OSPAR COMMISSION

Pilot Assessment of Ambient Noise

OSPAR

QUALITY STATUS REPORT 2023

2022

OSPAR's Quality Status Report 2023

Pilot Assessment of Ambient Noise

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. The Contracting Parties are Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Convention OSPAR

La Convention pour la protection du milieu marin de l´Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d´Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. Les Parties contractantes sont l´Allemagne, la Belgique, le Danemark, l´Espagne, la Finlande, la France, l´Irlande, l´Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume- Uni de Grande Bretagne et d´Irlande du Nord, la Suède, la Suisse et l´Union européenne

Contributors

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Citation

Kinneging, N. 2022. *Pilot Assessment of Ambient Noise.* In: OSPAR, 2023: The 2023 Quality Status Report for the Northeast Atlantic. OSPAR Commission, London. Available at: https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/indicator-assessments/ambient-noise-pilot

Contents

Key Message

Shipping noise is dominant in the underwater soundscape of the North Sea. In the southern part and along the major shipping routes the noise exceeds the natural sound by more than 20 dB for more than 50% of the time. Marine protected areas (MPAs) don't seem to give additional protection against continuous noise.

Message clé

C'est le bruit du transport maritime qui domine dans le paysage sonore sous-marin de la mer du Nord. Dans la partie sud et le long des principales routes maritimes, le bruit dépasse le son naturel de plus de 20 dB pendant plus de 50 % du temps. Les aires marines protégées (AMP) ne semblent pas offrir de protection supplémentaire contre le bruit continu.

Background (brief)

Sound is omnipresent in the underwater environment. For marine animals, such as whales, fish and even invertebrates, the auditory senses are very important. Animals use sound to navigate, find food, communicate with potential partners and as a warning against various threats. Man-made noise can disturb one or more species depending on acoustic abilities and sound characteristics.

Sound sources can be categorised as continuous or impulsive. Most continuous noise at sea is caused by multiple sources, with shipping one of the most dominant sources. Underwater sound can carry over large distances depending on its properties and is typically a transnational phenomenon. Two major elements have to be considered for environmental management: good knowledge of the effects of noise on marine life (biological relevance and significance of sound) and good knowledge of sound properties, and its spatial and temporal distribution (physical conditions).

Shipping is essential for the world economy with 90% of all cargo being transported by ships. The European marine waters are known to be among the densest shipping areas in the world. The OSPAR Region II (Greater North Sea) and Region IV (Bay of Biscay and Iberian Coast) accommodate some major shipping routes, like those from the Gibraltar Strait to Rotterdam and Hamburg.

The assessment will be based on the OSPAR monitoring strategy, which has been elaborated in the JOMOPANS (Joint Monitoring Programme for Ambient Noise in the North Sea) and JONAS (Joint Framework for Ocean Noise in the Atlantic Seas) projects.

Background (extended)

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. Underwater visibility is usually very low. Animals use sound to navigate, find food, communicate with potential partners and as a warning against various threats. Man-made noise can disturb one or more of these biological functions essential to animal survival. Sound is therefore directly relevant for marine life, yet the overall impact of sound on marine life is largely unknown. Underwater noise is now recognised as a pollutant and subsequent actions need to be taken.

Moreover, underwater sound can carry over large distances depending on its properties and properties of the dynamic marine environment being thus a transnational phenomenon. Two major elements have to be considered for environmental management: good knowledge of the effects of noise on marine life (biological relevance and significance of sound) and good knowledge of sound properties, and its spatial and temporal distribution (physical conditions).

Sound sources can be categorised as continuous or impulsive. Impulsive sounds are of short duration and with a rapid onset (e.g. explosions, pile driving, seismic airguns, sonar), while continuous sounds are long lasting and do not have pulse characteristics (e.g. shipping, dredging) and can be of longer duration. One of the major sources of continuous noise at sea is caused by shipping.

Shipping is essential for the world economy with 90% of all cargo being transported by ships. The European marine waters are known to be among the densest shipping areas in the world. The OSPAR Region II (Greater North Sea) and Region IV (Bay of Biscay and Iberian Coast) accommodate some major shipping routes, like those from the Gibraltar Strait to Rotterdam and Hamburg.

Descriptor 11 of the EU Marine Strategy Framework Directive (2008/56/EC) (MSFD), contains two Criteria of Good Environmental Status (GES) in European waters: D11C1 on "Anthropogenic impulsive sound in water" and D11C2 on "Anthropogenic continuous low-frequency sound in water". D11C2 is defined as "The spatial distribution, temporal extent and levels of anthropogenic continuous low-frequency sound do not exceed levels that adversely affect populations of marine animals." At present, there are no quantitative targets for GES, although these are expected to be defined since the Directive requires that "Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or sub-regional specificities." OSPAR has adopted Criterion D11C2 as an OSPAR Common Indicator for carrying out its Quality Status Report (QSR) 2023.

The assessment will be based on the OSPAR monitoring strategy (Snoek et al., 2015), which has been elaborated in the JOMOPANS (Joint Monitoring Programme for Ambient Noise in the North Sea) and JONAS (Joint Framework for Ocean Noise in the Atlantic Seas) projects. This is the first assessment based on the new indicator for ambient noise. It is expected that future assessments will be further developed as experience on noise and knowledge is expected to increase in the coming years.

Although assessing the environmental status in relation to continuous noise for the MSFD and the QSR 2023 is the main objective, continuous noise also has interfaces with other policy fields:

- United Nations Convention on the Law of the Sea (UNCLOS)
- Marine Spatial Planning
  - Shipping routes
  - Offshore wind
  - Other human activities
- Environmental agreements
  - Strategic Environmental Assessment (SEA) Directive (2001/42/EC) and Environmental Impact Assessment (EIA) Directive (2014/52/EU)
  - OSPAR Biological Diversity and Ecosystems Strategy 2010
  - ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas), ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area)Agreements

Habitats Directive (Council Directive 92/43/EEC) and Natura2000

Figure 1: 90% of all cargo is transported by ships. *Source: picrepro.com*

Assessment Method

Masking by noise is the reduction of listening and communication space of marine organisms due to increased levels of noise in the environment. Masking is closely related to the signal-to-noise ratio, i.e. the ratio between the intensity of a sound an animal is interested in hearing and the intensity of all other sounds (whether natural or man-made) within the same frequency band as the signal. The potential for masking can be assessed by evaluating how much anthropogenic noise elevates the ambient noise. The difference between the total noise (wind + ships) and the reference condition, referred to as the excess level, is a measure of the degree of deterioration of conditions for hearing and communication in the particular frequency band.

For underwater noise, disturbance usually refers to a change in behaviour of the individual exposed to the noise. This change can be negative (eliciting fleeing or other anti-predator behaviours), positive (attraction, curiosity) or neutral (increased attention and orienting behaviours). In all cases, the effect of a disturbance is a change of behavioural state, which is an effect on the time budget. More time is spent on the behaviours elicited by the noise and less time spent on other behaviours. In general, the absolute (weighted) sound level is considered a metric for a received level above which potentially harmful noise effects may occur.

In the current OSPAR approach to assessing ambient noise, masking is regarded as the main and best-known effect to be considered, however the methodology is preliminary and will undergo further development.

A detailed description of the assessment framework is given by Van Oostveen et al., (2020) and based on the agreed framework for monitoring continuous sounds (Snoek, 2015) contains the following elements:

0. **Set spatial and temporal resolution**

   The spatial and temporal parameters are to be set by specifying time (e.g. season) and space (e.g. geographic area). This will help determine the spatial and temporal resolution for the input and output data. The temporal and spatial resolution of the maps can be dependent on the region. The assessment will focus on the whole North Sea, but also sub-regions may be chosen. Marine protected areas (MPAs) will be specifically considered. MPAs will also explicitly be considered to allow for estimation of pressure in comparison to other areas.

1. **Collect information on human activities**

   The human activities that generate low-frequency continuous sound need to be evaluated. Sources of this information are Automatic Identification System (AIS, for shipping intensities), Vessel Monitoring System (VMS, for fishery activities) and the OSPAR impulsive noise register (for other sources of noise). These data need to be obtained with a temporal resolution of 1 hour maximum.

2. **Collect acoustical properties of the sources**

   Acoustical properties of most of the sources are not available in sufficient detail. Literature can provide statistical proxies for these properties. JOMOPANS has developed in co-operation with JASCO and the ECHO project (Port of Vancouver) a model for ship noise source levels, RANDI3.1c (see MacGillivray et al., 2021). It is important to continuously improve the knowledge of the source properties. These models are verified using field measurements from the ECHO project (Vancouver area) where required.

3. **Collect physical properties of the environment**

   Bathymetry and properties of the sea bottom (composition) are important for the numerical modelling of sound propagation. These parameters can be considered static. (Meteo) parameters, like wind, rain, current, temperature, isoclines, salinity are dynamic.

4. **Calculate maps of the sound scape, the excess levels and dominance**

   Through acoustical propagation modelling sound scape maps (sound pressure level (SPL) as well as background level) will be calculated as defined in the indicator metric.

   Acoustical models for sound from natural sources are available and being evaluated. Propagation models for sound propagation of various sound sources can be chosen.

   From these, excess level maps and dominance maps can be derived.

5. **Measure long term acoustical parameters at a number of stations**

   At a number of measurement stations the soundscape is monitored on an ongoing basis. From these measurements statistical parameters of the SPL can be derived. The measurements are in this assessment used to validate the modelling. Other purposes for measurements are identified (Fischer et al., 2021), e.g. for a detailed assessment of areas of special interest. This is not part of the first North Sea indicator assessment.

6. **Evaluate the excess level maps and produce confidence maps**

   Using the sound scape maps and the measurements, a validation is performed, and confidence maps will be produced which indicate where there is greater or lesser confidence in the model predictions.

Van Oostveen et al., (2020) also describe subsequent steps towards a risk-of-impact indicator. At present these steps are still under discussion.

Underwater sound varies with time and space and therefore evaluation needs to be done on statistical parameters of the sound field. It has been chosen to use the median sound pressure level per month and per year for evaluation. The median is a robust metric and not very much influenced by short period of very high sound levels. An alternative could be to evaluate the arithmetic mean of the sound pressure levels.

A pressure curve and pressure index as described by Merchant et al., (2018) are proposed to evaluate the overall pressure by continuous noise in both time and space. The pressure curves and indices show a monotonous correlation with environmental pressure by continuous noise. Note that a different normalisation is chosen compared to Merchant et al., (2018). Here the index is calculated as the area below the pressure curve, where the axes range from 0 to 1 (and depicted from 0% to 100%) and thus normalised to 1. Because of the different character of continuous noise to impulsive noise the indices may not be directly compared anyway.

Results (brief)

The results of this assessment have been based on the EU funded JOMOPANS (Joint Monitoring Programme for Ambient Noise in the North Sea) project's results. The indicator for this assessment has not yet been agreed as an OSPAR Common Indicator but is presented, as it is OSPAR's first assessment of ambient noise. The underlying assessment methodology is preliminary and is undergoing further development, *inter alia* through further validation of its general principles. The further development will be based on results achieved in the EU MSFD (Common Implementation Strategy (CIS) process. A guidance on methodology and criteria is currently being finalised by the EU MSFD TG-Noise where open issues are discussed in detail.

Different indicator species are sensitive in different parts of the frequency spectrum. This must be included in the assessment by selection of an appropriate frequency band for the assessment and can be narrow band (1/3 octave) or wider, but fundamental knowledge is lacking at this moment on the perception properties of marine animals. The JOMOPANS tool currently allows assessment for the MSFD bands 63 Hz and 125 Hz, and decadal bands 20-200 Hz, 200H-2 kHz and 2 kHz-20 kHz. Since the indicator is meant to evaluate pressure selection of appropriate frequency band for assessment is beyond the scope of this assessment.

JOMOPANS calculated the soundscape maps for the 63 Hz, 125 Hz 1/3-octave band as well as broadband. In this assessment the maps of the 125 Hz 1/3-octave are presented. This band contains the major noise levels caused by shipping noise.

Underwater noise can vary greatly in time and space. A large number of maps have been made to cover both the temporal and spatial variations. The final maps are presented as the median value for the evaluation period (one year, 2019).

A dominance map aims to make the temporal variations more visible.

For the North Sea (OSPAR Region II except for the Channel) a baseline sound level of about 90 dB@1mPa^2 median SPL was found. In the southern part of the North Sea and along major shipping routes a considerable increase of this level by 20 to 30 dB@1mPa^2 was found, while in the central part of the North Sea the median SPL shows less than 10 dB@1mPa^2 increase.

In the areas where a large increase of the sound pressure level was found, this increase occurred over a long period of time, with an almost permanent high noise level in the southern part of the North Sea.

The modelling results were validated with the measurements of the JOMOPANS project. Major differences could be attributed to:

- Vessels without active AIS transponders
- Seismic surveys
- Wind farm operational noise, construction noise and service vessels
- Generator/ platform noise

Finally, pressure curves and indices were calculated, which showed the seasonal differences, as well as differences for some sub-regions in the North Sea. The pressure curves and indices show a monotonous correlation with environmental pressure by continuous noise.

Finally, the noise was analysed for all North Sea MPAs (as one disconnected sub-region).

There is a **moderate confidence** in the methodology used and **moderate confidence** in the data availability.

Results (extended)

A first elaborate assessment for the North Sea has been made within the JOMOPANS project (see Kinneging and Tougaard, 2021). At the moment of drafting this assessment no information on continuous noise in OSPAR Region IV (Bay of Biscay and Iberian Coast) and the Channel was available.

Different indicator species are sensitive in different parts of the frequency spectrum. This must be included in the assessment by selection of an appropriate frequency band for the assessment and can be narrow band (1/3 octave) or wider. The JOMOPANS tool currently allows assessment for the MSFD bands 63Hz and 125 Hz, and decadal bands 20-200 Hz, 200H-2 kHz and 2 kHz-20 kHz. A broadband level (20 Hz-20 kHz) is also supplied, but for reference only, as the broadband level will be almost completely dominated by the lower frequencies and therefore provide little additional insight compared to the other bands. Selection of appropriate band for assessment is beyond the scope of this assessment, however. Since the assessment concerns a pressure indicator only, no indicator species have been selected. It is simply assumed that the band selected is relevant to the major species.

JOMOPANS calculated the soundscape maps for the 63 Hz, 125 Hz 1/3-octave band as well as broadband. In this assessment the maps of the 125 Hz 1/3-octave are presented. This band contains the major noise levels caused by shipping noise.

Underwater noise can vary greatly in time and space. Ultimately the aim of an assessment is to establish for an assessment area whether good environmental status is reached or not.

The maps presented in **Figure 2, Figure 3** and **Figure 4** display the spatial variation of the soundscape and the temporal variations are reduced by taking the median value for the evaluation period (one year, 2019).

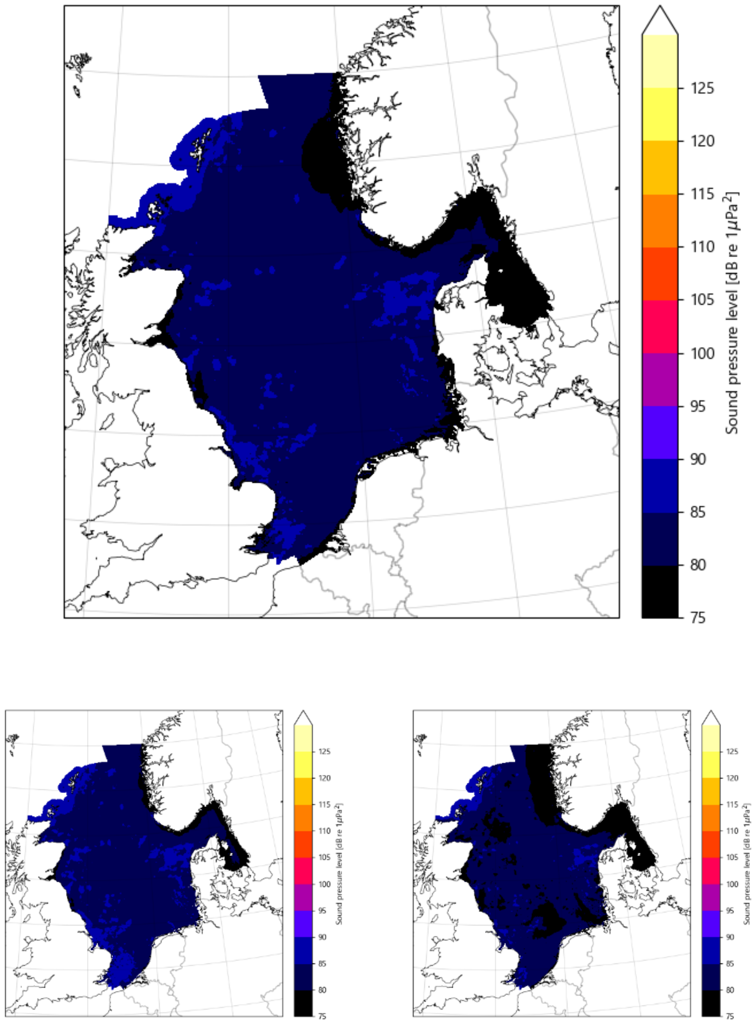

Figure 2: Median Background Sound Level 125 Hz band (wind). Below the Background Sound Level for the winter (left) and summer (right) months.

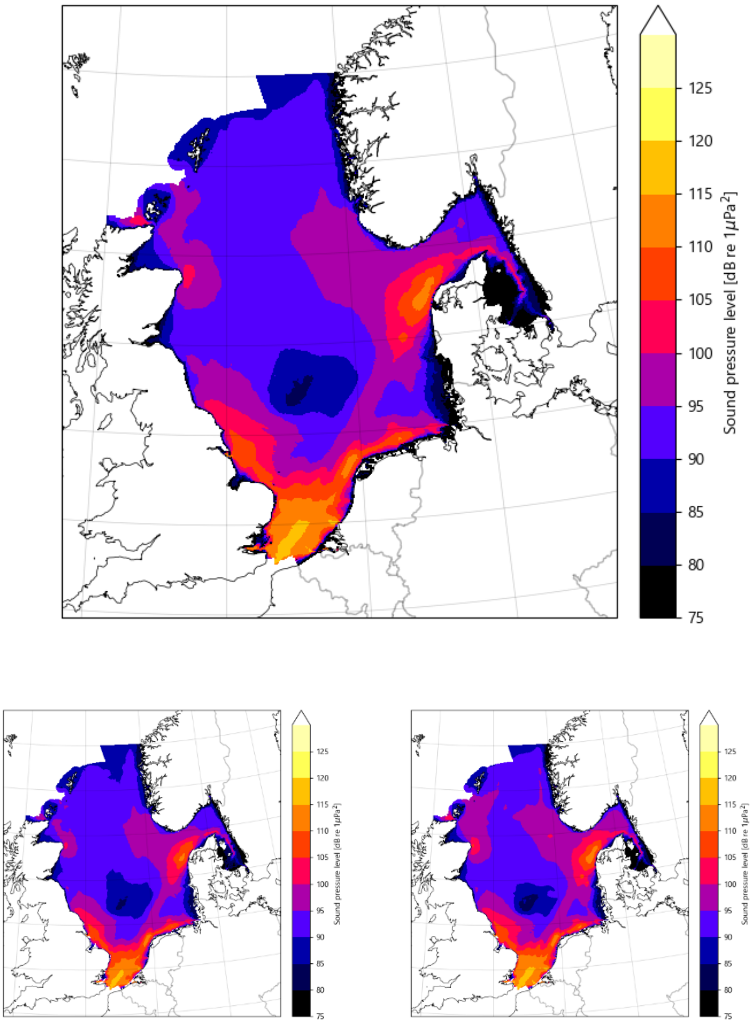

Figure 3: Median total Sound Pressure Level, 125 Hz band. Below monthly maps for January (left) and July (right) 2019.

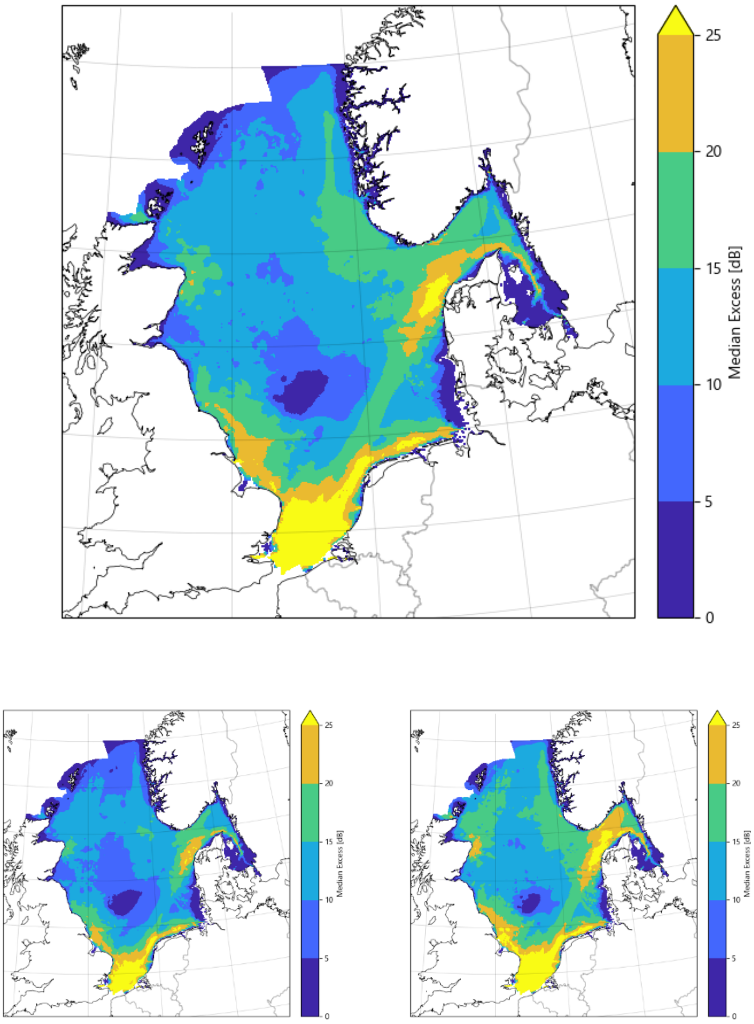

Figure 4: Median Excess Level, 125 Hz band. Below monthly maps for January (left) and July (right) 2019.

A dominance map aims to make the temporal variations more visible. Dominance is the percentage of time that the excess level is higher than a certain cutoff level. In **Figure 5** the dominance is shown for a cutoff level of 20 dB. In case of a risk-of-impact indicator the cutoff level should be chosen on the expected impact for an indicator species. For this assessment of the pressure indicator a value of 20 dB is chosen. For this level the Dominance shows enough dynamic range to assess the temporal pressure of ambient noise.

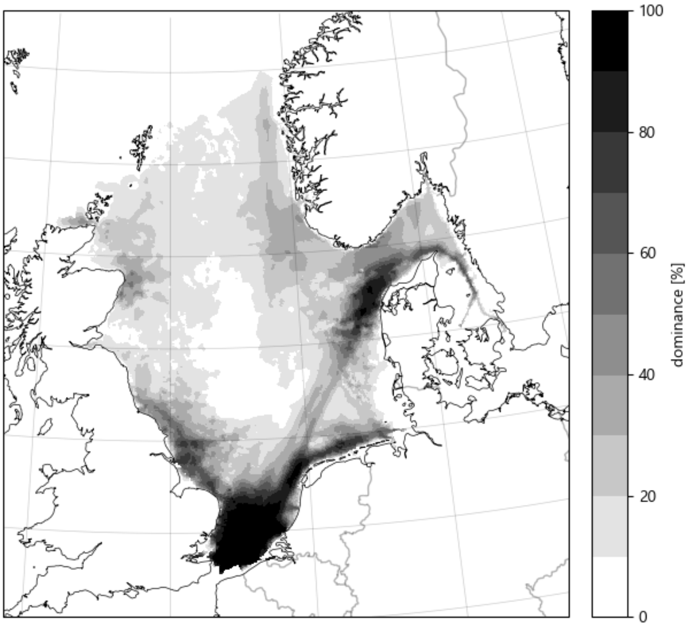

Figure 5: Dominance maps for a cutoff level of 20 dB of the Excess Level.

For the North Sea (OSPAR Region II except for the Channel) a background sound level (**Figure 2**) of about 90 dB@1mPa^2 median SPL was found. There is a difference of about 5 dB between the winter background sound levels and the summer values.

The total median sound pressure levels (**Figure 3**) show large spatial variations, but less variations over the months. In the summer months the levels are a few dB higher. The same differences were also found in long term measurement stations. The lowest yearly median SPL is 99 dB@1mPa^2 for the Danish Anholt station in the Skagerrak and the highest is 125 dB@1mPa^2 for the Belgium Westhinder station.

In the southern part of the North Sea (south of 53° latitude) and along major shipping routes a considerable increase of this level by 20 to 30 dB@1mPa^2 (**Figure 4**) was found, while in the central part of the North Sea around 55°N and 2°E (Dogger Bank) the median SPL shows less than 10 dB@1mPa^2 increase.

In the areas where a large increase of the sound pressure level was found, this increase occurred over a long period of time, with an almost permanent high noise level in the southern part of the North Sea, as can be seen in the Dominance (**Figure 5**).

Putland et al., (2021) validated the median sound pressure levels obtained modelling with the measurements of the JOMOPANS project. The results are depicted in **Figure 6**. Major differences could be attributed to:

- Vessels without active AIS transponders (recreational and fishing vessels)
- Seismic surveys
- Wind farm operational noise, construction noise and service vessels
- Generator/ platform noise

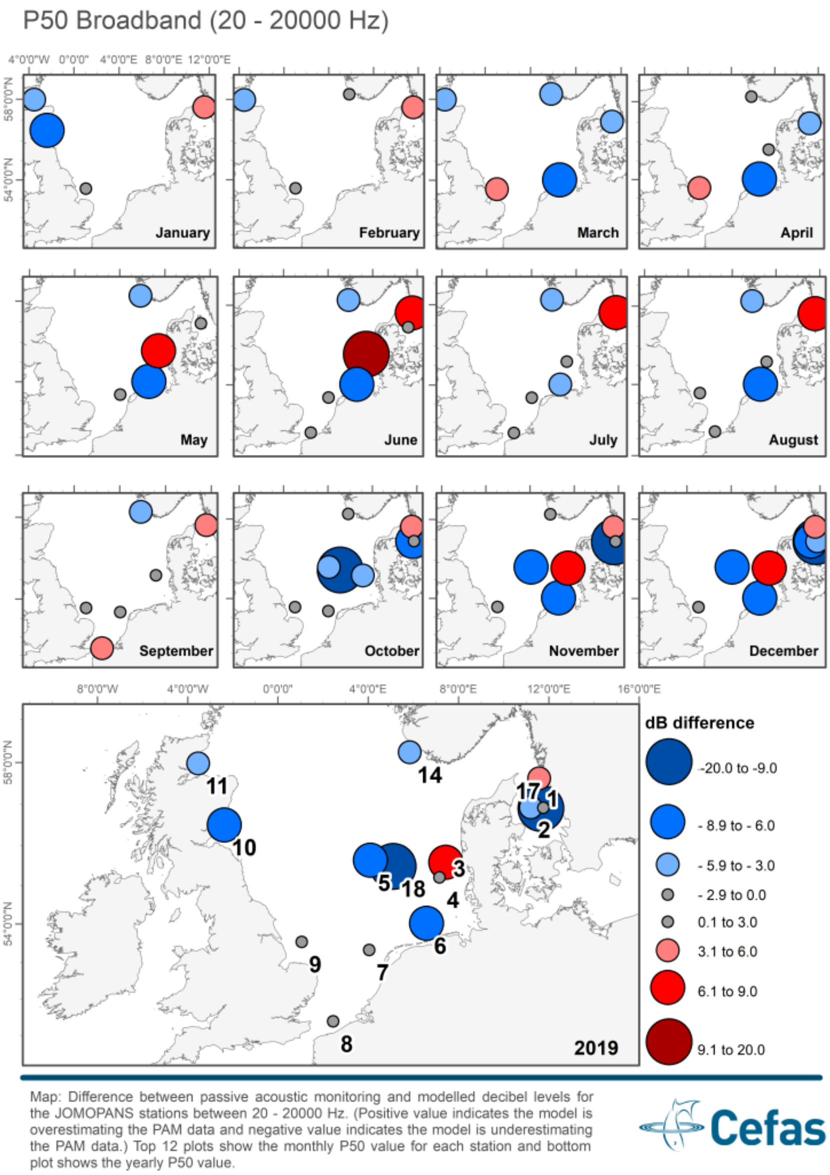

Figure 6: Difference in P50 (median) between passive acoustic monitoring (PAM) and modelled decibel levels for the JOMOPANS stations between 20 – 20000 Hz. Positive (red) value indicates model predictions are larger than the PAM data and a negative (blue) value indicates the model predictions are lower than the PAM data. Top 12 plots show the monthly P50 value for each station and bottom plot the yearly P50 value.

Across all sites, the general pattern of difference between model and measurement data was the model underestimated noise levels (relative to the field measurements) at low frequencies (< 50 Hz), either under or overestimated noise levels at mid frequencies (100 – 1000 Hz) depending on station and had comparatively low uncertainty (< 6dB) at high frequencies (> 1 kHz).

Figure 7 shows the monthly pressure curves for continuous noise in the North Sea with a pressure indices varying from 0,16 to 0,30 and an index of 0,24 for the whole year. The differences in the curves and indices are caused by lower background levels and slightly higher shipping noise levels in the summer months.

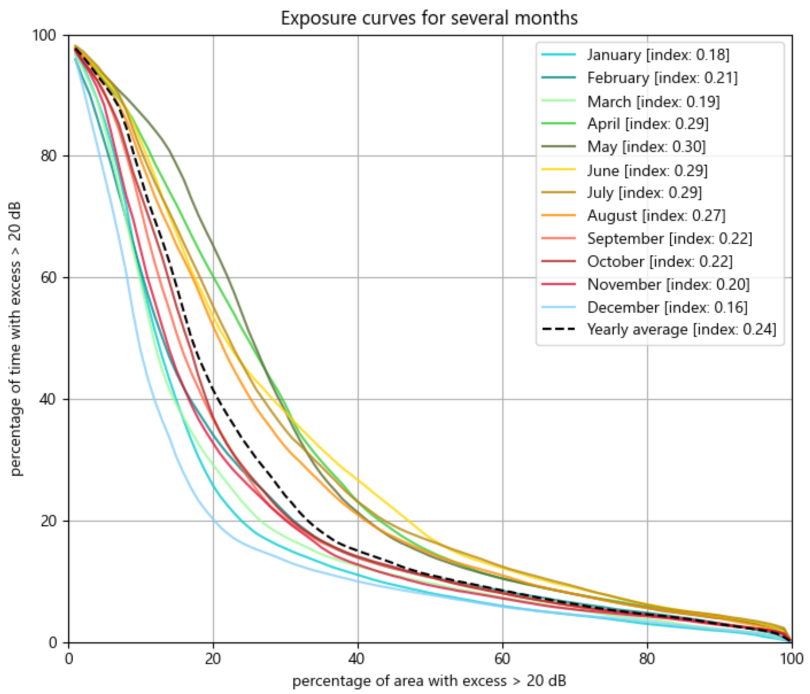

Figure 7: Monthly pressure curves for continuous noise in the North Sea. The corresponding indices vary from 0,18 to 0,30. The year index is 0,24.

To analyse regional differences in more details the pressure curve can also be calculated for sub-regions. Kinneging and Tougaard (2021) describe the pressure curves for a number of OSPAR sub-regions. For the southern North Sea a pressure index of 0,40 is found, while the Dogger Bank has an index of 0,07. Also the pressure curve is presented for marine protected areas (MPAs) under the Natura 2000 network. **Figure 8** shows the Dominance maps overlayed with the chosen MPAs. It will be evaluated whether these areas with special environmental protection also provide less pressure from continuous noise. The pressure curves for the subregions, the MPAs and the whole North Sea are plotted in **Figure 9**. The pressure index for the MPAs is 0,37.

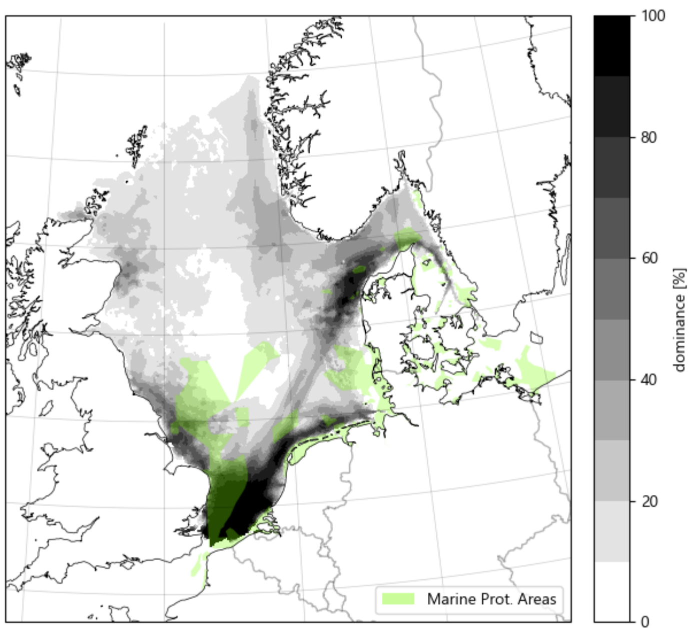

Figure 8: Dominance maps for a cutoff level of 20 dB of the Excess Level overlayed with the marine protected areas.

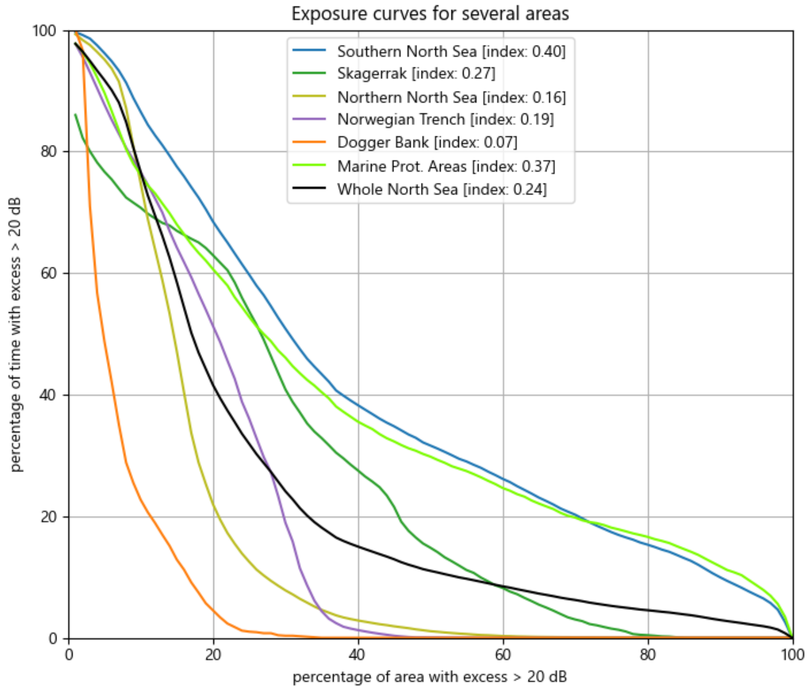

Figure 9: Pressure curves for continuous noise in the North Sea and for the MPAs within the North Sea. The corresponding indices are 0,24 and 0,37.

Conclusion (brief)

Continuous noise should be evaluated in both time and space. The maps of Excess Level show that almost all over the North Sea shipping noise causes a median Excess Level of 6 dB or more, but the major increase of 20 dB and more is concentrated in the southern part of the North Sea and along the major shipping routes.

The areas with a high median Excess Level are exposed to continuous noise for a high percentage of time.

Validation of the results showed a good match for a number of stations, but also showed some relevant noise sources were missing in the modelling, that contribute to the total noise levels.

The overall pressure index is 0,24, but large differences occur for different sub-regions. An assessment for the North Sea as one assessment area seems to be implausible. The lowest index is found for the Dogger Bank (0,07) and the highest for the southern North Sea (0,40).

Analysis of the MPAs as a separate area shows the same type of disturbance for these areas as for the southern part of the North Sea, where they are mostly located.

MPAs do not seem to give additional protection against continuous noise, noting that MPAs were not designed to give protection against noise.

Conclusion (extended)

This assessment concerns the analysis for OSPAR Region II (excluding the Channel), the North Sea. It is based on the results of the JOMOPANS project. When data from the JONAS project become available an analysis of the Channel and OSPAR Region IV (Bay of Biscay and Iberian Coast) can be added.

Continuous noise should be evaluated in both time and space. The JOMOPANS project produced a huge amount of information (about 1 250 maps) to enable such an analysis.

The maps of Excess Level show that almost all over the North Sea shipping noise causes a median Excess Level of 6 dB or more, but the major increase of 20 dB and more is concentrated in the southern part of the North Sea (south of 53° latitude) and along the major shipping routes. The area around 55°N and 2°E (Dogger Bank) is relatively quiet.

The areas with a high median Excess Level are exposed to continuous noise for a high percentage of time. In these areas shipping noise is almost dominant over natural sounds.

A modelling approach to continuous noise proves to be the best option. Measurement conditions in the North Sea are difficult and no locations exist to determine a Reference Condition (Background Level) by measurements.

Validation of the results showed a good match for a number of stations, but also showed some relevant noise sources were missing in the modelling, that contribute to the total noise levels.

A pressure curve and pressure index are proposed to evaluate the overall pressure by continuous noise in both time and space. The pressure curves and indices show a monotonous correlation with environmental pressure by continuous noise, but no quantitative threshold value for good environmental status has been determined yet.

The overall pressure index is 0,24, but large differences occur for different regions. An assessment for the North Sea as one assessment area seems to be implausible. The lowest index is found for the Dogger Bank (0,07) and the highest for the southern North Sea (0,40). Seasonal variations in the pressure indices are mainly caused by the level of the background sound.

Analysis of the MPAs as a separate (disconnected) area shows the same type of disturbance for these areas as for the southern part of the North Sea (indices of 0,37 versus 0,40). The index for MPAs is even higher than for the whole North Sea, because most MPAs are situated in the southern part of the North Sea.

MPAs do not seem to give additional protection against continuous noise, noting that MPAs were not designed to give protection against noise.

Knowledge Gaps (brief)

The major knowledge gaps for continuous noise concern the effects of continuous noise on marine life, both on species that can be potentially affected and on populations of relevant species. The choice of species to assess in the North Sea needs to be made.

The maps for continuous noise show large spatial variations. An assessment for the North Sea as one assessment area seems to be implausible. At this moment there are no criteria to define sub-regions.

The method for monitoring and assessment can be improved by including more sources of continuous noise with a proper description of their source strength.

The models used for this assessment are not suited to very shallow water and intertidal areas.

Knowledge Gaps (extended)

The major knowledge gaps for continuous noise concern the effects of continuous noise on marine life, both individual animals and the whole population. The choice of species to assess in the North Sea needs to be made based on objective criteria. From these effects masking (for marine mammals) is best known and the influence of continuous noise on the signal-to-noise ratio can be calculated directly. Other effects, like disturbance, can lead to assessing absolute sound pressure levels as well and may be more appropriate for other OSPAR Regions than Region II.

There is a lack of knowledge concerning the ecological situation in an undisturbed North Sea or even about a realistic feasible minimum of ecological quality in relation to the human activities in the North Sea. Furthermore, there is lack of knowledge concerning the cumulative impact on the ecosystem of human activities in the North Sea, like fisheries, shipping and windfarm development.

An interdisciplinary effort is needed to get a better view on the good environmental status in relation to noise.

The validation process highlighted the complexity of analysis and limitations in both the field measurements and the acoustic modelling which could be improved upon (Putland et al., 2021).

As a next step in the assessment of continuous noise, OSPAR’s Intersessional Correspondence Group on Noise (ICG Noise) has planned to develop a risk-of-impact indicator for continuous noise. In a risk-of-impact indicator noise maps are overlayed with maps of habitat suitability (where are the conditions for marine animals best without human interference). At this moment these maps are not available for most species. They should be developed in collaboration with marine biologists. Distribution maps can be a proxy for habitat suitability, but also spawning areas, where animals are most vulnerable. As an example, cod spawning areas (source: IMR, Norway) and the major spawning months (spring) for cod were used to calculate the risk-of-impact indices (see **Figure 10**).

The maps for continuous noise show large spatial variations. An assessment for the North Sea as one assessment area seems to be implausible. The choice for a separate analysis of MPAs does not show a clear distinction. The regional subdivision described by Kinneging and Tougaard (2021) illustrates the regional differences and their effect on the pressure index. A subdivision of the North Sea needs to be determined. This can be based on:

- Ecological characteristics
- Physical characteristics
- Functions for human activities

The method for monitoring and assessment can be improved by including more sources of continuous noise with a proper description of their source strength.

The models used for this assessment are not suited for very shallow water (less than 10 metre water depth) and intertidal areas. These areas are also characterised by a very different type of shipping. The vessels in these areas are mostly recreational and small fishing vessels. More knowledge on the pressure and effects of continuous noise in shallow waters is needed.

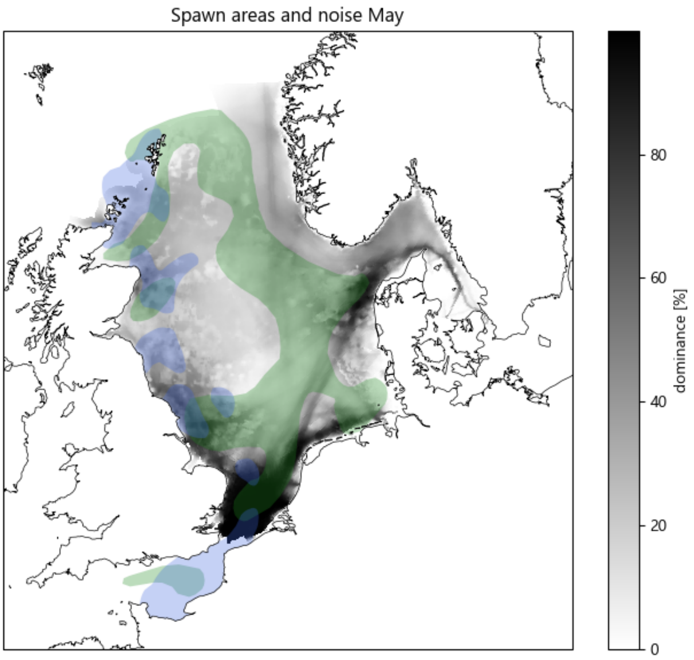

Figure 10: Dominance maps for a cutoff level of 20 dB of the Excess Level overlayed with the spawning areas for cod, calculated for the month February.

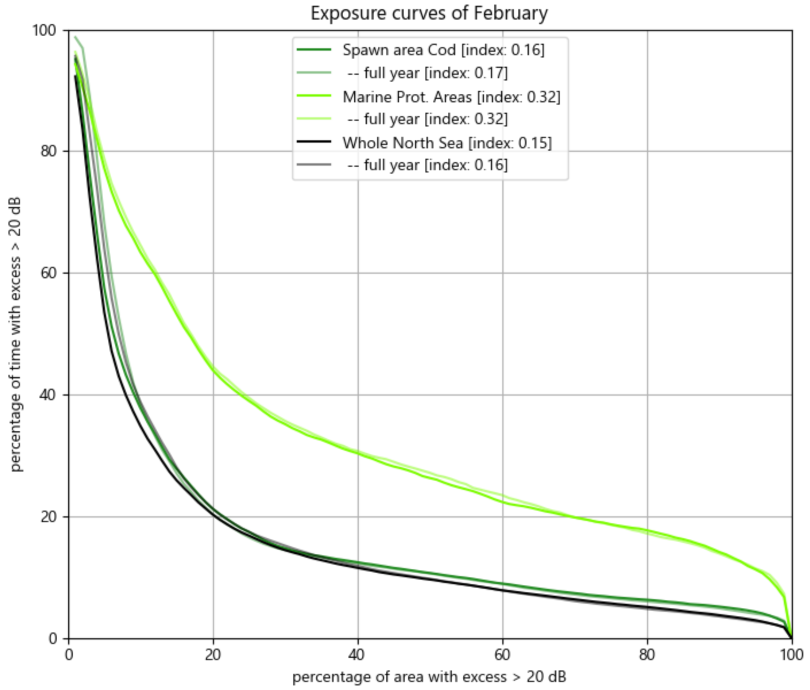

Figure 11: Pressure curves for continuous noise in the North Sea and for the cod spawning areas within the North Sea.

References

All JOMOPANS reports are available on the JOMOPANS website:

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Assessment Metadata

Field	Data Type	
Assessment type	List	Pilot Assessment
Thematic Activity	List	Biological Diversity and Ecosystems - Management of specific human pressures
Relevant OSPAR Documentation	Text	OSPAR 15-05ef_agreement_monitoring_strategy_ambient_noise: Snoek, R., Ambient noise monitoring strategy and joint monitoring programme for the North Sea - Part I: Monitoring strategy ambient noise, Arcadis report 078324541:A-Final, March 2015 OSPAR 21-05e_Agreement_CEMP_Guideline_Ambient_Underwater_Noise: Van Oostveen, M., Barbé, D. and Kwakkel, J., Proposal assessment framework, OSPAR candidate indicator ambient underwater sound, Royal Haskoning DHV-report, ref. BH2849WATRP2011251151, November 2020 (Final 5.0) Dekeling, R., Tasker, M., Van der Graaf, A. J., Ainslie, M., Andersson, M., André, M., Castellote, M., et al. 2014. Monitoring Guidance for Underwater Noise in European Seas. JRC Scientific and Policy Report EUR 26557 EN, Publications Office of the European Union, Luxembourg, 2014.
Linkage	URL	https://northsearegion.eu/jomopans/publications-presentations-reports/wp5-reports/ https://www.mdpi.com/2077-1312/9/4/369 https://northsearegion.eu/jomopans/publications-presentations-reports/wp6-reports/
Date of publication	Date	2022-06-30
Conditions applying to access and use	URL	https://oap.ospar.org/en/data-policy/

OSPAR's Quality Status Report 2023

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Our vision is a clean, healthy and biologically diverse North-East Atlantic Ocean, which is productive, used sustainably and resilient to climate change and ocean acidification.

Publication Number: 886/2022