OSPAR COMMISSION

Underwater Noise Thematic Assessment

OSPAR

QUALITY STATUS REPORT 2023

2022

OSPAR's Quality Status Report 2023

Underwater Noise Thematic Assessment

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

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Citation

OSPAR, 2023. *Underwater Noise Thematic Assessment.* In: OSPAR, 2023: Quality Status Report 2023. OSPAR Commission, London. Available at: https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/thematic-assessments/underwater-noise

Contents

Executive summary

Anthropogenic noise in the OSPAR Maritime Area can be continuous (mainly from shipping) or impulsive (e.g. from seismic surveys, explosions and pile driving). Noise can interfere with the hearing or physiology of marine animals or cause behavioural disturbance or injury. Shipping noise and impulsive noise are particularly intense in the Greater North Sea. Measures to mitigate impulsive noise have had some impact, but international guidelines on reducing continuous noise appear to have had little effect to date. OSPAR has committed to producing a regional action plan of measures to reduce noise, and to improving the monitoring of noise levels.

More detailed information on the assessments of pressure and state relating to anthropogenic noise can be found in the OSPAR Common and Candidate Indicators here; more information (including further references) on activities contributing to anthropogenic noise can be found in the series of feeder reports here.

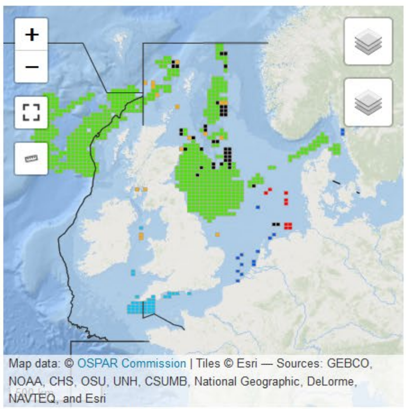
Q1. Identify the problems? Are they the same in all OSPAR regions?

Noise can affect marine animals by interfering with their ability to communicate, navigate, find food, or detect threats; by provoking fleeing or distraction; or by causing injury or death. As yet there is no agreed definition of good environmental status for underwater noise, but OSPAR has committed to reducing noise pollution in the OSPAR Maritime Area.

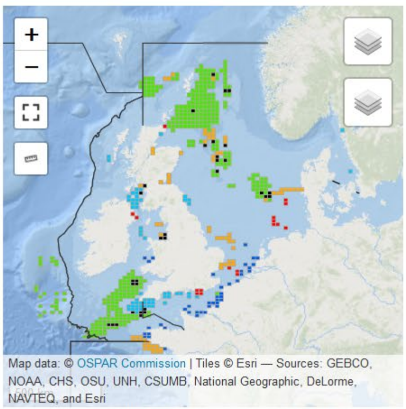
The dominant source of continuous underwater noise is shipping; other sources include recreational boating, fishing, aggregates extraction, oil and gas activities, and offshore wind turbines. As yet, only the Greater North Sea is covered by an OSPAR assessment for continuous noise. In large areas of the Southern North Sea, and along major shipping routes, the noise exceeds natural sound in the low frequency bands by over 20 dB for over 50% of the time.

Impulsive noise is produced by seismic air gun surveys, pile driving for offshore wind turbines and other construction, explosions, military activities, and some acoustic deterrent devices. Reported impulsive noise increased from 2015 to 2019, with most activity in the OSPAR Maritime Area occurring in the Greater North Sea. Since data are unavailable for some Contracting Parties and sound sources, the data underestimates this activity. The risk of disturbance to harbour porpoise from reported impulsive noise decreased from 2015 to 2017, then increased to 2019.

For both impulsive and continuous noise, it is not yet possible to establish any definitive long-term trends in noise levels, including since the Quality Status Report 2010 (QSR 2010).



Activity type of Pulse Block Days reported for 2015.
Available at: ODIMS



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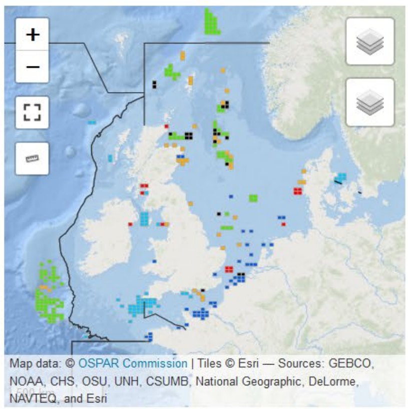

Activity type of Pulse Block Days reported for 2017.
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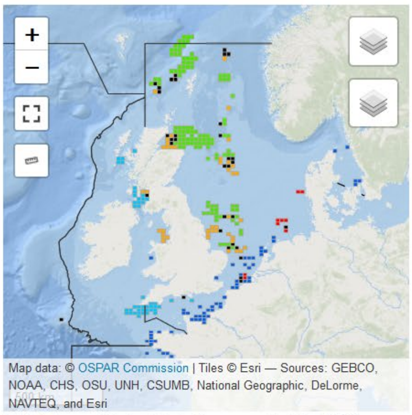
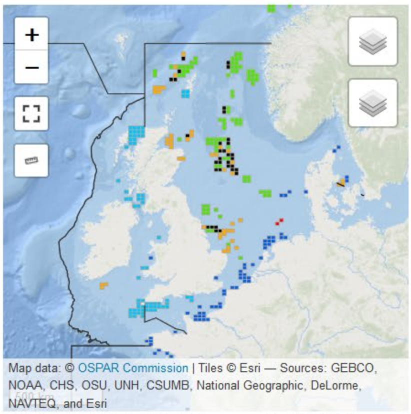


Activity type of Pulse Block Days reported for 2018.
Available at: ODIMS



Activity type of Pulse Block Days reported for 2019.
Available at: ODIMS

Figure 1: Activity type of Pulse Block Days reported for 2015-2019

Q2. What has been done?

For both types of noise OSPAR has developed a monitoring programme and has contributed to the development and maturing of assessment methodologies. The programme for impulsive noise has been operational since 2016, and is in line with the guidance from the European Union (EU) Technical Group on Underwater Noise (TG Noise). The monitoring of continuous noise has been taken forward through the JOMOPANS and JONAS projects, although it is still under development by the Contracting Parties.

The International Maritime Organization (IMO) has produced voluntary guidelines on noise reduction, including from key sources such as propellers or machinery vibrations. It is possible to reduce noise from shipping through technical measures, such as hull and propeller design, and operational measures such as spatial restrictions or reducing shipping speeds.

For percussive pile driving, technical measures to mitigate adverse effects include the use of bubble curtains, isolation casings and hydro sound dampers. These measures are very effective in reducing levels of impulsive noise from pile driving in the OSPAR Maritime Area. Alternative, quieter, installation methods such as suction buckets and drilling can also be used in some areas. Bubble curtains could be used to abate noise from the detonation of unexploded ordnance (UXO), although this is unlikely to be practical in most situations.

Pile driving operation with bubble curtain. © Trianel/Lang

For geophysical surveying, noise from seismic surveys can be reduced to a small extent by changes in the design and configuration of airgun arrays. To achieve significant reductions, alternative technologies are needed; marine vibrator technologies are under development.

Operational measures can also be taken to reduce the risk of adverse effects, including injury, of impulsive noise on sensitive species, such as use of acoustic deterrent devices, choice of less critical times or areas for activity (e.g. avoiding feeding areas, reproductive sites or migration routes), and use of marine mammal observers or acoustic monitoring to detect animals in the vicinity of operations.

National standards for noise management have been put in place by several OSPAR Contracting Parties.

Q3. Did it work?

To date, it is thought that the 2014 IMO voluntary guidelines have not yet had an effect on overall shipping noise, and IMO has adopted the initiative of Canada, USA and Australia to review and update these guidelines. The review should be finished by 2023.

The OSPAR Common Indicator on the Risk of Impact from Impulsive Noise has reported some reduction in noise exposure for harbour porpoise as a result of measures taken to reduce noise from piling activity. Further abatement measures in future would improve upon this risk reduction.

Through its indicator assessments, OSPAR has contributed to the awareness of underwater noise pollution among various groups, such as policy makers, scientists, industry, non-governmental organisations, and the general public.

Q4. How does this field affect the overall quality status?

At the time of writing, there are not yet agreed threshold values for underwater noise, but OSPAR nevertheless considers that noise should be reduced to levels that do not adversely affect the marine environment. However, work is ongoing to develop such threshold values within OSPAR, HELCOM and the EU.

Q5. What do we do next?

The North-East Atlantic Environmental Strategy 2030 (NEAES 2030) commits OSPAR to producing a regional action plan, by 2025, of measures to reduce noise pollution and to implementing, by 2022, a monitoring programme for continuous sound in the OSPAR Maritime Area, taking account of developments in the EU. The action plan will bring together the best from the Contracting Party scientific and policy communities and will:

- develop and manage a programme of prioritised actions on reducing pressure from underwater noise, to be implemented from 2025 (or earlier where possible);
- be supported by:
    - monitoring and assessment programmes for all OSPAR regions;
    - assessments of the latest evidence on harm;
    - risk assessments for additional species and habitats beyond harbour porpoise;
    - models and analysis to identify and develop Best Available Techniques (BAT) and Best Environmental Practice (BEP) for measures to achieve agreed threshold values and targets.

It will:

- include all significant sources of both impulsive and continuous underwater noise;
- add value to other regional and global measures and processes, for example by developing local and regional-scale measures in accordance with IMO guidance and standards;
- support the delivery of other operational objectives in the NEAES 2030, in particular objectives to enable the recovery of marine species and habitats and to increase resilience;
- give priority to measures to enable the recovery of OSPAR-listed threatened and / or declining species and habitats.

Priority areas include:

- engaging with IMO on the review of guidelines for noise reduction from shipping, and identifying and implementing ways to improve the uptake of this guidance by shipping using the OSPAR Maritime Area;
- assessing national standards in OSPAR Contracting Parties for the reduction of impulsive noise from piling, and promoting the implementation of BAT and BEP;
- assessing and promoting the implementation of BAT and BEP in reducing other sources of impulsive noise, including from seismic surveys and the removal of UXO;
- identifying and implementing options for reducing adverse impacts of underwater noise on marine protected areas (MPAs), in particular those important for species known to be particularly sensitive to underwater noise;
- further improving the extent and quality of reporting to the OSPAR Impulsive Noise Register, and of the validation of models used to assess continuous noise.

D - Drivers

Drivers of activities producing underwater noise

Underwater noise is generated by multiple human activities in the North-East Atlantic, including offshore energy production from oil, gas and offshore wind; military activities; detonation of unexploded ordnance such as mines or munitions; shipping, fishing vessels and recreational boating; research activities; aggregates extraction; and aquaculture.

Underwater noise is generated by offshore energy production activities © Shutterstock

These activities are affected by many social and economic drivers (Society's need for food; Society's need for health and well-being; Society's need for education; as well as underlying influences such as economic growth, globalisation, issues of energy security, issues of national security and technological innovation. For example, factors affecting international trade influence the pressure from shipping. Recent reviews have generally anticipated growth in global volumes of shipping in the short and longer terms, but with uncertainties about the extent of that growth and how it might be affected by risks to trade such as slower overall economic growth, trade tensions, shifts towards more regionalised trade flows, economic transitions, supply side disruptions, climate-change related impacts, and the impact of Covid-19 (see, for example, UNCTAD, 2021).

Environmental policies (Society's needs and appreciation of nature and biodiversity; Society's need to mitigate the effects of Climate Change; Society's need to adapt to the effects of climate change) promoting low-carbon energy, combined with technological innovation, are driving major expansion in offshore wind energy, with consequent increases in impulsive noise from construction of wind turbine foundations and on-site removal of unexploded ordnance, as well as operational noise from wind farms, including from service vessels. Carbon sequestering technologies such as storage of CO_2 in exploited oil and gas deposits, and associated seismic surveys for characterisation and monitoring of storage sites, could also increase noise.

Economic demand for resources (Society's need for stable economies; Society's need for materials) may also lead to development of new activities with the potential to generate noise, such as deep-sea mining for minerals or an expansion in aggregates extraction to supply increased construction demand.

Greater levels of environmental awareness (Society's needs and appreciation of nature; Society's need for health and well-being) may also influence the willingness of governments and businesses to implement measures to reduce environmental impacts, including noise.

References

UNCTAD (2021). *Review of Maritime Transport 2021*. Available at: https://unctad.org/system/files/official-document/rmt2021_en_0.pdf

A - Activities

Activities producing underwater noise

Sound sources are categorised as continuous or impulsive. Continuous sounds are long lasting without pulse characteristics. Impulsive sounds are of short duration, with rapid onset. High-frequency sounds propagate less well in the marine environment than low- frequency sounds, which can travel far in waters that are sufficiently deep. Most anthropogenic sound sources considered in this assessment are low-frequency, but may have high frequency components, for example, shipping, seismic airguns, pile driving, and detonation of unexploded ordnance. Higher frequency sources include sonar, some acoustic deterrent devices (ADDs), and some geophysical surveys.

Table A.1: Intensity and trends of selected human activities in OSPAR Regions.

Cell entries represent intensity (high, medium, low), trend since QSR 2010, and forecast trend to 2030. The symbol '↔' is used where there has been little change in intensity since QSR 2010; the symbol '?' is used where future trends are uncertain.

Main activities	Arctic Waters	Greater North Sea	Celtic Sea	Bay of Biscay and Iberian Coast	Wider Atlantic
Aggregates extraction					
Intensity	L	H	M	M	L
Trend since QSR2010	↔	↓	↔	↑	↔
Trend to 2030	?	?	?	?	?
Aquaculture					
Intensity	H	H	M	M	L
Trend since QSR2010	↑	↑	↔	↑	↑
Trend to 2030	↑	↑	↑	↑	↑
Fisheries					
Intensity	H	H	H	M	L
Trend since QSR2010	↓	↑	↑	↔	↔
Trend to 2030	?	?	?	?	?
Oil / gas production					
Intensity	M	H	M	L	L
Trend since QSR2010	↔	↔	↔	↔	↔
Trend to 2030	↔	↔	↔	↔	↔
Renewable energy					
Intensity	L	H	M	L	L
Trend since QSR2010	↑	↑	↑	↑	↔
Trend to 2030	↑	↑	↑	↑	↔
Shipping					
Intensity	M	H	H	H	L
Trend since QSR2010	↔	↔	↔	↔	↔
Trend to 2030	?	?	?	?	?
Tourism					
Intensity	L	H	M	H	L
Trend since QSR2010	↑	↑	↔	↑	↑
Trend to 2030	↑	↑	↔	↑	↑

Human activities producing continuous noise

Shipping is the main source of anthropogenic continuous noise in the OSPAR Maritime Area. Between 75% and 90% of the EU's external trade and one third of intra-EU trade involve maritime transport. The Greater North Sea, Celtic Seas, and the Bay of Biscay and Iberian Coast have a particularly high amount of shipping, with the highest densities in the English Channel, the Southern and Eastern North Sea, and the entrance to the Mediterranean. The OSPAR Maritime Area includes three of the twenty leading container ports globally, and ten of the twenty largest ports in Europe.

In 2018, the overall weight of goods handled and passenger numbers in OSPAR ports were little changed from 2008. Annual reviews by the United Nations Conference on Trade and Development (UNCTAD) anticipate some increase in global shipping in the future, but note that this could be affected by factors such as slow economic growth, trade tensions, or more regionalised trade flows. Shipping routes and their usage could also change somewhat – for example, due to rerouting of cargo vessels away from wind farms, increased traffic related to wind farms or increases in shipping, including cruise ships, via Arctic Waters. This could add to the pressure from noise in previously less disturbed areas. Fleet composition may also change, including more larger ships, more energy-efficient ships and, potentially, alternative fuels.

Dredging activities associated with shipping also generate noise. Special-purpose vessels, used in a variety of activities, often have dynamic positioning systems which generate noise at higher frequencies than those from propulsion machineries or pumps.

Tourism and recreation generate continuous noise. Recreational boating (including jet skis, motor boats and power boats) can be a significant source of mid- to high-frequency underwater noise in shallow coastal waters. This is not currently included in noise assessment models as these craft do not have the automatic identification systems (AIS) used in the models, and noise propagation in shallow coastal waters, in particular tidal waters, is more difficult to model and predict (Hermannsen et al., 2019). OSPAR intends to include this source in future modelling, although how data is obtained needs further consideration.

Fishing contributes to underwater noise from vessel movements, and from bottom trawls dragging the seabed.

The offshore oil and gas industry is a source of continuous noise from drilling equipment and production platforms. The number of wells drilled increased over the period from 2009 to 2019; most wells drilled are development wells rather than exploration and appraisal wells.

Renewable energy produced from operational offshore wind turbines is a source of low-frequency underwater noise. While noise from individual turbines is low compared with noise from ships, the high projected increase in offshore wind farms means that the cumulative contribution of wind farms to the underwater soundscape requires assessment (Tougaard *et al*., 2020).

Extraction of aggregates (sand and gravel), notably in the Greater North Sea, produces continuous noise (through extraction, material passing through pumps and pipes, and vessel movements).

Human activities producing impulsive noise

Impulsive noise is produced by several sources. OSPAR's Common Indicator on the Pressure from Impulsive Noise categorises these as seismic airgun surveys, pile driving, explosions, sonar and acoustic deterrents, and generic, which includes sources such as non-airgun seismic surveys (e.g. sub-bottom profilers). Some of the loudest and most potentially damaging sources of underwater impulsive noise, in terms of severity of injuries, are caused by explosives.

Seismic surveys, using seismic airguns, are used in the oil and gas industry in discovering and defining new hydrocarbon reservoirs, assessing the extent and depletion of those reservoirs, and for characterising and monitoring geological structures for the storage of carbon dioxide. The oil and gas industry also carries out non-airgun seismic surveys (sub-bottom profilers). It uses explosives for cutting (e.g. casing and tubing, or in decommissioning) or for perforating well casings. Infrastructure installation activities in the oil and gas industry involve underwater hammer piling.

Renewable energy development, through percussive pile driving during the installation of offshore wind turbines, as well as through site surveys, is an increasing source of impulsive noise. Offshore wind capacity in the North-East Atlantic increased substantially between 2009 and 2019, from 1,9 GW to over 22 GW. The Greater North Sea had 77% of this capacity and the Irish Sea 13%. Offshore wind installation in other OSPAR regions was very small in comparison. At present, the majority of turbines use impact-driven monopile foundations.

Planned growth in offshore wind energy is ambitious: in 2020, the European Commission envisaged an expansion in offshore wind in the EU 27 from 12 GW to at least 60 GW by 2030 and 300 GW by 2050, and the United Kingdom Government set out plans for a fourfold increase to 40 GW by 2030. Under a maximum scenario developed by the wind industry, 212 GW could be installed in the North Sea by 2050, with 85 GW in the Atlantic and Irish Sea off France, Ireland and the United Kingdom. Initially, most new capacity will be bottom-fixed installations requiring pile driving, although floating offshore wind, which uses less noisy techniques for anchoring installations, is also expected to develop further. Other low-noise foundations such as suction bucket or gravity base foundations are infrequently used at present.

Shipping and ports development generates pile driving noise in inshore waters as a result of construction works for ports, and noise from explosives used for cutting purposes in activities including ship repair, harbour works and salvage or removal of shipwrecks and cargos.

Military activity is a source of impulsive noise but is outside the remit of OSPAR to regulate. Military activity is a source of impulsive noise from sonar. It could generate explosions, either operationally or for training. Explosions mainly arise from the detonation of unexploded ordnance, such as mines or ammunition, left undetonated or dumped after the World Wars. Detonation is necessary for health and safety reasons (e.g. before offshore construction activities begin).

In aquaculture, acoustic deterrent devices (ADDs) producing loud, mid-frequency sound are used to deter seals from approaching fish farms. These can have unintended consequences for non-target species, particularly cetaceans. While newer generation ADDs reduce sound outputs at frequencies most likely to disturb cetaceans, more research and development concerning their possible use is still required, including if the noise produced is impulsive or continuous (Marine Scotland, 2021).

Seismic surveys are also used to gather data for academic and governmental needs, for example seabed surveys or analysis of geological features below the seabed.

Other sources of impulsive noise include echosounders, underwater communication systems and measurement instruments, although as high-frequency sources, their effects are likely to be localised.

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Harbour Porpoises are a type of cetacean which use sonar to locate food. Source: Ecomare

References

Hermannsen, L., Mikkelsen, L., Tougaard, J., Beedholm, K., Johnson, M. & Madsen, P.T. (2019). *Recreational vessels without Automatic Identification System (AIS) dominate anthropogenic noise contributions to a shallow water soundscape*. Scientific Reports 9, Article 15477. Available at: https://www.nature.com/articles/s41598-019-51222-9

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P - Pressures

Pressures from underwater noise

Continuous and impulsive noise fall under the pressure category ‘Input of anthropogenic sound (impulsive, continuous)’.

The Quality Status Report 2010 (QSR 2010) discussed noise in qualitative terms, as quantified data on noise was scarce at that time. It noted that human activities producing noise were particularly intense in the Greater North Sea and the Celtic Seas. Trends in human activities have varied since QSR 2010 (see Activities section above), and do not permit a quantitative or qualitative assessment of the changes in overall noise levels since then. Initial data on activities producing impulsive noise in 2015 were presented in the Intermediate Assessment 2017.

More recently, indicators on noise have been developed by OSPAR. Pressure from continuous noise is covered by OSPAR's Candidate Indicator on Pressure from Ambient Noise. Pressure from impulsive noise is covered by OSPAR's Common Indicator for the Pressure from Impulsive Noise. It is not yet possible to establish significant trends from these indicators.

More detail of the methodologies used is given in the respective Indicator Assessments, and readers should refer to these documents if they require further information.

Pressure from continuous noise

Natural ambient sound (e.g. from wind, rain and waves) is omnipresent in the marine environment. This is added to by noise from human activities – in the OSPAR Maritime Area, predominantly from shipping.

In 2015, OSPAR agreed a monitoring strategy for ambient underwater noise (Agreement 2015-05). Monitoring is to be undertaken at acoustic basin scale. In the Greater North Sea, monitoring is carried out under the EU-funded JOMOPANS project (JOMOPANS monitoring does not include the English Channel). Results from this programme are presented in OSPAR's Candidate Indicator on Pressure from Ambient Noise. The EU-funded JONAS project is developing monitoring for the Bay of Biscay and Iberian Coast, but results of that work are not yet available to inform the Candidate Indicator. OSPAR's North-East Atlantic Environmental Strategy 2030 (NEAES 2030) includes a commitment for OSPAR to develop and implement, by 2022, a coordinated monitoring programme for continuous sound, to support an assessment of anthropogenic underwater noise in the OSPAR Maritime Area (NEAES Operational Objective S8.02).

The detailed assessment methods are described in the CEMP Guidelines for the Candidate Indicator on ambient underwater noise (OSPAR Agreement 2021-05). The methods are consistent with the 2014 Monitoring Guidance for Underwater Noise in European Seas produced by the EU's MSFD Technical Subgroup on Underwater Noise (TG-Noise), and are considered consistent with the ongoing further development of the TG-Noise assessment methodology.

The assessment approach uses the median sound pressure level as the metric for evaluation, as it is robust and not overly influenced by short periods of very high sound levels. It uses the noise frequency band 125 Hz 1/3-octave band, which contains the major noise levels caused by shipping noise. As yet, the assessment method does not include sources other than shipping and fishing vessels with automatic identification or vessel monitoring systems.

Background underwater sound levels (without anthropogenic contribution) across the North Sea are approximately 90 dB re 1 µPa median sound pressure level (SPL) for the 125 Hz band. Winter levels are slightly higher (about 5 dB) than summer values, due to windier conditions in winter.

Figure P.1 shows the overall median sound pressure level across 2019, from natural and anthropogenic sources combined. This was considerably higher in the southern part of the North Sea and along major shipping routes, with an increase in background levels of 20 to 30 dB re 1 µPa, most of the time. The central part of the North Sea was less affected by anthropogenic noise: the median SPL was less than 10 dB re 1 µPa above the background level. In all areas, there was relatively little variation in total sound pressure across the year, although levels of noise in the summer months were a few dB higher than in winter, reflecting increased shipping activity.

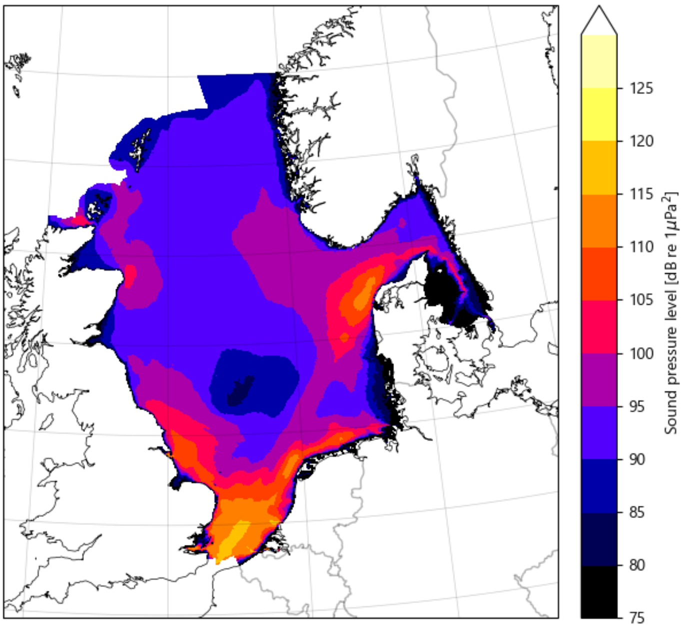

Figure P.1: Median total sound pressure level, 2019, measured in 125 Hz band

The median sound pressure levels obtained by modelling have been validated with the site-based measurements of the JOMOPANS project. 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 the noise monitoring station concerned, and had comparatively low uncertainty at high frequencies (> 1 kHz). Discrepancies appear to be caused by a combination of factors. The validation process highlighted the complexity of the analysis and the limitations in both the field measurements and the acoustic modelling which could be improved upon in the future.

Pressure from impulsive noise

Impulsive underwater noise is monitored by OSPAR Contracting Parties according to EU technical guidance (adopted as OSPAR Guidelines under OSPAR Agreement 2014-08) and an associated reporting format (OSPAR Agreement 2014-10). Since it is not always possible to comprehensively monitor impulsive noise in the marine environment itself, common monitoring is done through data held on activities causing low- and mid-frequency impulsive noise. Information on impulsive noise events is held in the Impulsive Noise Register, maintained for OSPAR by the International Council for the Exploration of the Sea (ICES).

OSPAR Contracting Parties provide data for the register within the framework of OSPAR monitoring. Between 2015 and 2019, data were reported in five sound source categories: seismic airgun surveys; pile driving; explosions; sonar and acoustic deterrents; and generic, including sources such as non-airgun seismic surveys and noise where the source type was not recorded. Information is not complete, as data were not available for all activities and Contracting Parties during the assessment period. For example, no Norwegian data were included before 2019, and there are no data from Spain or Iceland. Nor did the data include activities which do not require a licence, such as some ADDs.

This information has been used to inform the OSPAR Common Indicator for the Pressure from Impulsive Noise. This is based on so-called 'pulse block days' - the number of days in a calendar year that anthropogenic impulsive sound (pulse) occurred within a specified area (block). The spatial area used is the ICES statistical sub-rectangle ('ICES sub-block' - 10' latitude x 20' longitude), providing detailed resolution at the regional scale. Only impulsive sounds above a minimum intensity are included, above which the risk of impact on marine animals is judged to be significant.

The indicator does not at this stage take account of actual sound intensity, as this information is only available for some activities. Work to improve the reporting of sound intensity is ongoing. Nor does the information reported in the registry take account of the duration of an activity within a pulse block day.

The total of pulse block days reported for each OSPAR region between 2015 and 2019 is shown in **Figure P.2** below. The highest level of reported activity was in 2019, when Norwegian seismic airgun activity was included for the first time. The higher level of activity in the Wider Atlantic in 2017 was due to seismic airgun activity. A definitive trend in noise activity cannot be determined because of the incompleteness of the data set. More consistent reporting in future years should result in improved confidence in the comprehensiveness of assessments.

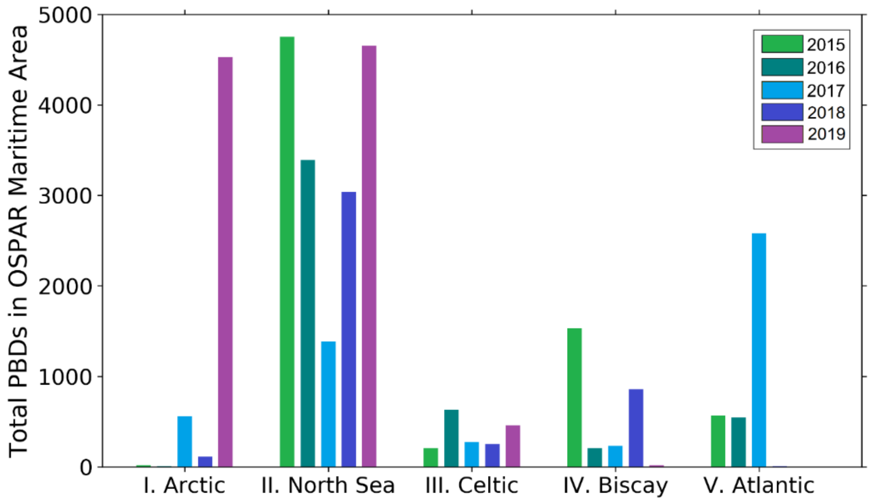

Figure P.2: Total Pulse Block Days per OSPAR Region reported for 2015-2019

Key message from indicator assessment

Reported impulsive noise activity increased overall during the assessment period (2015-2019), with most reported activity occurring in the North Sea. Seismic airgun surveys were the dominant sound source. Since data are unavailable for some countries and sound sources, these results represent an under-estimation of activity in the OSPAR Area.

Information on the source of activities giving rise to impulsive noise is shown in **Figure P.3**. The most common source was seismic airgun surveys. The second most frequent category, 'generic', is thought to be dominated by sub-bottom profiler geophysical surveys. Pile driving occurred across the period; the low levels for 2019 may be due to incomplete reporting, given the continued increase in offshore renewable energy capacity in that year. Reported explosions were concentrated in the Southern North Sea due to the destruction of unexploded ordnance. Within the ADD / sonar category, most of the reported activity is understood to be military sonar activity.

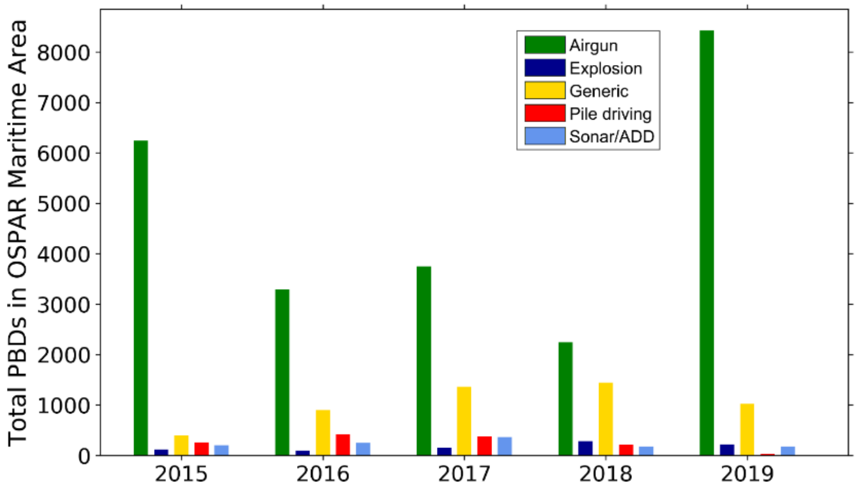

Figure P.3: Activity type of Pulse Block Days reported for 2015-2019 in the OSPAR Maritime Area

The distribution and frequency of pulse block days in the OSPAR Maritime Area is illustrated in **Figure P.4.** It can change markedly between years. For example, the maps for 2015 and 2016 show the noise from a large-scale seismic airgun survey carried out in UK waters in those years by the United Kingdom Oil and Gas Authority.

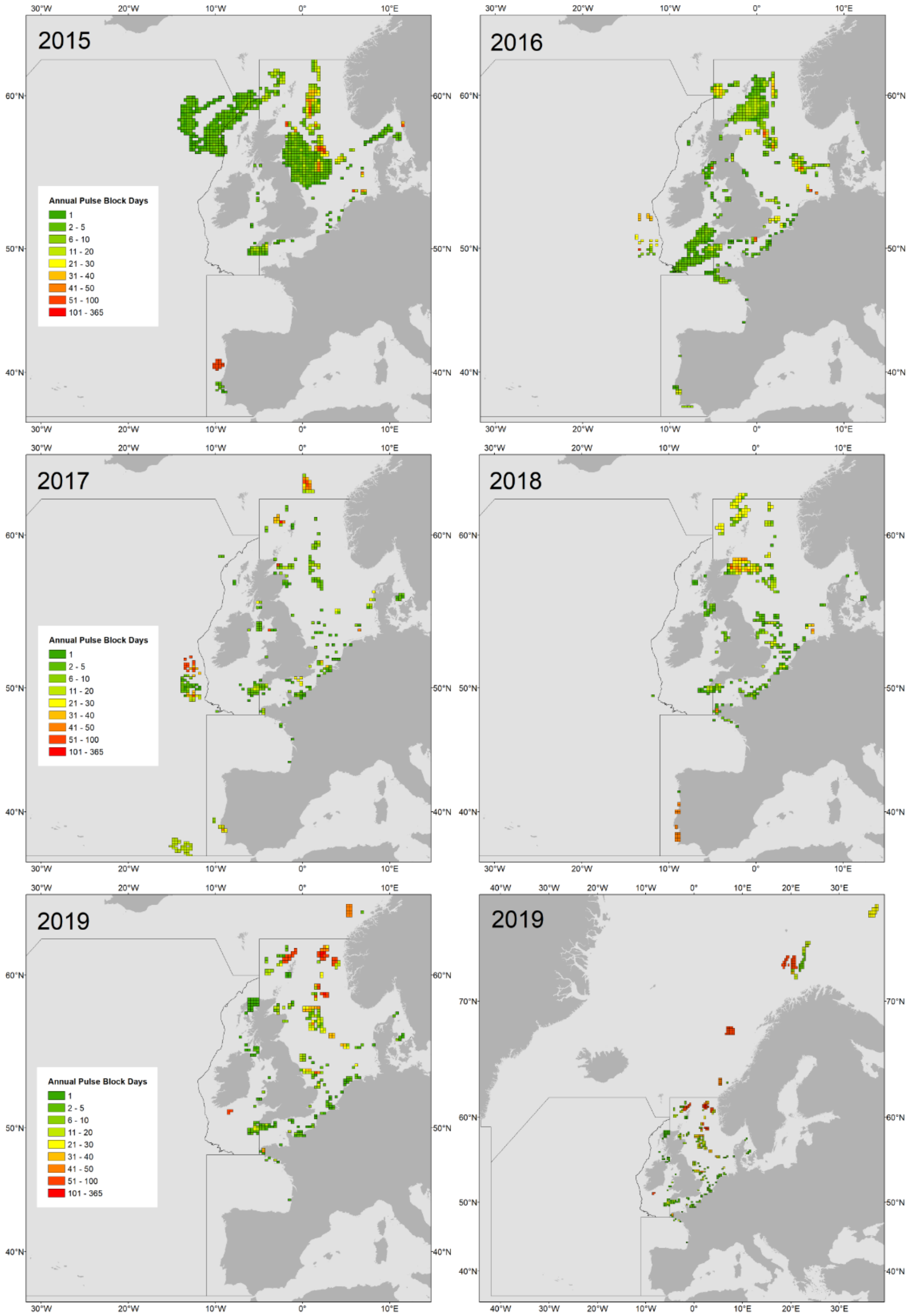

Figure P.4: Total Pulse Block Days reported for 2015-2019 per ICES sub-rectangle

Confidence assessment for pressure from continuous and impulsive noise

A combined regional confidence assessment of the level of evidence and degree of agreement of the underlying assessment methodology for pressure from continuous and impulsive noise is given below. The confidence assessment reflects the fact that data on noise, and on activities which produce noise, are more developed for the Greater North Sea than for other OSPAR regions.

OSPAR Region	Arctic Waters (Region I)	Greater North Sea (Region II)	Celtic Seas (Region III)	Bay of Biscay and Iberian Coast (Region IV)	Wider Atlantic (Region V)
Confidence	Low	Medium	Low	Low	Low

S – State

Effect of underwater noise on the state of the marine environment

Effect of continuous noise on state of marine environment

The material in this section is taken from OSPAR's Candidate Indicator on Pressure from Ambient Noise, where more detailed information on the indicator methodology is presented.

The thresholds at which continuous noise from human activities is of concern is uncertain – for example, there is as yet no assessment of good environmental status for continuous noise under the Marine Strategy Framework Directive (2008/56/*EC*). Noise can affect marine animals through 'masking' – interfering with their ability to communicate, navigate, find food, or detect threats – or through behavioural disturbance, such as fleeing or distraction. The pressure index proposed in JOMOPANS specifically addresses masking, and is set at an excess level of 20 dB or more above natural background levels. This gives a clear discrimination in the 'dominance map' below, but at this time there is no biological rationale behind the 20 dB level. Work on defining threshold values for continuous noise is in progress in OSPAR and in the EU.

Figure S.1 is a 'dominance map' which illustrates the percentage of time for which the 'excess level' is more than 20 dB for the 125 Hz band. The excess level is defined as the difference between total noise (from wind and ships) and the reference condition (i.e. natural background noise levels). In areas such as the Southern North Sea and the sea near the north-west of Denmark, shipping noise exceeds that threshold most of the time, whereas in some other areas (e.g. the Dogger Bank and the shallow parts of the Kattegat) sound pressure levels were within 20 dB of the reference condition for most of the time in the low frequency bands.

Key message from indicator assessment

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.

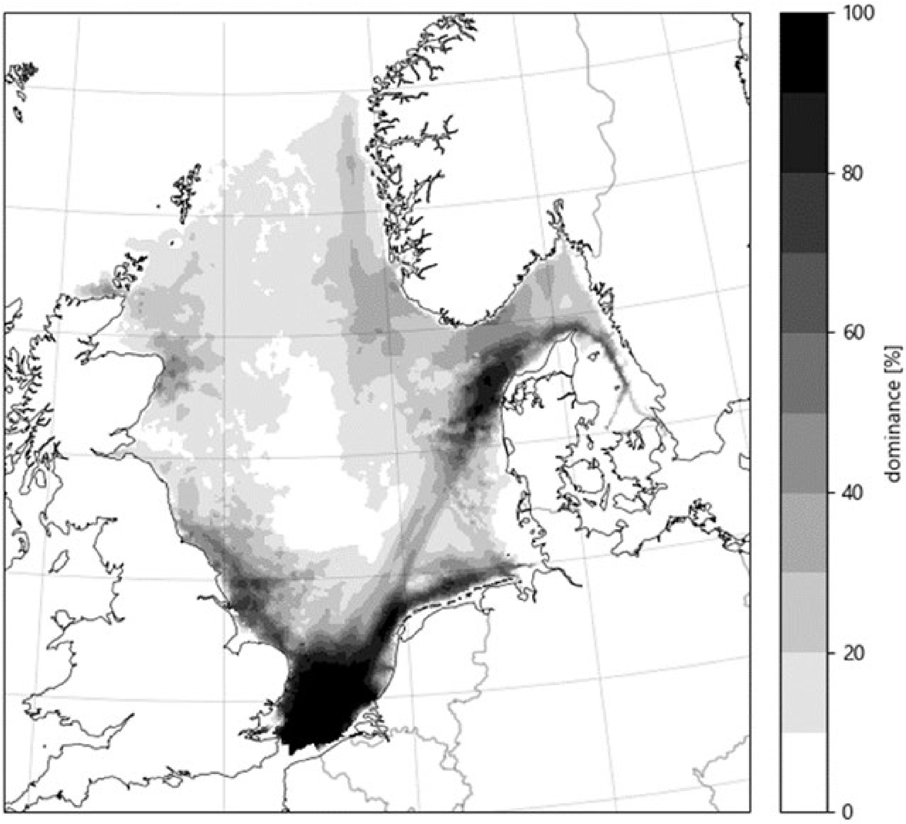

Figure S.1: Dominance map for a cut-off level of 20 dB of the excess level

Exposure curves can be used to illustrate the extent to which geographical areas are subject to excess noise over time. They plot the percentage of a geographical area subject to noise above the excess level (20 dB) against the percentage of time with that excess. The area below the curve gives a pressure index, which can be compared between geographical areas. **Figure S.2** below does this for various parts of the North Sea, and for marine protected areas (MPAs) within the North Sea. Some MPAs, many of which are in the southern part of the North Sea, are among the areas affected by particularly high levels of anthropogenic noise.

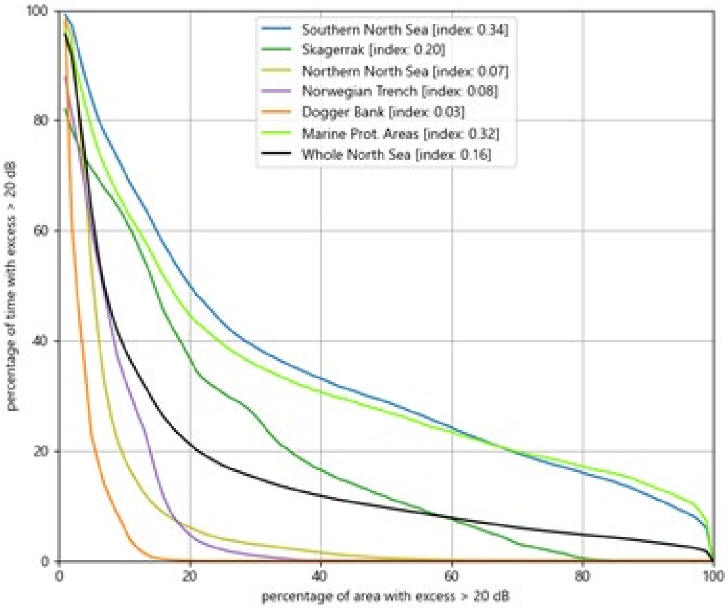

Figure S.2: Pressure curves for the 125 Hz band for continuous noise in the North Sea and for the MPAs within the North Sea

Effect of impulsive noise on the state of the marine environment

Impulsive sound can cause temporary displacement of cetaceans, physiological stress in fish, developmental abnormalities in invertebrate larvae and, in severe cases, permanent hearing damage and blast injuries. It remains uncertain what this means at the population or ecosystem scale and, as yet, there are no agreed threshold values for good environmental status for impulsive noise under the Marine Strategy Framework Directive.

The OSPAR Common Indicator on the Risk of Impact from Impulsive Noise addresses this by assessing the exposure to impulsive sound of species known to be particularly sensitive to disturbance or physiological stress from such sound. It analyses the distribution, in space and time, of impulsive sound sources and relates this to the distribution, again in space and time, of selected species or habitats. This produces an exposure assessment which is taken as a measure of the risk of impact on each species or habitat. A detailed explanation of the assessment methodology and information sources is given in the Common Indicator.

The first assessment under this Common Indicator uses the harbour porpoise as the indicator species. It is the most common cetacean in the North Sea, is particularly sensitive to impulsive sound, and has relatively high-quality modelled density estimates; as such, it is particularly suitable for this assessment and may serve as a sentinel for other cetaceans. Future assessments will consider additional species for risk assessment, and more comprehensive reporting in future years should reduce uncertainty in the impulsive sound activity used in the assessment.

Modelled densities of porpoise in the maritime area used for the assessment are shown in **Figure S.3.** Norwegian waters were not included because no impulsive noise data were available before 2019. The density data cover the months from March to November.

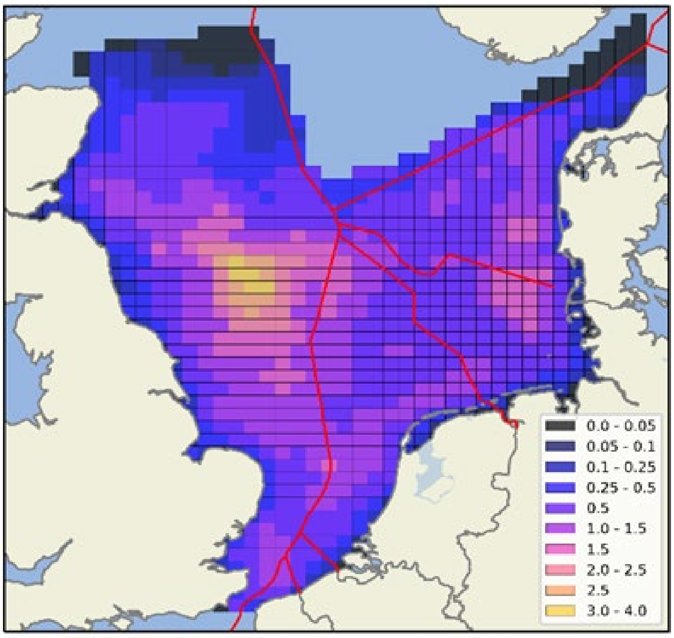

Figure S.3: Average annual density of harbour porpoise (animals per km^2, March – November)

Combining information on harbour porpoise densities with information on sources of impulsive noise allows risk maps to be produced that show the extent to which pressure from impulsive noise coincides with the presence of porpoises. The metric used for the maps is the base 10 logarithm of the average number of pulse block days in each block across the assessment period (e.g. a month or year) multiplied by the number of animals estimated to be in that block at the time.

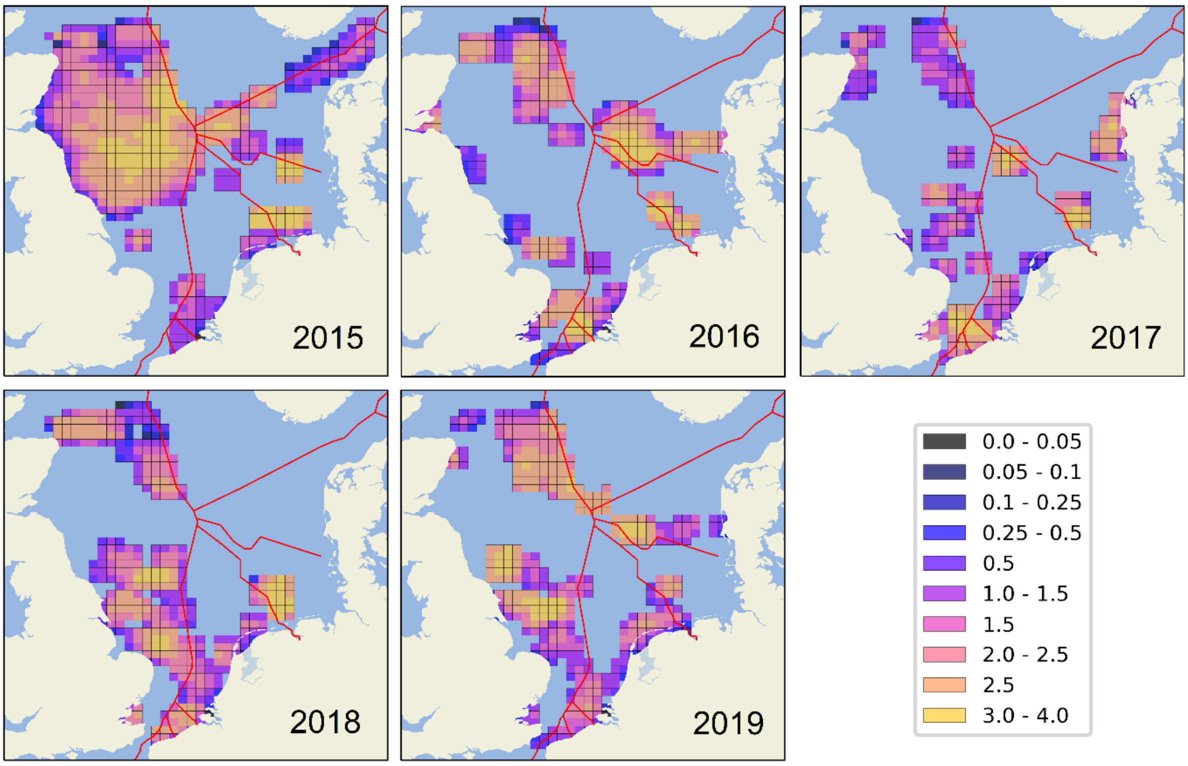

Figure S.4: Annual risk maps for harbour porpoise, 2015-2019, March-November

Annual risk maps indicate that risk was more widespread in 2015 than in subsequent years, due to the large-scale seismic survey programme carried out by the United Kingdom Oil & Gas Authority at that time. Monthly risk maps can also be produced, which show that risk was most widespread from August - October.

Although data on harbour porpoise densities was not available for the winter months (December - February), estimates could be made for the extent of habitat area (**Figure S.3**) exposed to impulsive noise. For those months, the daily exposed habitat area was <2.5% in all years), while during March to October this was typically <5%.

In 2015 and 2016, most estimated disturbance resulted from seismic airguns, whereas in later years no single source dominated (see **Table S.1** below). The low proportion estimated for piling in 2019 may be due to incomplete reporting. The indicator shows that highest noise exposure in 2017 and 2018 comes from piling, despite it being a relatively low contributor to pulse block days. This may be because populations of harbour porpoise tended to be in the areas favoured for offshore wind construction in those years.

Table S.1: Proportion of harbour porpoise noise exposure attributable to each source type. The generic category is thought to be dominated by non-airgun seismic sources

Source type	% of 2015 exposure	% of 2016 exposure	% of 2017 exposure	% of 2018 exposure	% of 2019 exposure
Explosions	1	1	11	7	6
Airgun array	77	51	24	25	47
Sonar/ADD	0	0.1	0	0.2	0
Generic	2	23	19	35	37
Piling	16	22	42	31	2
Multiple	2	3	4	3	9

Key message from indicator assessment

The estimated risk of disturbance to harbour porpoise from reported anthropogenic impulsive sound decreased by 48% from 2015 to 2017, then increased by 31% from 2017 to 2019. Exposure of harbour porpoise to anthropogenic impulsive sound was typically greatest during August - October. More comprehensive reporting will improve confidence in the assessment.

The data can be used to produce exposure curves which plot the percentage of the porpoise population density exposed to impulsive noise against the percentage of the assessment period for which that exposure occurred. The area under the curve can be used to derive an exposure index (EI), a single number indicative of the overall amount of noise exposure for a population or habitat. The methodology used means that, for example, an exposure index of 20 is equivalent to 20% of the population or habitat being exposed for 20% of the assessment period.

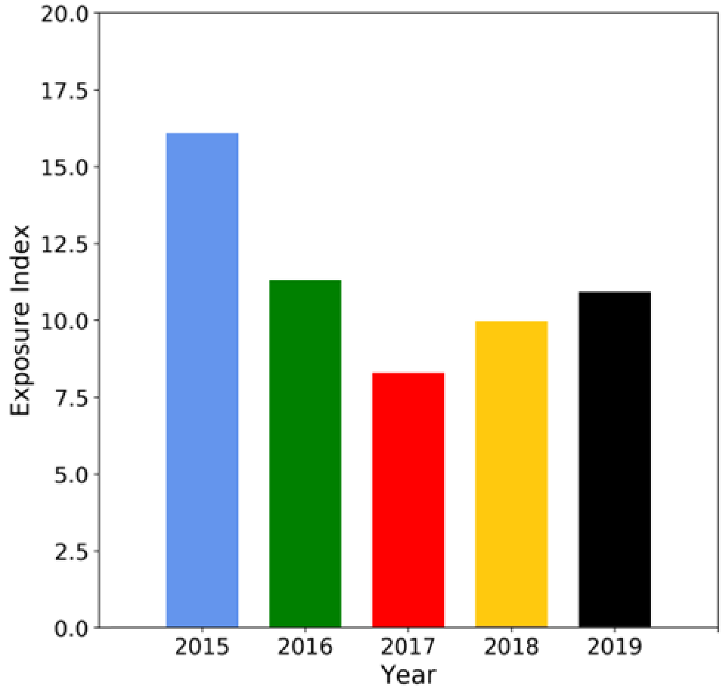

Figure S.5: Annual exposure indices for harbour porpoise

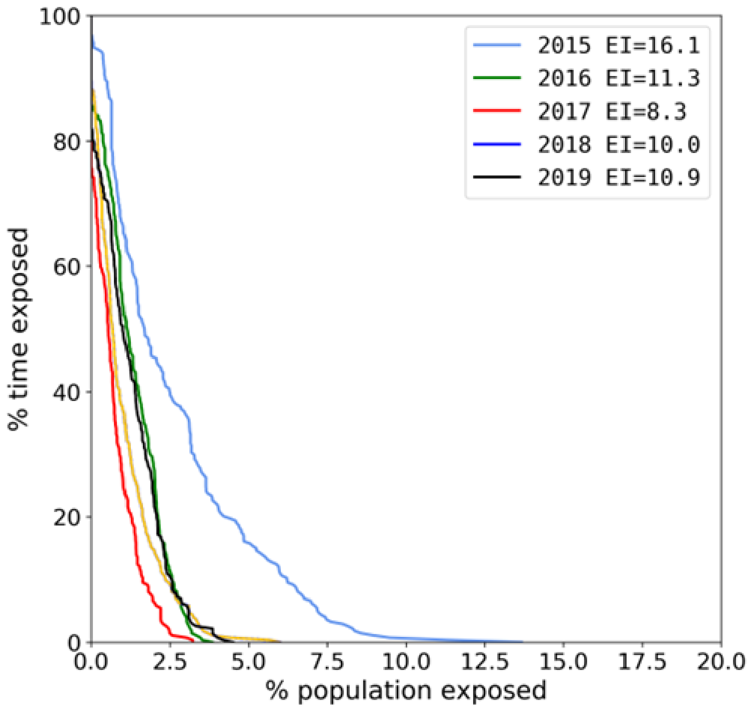

Figure S.6: Corresponding exposure curves for harbour porpoise

More comprehensive reporting will improve confidence in the assessment. No overall trends in long-term noise levels can be inferred from these results.

The exposure curves show that a relatively small proportion of the population density was exposed for a large proportion of time (up to 95% of the assessment period during 2015). The majority of the population density was unexposed, with the maximum population in any one year exposed to any reported impulsive noise being approximately 13% in 2015. However, since the harbour porpoise is a highly mobile species, these results should not be interpreted as meaning that 13% of animals in the population were estimated to be exposed, but that 13% of the habitat was exposed when weighted for how frequently that habitat is used. The number of individual animals exposed may be much higher than 13% of the population, since individual animals may incur multiple exposures in different areas.

The effect of noise abatement systems used for pile driving operations in German, Danish, Dutch and Belgian waters was taken into account in the exposure indices. These were also modelled. They reduced the annual exposure indices, compared with unabated piling, by at least between 0.1 and 0.9, depending on the year. This is likely to be an underestimate in exposure reduction due to conservative assumptions underlying the exposure calculations.

Exposure in marine protected areas (MPAs) was also assessed. MPAs were not designated with noise management specifically in mind. The exposure index was lower inside the MPAs than outside during 2015, 2016 and 2019, but higher in the intervening years.

I – Impact

Impacts of underwater noise on ecosystem services in the marine environment

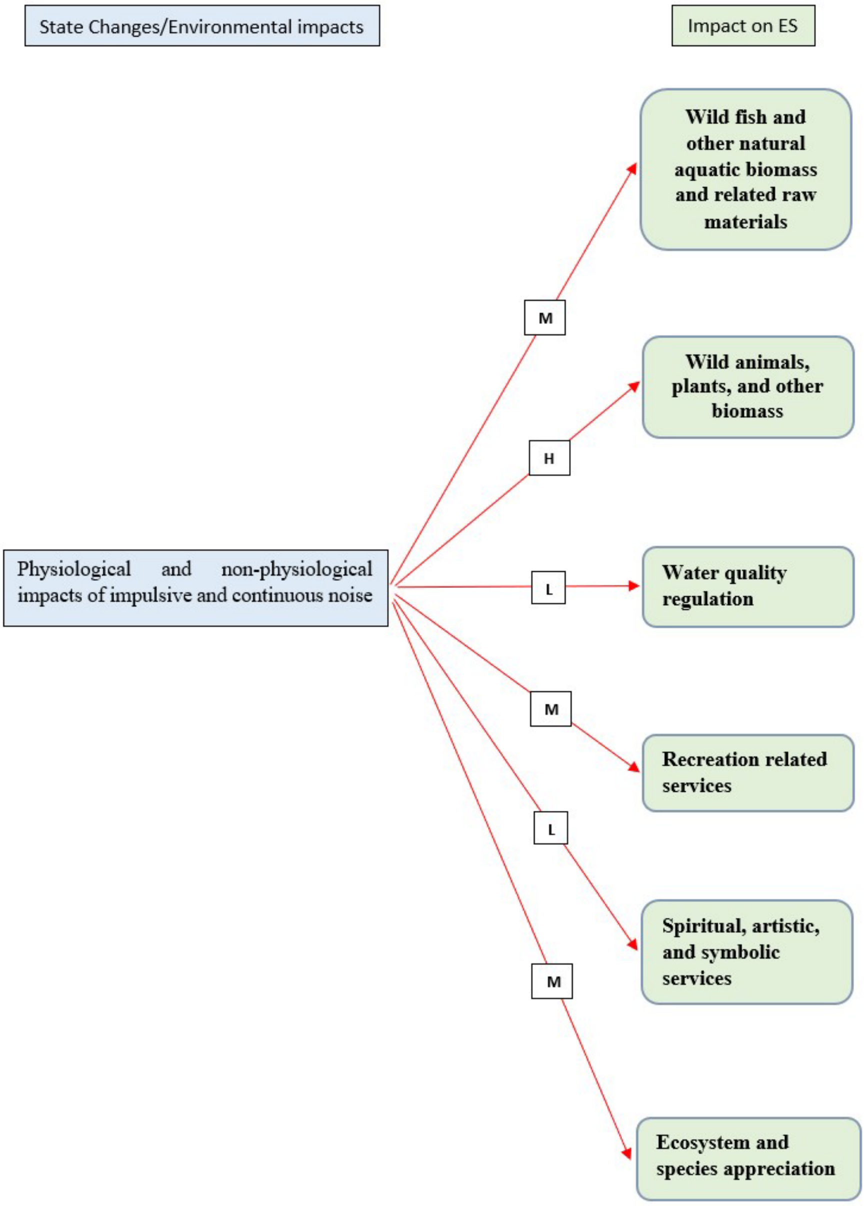

Figure I.1: Overview of the 'state changes/environmental impacts' - 'impacts on ES' linkages for the Underwater Noise Thematic Assessment. The presented ecosystem services represent those considered most relevant in relation to the Underwater Noise thematic assessment. Each arrow is also associated with an expert-based estimate of the magnitude of the impact of environmental state change on a particular ecosystem service (H = high impact, M = medium impact, L = low impact, U = unknown impact)

As shown schematically, state changes / environmental impacts associated with underwater noise impact on different marine ecosystem services. The following provides a further elaboration on the reasoning behind the identified impacts on ecosystem services.

<u>Wild fish and other natural aquatic biomass</u>: lethal and sub-lethal physiological stresses, including physical injury, leading in severe cases to death, reduce the overall provision of wild aquatic biomass. In addition, exposure to the underwater noise produced by seismic surveys has been observed to lead to reductions in the abundance of fish stocks, including commercially important species such as cod and haddock (Weilgart, 2018).

Wild animals, plants, and other biomass: Adverse effects of anthropogenic noise have been observed at a wide range of trophic levels, from megafauna to zooplankton. Significant zooplankton mortality has been observed after exposure to seismic airgun surveys (McCauley et al., 2017), while known effects on larger taxa such as marine mammals and fish include mortality, auditory impairment, heightened physiological stress, masking of biologically important sounds, and behavioural responses (Duarte et al., 2021). Noise can also affect species interactions, thereby altering food web dynamics (Simpson et al., 2016). Ultimately, the effects of noise on individual animals may lead to changes in population growth rates (Slabbekoorn et al., 2010; Pirotta et al., 2018), affecting the supply of wild biomass, a key ecosystem service for industrial and recreational fishing activities.

Water quality regulation: exposure to ship noise can compromise the ability of blue mussels to filter water (Wale et al., 2016) and diminishes the benthic nutrient cycling carried out by some benthic species (Solan et al., 2016).

Recreation-related services: the effects described above related to exposure to continuous noise may undermine activities such as recreational fishing, diving, wildlife watching, and others (HELCOM, 2019).

In addition, it can be assumed that the negative impact of underwater noise exposure on marine biodiversity could also affect the provision of cultural services, for example inspirational, and simple appreciation of species and the marine ecosystem, as people care about the existence and good maintenance of a healthy marine environment (Culhane et al., 2019).

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R – Response

Response measures addressing underwater noise

Continuous noise

Mitigation strategies for continuous noise focus on reducing masking and disturbance of sensitive marine animals such as mammals and fish. The main source of continuous noise is shipping. Measures to reduce shipping noise are most effectively aimed at reducing the source levels ('quiet ships'). Secondly, operational measures such as speed reduction can be considered, and thirdly, measures can be aimed at protecting specific vulnerable areas, for example through rerouting. Such areas could be designated as Particularly Sensitive Sea Areas (PSSAs). In these areas special measures for shipping can be applied. A PSSA is an area that requires special protection through IMO measures because it is significant for recognised environmental, socio-economic or scientific reasons and, at the same time, may be adversely affected in its ecological functions by the impact of international shipping traffic from activities in the sea area.

Technical measures have a high potential to reduce shipping noise in the long term. IMO (2014) has published voluntary guidelines on how the noise of vessels' main sources, notably propeller noise or machinery vibrations radiated into the water through hull structures, can be reduced. In Europe, the AQUO (Achieve QUieter Oceans by shipping noise footprint reduction) and SONIC (Suppression of UW Noise Induced by Cavitation) projects produced a set of guidelines covering ship design, including for propellers, and traffic management. The World Organisation of Dredging Associations has also published guidance on underwater noise associated with dredging, which mainly offers the maintenance and cleaning of equipment as an effective way of reducing sound (WODA, 2013).

Some of these measures concern ships' hull design and thus are feasible only on newly built vessels. Others, such as optimised new propellers, would not only reduce noise in existing ships but at the same time save fuel costs, generate income if shipping is included in emission trade systems, and help achieve commitments to reduce carbon dioxide emissions. A cost-benefit analysis of technical options and incentives for reducing shipping noise can be found on the Netherlands government portal on the North Sea (Strietman et al., 2018), and covers incentives such as the inclusion of noise in green shipping indices and voluntary or mandatory measures to promote slow shipping speeds. In 2019 Vard Marine Inc. published a report that describes various means to mitigate underwater radiated noise by ships (Vard Marine Inc., 2019). This study was commissioned by Transport Canada.

To date, it is thought that the 2014 IMO guidelines have not yet had an effect on overall shipping noise, and some modelling suggests that underwater noise has increased in EU waters since 2014 (EMSA/EEA, 2021). In 2021, the IMO Maritime Environment Protection Committee (MEPC) approved a proposal, initiated by Canada, the United States and Australia, for a review of the IMO guidelines. This proposal was supported by the EU and many other OSPAR Contracting Parties.

The costs of some technical measures may be a barrier to rapid noise reduction. Thus, additional operational measures need to be put in place if noise is to be reduced in the short term. These can include reductions in speed or optimisation of operational parameters (e.g. adjustments of rotational speed and screw blade pitch to reduce cavitation) with respect to noise emissions. In addition, rerouting measures and avoidance of areas critical for sensitive species offer a short-term solution; however, such rerouting needs approval by IMO.

Impulsive noise

The mitigation strategies for impulsive noise focus on avoiding injuries to marine animals and the disturbance of sensitive animals such as mammals and fish. A combination of operational and technical measures can be used to mitigate adverse effects, together with assessment during the planning phase of infrastructure developments.

There are technical measures for some impulsive noise-generating activities such as pile driving or blasting. Among the technical measures to reduce piling noise are Big Bubble Curtains, Isolation Casings, and Hydro Sound Dampers (OSPAR, 2016). These three are currently considered state-of-the-art at water depths of up to 40 m (Bellmann et al., 2020). In increasingly large diameter monopiles, a combination of these technologies is advised in order to meet national standards.

A number of emerging technologies have a high potential to reduce noise, but may need some further development. Some alternative low-noise foundation methods are already market-available but are rarely considered by the industry due to their higher costs or limited applicability at specific sites (Koschinski & Lüdemann, 2020). As a means to reduce the shock wave of underwater explosions, which can injure marine vertebrates at ranges of many kilometres (von Benda-Beckmann et al., 2015; Siebert et al., 2022), the Big Bubble Curtain was shown to be effective in reducing the radiation of blast pressure during systematic experiments in coastal waters (12 m depth) conducted between 2008 and 2012 (e.g. Nuetzel, 2008; Schmidtke, 2010; Schmidtke, 2012). These might need to be adapted if they were to be used in deeper waters. Mitigation techniques such as the Big Bubble Curtain, together with other noise reduction techniques such as deflagration or recovery of munitions, should be further tested and evaluated. Such consideration would need to take account of wider possible impacts on the environment as well as safety implications.

For geophysical surveying, noise from seismic surveys can be reduced to a small extent by changes in the design and configuration of airgun arrays. To achieve significant reductions, alternative technologies are needed; marine vibrator technologies are under development.

A number of operational mitigation measures are available to complement the technical mitigation methods. For example, timing and location can be critical for reducing adverse effects on biota or habitats and avoidance of sensitive times and places (e.g. feeding areas, reproductive sites, areas of seasonal migrations). The selection of a less critical time or the relocation of an activity can be simple and effective. Protected species observers and passive acoustic monitoring help in detecting animals within the vicinity of the activity.

Safety procedures which allow the ceasing of noisy activity when animals are sighted or acoustically detected can prevent the most serious injury. Pre-activity monitoring of sensitive species give indications whether animals are in the vicinity and in what densities, and thus help determine efficient and cost-effective mitigation methods. Post-activity monitoring at sea or of stranded animals shows whether mitigation was successful and may allow medical treatment of injured animals.

Despite the availability of measures, their application in oil and gas industry activities is likely to be very varied within the OSPAR area, as guidelines to prevent or minimise the impact of noise on marine mammals currently vary and there is international recognition of the need for more consistent, evidence-based guidelines.

OSPAR response

OSPAR has published an inventory of measures to mitigate the emission and environmental impact of underwater noise, last updated in 2020. This includes annexes covering noise from pile driving and from seismic surveys (the latter is due to be updated).

OSPAR Contracting Parties have also engaged with the International Association of Oil and Gas Producers, which has coordinated a Joint Industry Programme on Exploration and Production Sound and Marine Life.

OSPAR's North-East Atlantic Environmental Strategy 2030 commits OSPAR to agree a regional action plan on underwater noise by 2025, which will set out a series of national and collective actions and, as appropriate, OSPAR measures to reduce noise pollution (NEAES Operational Objective S8.01).

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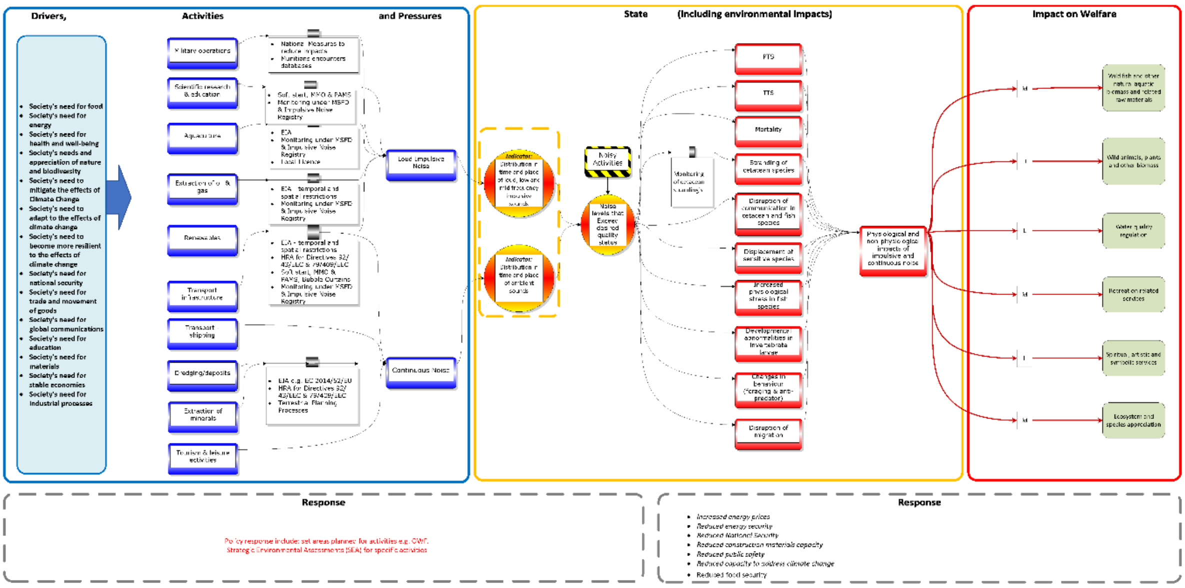
Cumulative Effects

Bow-tie diagram for underwater noise



Please Note: The Thematic Assessment and accompanying Bow Tie Analysis are ongoing pieces of work and should be regarded as draft. There may be areas and linkages that have not yet been identified. These will be added as the expert groups review and update the thematic assessments. Work on identifying the responses, management measures and impacts on ecosystem services has recently started. The thematic assessments and bow tie analysis will be updated with the outputs as they become available.

Bow-tie diagram aligns with the DAPSIR narratives in the Thematic Assessment - **provisional** confidence assessment: Medium (Medium Agreement on DAPSIR content + Medium Evidence to support connections) based on approach described in Agreement 2019-02

The bow-tie analysis for underwater noise shows the relationships between the DAPSIR components which need to be considered in a cumulative effects assessment. Human activities have been identified which exert either impulsive and / or continuous underwater noise pressures with the potential to both individually and cumulatively contribute to biodiversity state changes in the thematic assessments for:

- Fish - Input of anthropogenic sound (impulsive, continuous): Anthropogenic noise can result in behavioural impacts, physical and/or physiological impacts, masking and death. The behavioural impacts can be displacement and changes in swimming patterns, which can impact their fitness, survival and reproduction success. Masking due to anthropogenic noise makes it difficult to detect biologically important sound, and this can result in reduced survival for fish species. The physical and/or physiological impacts can be temporal threshold shift (TTS) or permanent threshold shift (PTS). (Hawkins & Popper, 2016)
- Marine Mammals - Input of anthropogenic sound (impulsive, continuous): Anthropogenic noise can have behavioural and physiological impacts on marine mammals. The behavioural impacts can be changes in resting, breathing, and diving patterns, vocalizations, changes between spatial relationships and avoidance behaviour. Masking due to anthropogenic noise may interfere with social interaction and communication. The physiological impacts can be temporal threshold shift (TTS) or permanent threshold shift (PTS). In the worst case, underwater noise can lead to injury or even death.

Input levels, frequency of occurrence, spatial extent and exposure to different human activities all collectively contribute to the extent to which underwater noise pressures are exerted on fish and marine mammals. To undertake a full quantitative analysis of cumulative effects requires consideration of the exposure pathways and ecological impacts. The annual risk maps for harbour porpoise (**Figure S.4** in the State section) exposure indices (**Figure S.5**) and the associated narrative provide an indication of cumulative disturbance trends from reported impulsive sound in the North Sea. Further analyses and evidence of ecological impacts are required in order to progress the assessment of cumulative effects.

Underwater noise can also combine with other pressures to collectively affect marine species and habitats. The assessment of cumulative effects is considered within the biodiversity Fish and Marine Mammal Thematic Assessments.

Climate change

Climate change and underwater noise

Climate change may affect levels of underwater noise, and the impact of noise on marine environments, in various ways. Changes in human activities resulting from climate change, or from policies to address climate change, can change the levels and / or distribution of underwater noise. Effects on the physical environment may also influence natural levels of ambient sound, or the extent to which noise is transmitted.

Reduction in Arctic ice may lead to increased noise from shipping activity. For example, a United Kingdom Government study noted that the Arctic shipping season could triple in length by mid-century, potentially saving 10-12 days on routes from East Asia to Europe. The scale of any increase remains uncertain, as there will be a trade-off between gains from the shorter distance and the higher costs of Arctic shipping. The impacts of increased Arctic shipping could extend beyond Arctic Waters, for example if new routes from European ports to the Arctic crossed areas currently less affected by shipping noise, such as the central North Sea. Changes in the Arctic environment may also allow tourism vessels to operate in more months of the year.

The major expansion of offshore wind energy referred to above will lead to increased piling and survey activity generating impulsive noise as well as continuous noise from the operation of the turbines themselves and from service vessels. The noise effects of other offshore energy sources, such as tidal energy, are unknown, although all human activities will cause extra underwater noise.

Changes to the spatial distribution of fish stocks and other marine organisms due to climate change may cause changes in the noise associated with fishing activity as well as, more generally, in the impact of underwater noise on different parts of the marine environment.

Effects on the physical environment which could influence natural levels of sound, or transmission of sound, include changes in ice coverage, temperature change (including stratification), sea-level rise and changes in weather, such as storminess.

Ocean acidification is a perturbation of the physicochemical environment of the world's oceans that changes the acidity of the water (pH). The way ocean acidification is influencing or could be influenced by underwater noise was considered when drafting this assessment, however no clear links were described at this time.

Thematic Metadata

Field	Explanation
Linkage	https://www.itap.de/media/experience_report_underwater_era-report.pdf https://doi.org/10.1016/j.scitotenv.2018.12.346 https://doi.org/10.1126/science.aba4658 https://www.eea.europa.eu/publications/maritime-transport/ https://www.helcom.fi/wp-content/uploads/2019/08/BSEP167.pdf https://doi.org/10.1093/icesjms/fsw205 https://www.nature.com/articles/s41598-019-51222-9 http://www.imo.org/en/MediaCentre/HotTopics/Documents/833%20Guidance%20on%20reducing%20underwater%20noise%20from%20commercial%20shipping%2C.pdf https://tethys.pnnl.gov/publications/noise-mitigation-construction-increasingly-large-offshore-wind-turbines

	https://www.gov.scot/publications/acoustic-deterrent-device-add-use-aquaculture-sector-parliamentary-report/ https://doi.org/10.1038/s41559-017-0195 https://doi.org/10.1002/ece3.4458 https://pub.dega-akustik.de/DAGA_2010/data/articles/000140.pdf https://doi.org/10.1016/j.envint.2021.107014 https://doi.org/10.1038/ncomms10544 https://doi.org/10.1016/j.tree.2010.04.005 https://doi.org/10.1038/srep20540 https://www.noordzeeloket.nl/publish/pages/153829/measures_to_reduce_underwater_noise_and_beach_litter_an_assessment_of_potential_additional_measures_.pdf https://doi.org/10.1121/10.0002453 https://unctad.org/system/files/official-document/rmt2021_en_0.pdf https://tcdocs.ingeniumcanada.org/sites/default/files/2019-07/Ship%20Underwater%20Radiated%20Noise%20v5.pdf https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=1058:assessing-the-impact-of-underwater-clearance-of-unexploded-ordnance-on-harbour-porpoises-phocoena-phocoena-in-the-southern-north-sea&catid=61&Itemid=157 https://www.masts.ac.uk/media/36069/2016-abstracts-gen-sci-session-3.pdf https://www.oceancare.org/wp-content/uploads/2017/10/OceanNoise_FishInvertebrates_May2018.pdf. https://dredging.org/documents/ceda/html_page/2013-06-woda-technicalguidance-underwatersound_lr.pdf
Relevant OSPAR Documentation	OSPAR Agreement 2014-08 Monitoring Guidance for Underwater Noise in European Seas. OSPAR Agreement 2014-10 Explanatory notes - Impulsive noise monitoring reporting format. OSPAR Publication 2016-706 OSPAR inventory of measures to mitigate the emission and environmental impact of underwater noise (2016 update). OSPAR Agreement 2017-07 CEMP Guidelines for Monitoring and Assessment of loud, low and mid-frequency impulsive sound sources in the OSPAR Maritime Region. OSPAR Agreement 2021-05 CEMP Guidelines for the candidate indicator on ambient underwater noise. OSPAR Publication 2022-884 Distribution of Reported Impulsive Sounds in the Sea OSPAR Publication 2022-885 Risk of Impact from Anthropogenic Impulsive Sound OSPAR Publication 2022-886 Pilot Assessment of Ambient Noise

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: 880/2022