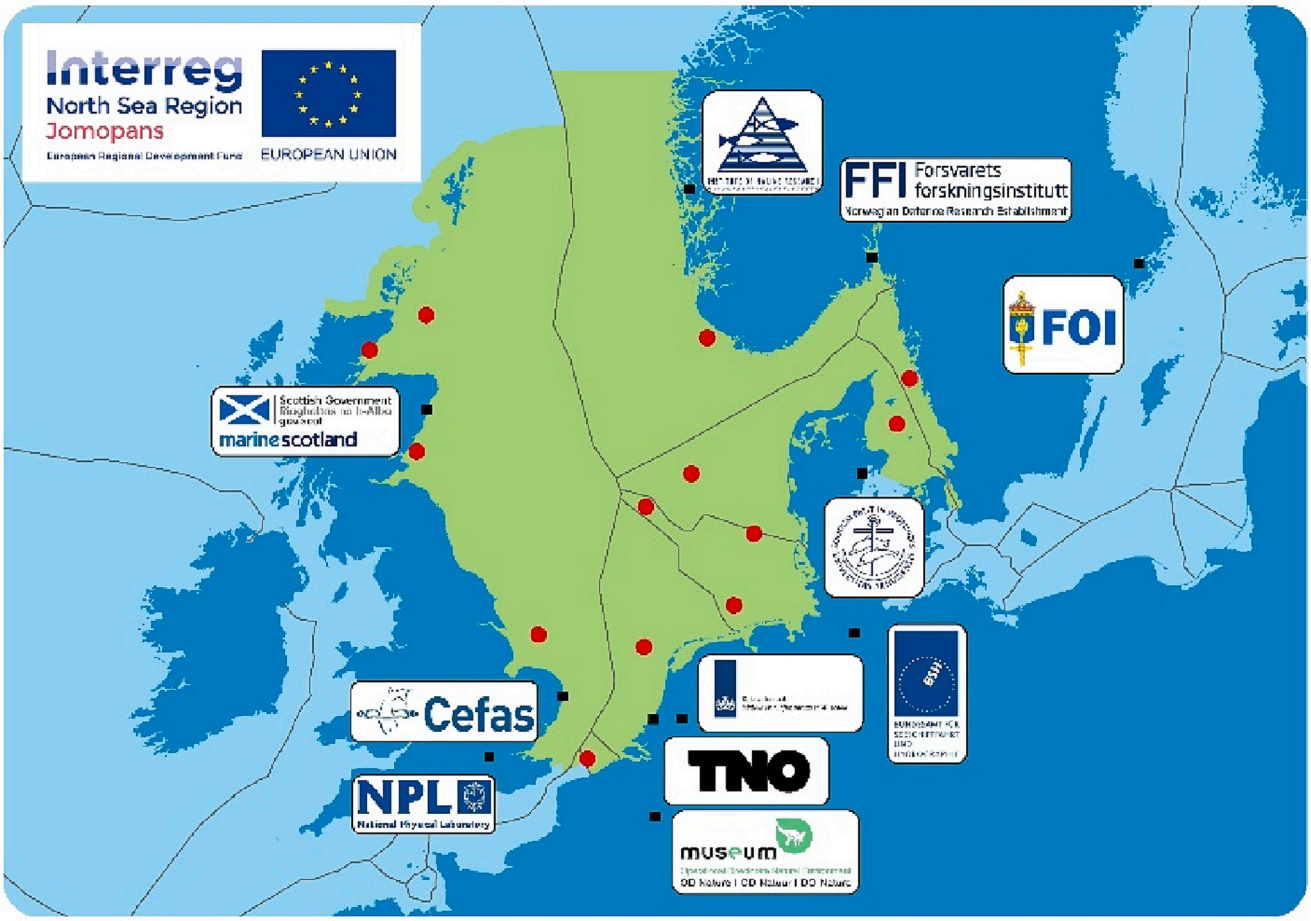

Fig. 1. Map of the North Sea with the measurement locations for the Jomopans project, as well as the logos of the participating institutes.

it should be implemented as a joint effort of all relevant countries. The North Sea is bordered by 7 countries and 11 institutes from these countries have formed the Jomopans consortium. Jomopans has set up a framework for joint monitoring.

As part of the implementation of the MSFD Dekeling et al. (2013) outlined a monitoring strategy and the Jomopans project set up a monitoring framework for the North Sea based on this guidance. This strategy involves numerical modelling of the Soundscape of the North Sea as well as high quality measurements taken at a few locations in the North Sea (see Fig. 1). Sertlek et al. (2019) showed that numerical modelling is a powerful tool show the spatial and temporal variations of the soundscape in the North Sea. Jomopans has modelled the soundscape in more detail and validated the result by field measurements.

This paper focusses on the results from the numerical modelling. Putland et al. (2022) describe the results of the validation effort by Jomopans.

3. What has Jomopans done?

In Jomopans, monthly maps of depth-averaged sound pressure levels for the North Sea were produced. These maps will enable policy makers to identify, where noise may adversely affect the North Sea ecosystem.

Input to the modelling were detailed information of the shipping from AIS data and environmental parameters obtained from EMODNET portals (bathymetry, sea bottom composition). Furthermore a source model for underwater radiated noise was developed in collaboration with the ECHO project (MacGillivray and De Jong, 2021; MacGillivray et al., 2020). The advantage of numerical modelling is that various aspects of the soundscape can be viewed in isolation, which is impossible

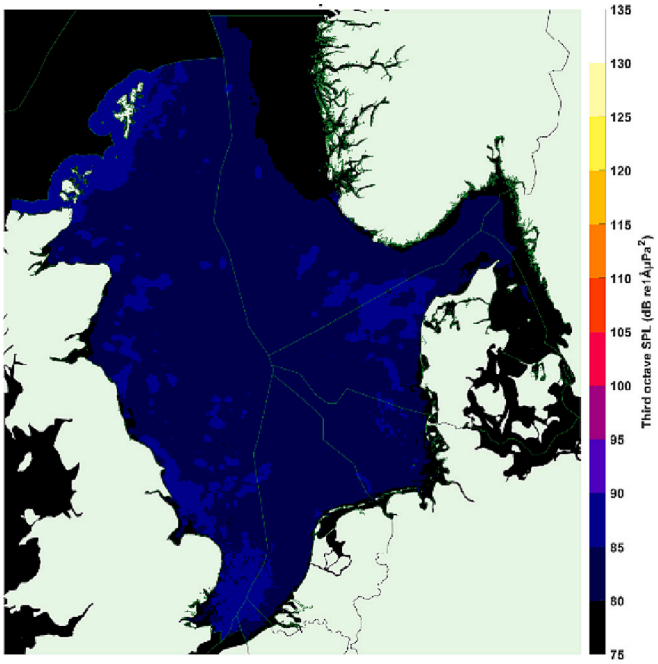

Fig. 2. Median Background Sound Level 125 Hz band (wind).

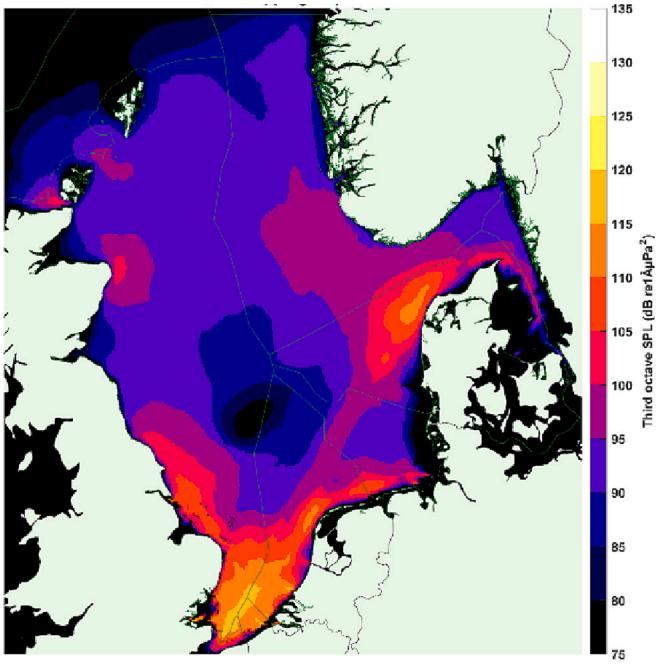

Fig. 3. Median Sound Pressure Level by shipping, 125 Hz band.

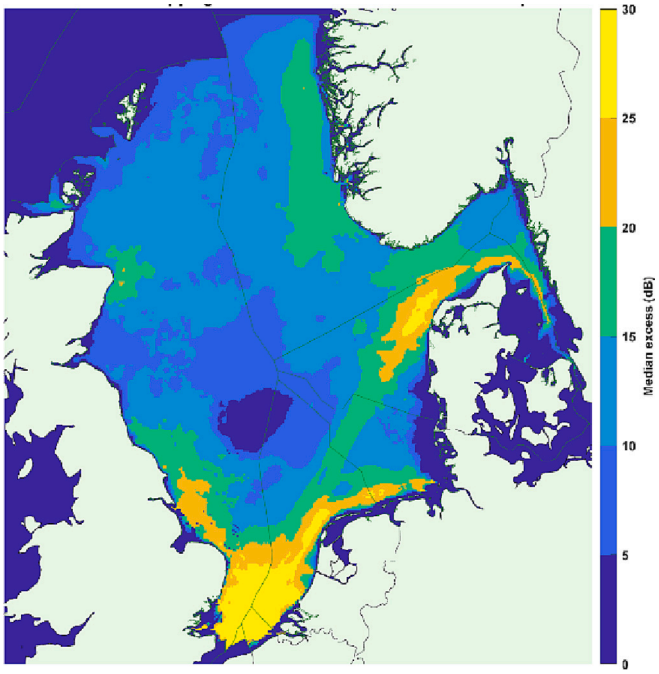

Fig. 4. Median Excess Level, 125 Hz band.

in field measurements. A large number of maps describe contributions from various ship types to the total soundscape, as well as the spatial and temporal variations.

As an illustration I present the 125 Hz band soundscape maps averaged over the year 2019. The 125 Hz decidecade band is the major frequency band for shipping noise. A map of the median sound pressure level for wind sound is shown in Fig. 2. It should be noted that also other abiotic and biotic sources than wind contribute to the background sound level, which were not modelled here. Numerical modelling of the underwater sound of the known ship movements (from AIS) and the wind sound results in the map shown in Fig. 3.

In the Jomopans project the reduction of the communication range (masking) was addressed as the major effect of continuous noise in the North Sea. Excess Level, the difference between the total sound pressure and the natural sound pressure, was taken as a quantity related to the reduction of the communication range. Fig. 4 the Excess Level displays a map of the Excess Level.

Soundscape maps of the Sound Pressure Level are best suited to show the spatial variation of the soundscape, but also temporal variations are important to assess the underwater noise pollution. A dominance map aims to make the variations in time more visible. Dominance is defined as the percentage of time that the Excess Level is higher than a certain LOBE (Level of Onset of Biological Adverse Effects). The Dominance map for a LOBE of 20 dB is shown in Fig. 5.

4. How can Jomopans information be used in environmental management?

As shown with the Jomopans results in large parts of the North Sea the underwater sound is dominated by shipping sound. Other sources than shipping were not modelled and may be significant for other parts of the North Sea. The soundscape maps show the spatial and temporal variations of the underwater noise. More knowledge on the effects of continuous underwater noise on marine life is needed to evaluate the impact on the environment.

However the amount of noise warrants the need to take measures to reduce this pollution. Environmental marine management of underwater noise has some options.

The most effective way to mitigate noise is by reducing the sound levels of the sources, here the ships. In 2014 the IMO published recommendations (IMO, 2014) to reduce the underwater radiated noise (URN) and a study of Kendrick and Terweij (2019) outlines various possibilities to reduce URN. Source level reduction will have a global effect, but at this moment too few incentives are present to make this measure effective. The incorporation of underwater noise in certification schemes and subsequent measures by harbour authorities and government are needed. A consequence is that standardisation of source level measurements must be improved and easy access to measurement facilities is a requirement. The current effort by the IMO to update the guidelines on URN promise to give marine managers, ship owners and whip operators more tools to handle underwater noise.

Another relatively simple approach to reduce shipping noise is the adoption of a slow steaming regime, especially in the approach to major harbours. There are indications that the radiated noise is reduced if the speed of ships is reduced. Voluntary slow shipping in the access to the Vancouver harbour resulted in reductions up to 5 dB (MacGillivray et al., 2020). The speed reduction may not hinder shipping safety and may not be possible in all sea regions. The economic consequences also need to be evaluated.

The maps of the North Sea show large spatial differences and worldwide the differences will be even larger. Environmentally sensitive areas, like e.g. the Arctic seas, will be threatened by an increase of shipping when they become more navigable due to the retreat of sea ice. Programmes should be adopted to protect these areas from increasing underwater noise. Regulated access and careful planning of shipping routes can prevent further pollution.

5. Conclusions

Underwater noise forms a threat to marine life and gets more attention. Chou et al. (2021) already give an overview of various policies with respect to management of noise. International co-operation is essential for the success of these programmes. For shipping noise the IMO can have a major influence and reverse the increasing trend in noise levels.

Also more studies are needed on the various effects of underwater noise on marine life are needed. The influence of noise on various

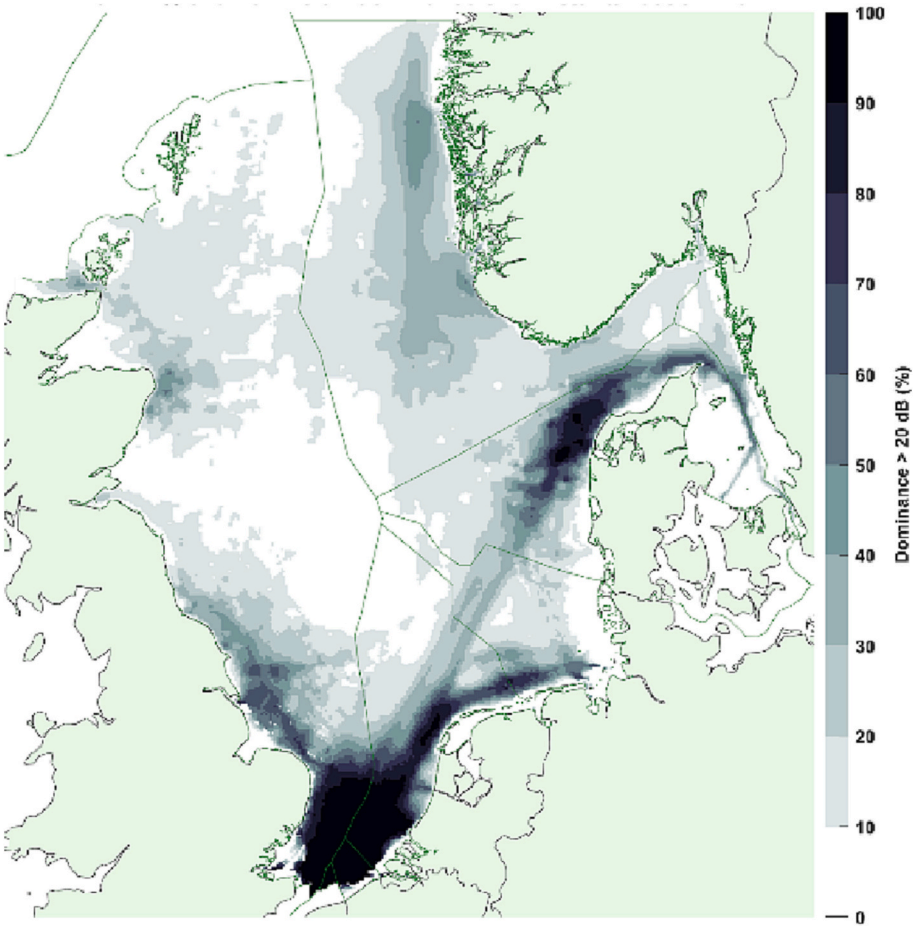

Fig. 5. Dominance maps for a LOBE of 20 dB of the Excess Level.

species in the short and long term are much more complicated than can be expressed in a dose-effect relation.

More information: https://northsearegion.eu/jomopans/

Declaration of Competing Interest

The author is not aware of any conflicts of interest with respect to this paper.

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