OSPAR COMMISSION

Area of Habitat Loss

Pilot Assessment

OSPAR

QUALITY STATUS REPORT 2023

2023

OSPAR's Quality Status Report 2023

Pilot Assessment of Area of Habitat Loss

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

Contributor

Authors: Petra Schmitt, Cristina Vina-Herbon and Liam Matear

Delivered by

This work was co-funded by the European Maritime and Fisheries Fund through the project: "North-east Atlantic project on biodiversity and eutrophication assessment integration and creation of effective measures (NEA PANACEA)", financed by the European Union's DG ENV/MSFD 2020, under agreement No. 110661/2020/839628/SUB/ENV.C.2.

Citation

Schmitt, P., Vina-Herbon, C. and Matear, L. 2023. *Pilot Assessment of Area of Habitat Loss*. In: OSPAR, 2023: The 2023 Quality Status Report for the North-East Atlantic. OSPAR Commission, London. Available at: https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/indicator-assessments/area-habitat-loss-pilot

Contents

Key Message

Habitat loss is caused by sealing and by other activities leading to substrate changes. 92 km² were lost to offshore structures assessed in the Greater North Sea. A risk assessment highlights areas and habitat types most at risk from bottom trawling. Not all structures and activities contributing to loss are covered.

Message clé

La perte d'habitat est causée par l'étouffement du substrat et par ses changements dues à d'autres activités. 92 km² ont été perdus à cause des structures offshore évaluées dans la Mer du Nord au sens large. Une évaluation des risques met en évidence les zones et les types d'habitats les plus menacés par le chalutage de fond. Toutes les structures et activités contribuant à la perte ne sont pas couvertes.

Background (brief)

The indicator aims to estimate the extent and proportion of benthic habitat types that is lost due to human activities. Habitat loss may be caused by placement of offshore structures like foundations of wind turbines or by disposal of sediments onto the seafloor (sealed loss). Physical disturbance with a very high intensity may also alter the habitat type and therefore lead to a loss of habitat area (unsealed loss). This pilot assessment focuses on offshore structures that cause a sealed loss of the seabed. A risk assessment is produced for unsealed loss by bottom trawling and aggregate extraction. The impact of sealed loss is estimated for benthic broad habitat types as well as for the OSPAR listed threatened and / or declining habitat types.

The assessment of habitat loss complements the assessment of physical pressures on benthic habitats together with the Common Indicator BH3 on the 'Extent of physical disturbance to benthic habitats' (**Figure 1**). While BH3 focuses on the response of the biological community to physical disturbance, BH4 targets the change of the habitat type as defined by depth and sediment type due to very high disturbance by bottom trawling, aggregate extraction or the placement of structures. While habitat loss can also be caused by biological and hydrological pressures, this pilot assessment is restricted to habitat loss by physical pressures (physical loss).

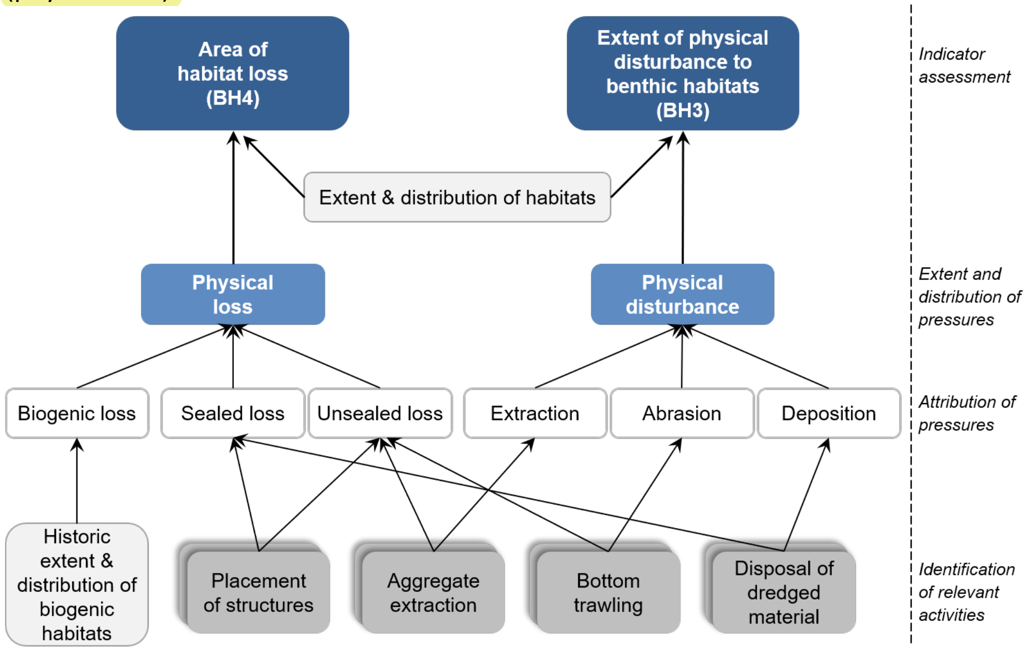

Figure 1: Conceptual overview of the indicator methodology showing the components for the assessment of habitat loss by physical pressures (BH4) and physical disturbance (BH3).

Background (extended)

Physical loss is defined as a permanent change of the seabed that is defined as a change which has lasted or is expected to last for 12 years or more, whereas physical disturbance (assessed by BH3) is understood as a change to the seabed from which it can recover if the activity causing the disturbance pressure ceases (Commission Decision 848/2017). The definition of physical loss includes the loss of marine habitat area by sealing with structures or sediment as well as the permanent change of the seabed by human activities. According to the Commission Decision 848/2017, permanent changes relate to natural seabed substrate type or morphology. The indicator uses the European Nature Information System (EUNIS) 2019 level 2 habitat classifications as a basis for defining changes in broad habitat types: Physical loss means a shift in habitat type from one category to another, e.g., from circalittoral mud (MC6) to circalittoral sand (MC5).

The indicator distinguishes between three types of physical loss: sealed loss, unsealed loss and the historic loss of biogenic habitat (ICES 2019a). Sealed loss results from the placement of structures in the marine environment (e.g., foundations of wind turbines, platforms) and also from the introduction of substrates that seal off the seabed (e.g., dredge disposal). Unsealed loss results from permanent changes in physical habitat caused by human activities (e.g., bottom trawling, aggregate extraction) and by indirect effects of placement of man-made structures (e.g., a structure causing hydrological changes that ultimately change the habitat type at EUNIS level 2). Activities like trawling and dredging also cause disturbance or changes to the biological community, but these biological alterations are assessed with the indicator 'Extent of physical disturbance to benthic habitats' (BH3). Estimating loss of historic biogenic habitats relies on the availability of relevant historical records and / or the development of appropriate habitat suitability models in order to estimate historic distribution and the extent of biogenic habitats (ICES 2019a). The present assessment is limited to the assessment of selected activities causing sealed and unsealed loss on the present distribution of habitat types, including biogenic habitats. Loss of historic biogenic habitat may be considered in a future assessment.

Loss of habitat is of most concern for habitats of special interest, often defined by long-lived and bio-engineering species such as reefs of cold-water corals, horse mussels (*Modiolus modiolus*) or reefs of the ross worm (*Sabellaria spinulosa*), due to their specific habitat requirements, the long-term recovery and their often limited natural extent. Changes in the extent of these habitats may be caused not only by sealing but also by other anthropogenic physical influences such as bottom-trawl fisheries (Roberts *et al.*, 2000, Strain *et al.*, 2012) or by climate change in changing the distribution of species forming biogenic habitats (Morato *et al.*, 2020). Small-scale boulder reefs may also be endangered by bottom trawling in some areas, as boulders could be moved and submerge in the seabed or be extracted by fishing gears.

Any habitat type can be assessed with this indicator through a spatial analysis that combines pressure and habitat data with information on the impact of those pressures on the habitats. The spatial distribution and extent of habitat area can be based on survey data or on predictive habitat modelling. The indicator is applicable to broad- and small-scale habitat types across the North-East Atlantic region. The assessment is largely built on a modelling approach; this is cost-efficient as it maximises the use of data from several sources and it is not dependent on monitoring data. However, access to data on the spatial extent and intensity of licensed and other activities causing physical loss is a necessary prerequisite to ensure the spatial footprint of activities is accurately assessed.

Assessment Method

1 General methodology

The metric of this indicator is the area of a given habitat that is predicted to have been lost due to anthropogenic activities per assessment unit. The two mechanisms leading to loss, sealed and unsealed loss, require different assessment approaches (**Figure a**). The components of the analysis for sealed loss are the extent and distribution of activities causing habitat loss and the extent and distribution of benthic habitat types. The placement of structures invariably leads to a loss of habitat area, regardless of the sediment and hydrodynamic characteristics.

The assessment of unsealed loss includes further information on the intensity of the activity, as only activities with a very high intensity and / or duration may cause severe sediment changes. In addition, the risk of habitat loss depends on the susceptibility of the habitat type to sediment alterations. The extent and proportion of loss or risk of loss per habitat type and assessment unit is obtained by spatially combining the different components of the analysis.

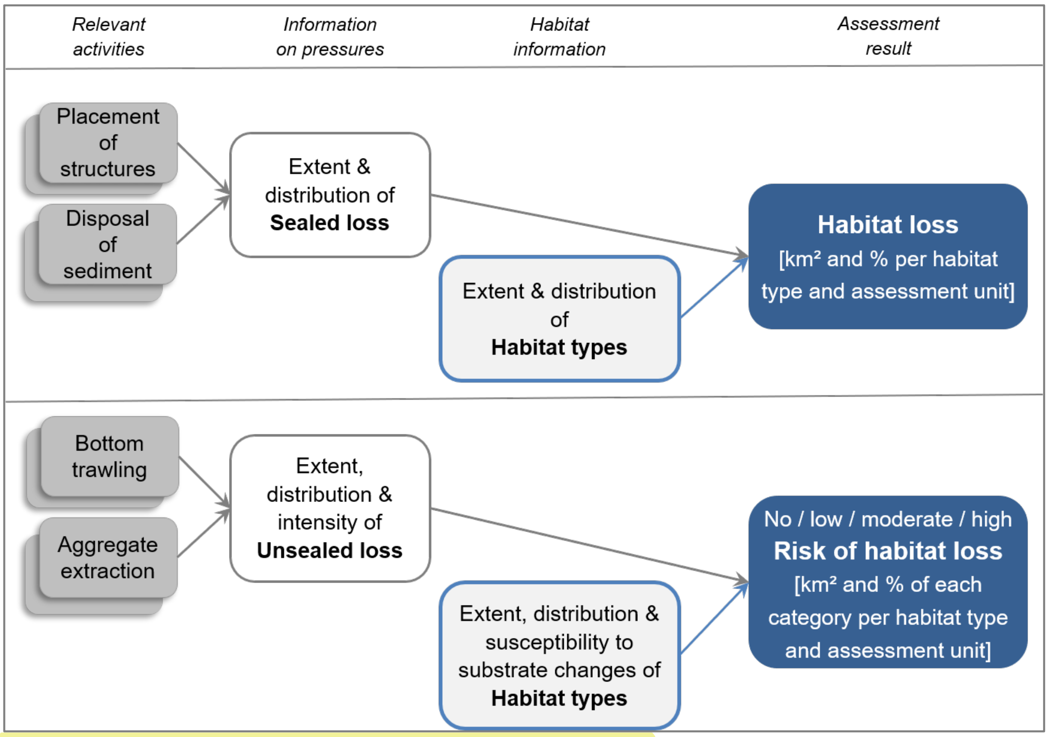

Figure a: Assessment method for sealed and unsealed loss.

2 Assessment area

The pilot assessment is presented for the MSFD (Marine Strategy Framework Directive) Sub-region 'Greater North Sea, including the Kattegat and the English Channel', which is similar to the OSPAR Region 'Greater North Sea', but without the section to the north-west of Shetland. Five benthic assessment units have been distinguished in the Greater North Sea: Channel, Southern North Sea, Central North Sea, Kattegat and Norwegian Trench.

3 Habitat types assessed

The spatial assessment of this indicator is undertaken at EUNIS level 3 as classified by EMODnet EUNIS 2019 (EUSeaMap 2021) and for OSPAR threatened and / or declining habitats (OSPAR 2020a, b). The spatial extent of habitat loss is calculated per region and assessment unit.

3.1 Broad habitat types

The results for broadscale habitat types used in the assessment are defined according to the EUNIS 2019 habitat classification at level 3 (**Figure b**). Level 3 of EUNIS (which is the same as level 2 except that it also differentiates according to biogeographic region) was chosen as there are Atlantic as well as some Arctic habitat types present in the Greater North Sea. The EUNIS 2019 classification is closely aligned with the MSFD classification for Benthic Broad Habitat Types (**Table a**). EUNIS 2019 additionally distinguishes between 'rock' and 'biogenic habitat' which is particularly important for the assessment of the risk of loss by trawling. In the MSFD classification both are combined as 'rock and biogenic reef'. Also, in the MSFD classification the deeper sediments (e.g., upper bathyal) are not further differentiated according to the prevailing sediment type. Areas with no sediment information or with no clear assignment to a benthic broad habitat type were listed as 'no habitat data'.

The data source selected for this assessment is the 2021 EMODnet broad-scale seabed habitat map for Europe, known as EUSeaMap (Vasquez *et al*., 2021). It should be noted that the current EUSeaMap separates sand and mud habitats at a mud content of 10%, whereas according to the EUNIS classification mud habitats are defined by a mud content of 20%. Also, the definition of substrate types is often not clear in the EUNIS habitat classification and therefore the assignment of broad habitat types may be handled differently by the

Contracting Parties. For example, boulder reefs could be reported as mixed sediments or as rock which would have an effect on the probability of loss (see section 4.4). The EUSeaMap is further restricted to sublittoral habitats and does not include littoral substrates. An assessment of sealed and unsealed loss for littoral sediment and littoral rock and biogenic reef could therefore not be accomplished.

Table a: EUNIS 2019 and MSFD classification of broad habitat types assessed in the Greater North Sea.

EUNIS 2019 Code	EUNIS 2019 Habitat type	MSFD Benthic Broad Habitat Type
MB12	Atlantic infralittoral rock	Infralittoral rock and biogenic reef
MB22	Atlantic infralittoral biogenic habitat	
MB32	Atlantic infralittoral coarse sediment	Infralittoral coarse sediment
MB42	Atlantic infralittoral mixed sediment	Infralittoral mixed sediment
MB52	Atlantic infralittoral sand	Infralittoral sand
MB62	Atlantic infralittoral mud	Infralittoral mud
MC12	Atlantic circalittoral rock	Circalittoral rock and biogenic reef
MC22	Atlantic circalittoral biogenic habitat	
MC32	Atlantic circalittoral coarse sediment	Circalittoral coarse sediment
MC42	Atlantic circalittoral mixed sediment	Circalittoral mixed sediment
MC52	Atlantic circalittoral sand	Circalittoral sand
MC62	Atlantic circalittoral mud	Circalittoral mud
MD12	Atlantic offshore circalittoral rock	Offshore circalittoral rock and biogenic reef
MD22	Atlantic offshore circalittoral biogenic habitat	
MD32	Atlantic offshore circalittoral coarse sediment	Offshore circalittoral coarse sediment
MD42	Atlantic offshore circalittoral mixed sediment	Offshore circalittoral mixed sediment
MD52	Atlantic offshore circalittoral sand	Offshore circalittoral sand
MD62	Atlantic offshore circalittoral mud	Offshore circalittoral mud
ME11	Arctic upper bathyal rock	Upper bathyal rock and biogenic reef
ME12	Atlantic upper bathyal rock	
ME42	Atlantic upper bathyal mixed sediment	Upper bathyal sediment
ME52	Atlantic upper bathyal sand	
ME62	Atlantic upper bathyal mud	

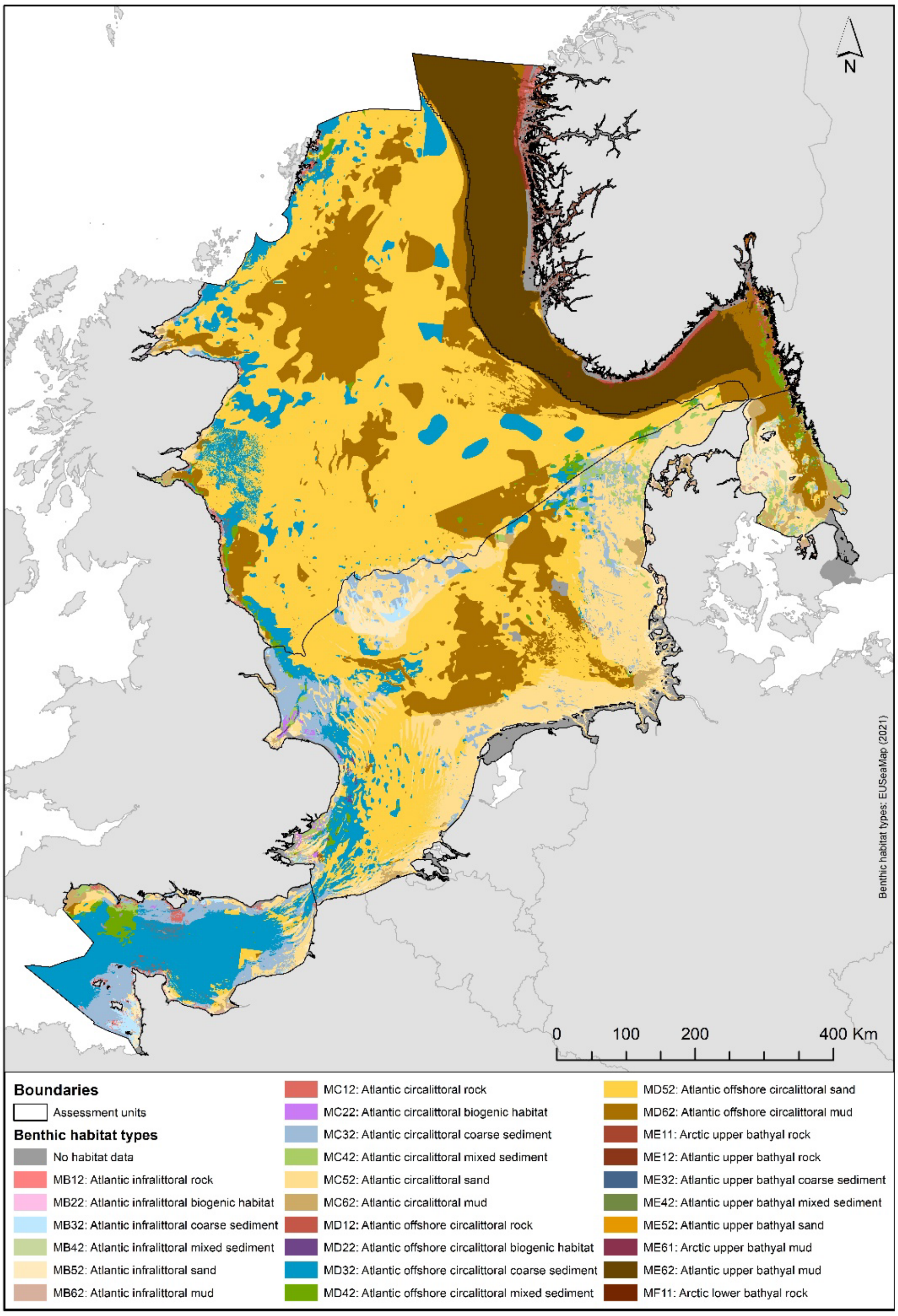

Figure b: Benthic broad habitat types at EUNIS classification (2019) level 3 in the Greater North Sea according to EUSeaMap 2021 (Vasquez *et al* 2021).

3.2 OSPAR Threatened and / or declining habitat types

The OSPAR list of threatened and/or declining species and habitats includes habitat types at a finer level of detail than the broad habitat types, which are usually defined by a dominant species. A composite data product showing the best available evidence on the extent and distribution of these habitats is periodically compiled for OSPAR by its Contracting Parties. The version used in this assessment was version 2020 (OSPAR 2020a, b). It contains a mixture of polygon and point data **(Table b, Figure c)**.

OSPAR Contracting Parties have submitted spatial information on threatened and / or declining habitats as polygon and as point data (OSPAR 2020a, b). A spatial assessment of sealed loss was produced for polygon data. Where only point data were available, the presence of points near offshore structures was assessed. In order to estimate the impact, an arbitrary buffer around the structures with a radius of 2 km was applied and

the number of points in this area was summed up per habitat type. Intertidal mudflats were excluded from the analysis, as there were in some areas several habitat polygons from different submission years on top of each other that required high computing capacities and produced uncertain results. Kelp forests and *Haploops* habitat have recently been added to the OSPAR List but were not included in the analysis because there was not yet any data on their extent or distribution in the data product.
The impact of unsealed loss on threatened and / or declining habitat types has not yet been assessed, as both habitat and activities data are associated with considerable uncertainties (see Confidence section).

Table b: Data availability for OSPAR Threatened and / or declining habitats present in the Greater North Sea.

Habitat type	Polygon data	Point data
Coral gardens		X
Deep-sea sponge aggregations		X
Intertidal mudflats	X*	X*
Intertidal *Mytilus edulis* beds on mixed and sandy sediments	X	X
Littoral chalk communities	X	X
Lophelia pertusa (*Desmophyllum pertusum*) reefs		X
Maerl beds	X	X
Modiolus modiolus horse mussel beds	X	X
Ostrea edulis beds	X	X
Sabellaria spinulosa reefs	X	X
Sea-pen and burrowing megafauna communities	X	X
Zostera beds	X	X

* not included in the BH4 assessment

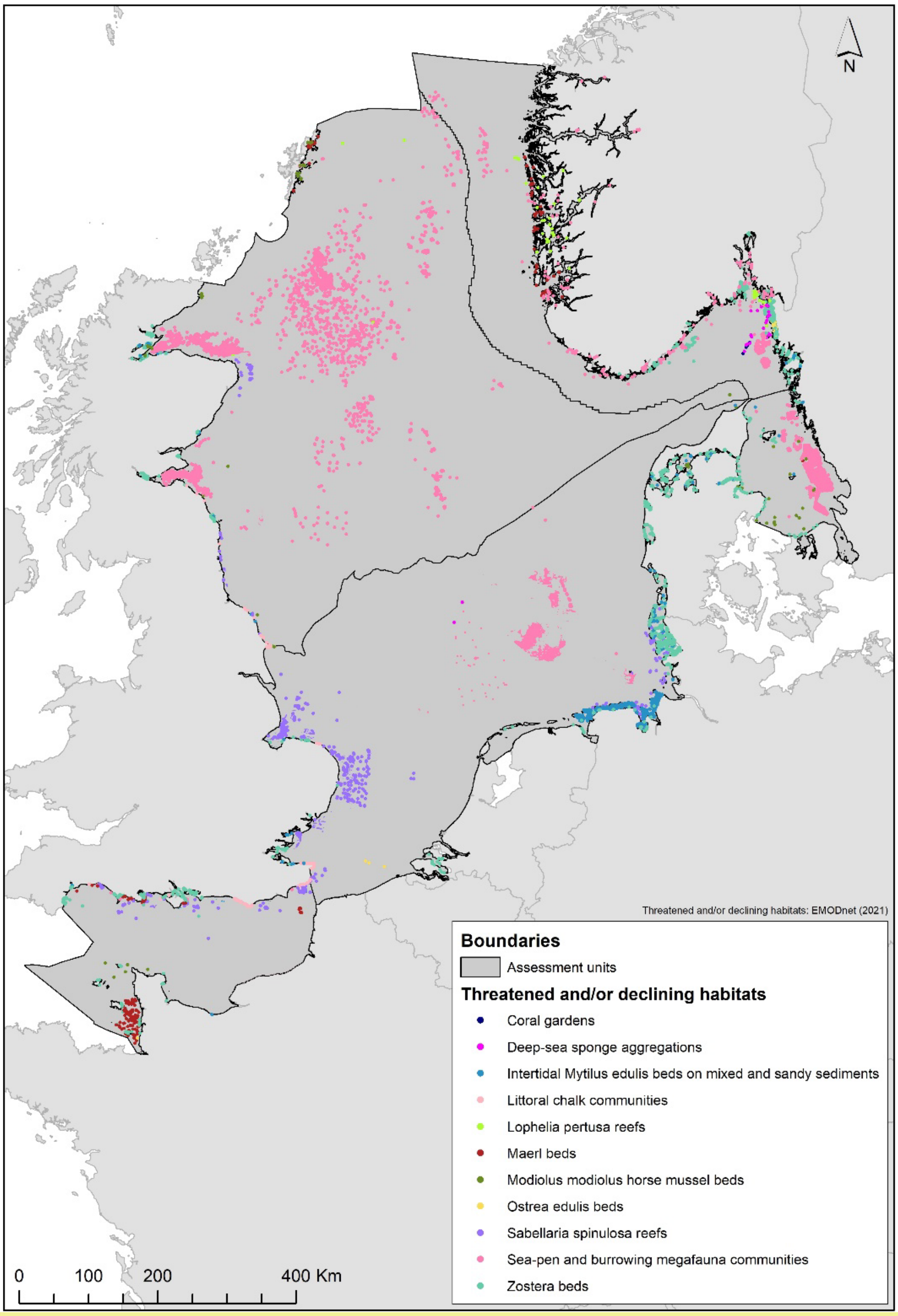

Figure c: OSPAR Threatened and / or declining habitats in the Greater North Sea as used in the BH4 assessment according to OSPAR (2020a, b).

4 Assessment of human activities

The spatial extent of sealed loss caused by offshore installations (offshore wind farms, oil and gas platforms and pipelines) is assessed with the actual extent of the structure and / or a buffer that gives an estimate of the spatial footprint of habitat loss (see section 4.1 to 4.3). Aggregate extraction and bottom trawling can be assigned to both loss and disturbance, depending on the intensity of the pressure and the probability of sediment changes. For these unsealed loss pressures, a risk assessment is carried out taking into account various factors in order to highlight areas where a habitat may have already changed or is subject to a higher risk of alteration.

The assessment of human activities includes all offshore structures that are currently present in the Greater North Sea. For bottom trawling, aggregated datasets for the time periods 2009-2014 and 2015-2020 were used. The assessment of aggregate extraction includes the present distribution of licensed areas and the areas and amounts dredged in 2019. Data sources for offshore structures are summarised in **Table c**.

4.1 Offshore wind farms

The footprint of physical loss caused by wind farms includes the area sealed by the foundations of the turbines and supporting platforms as well as the area sealed by scour protection. The size of the area sealed depends on the type of foundation used. Monopiles have been chosen for more than 80% of the installed offshore wind farms to date (EWEA 2019). The diameter of a monopile depends on the water depth and may extend up to 7.8 m (e.g., wind farm Veja Mate, Germany). The average diameter of a monopile is approximately 5 m (Negro *et al*., 2017). Tripods or tripiles (three legs) and jackets (four legs) are anchored by driven or drilled piles, typically ranging from 0,8 to 2,5 m in diameter. These types of foundations are used with larger turbines and may be located in deeper waters (EWEA 2019). Gravity based structures have also been used on several projects. The diameter depends on the foundation type and varies between 16 m (e.g., Middelgrunden, Denmark) and 23,5 m (e.g., Thornton Bank, Belgium) and may reach a size of approximately 30 m diameter in future projects (Esteban *et al*., 2019). Gravity-based structures can also vary in shape; they may be circular or rectangular. If the size of the foundation and the extent of scour protection is not known, a buffer has to be applied to account for the area lost. Buffers for pile foundations (including scour protection) used in scientific literature range from 15 m (e.g., Foden *et al*., 2011) to 30 m (HELCOM 2017). The type of the foundation is available from the ODIMS dataset on offshore renewable energy developments, therefore a buffer based on the foundation type can be applied (**Table c**). As the exact locations of the piles are not known, the footprint of the foundations is added up per wind farm polygon and assigned to the prevailing habitat type.

4.2 Oil and gas platforms

Platforms for the extraction of oil and gas are usually founded on jacket structures with mostly four legs and a diameter of 1-2 m each (Eastwood *et al*., 2007). The area sealed by the structure as well as scour protection is considered as loss. Information on oil and gas platforms is only available as point data, therefore a buffer for the area impacted has to be applied. In addition to the presence of fixed structures, physical loss is caused by the accumulation of drill cuttings around operational platforms. Activity footprints to account for the effects of drill cuttings vary from a radius of 100 m (Foden *et al*., 2011) to 500 m (Eastwood *et al*., 2007). However, most studies included also changes that were observed in benthic communities (e.g., reduced abundance or diversity) and not in sediment characteristics. According to Foden *et al*., (2011), the drill cuttings have been reported to reach approximately 100 m from the well, therefore this radius is used as a standard dimension for operational oil and gas platforms.

Other platforms, e.g., for accommodation or processing, were assigned a buffer according to the dimensions of the foundation and similar to those used for offshore wind farms (**Table c**). If the type of the foundation is not known, it is assumed that a jacket with four legs is used, as this is the most frequently installed structure. This applies to 13% of the dataset. Platforms that are classified as ‘decommissioned’ or ‘derogation’ were included in the assessment, as generally the subsea structures remain in place and continue to cause physical loss. The effect of drill cuttings is not assessed for decommissioned platforms, however, as the date of decommissioning is generally not available, there may still be areas that have not yet recovered from these impacts.

4.3 Oil and gas pipelines

Pipelines are usually laid directly on the sea floor without further coverage. The area lost includes the pipeline itself as well as a buffer for sediment changes occurring around the structure. Published pressure assessments accounting for loss by pipelines either used the exact dimensions of the pipelines without considering alterations of the sediment around (e.g., Eastwood *et al*., 2007, Foden *et al*., 2011) or applied a buffer with a radius of up to 15 m (HELCOM 2017). Data on the length and for the majority (92,5%) of pipelines in the Greater North Sea also the exact diameter is available from EMODnet. If the exact dimensions of a pipeline are not known, the size can also be estimated from the length of the pipeline, as with increasing pipeline length the diameter also increases. For the remaining 7,5% of pipelines without size information, a standard diameter is thus calculated. The exact dimensions or dimensions estimated from length are used to assess sealed loss due to the structure of the pipeline. In order to account for sediment changes by scouring, the diameter of the pipeline is used as a buffer on each side (**Table c**).

Table c: Activity footprints and data sources for the assessment of offshore structures.

Activity	Structure	Buffer	Footprint for physical loss	Data source
Offshore wind farms	Monopile	15 m	707 m²	ODIMS Offshore renewable energy developments (2020) EMODnet Wind farms (2021)
	Tripod / tripile / jacket	20 m	1 257 m²	
	Gravity-base / suction bucket	30 m	2 827 m²	
Oil and gas platforms - operational	Physical structures and impacts by drill cuttings	100 m	31 416 m²	ODIMS Inventory of offshore installations (2019) EMODnet Oil and gas offshore installations (2020)
Oil and gas platforms – inactive or infrastructure	Monopile	15 m	707 m²	
	Jacket with 3 or 4 legs	20 m	1 257 m²	
	Jacket with 6 or 8 legs	25 m	1 963 m²	
	Jacket with 12 legs / gravity-base	30 m	2 827 m²	
Oil and gas pipelines	Pipelines resting on the surface of the seabed	3 x diameter	dependent on size	EMODnet Pipelines (2019)

4.4 Bottom trawling

Intense bottom trawling may lead to a change in sediment type by abrasion and resuspension of sediment. The main factors determining the impact on the physical habitat are trawling intensity, prevailing sediment type and the hydrodynamic regime (Jennings & Kaiser 1998, Mengual *et al*., 2016, Oberle *et al*., 2016). Physical loss as a result from bottom trawling may occur when biogenic substrates are affected by abrasion (e.g., *Ostrea edulis* beds, *Sabellaria* reefs, *Lophelia* reefs, Modiolus beds). Depending on the life-history traits and distribution of the affected species, recovery of the reef structures may take several decades or may not take place at all (e.g., Fariñas-Franco *et al*., 2014, Kaiser *et al*., 2018, Perry *et al*., 2020, Tillin 2016, Tillin *et al*., 2020, Tyler-Walters *et al*., 2019). Biogenic habitats display the highest vulnerability of all substrate types to trawling and low intensities of trawling may suffice to result in severe disturbances and physical loss.

Another impact from bottom trawling is the resuspension of sediments that can lead to a change in the grain size composition of soft sediments. Both coarsening and fining of trawled areas have been described, depending on the affected sediment and the hydrodynamic setting in the fished area and its surroundings (Mengual *et al*., 2016, Oberle *et al*., 2016, Trimmer *et al*., 2005). Fining of the sediment occurs when the top layer of the sediment is reworked by fishing gear and fine sediment particles settle on top of the heavier, coarser particles resulting in a changed vertical sediment distribution. Fining also occurs when trawl marks and scars are filled up with fine sediment that are transported by currents from adjacent areas. A coarsening of the sediment has been reported for muddy sediments when bottom trawling stirs up the silt fractions of the sediment which get transported away from the trawled area by bottom currents (Mengual *et al*., 2016, Oberle *et al*., 2016). Depending on the fishing intensity and the hydrodynamic setting in the area, these changes in the sediment structure may lead to long term alterations of the habitat type indicating physical loss of the initial habitat.

Geogenic hard substrates are not assumed to suffer a substantial loss of rocky habitat area, as they are relatively resistant to physical damage from fishing gears. Steep and rocky substrata are unsuitable for trawling and are generally avoided by fishermen (Roberts *et al*., 2010, Hintzen *et al*., 2021). Towed gears may displace or overturn rocks and lead to a reduced habitat complexity, but a change of habitat type at a larger scale is considered unlikely. However, smaller boulders may disappear due to shifting by fishing gears and sinking in surrounding softer sediments or they may be extracted and displaced. This is not covered in the assessment, as rock habitats are herein considered as solid rocky surface area (i.e., bed rock). Due to the ambiguous EUNIS definition for rock, hard and mixed sediments, it is not clear how boulder reefs have been classified in the EUSeaMap. The probability of loss for the different substrate types may therefore have to be adapted in future assessments, when the EUNIS and MSFD habitat types have been clearly defined and aligned.

Table d: Impact by bottom trawling and probability of loss per substrate type.

Substrate type	Trawling impact	Probability of habitat loss
Rock	Displacement, overturning of rocks, reduction of complexity	None: Trawling disturbance is unlikely to affect larger areas
Biogenic habitat	Destruction of reef structure	Very high: Loss may occur already at low trawling intensities; recovery of reef-forming species is generally low due to slow growth rate and / or sporadic recruitment
Coarse sediment	Trawl marks, overturning and removal of stones and cobbles, siltation	Medium / high, depending on hydrodynamic regime: Fining (refilling of trawl marks with finer sediment) may occur at very high trawling intensities and low current velocities at seabed Slow recovery, as coarse sediment particles are less likely to be transported by currents from adjacent areas
Mixed sediment	Removal of stones and cobbles, increase of sediment sorting	Medium: Loss of habitat may occur when the heterogeneity of the sediment is reduced by e.g., removal of coarse fraction
Sand	Trawl marks, fining of sediment due to siltation processes	Low: Disturbed sandy areas may be refilled by similar particles in a short time span Sediment particle size distribution may shift to finer particle sizes but a permanent change of sediment classification is unlikely
Mud	Winnowing of the silt fraction of the sediment, coarsening of sediment	Medium / high, depending on hydrodynamic regime: Fine sediments are resuspended and transported away by currents, larger particles remain Coarsening may occur at very high trawling intensities and increased sediment transport

Based on a literature review of the impacts of bottom trawling on different substrates (**Table d**), the probability of habitat loss of the main sediment types has been defined (**Table e**). Particularly for coarse sediments and mud, the hydrodynamic regime has been identified as essential with regard to the likelihood of sediment changes. In order to estimate the intensity of hydrodynamic conditions, the energy classification for habitat types from EMODnet EUSeaMap broad-scale seabed habitat map for Europe, EUSeaMap (version 2021) is used which combines both current and wave energy data, selecting the highest of the two energy layers and producing three grades of exposure (Populus *et al*., 2017). Wave and current energy are generally higher in shallower coastal areas and lower in offshore areas, thus increasing the risk for infralittoral and circalittoral mud habitats and for deeper coarse sediments.

Table e: Assessment of probability of habitat loss to trawling by combining substrate types with energy at the seabed.

Probability of loss	Substrate type					
Energy at the seabed	Biogenic habitat	Coarse sediment	Mud	Mixed sediment	Sand	Rock
Low energy	very high	high	medium	medium	low	none
Moderate / high energy	very high	medium	high	medium	low	none

Trawling disturbance is assessed as ‘swept area ratio’ (SAR) or proportion of cell area swept per year. The swept area is calculated as the width of the fishing gear multiplied by the average vessel speed and the time fished. The SAR is then calculated by dividing the swept area by the grid cell area. Studies on the physical impact indicate that strong sediment disturbances only become visible at SAR > 8 (Mengual *et al*., 2016, Oberle *et al.*, 2016, Schratzberger & Jennings 2002). Therefore, it is assumed that habitat loss is unlikely to occur at trawling intensities of SAR < 8, except for habitats with a very high probability of habitat loss, where SAR > 0-8 is considered a moderate risk. At trawling intensities higher than that value, first signs of habitat alterations can become apparent and especially for biogenic habitats, mechanical destruction can lead to habitat loss. At SAR > 16 the risk of habitat loss is assumed to be further increasing, depending on the susceptibility of the habitat type to sediment changes. Oberle *et al.*, (2016) and Mengual *et al.*, (2016) observed high or very high sediment alterations at SAR values > 16. Based on these findings, a matrix has been produced that determines four categories for risk of habitat loss (none, low, moderate and high) by combining probability of loss and trawling intensity (**Table f**).

Table f: Matrix showing the risk of loss due to bottom trawling by combining probability of loss and trawling intensity (SAR = Swept Area Ratio, mean annual value over the 6-year assessment period).

Risk of loss	Probability of habitat loss			
Trawling intensity	Low	Moderate	High	Very high
SAR = 0	none	none	none	none
SAR ≤ 8	none	none	low	moderate
SAR > 8-16	none	low	moderate	high
SAR > 16	low	moderate	high	high

For the assessment of loss by bottom trawling, data provided by ICES (Data for OSPAR request on the production of spatial data layers of fishing intensity/pressure 2021) were used. The average SAR values were calculated per c-square (grid cell) for the time periods 2009-2014 and 2015-2020. Both assessment periods were analysed in the same way, which means that results from the first period were not taken into account for the second time period.
Sweden provided a spatial layer for a fishery exclusion area in the Kattegat, where it is despite available VMS records assumed that no fishing occurs. In fact, SAR values in this area were consistently below 8.

4.5 Aggregate extraction

Extraction of sand and / or gravel is considered as physical loss when the dredging activity changes the sediment type. An alteration of the sediment may take place by several mechanisms, depending on the method used or the intensity of the impact.
Stationary or anchor dredging creates local depressions of 5-10 m or more in depth that remain visible after decades. Backfilled material is generally composed of finer material than previously existed in the area (Mielck *et al.*, 2021, Newell & Woodcock 2013, Petersen *et al.*, 2018). This type of dredging can therefore lead to considerable alterations in seabed topography, hydrodynamics and sediment composition.
The sediment composition may also change if on-board screening is applied: The dredged material is passed over a mesh screen and a proportion of the finer sediment is returned to seabed, while the coarser sediment is retained on board the dredger. It has been estimated that in order to obtain a gravel:sand ratio of 60:40 from a typical North Sea deposit with a relatively low gravel content, it is necessary for the operating vessel to return approximately 60% of excess sand to the seabed (Newell & Woodcock 2013). Still, water currents may remove these fine sediments so that the seabed will become coarser again over time (Tillin *et al.*, 2011). The extent to which this occurs depends on the prevailing hydrodynamic regime and the degree of natural mobility of sediment particles or larger-scale bedforms.
Long-term intense dredging may also lead to physical loss of the sediment type. The most commonly used dredging method in the North Sea is trailer suction dredging. This method creates shallow furrows that are generally 2-3 m wide and initially approximately 0,5 m deep. Over time however, the seabed may be lowered by up to 3 m (Tillin *et al.*, 2011). The changed seabed topography and dredge furrows often reduce current velocity so that the deposition of fine particles increases (Hill *et al.*, 2011).
Physical recovery at aggregate sites where dredging had ceased is generally reported to be dependent on dredging intensity, substrate type and the hydrodynamic regime (Foden *et al.*, 2009, Hill *et al.*, 2011, Desprez 2012). The fastest restoration occurs in sandy deposits with strong tidal streams, where physical recovery was observed to last 1 to 3 years. Reported recovery rates for coarser deposits which are mainly targeted for

aggregate extraction were amongst the slowest, with a recovery time for the physical substrate of as much as 20 years (Foden *et al*., 2009). Hill *et al*., (2011) predict a slow recovery (years to decades) for coarse sediments in a low or moderate energy environment and where dredging intensity is high and affects a larger area. Desprez (2012) expected physical recovery times of more than 10 or even 20 years in sites with stationary dredging and also with intensive trailer suction dredging in coarse sediments and low energy sands.

Sediments that are subject to aggregate dredging are predominantly coarse and sandy substrates, but also mixed sediments. Vulnerable habitats such as biogenic habitats and rocks may occur in the vicinity of extraction sites and may be impacted by sedimentation and increased turbidity. Sedimentary changes have been detected at distances up to 2 km from dredge sites after sediment remobilisation by strong local tidal currents (ICES 2019b). However, these effects are regarded as temporary and not causing long-lasting impacts. This indicator therefore assesses only habitats directly impacted by extraction.

Based on the described impacts and recovery times, the risk of loss for the habitats concerned in relation to the dredging method and its intensity (where relevant) is estimated (**Table g**).

Table g: Matrix showing the risk of loss due to aggregate extraction according to the combination of sediment type and energy at the seabed with dredging method and intensity.

Risk of loss	Sediment type / energy at the seabed					
	Sand		Mixed sediment		Coarse sediment	
Dredging method / intensity	low/moderate energy	high energy	low/moderate energy	high energy	low/moderate energy	high energy
Trailer suction dredging / low	none	none	none	none	none	none
Trailer suction dredging/moderate	low	none	low	none	moderate	none
Trailer suction dredging / high	moderate	low	moderate	low	high	moderate
Screening	-	-	high	moderate	high	moderate
Anchor dredging	high	high	high	high	high	high

The intensity of trailer suction dredging can be defined by the time dredged or by the amount extracted per area. Assessing the risk of loss by aggregate extraction requires detailed information on the method employed, the area dredged and the intensity. As these data are only partly available at present, the assessment is currently confined to a description of dredging activities and an estimation of whether loss by extraction is probable.

5 Combining pressures and habitat types

The pressure layers for offshore structures, bottom trawling and aggregate extraction are spatially combined with the habitat layers in a Geographical Information System (GIS) in order to estimate the area and proportion per habitat type that is lost or subject to a higher risk of loss. The spatial extent of area lost or with a risk of loss was summed and presented in terms of area (km²) and as a proportion (%) of the total area of the assessed habitat type per assessment unit.

Results

Sealing by offshore structures leads to an estimated loss of approximately 92 km² (0,014%) within the Greater North Sea. Pipelines cause the largest area sealed in the assessment area with 75 km² (0,012%) lost, whereas the impact of offshore wind farms is relatively low with only 3 km² (0,0005%). A higher amount of habitat loss is recorded in the Central (43 km², 0,015%) and Southern North Sea (40 km², 0,019%), mainly induced by a higher density of oil and gas platforms and the pipelines needed for transporting the products.

The risk of loss by bottom trawling is assessed in two time periods. The area calculated as having a low, moderate or high risk of loss has only slightly increased from 69 574 km² (10,6%) in 2009-2014 to 69 905 km²

(10.7%) in 2015-2020. A high risk of loss is estimated for an area of 50 km² (0,01%) in the first assessment period and 101 km² (0,02%) in the second.

A higher probability of loss by trawling is observed in the assessment units Channel and Southern North Sea, whereas in the Norwegian Trench and the Kattegat fishing pressure is considered to pose a lower risk of sediment changes.

The habitat types that are most affected by sealing as well as by trawling are biogenic habitats. Offshore circalittoral biogenic habitat (MD22) in the Southern North Sea has the highest relative impact of all habitat types due to the placement of a pipeline. More than half of the area of biogenic habitats is regarded as threatened by a moderate or high risk of loss by trawling. The small size and the high vulnerability towards physical disturbance makes biogenic habitats particularly susceptible to habitat loss. The probability of loss by trawling also increases for mud in the upper depth zones and for coarse sediment in the deeper zones with lower energy.

A risk assessment of habitat loss by aggregate extraction has to be site-specific and based on detailed information on dredging activities and intensity. The data currently available only allow for a very general evaluation of risk factors. Licensed areas for extraction activities are present in the Southern North Sea and the Channel. Risk is assumed to be increased in the Channel and along the southwest coast of England, where coarse sediments and moderate current energy prevail and sediment recovery times may be elongated. Habitat types along the Belgian, Dutch, German and Danish coasts seem to be in general subject to a lower risk, as the predominant sandy sediments in a high energy environment are characterised by a high recoverability. The risk may increase due to the use of dredging techniques like screening and deep extraction.

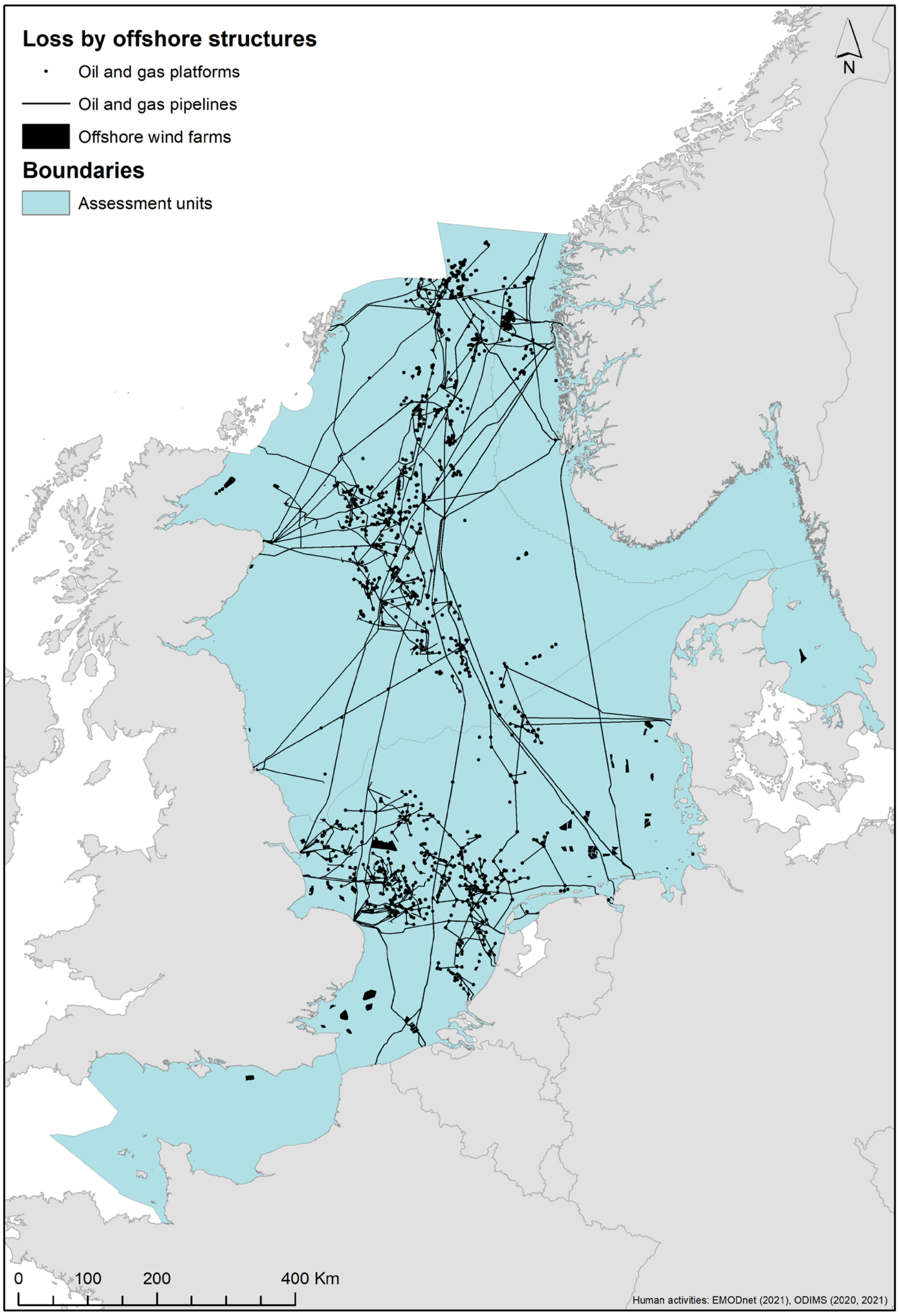

Figure 2: Present distribution of offshore wind farms, oil and gas platforms and pipelines which may cause sealed loss in the Greater North Sea.

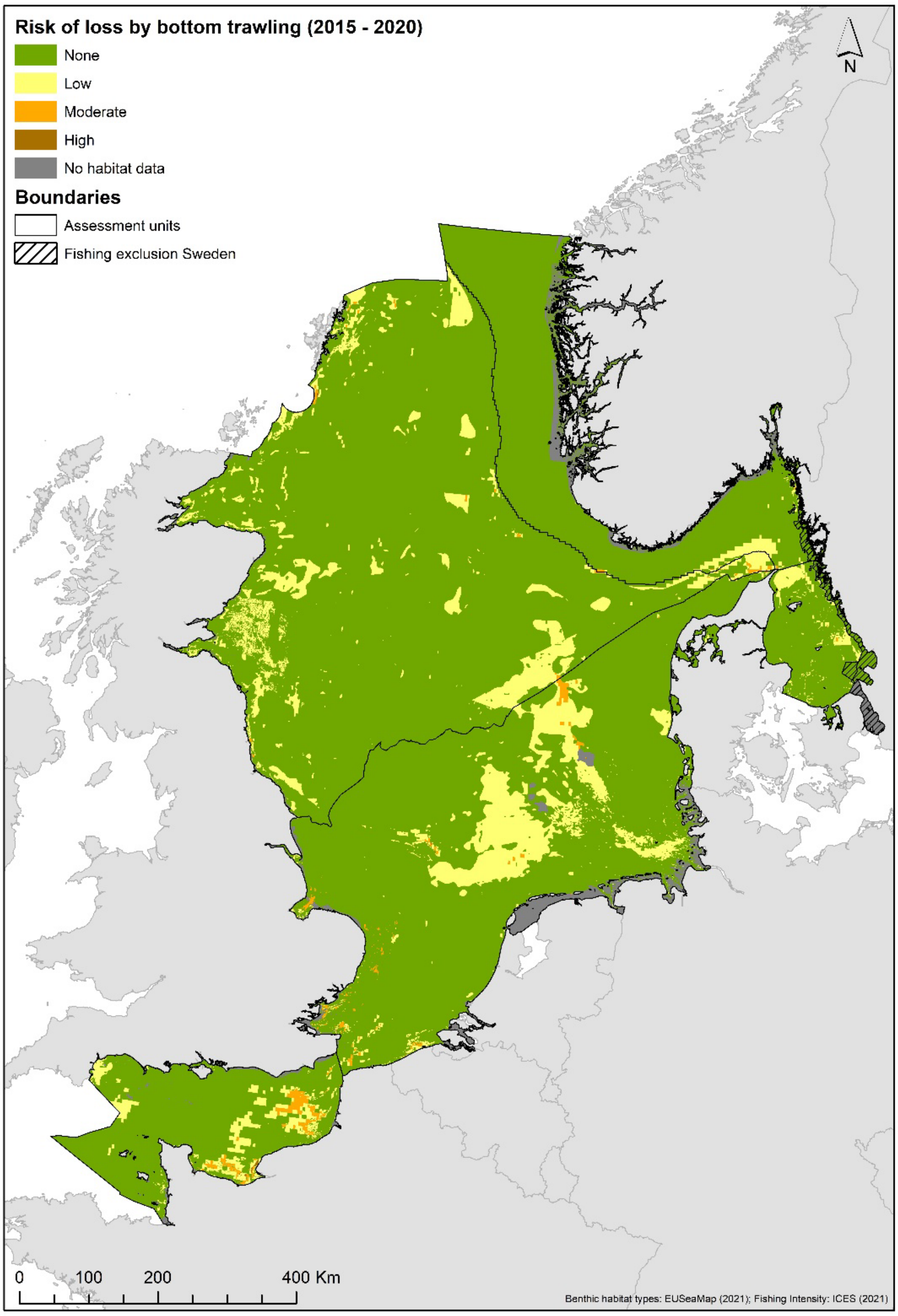

Figure 3: Distribution of risk of habitat loss by bottom trawling in the Greater North Sea for the assessment period 2015-2020

Results (extended)

1 Benthic broad habitat types in the Greater North Sea

1.1 Loss by offshore structures

Altogether an area of 91,8 km² (0,014% of the assessment area) is considered as sealed by offshore wind farms, oil and gas platforms and pipelines (**Table h**). Pipelines cause the largest area of loss with approximately 75,1 km² (0,012%), followed by oil and gas platforms with 13,6 km² (0,002%) and offshore wind farms with 3,1 km² (0,0005%).

Table h: Extent (km²) and proportion of habitat area sealed by offshore structures per habitat type in the Greater North Sea.

Habitat type	Total area km²	Offshore wind farms		Oil and gas platforms		Pipelines		Estimated total loss	
		km²	%	km²	%	km²	%	km²	%
MB12	1 729	<0,1	<0,001	-	-	<0,1	<0,001	<0,1	<0,001
MB22	93	-	-	-	-	-	-	-	-
MB32	3 195	-	-	-	-	<0,1	<0,001	<0,1	<0,001
MB42	1 340	<0,1	0,004	-	-	-	-	<0,1	0,004
MB52	14 326	<0,1	<0,001	0,2	0,002	0,2	0,001	0,5	0,003
MB62	2 092	-	-	-	-	<0,1	<0,001	<0,1	<0,001
MC12	2 886	-	-	-	-	<0,1	<0,001	<0,1	<0,001
MC22	693	<0,1	0,013	-	-	<0,1	0,003	0,1	0,016
MC32	27 825	0,4	0,001	0,7	0,002	2,2	0,008	3,2	0,012
MC42	6 144	<0,1	<0,001	<0,1	0,001	0,1	0,002	0,2	0,004
MC52	72 263	1,4	0,002	2,5	0,003	6,5	0,009	10,4	0,014
MC62	8 476	<0,1	<0,001	<0,1	<0,001	0,3	0,004	0,4	0,004
MD12	5 046	-	-	-	-	0,1	0,002	0,1	0,002
MD22	326	-	-	-	-	0,8	0,245	0,8	0,245
MD32	67 790	0,2	<0,001	0,7	0,001	6,5	0,010	7,3	0,011
MD42	6 659	-	-	-	-	0,4	0,006	0,4	0,0057
MD52	239 978	0,8	<0,001	6,2	0,003	35,3	0,015	42,3	0,018
MD62	105 938	<0,1	<0,001	3,1	0,003	13,2	0,012	16,4	0,015
ME11	24	-	-	-	-	-	-	-	-
ME12	2 277	-	-	-	-	0,2	0,011	0,2	0,011
ME42	1	-	-	-	-	-	-	-	-
ME52	279	-	-	<0,1	<0,001	<0,1	0,001	<0,1	0,002
ME62	60 969	-	-	<0,1	<0,001	8,0	0,013	8,1	0,013
No habitat data	23 863	<0,1	<0,001	<0,1	<0,001	1,2	0,005	1,3	0,005
Total	**654 210**	**3,1**	**0,0005**	**13,6**	**0,002**	**75,1**	**0,011**	**91,8**	**0,014**

The habitat type with the largest extent in the Greater North Sea, Offshore circalittoral sand (MD52), has also the largest area affected by sealed loss with approximately 42 km² (<0,02% of the habitat area) (**Figure d**). For the majority of habitat types, the area estimated as lost is less than 1 km². The relative share of sealed loss is less than 0,02% for each of the habitat types assessed (**Figure d**). An exception is the habitat type Offshore circalittoral biogenic habitat (MD22), which has only a small extent of 326 km² in the Greater North Sea. Approximately 0,25% of the habitat area is estimated to be crossed by a pipeline.

Sealing with offshore structures occurs predominantly in the offshore circalittoral zone, as most platforms and wind farms are constructed further from the coast. The infralittoral zone is least impacted. Offshore structures are primarily built on sand and mud, whereas rocky and mixed sediments are only marginally affected. Biogenic habitats have the highest proportion of habitat area estimated to be subject to sealed loss. This may be explained by the relatively small mapped extent of this habitat, meaning that even a small overlap with a pressure can cause a large proportion of the habitat to be impacted.

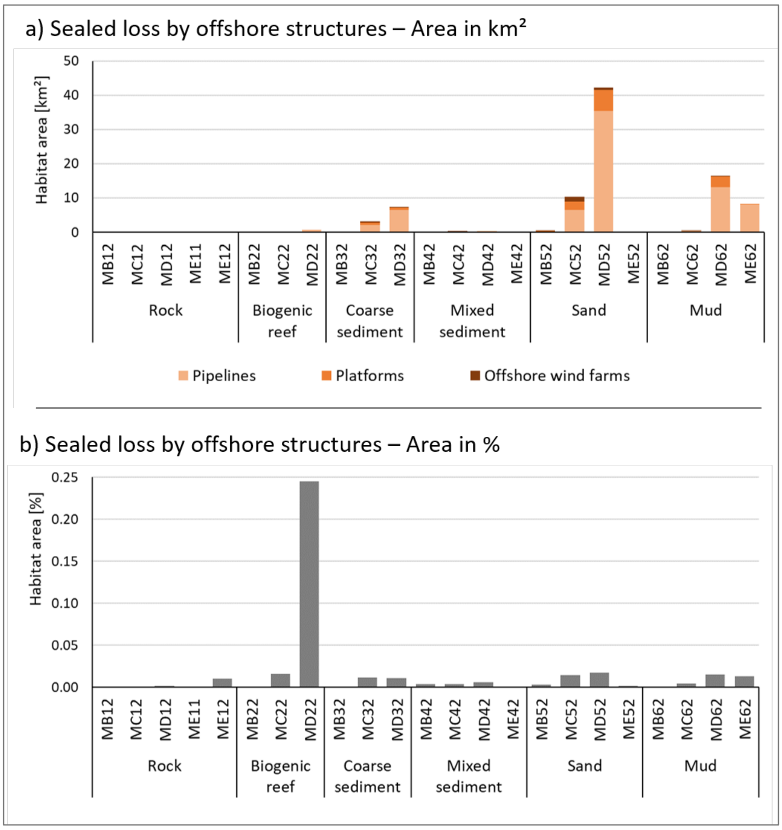

Figure d: Estimated a) extent (km²) and b) proportion (%) of habitat loss by offshore structures per habitat type in the Greater North Sea

1.2 Risk of loss by bottom trawling

In the Greater North Sea, an area of 101 km² (0,02% of the assessment area) is estimated to have a high risk of loss due to bottom trawling in the time period 2015-2020 (**Table i**). The high-risk areas are mostly very small habitat patches distributed all over the Greater North Sea. Larger areas with high risk, particularly for mud habitats and coarse sediments, are located in the Bay of the Seine and the western part of the Channel. An area of 4 153 km² (0,6%) is assessed as subject to a moderate risk and an area of 65 651 km² (10,1%) to a low risk of loss. Those areas can be found e.g., in the central Southern North Sea, the Channel, the Skagerrak and along the British coastline. An extensive proportion of the seabed (85,7%) is not considered to be at risk of sediment changes.

In the assessment period 2015-2020, average fishing intensity is in large parts of the assessment area (80%) below a SAR value of 8 (**Table j**), which seems unlikely to cause a high risk of loss, even for habitats with a very high probability of sediment changes. A proportion of 2,7% of the area has a SAR value between 8 and 16 and 0,6% are subject to a fishing intensity of more than 16. The area where no fishing data are recorded amounts to 16,8%.

The probability of habitat loss mainly depends on the substrate and hydrodynamic characteristics. For rocky habitats, a destruction of the physical substrate is unlikely, therefore these habitats are not considered to be at risk (**Figure e**). The risk for sandy habitats is also negligible with less than 1% per habitat type assessed with a low risk. Larger areas of muddy sediments in the upper depth zones (infralittoral, circalittoral, offshore circalittoral) are subject to a low risk of loss (26-60%), as there the energy at the seabed is moderate or high and resuspended fine sediments may be transported away with currents. In deeper areas, the tidal and current energy is lower and the prevailing mud sediments are less at risk. On the contrary, coarse sediments are more endangered by loss in a low energy environment and thus the risk increases with depth. However, the larger proportion of coarse sediments is located in areas with moderate or high energy and therefore the risk for these habitat types is generally lower. The probability of loss is regarded to be highest for biogenic habitats. More than half of the biogenic habitat area (52-72% in 2015-2020) is assessed with a moderate risk of loss, as biogenic structures may suffer severe damage even at low fishing intensities. A high risk of loss is assumed for some biogenic (MB22, MC22) and mud habitats (MB62, MC62, MD62) as well as for Offshore circalittoral coarse sediment (MD32). The habitat type Circalittoral mud (MC62) has the largest area (62 km²) assessed with a high risk of loss, whereas the habitat with the largest relative share (1,2%) is Infralittoral biogenic habitat (MB22). It should be noted that the low resolution of fishing data may not be adequate to assess the impact on habitat types with a very small extent, and also to note that VMS data are not available for small fishing boats operating close to the shore.

In comparison with the preceding assessment period of 2009-2014, the overall proportion of the area in the different categories has only slightly changed. The area that is assumed to have no or a low risk of loss decreased by 600 km² (0,1%), while there is an increase of 530 km² in the area with a moderate risk (**Figure f**). The area with an estimated high risk of loss has doubled from 50 km² (0,01%) in 2009-2014 to 101 km² (0,02%) in 2015-2020. In contrast, the area without fishing pressure has increased between the two assessment periods by 1.9% (**Table j**). There is also a slight increase in the area that is subject to SAR values of > 16. More than 94% of the c-squares in the assessment area are in the same SAR category in both assessment periods, which confirms that the pressure situation in the Greater North Sea is largely stable.

The risk assessment for habitat types is very similar between 2009-2014 and 2015-2020. For most of the habitat types the proportion of area per risk category has changed by less than 1%. Larger shifts are detected for small-scale habitat types like biogenic habitats. The area of moderate risk is reduced by 3% to 16% for the three biogenic habitats assessed, while the area without risk (i.e., without trawling) increases by nearly the same proportion. Still there is a slight increase in the proportion of the habitat area of MB22 and MC22 (Infralittoral and Circalittoral biogenic habitat) that is estimated to have a high risk of loss. Trawling is also intensified in coarse sediments, particularly for Circalittoral coarse sediment (MC32) with a shift of 1,4% of the area from none and low risk to moderate risk. The risk has further increased for Infralittoral mud (MB62), where the area of moderate and high risk has enlarged by 1,6%.

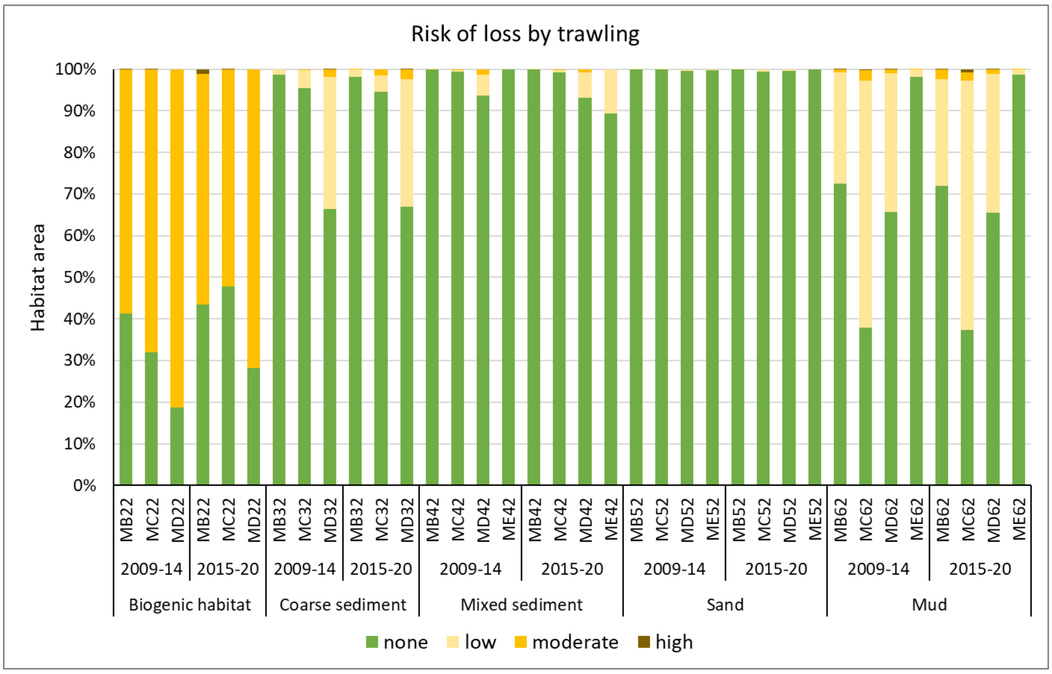

Figure e: Risk of loss by bottom trawling per habitat type in the Greater North Sea, assessment periods 2009-2014 and 2015-2020.

Table i: Extent (km²) of risk categories as defined by different intensities of bottom trawling and probability of loss per habitat type in the Greater North Sea, assessment periods 2009-2014 and 2015-2020.

Habitat type	Total area (km²)	Risk of loss (2009-2014) in km²				Risk of loss (2015-2020) in km²			
		none	low	moderate	high	none	low	moderate	high
MB12	1 729	1 729				1 729	-	-	-
MB22	93	38		54	0.1	40	-	51	1
MB32	3 195	3 151	44	-	-	3 133	59	2	-
MB42	1 340	1 339	0	-		1 339	0,3	-	-
MB52	14 326	14 324	2			14 309	17	-	-
MB62	2 092	1 516	558	17	0	1 506	535	48	3
MC12	2 886	2 886				2 886	-	-	-
MC22	693	222		471	<0.1	331	-	362	0.2
MC32	27 825	26 555	1 203	66	-	26 316	1 065	444	-
MC42	6 144	6 106	23	15		6 096	35	13	-
MC52	72 263	72 193	87			71 849	414	-	-
MC62	8 476	3 214	5 032	201	29	3 170	5 077	166	62
MD12	5 046	5 046				5 046	-	-	-
MD22	326	61		265	-	92	-	234	-
MD32	67 790	45 040	21 440	1 297	12	45 341	20 827	1609	13
MD42	6 659	6 240	329	90		6 204	397	58	-
MD52	239 978	239 078	902			238 829	1 149	-	-
MD62	105 938	69 646	35 218	1 066	9	69 466	35 327	1123	21
ME11	24	24				24	-	-	-
ME12	2 277	2 277				2 277	-	-	-
ME42	1	1	-	-		0,9	0,1	-	-
ME52	279	279	1			279	-	-	-
ME62	60 969	59 827	1 063	81		60 177	749	43	-
No habitat data	23 863								
Total	**654 210**	**560 792**	**65 901**	**3 623**	**50**	**560 441**	**65 651**	**4153**	**101**

Table j: Extent (km² and %) of SAR categories in the Greater North Sea, assessment periods 2009-2014 and 2015-2020.

Categories for fishing intensity	2009-2014		2015-2020	
	km²	%	km²	%
SAR = 0	97 686	14,9	110 005	16,8
SAR <= 8	536 198	82,0	522 760	79,9
SAR >8-16	17 505	2,7	17 487	2,7
SAR > 16	2 842	0,4	3 958	0,6

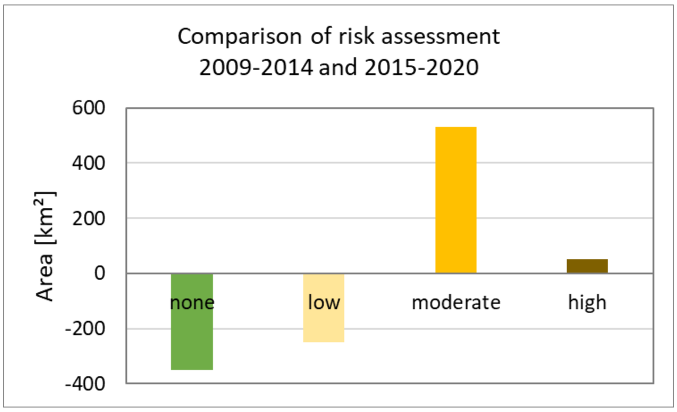

Figure f: Change in extent (km²) of risk of loss categories in the Greater North Sea from the assessment period 2009-2014 to 2015-2020.

1.3 Risk of loss by aggregate extraction

An assessment of the risk of loss by aggregate extraction has to be site-specific and based on information on the methods applied, the extent of the area impacted, the dredging intensity (either as amount extracted per site or time dredged) and the habitats affected. Currently the available data on extraction activities in the Greater North Sea are not sufficient to produce a detailed risk assessment per site. Instead, a summary of available information from Contracting Parties is presented (**Table k, Table l**) and potential risk factors are highlighted.

Belgium: Belgium has currently nine areas designated for aggregate extraction. Extraction below a depth of more than 5 m is not allowed. In several licensed areas the extraction of gravel is prohibited (ICES 2019b). The dominating habitat types in the licensed areas are Circalittoral and Offshore circalittoral sand (MC52, MD52). Some smaller patches of coarse sediment are also contained in extraction sites. The majority of sites is located in a high energy environment, a smaller proportion is subject to a moderate current energy. In 2019, about a third of the designated area was actively dredged and the sediment extracted per m² amounts to 0,06 m³. There is no information available on the use of screening techniques, however, due to the prevailing sandy sediments sieving is most likely not applied. In summary, there may be locally an increased risk for coarse sediments at high dredging intensities, but in general the recovery of the predominant sandy sediments at high current energy is considered to occur in less than 12 years.

Germany: The two active dredging sites in Germany are managed differently. At the extraction site in the EEZ trailer suction dredgers are used and the yearly amount extracted is quite low. The majority of aggregates (> 90% of the amount/year) is extracted at the coastal site, where static dredging is the main method applied. Strong sediment alterations with a backfill of very fine sand and mud have already been described for the deep extraction site (Mielck *et al.*, 2021). Both sites are subject to high tidal energy and Circalittoral sand (MC52) is the predominant habitat type. A few patches of coarse sediment are also present in both licensed areas. The risk of loss is considered low in the EEZ site due to the high recoverability of the prevailing sediment, still the locally present coarse sediments may be more endangered if dredging intensity is high. For the coastal site, the probability of habitat changes in the dredged area is regarded as high due to the dredging technique.

Denmark: The Danish OSPAR area has 35 single areas designated for aggregate extraction, some of them are sub-areas of a larger extraction site. Extraction takes place by static and trailer suction dredging. Dredging is only allowed at depths of > 6 m and it rarely exceeds depths > 30 m (Petersen *et al.*, 2018). There is no information on amounts extracted per site. The majority of extraction sites is located in an area with alternating sandy (MC52) and coarse sediments (MC32) in a high energy environment. Physical recovery is considered to be fast and not exceeding 12 years in these habitat types, particularly for sand. The risk may be increased for coarse sediments at high dredging intensities and in areas where static dredging is employed. However, the potential loss of habitat types will have to be evaluated when more detailed aggregate extraction data becomes available.

France: Several areas in the English Channel are licensed for the extraction of aggregates used for construction. Extraction also takes place for beach replenishment but without the requirement for a mining licence, therefore data is not available for these activities (ICES 2019b). Screening is prohibited in France, however, there is no information on the use of trailer or static dredging. Coarse sediments (MC32, MD32) are predominant in the Channel and thus also in the licensed areas. The majority (> 95%) of the licensed areas is subject to a moderate current energy. Loss may occur if dredging intensity is high in the prevailing coarse sediments, as recovery times may be extended in this hydrodynamic situation to more than 12 years (e.g., Foden *et al*., 2009, Hill *et al*., 2011).

The Netherlands: Along the Dutch coast, a large number of mostly small sites have been designated for sand extraction. The extent of licensed areas varies from year to year. In 2019, approximately 17% of the licensed area was actively dredged and 0,22 m^3 were extracted per m^2 on average (ICES 2019b). Generally, only shallow extraction down to 2 m below the seabed is permitted. For larger extraction areas (> 10 million m^3 of sediment), extraction depths of more than 2 m are allowed in areas 2 km seaward from the 20 m depth contour. The first deep extraction site was approved for the Rotterdam harbour expansion 'Maasvlakte 2'. Sediment changes in the borrow pit included decreasing median grain size and increasing mud values (de Jong 2016). The licensed areas are characterised by sand (MC52) and mostly high current energy. Some of the licensed areas contain also smaller patches of coarse sediment. The risk of loss is assumed to be low due to the high recoverability of the predominant habitat type. Locally, at deep extraction sites and where coarse sediments are intensively dredged, the probability of loss may be increased.

Norway: No extraction activities in the OSPAR area.

Sweden: No extraction activities in the OSPAR area.

United Kingdom: In the UK portion of the Channel and the Southern North Sea, 68 sites are licensed for aggregate extraction according to the Marine and Coastal Access Act 2009. Regional monitoring plans shall ensure long-lasting changes to sediment types are minimised or avoided and capacity for infaunal community recovery at cessation of dredging is retained. Approximately 10% of the licensed area was dredged in 2019 and on average 0,1 m^3 of sediment were extracted per m^2 (ICES 2019b). Static dredging may be employed in inshore areas. The main habitat types in licensed areas are Circalittoral (MC32) and Offshore circalittoral coarse sediment (MD32), that are for the most part subject to a moderate current energy. Near-shore circalittoral areas tend to have higher current energy. High intensity dredging in these predominant habitat types may lead to a local change of substrate type. The risk of loss may also be increased when screening or static dredging is applied.

Table k: Extraction activities and methods used in the marine area of Contracting Parties (CP) in the Greater North Sea.

CH = Channel, SNS = Southern North Sea

CP	Extraction activities	Assessment unit	Trailer suction dredging	Static (deep) extraction	Screening	Reference
BE	yes	SNS	only method	prohibited	no information	ICES (2019b)
DE	yes	SNS	in EEZ	in coastal area	no information	BfN (2022), LKN-SH (2021)
DK	yes	SNS, Kattegat	yes	yes	no information	Petersen *et al*., (2018)
FR	yes	CH	no information	no information	prohibited	ICES (2019b), Desprez (2012)
NL	yes	SNS	main method	one site for Maasvlakte 2	no information	ICES (2019b), de Jong (2016)
NO	no	-	-	-	-	ICES (2022)
SE	no	-	-	-	-	ICES (2019b)
UK	yes	Channel, SNS	offshore	inshore	no information	ICES (2019b) pers. comm. M. Russell

Table l: Main habitat types in licensed areas, extent and amount of extraction activities in 2019 in the marine area of Contracting Parties (CP) in the Greater North Sea.

CP	Area licensed [km²]	Area dredged [km²]	Area dredged per licensed area [%]	Amount extracted [m³]	Amount extracted per m² [m³]	Main habitat types in licensed areas
BE	203	59	29,1	3 490 000	0,06	MC52, MD52 high energy
DE	405	no information	no information	1 089 048	no information	MC52 high energy
DK	382	no information	no information	6 985 328	no information	MC52, MC32 high energy
FR	163	no information	no information	1 182 506*	no information	MD32, MC32 moderate energy
NL	548	95	17,3	20 424 636	0,22	MC52 high energy
UK	1079	105	9,7	10 498 874	0,10	MC32, MD32 moderate / high energy

* data on beach replenishment not included (no mining licence required)

2 Broad habitat types per assessment unit

2.1 Loss by offshore structures

Offshore structures are mainly located in the Southern and Central North Sea (**Figure g**). This is related to the considerable amount of oil and gas production in this area and the associated infrastructure. A small area is sealed in the Norwegian Trench and the only anthropogenic structure in the Channel and the Kattegat is a wind farm.

The majority of wind farms can be found in the Southern North Sea, whereas the area estimated as sealed is still small with 2,6 km². The overall proportion of sealed loss is between 0,01 and 0,02% for Southern North Sea, Central North Sea and Norwegian Trench. In the Channel and the Kattegat, the relative share of sealed habitat area is less than 0,001%.

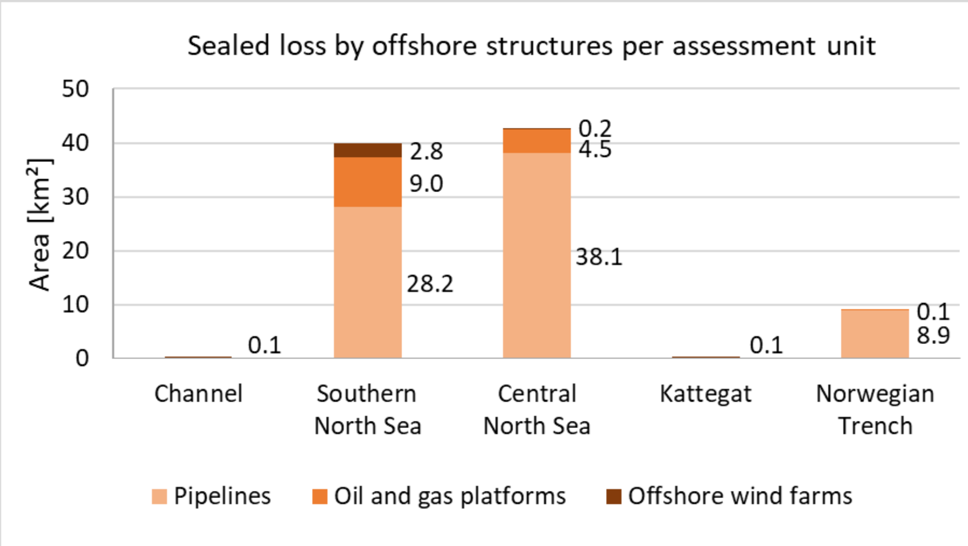

Figure g: Area of estimated extent (km²) of habitat loss by offshore structures per assessment unit.

Most offshore structures in the Southern and Central North Sea are built on Offshore circalittoral sand (MD52), in the Norwegian Trench on Upper bathyal mud (ME62). The proportion of habitat type sealed is in general less than 0,03% per assessment unit, with the exception of Offshore circalittoral biogenic habitat (MD22) in the Southern North Sea that has 0,25% of its area impacted by a pipeline.

2.2 Risk of loss by bottom trawling

In the assessment period 2015-2020, the area with no risk of loss by bottom trawling varies between 81% in the Southern North Sea and 90% in the Central North Sea (**Figure h**). The overall risk seems to be lowest in the Norwegian Trench with only 2,4% of the area assigned to a risk category, however, due to missing habitat data along the Norwegian coast 12% of the area could not be assessed. The seabed in the Channel and the Southern North Sea is subject to the largest risk with 14,7% and 14,1% of the area respectively, classified in a low, moderate or high risk category.

In the Southern North Sea, the Kattegat and the Norwegian Trench it is mostly mud habitats that are considered at risk, whereas in the Channel and the Central North Sea it is also deeper coarse sediments. Biogenic habitats are particularly endangered in the Channel, the Southern and the Central North Sea.

In comparison to the previous assessment period, the overall distribution of fishing pressure has remained constant in the Southern North Sea. In the Central North Sea and the Norwegian Trench, the area without risk has increased by 0,6% and 0,4% respectively. In contrast, the area with no risk of loss has slightly decreased by 0,3% in the Kattegat, corresponding to an increase in the low and moderate risk categories. The largest variation between assessment periods is observed in the Channel, where the areas with moderate and high risk have been extended by 1,9% of the total area. Particularly in the core fishing zones in the western part of the Channel, fishing intensity has further increased.

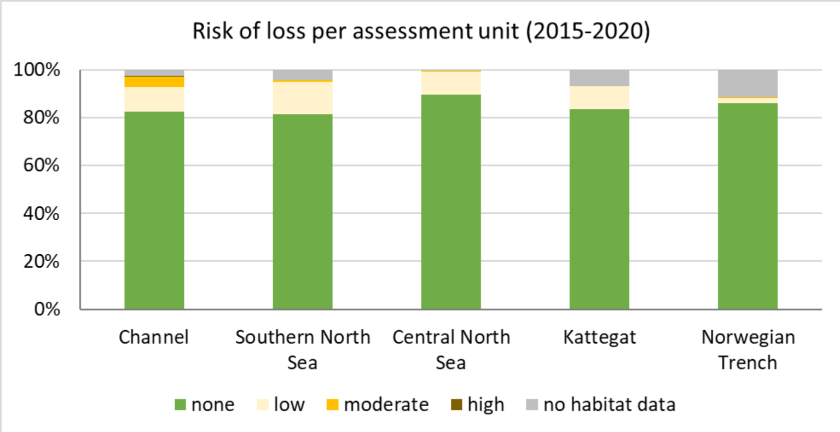

Figure h: Risk of loss by bottom trawling per assessment unit in the time period 2015-2020.

Channel

The seabed in the Channel is dominated by coarse sediments. Fishing intensity leads to a proportion of 11,6% of the total area classified with a low or moderate risk of loss (**Figure i**). Particularly the deeper Offshore circalittoral coarse sediments (MD32) are subject to a higher risk, as with less energy at the seabed the probability of substrate fining increases. The coastal infralittoral biogenic habitat MB22 has only a very small extent of 6,8 km^2 and is assumed to be especially endangered by trawling. For Circalittoral biogenic habitat (MC22) pressure seems to have been reduced in the current assessment period. It should be noted, however, that due to the low resolution of VMS data there is less confidence in the assessment of biogenic habitats, which have a relatively small extent. Mud habitats in the Channel also cover only a relatively small proportion (2,2%) of the total area. Almost the entire area of muddy sediments is heavily fished. There is also a considerable increase of the mud area with a high risk of 9 (Circalittoral mud) to 14% (Infralittoral mud) between the two assessment periods.

Southern North Sea

in the Southern North Sea, sandy sediments prevail, which are less subject to sediment changes by trawling. Coarse and mixed sediments also show a low risk of loss (**Figure i**). Mud habitats account for 14,4% of the total area. Particularly the mud habitat with the largest extent, Offshore circalittoral mud (MD62), is nearly completely fished with a high intensity. The majority of the habitat area has a higher probability of sediment changes as it is located in a moderate or high energy environment. Biogenic habitats comprise only 0,5% of the total area and are considered to be most endangered by trawling. With the exception of biogenic habitats, where fishing intensity appears to have decreased, there is little variation in the risk assessment between the two assessment periods.

Central North Sea

The Central North Sea is the assessment unit with the largest extent in the Greater North Sea. Habitat types of the deeper layers prevail, with 97% of the seabed classified as offshore circalittoral or upper bathyal habitats. The most widespread habitat type is Offshore circalittoral sand (MD52) with 61% of the total area, followed by Offshore circalittoral mud (MD62) with 24%. The overall increase in the area without risk of 0,6% is mainly associated with a reduced pressure on MD52, whereas in the more vulnerable mud habitats the fishing intensity has generally increased. Deeper Offshore circalittoral coarse sediments (MD32) also show a higher risk of loss and trawling has intensified in the current assessment period (**Figure i**). The small patches of biogenic habitats appear to be particularly endangered by bottom trawling.

Norwegian Trench

The seabed in the Norwegian Trench is mainly classified as Upper bathyal mud (ME62). A large part of the coastal zone (12% of the total area) cannot be assessed due to missing habitat information. Fishing is more common in the upper depth zones, as part of the upper bathyal is below 800 m, where a trawling ban is imposed. The risk of loss is altogether quite low, with only 2,3% of the total area categorised with a low and 0,1% with a moderate risk (**Figure h**). The overall area without risk has expanded by 0,4% in the current assessment period, which is primarily caused by a decrease in fishing pressure on the two habitats with the largest extent, MD62 and ME62.

Kattegat

The Kattegat is the assessment unit with the smallest extent in the Greater North Sea. The upper layers mainly consist of sandy and mixed sediments, while in the deeper areas mud is predominant. A higher risk of loss is estimated for mud sediments as well as for coarse sediments in the deeper zones (**Figure i**). Overall, the risk of habitat loss is considered to be low in the Kattegat, as only 0,1% of the total area is assessed with a moderate risk and there is no habitat subject to a high risk. Fishing pressure has slightly increased in the current assessment period with less area classified as without risk. This can be primarily attributed to an increase of risk on Offshore circalittoral mud (MD62).

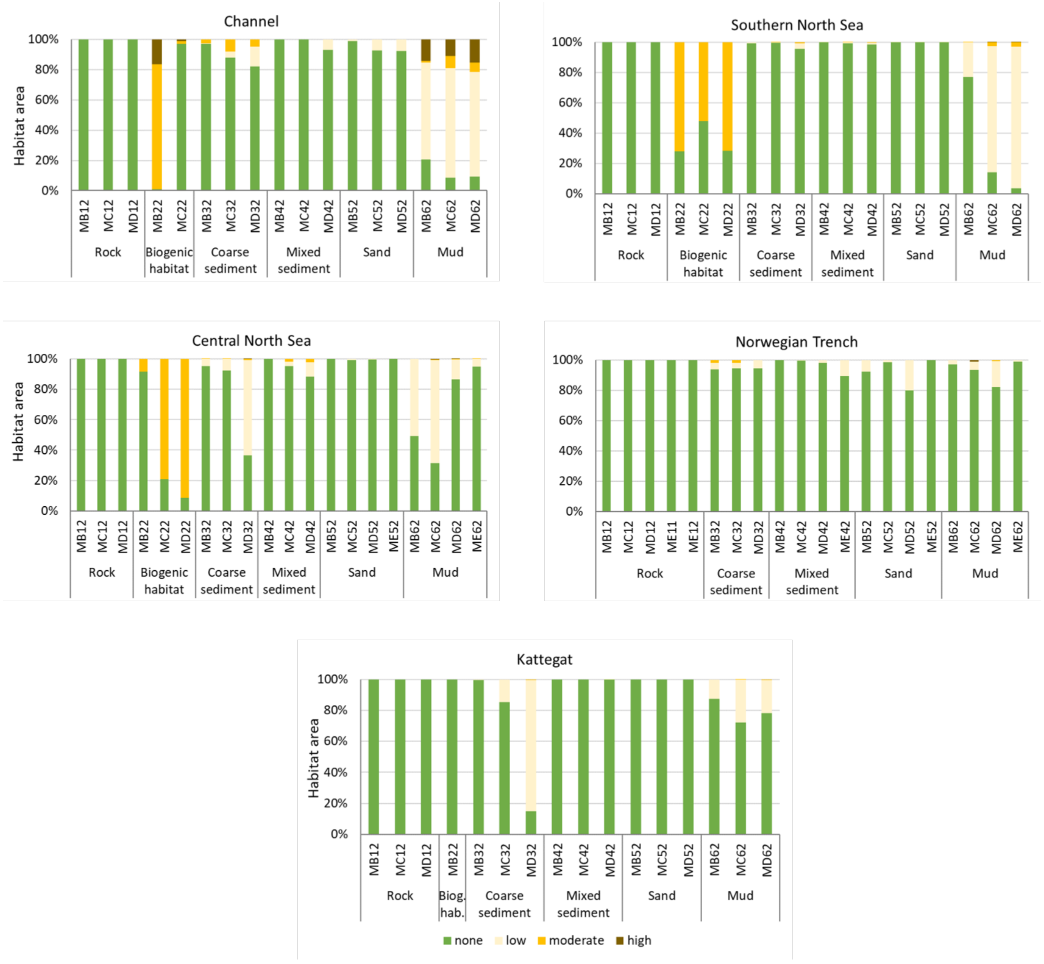

Figure i: Risk of loss by bottom trawling per habitat type and assessment unit in the time period 2015-2020.

3 Threatened and / or declining habitats

3.1 Loss by offshore structures

Based on the available polygon habitat data for threatened and / or declining habitats, an area of 1 km² is impacted by the placement of marine infrastructure. Three protected habitat types (Intertidal *Mytilus edulis* beds, *Sabellaria spinulosa* reefs, Sea-pen and burrowing megafauna communities) are affected by habitat loss due to the installation of pipelines or foundations of offshore wind farms. The largest area of sealed loss (0,75 km²) is observed for Sea-pen and burrowing megafauna communities, which is also the habitat type with the largest extent according to the available data.

For point data of threatened and / or declining habitats, the number of points within a buffer area of 2 km around a structure was counted as a proxy for the impact. The same habitat types as for the assessment of polygon data occur around the structures, with the addition of *Lophelia pertusa* reefs and *Zostera* beds. Again, Sea-pen and burrowing megafauna communities have the most points located near offshore structures, in particular platforms and pipelines.

The results can only give a brief insight of the risk to protected habitat types by sealing of the seabed. Due to several issues with the habitat data, confidence in the assessment is low.

Table m: Extent (km² and number of habitat points) of threatened and / or declining habitats that are estimated to be sealed by offshore structures.

	Habitat polygons [km²]			Habitat points [No. of points]		
Habitat type	**OWF**	**Platforms**	**Pipelines**	**OWF**	**Platforms**	**Pipelines**
Coral gardens	no data	no data	no data	-	-	-
Deep-sea sponge aggregations	no data	no data	no data	-	-	-
Intertidal *Mytilus edulis* beds	-	-	<0,01	-	-	3
Littoral chalk communities	-	-	-	-	-	-
Lophelia pertusa reefs	no data	no data	no data	-	2	5
Maerl beds	-	-	-	-	-	-
Modiolus modiolus beds	-	-	-	-	-	-
Ostrea edulis beds	-	-	-	-	-	-
Sabellaria spinulosa reefs	0,09	-	0,16	2	-	4
Sea-pen and burrowing megafauna	0,19	-	0,56	1	23	24
Zostera beds	-	-	-	-	1	2

4 Confidence

4.1 Confidence in methods

This is a first assessment of physical loss due to sealing by structures and human activities changing the sediment type in the Greater North Sea. Loss by placement of structures has been assessed before with a similar methodology in several studies (e.g., Eastwood *et al.*, 2007, Foden *et al.*, 2011, HELCOM 2017). The buffers used for the assessment of wind farms, oil and gas platforms and pipelines vary considerably between these studies. Data on the actual size of structures has improved recently, so it is assumed that the footprints used in the indicator assessment are quite precise. Still, it is an estimation of the impact and not a measurement of the exact area that has been subject to changes. The confidence for the assessment method of sealed loss is therefore considered as moderate.

A novel approach has been developed for estimating the risk of loss by bottom trawling and aggregate extraction. This method highlights areas that may be particularly endangered, but the results should be verified by ground truthing data. The SAR boundaries used for the risk analysis of different habitat types are based on published studies (e.g., Mengual *et al.*, 2016, Oberle *et al.*, 2016), however, the evidence could be improved by further evaluations in different regions and for a wider range of habitat types. The data on extraction activities are currently not sufficient for a detailed risk assessment. For future assessments with more complete data, the method must be further refined, particularly with regard to the effects of different dredging intensities on the sediment characteristics. Confidence in the risk assessment method for bottom trawling and aggregate extraction is rated as low.

4.2 Confidence in the data

Activities and habitats data have a variety of sources with varying accuracy:

- Offshore wind farms: Information on the wind farm area, the number and foundation type of turbines is available from ODIMS Offshore renewable energy developments and EMODnet Wind farms. The exact dimension of the foundations incl. scour protection (or scouring) and the location of single turbines are not known. The area regarded as sealed by different foundation sizes is based on standard dimensions from literature. Data is available from all Contracting Parties that engage in this activity. Confidence is therefore assessed as moderate.
- Oil and gas platforms: Data on the exact location and in most cases also on the type of structure and foundation is held in the ODIMS database on Inventory of offshore installations. All Contracting Parties producing offshore oil and gas have reported to OSPAR. The footprint of different foundations including scour protection (or scouring) and of actively producing installations is estimated based on literature data. The platforms dataset is accompanied by a moderate to high confidence.
- Oil and gas pipelines: The EMODnet pipelines dataset provides information on the length and for the majority of pipelines on the diameter of the structures as well. Standard dimensions have been calculated to account for missing values. The EMODnet database contains lines representing the actual routes of offshore pipelines in Denmark, Germany, Netherlands, Norway, and United Kingdom. Confidence in distribution and size of pipelines is moderate / high.
- Bottom trawling: Vessel monitoring system (VMS) data were provided by ICES following a request from OSPAR. The method used to produce spatial fishing layers has been established in 2017 (ICES 2017). The dataset is accompanied by several caveats (ICES 2021), e.g., data on vessels < 12 m (< 15 m until 2012) are not included which may lead to an underestimation of fishing impact particularly in coastal areas. Norwegian data were excluded as the submitted data did not pass the quality check. Also, the fishing pressure is assessed at a relatively low resolution of 0,05° x 0,05° which makes it difficult to exactly locate high fishing pressures on small-scale habitats such as biogenic habitats. It was discussed if areas without VMS data should be treated as 'no fishing' or 'no data'. The decision was to include these data as 'no fishing' as this is how it was dealt with in ICES EUTRADE (2021). Due to the mentioned data gaps, fishing pressure may be underestimated in many areas, not only in areas without VMS data. With regard to these limitations, confidence in the spatial layers of bottom trawling is assessed as moderate.

  As a measure of uncertainty of the fishing pressure analyses, the standard deviation was calculated for each c-square and assessment period (**Table n**). Fishing pressure is regarded as constant, if the mean SAR value of a c-square in an assessment period and the standard deviation are in the same SAR category as defined by the indicator methodology (e.g., SAR > 0-8). A low variability means that the mean SAR value and either the positive standard deviation or the negative standard deviation are in different SAR categories. Variability is classified as high, if the mean SAR value, the positive and the negative standard deviation are all in different categories.

  In both assessment periods, variation in fishing pressure is highest in the Channel, where 20% (in 2009-2014) and 16% (in 2015-2020) of c-squares have a low or high variability. In the Southern North Sea, the Central North Sea and the Kattegat fishing intensity is more constant, with generally less than 5% of c-squares classified with a low or high variability.

Table n: Variation of fishing pressure given as proportion of c-squares with no VMS data, constant pressure (no change in SAR category), low variability (change in one SAR category) and high variability (change in two SAR categories) per assessment unit.

Variability of fishing pressure	Proportion of c-squares (%)				
	Channel	Southern North Sea	Central North Sea	Kattegat	Norwegian Trench
2009-2014					
No VMS data	5,9	3,7	8,8	16,5	20,9
Constant pressure	74,1	92,5	86,5	80,3	68,6
Low variability	18,3	3,6	4,4	3,2	10,3
High variability	1,7	0,2	0,3	0,0	0,2
2015-2020					
No fishing data	4,2	5,9	10,4	19,9	30,2
Constant pressure	79,9	89,6	84,8	74,8	61,6
Low variability	15,2	4,1	4,6	5,1	7,9
High variability	0,6	0,4	0,2	0,2	0,3

- Aggregate extraction: The data on extraction activities submitted by Contracting Parties and ICES varies considerably. The datasets include the spatial distribution of licensed areas and the amount extracted per country. Only a few Contracting Parties could provide information on the actual area dredged or the amount extracted per site. Spatial layers for the area affected were not available and also the methods used for extraction were largely unknown. The aggregate dataset is therefore not sufficient to produce a risk assessment.
- Broad habitat types: The map used for broad habitat types in this assessment, EUSeaMap v2021 (Vasquez *et al*., 2021), is accompanied by a confidence assessment (**Figure j**, see also Populus *et al*., (2017)). The majority of the Greater North Sea is considered to have a moderate confidence. Areas with higher confidence are located along the coastlines and east of Scotland. A lower confidence in habitat classification is reported for larger areas of the Kattegat and the Southern North Sea. However, these are high-level indications of the level of confidence in the classification of the habitat types. EUSeaMap is a prediction of habitat types based on a combination of environmental factors and has a variable, but generally low, spatial resolution that does not always match the fine resolution of some of the activity data layers such as placement of structures. The underlying EUNIS data reveals that several habitats (e.g., sandy mud, rock, mixed, biogenic) have been defined differently in different areas and by different scientific groups. Therefore, a comprehensive revision and alignment of the habitat is required for the assessment of EUNIS and MSFD broad habitat types.
- Threatened and / or declining habitats: Spatial data on the distribution of threatened and / or declining habitats are submitted by Contracting Parties as polygons or points. The data product is considered to be incomplete because it only includes data from surveys, and is therefore limited to those areas that have been surveyed. The version used in this assessment (OSPAR 2020a,b) contains far more points than polygons. Point data indicate the presence of a specific habitat, but do not allow for a spatial assessment of the extent of loss. The total extent of the listed habitats assessed in the Greater North Sea is in most cases unknown. The publicly available dataset also does not contain records relating to sensitive species (e.g., *Ostrea edulis*) in the UK. In some areas there are several data layers from different years for the same habitat types available that make it difficult to show the current extent of these habitat types. Also, historic data on biogenic habitats that may have disappeared by now are included, as some data entries date back to the year 1900. Confidence in the habitat information is therefore assessed as low.

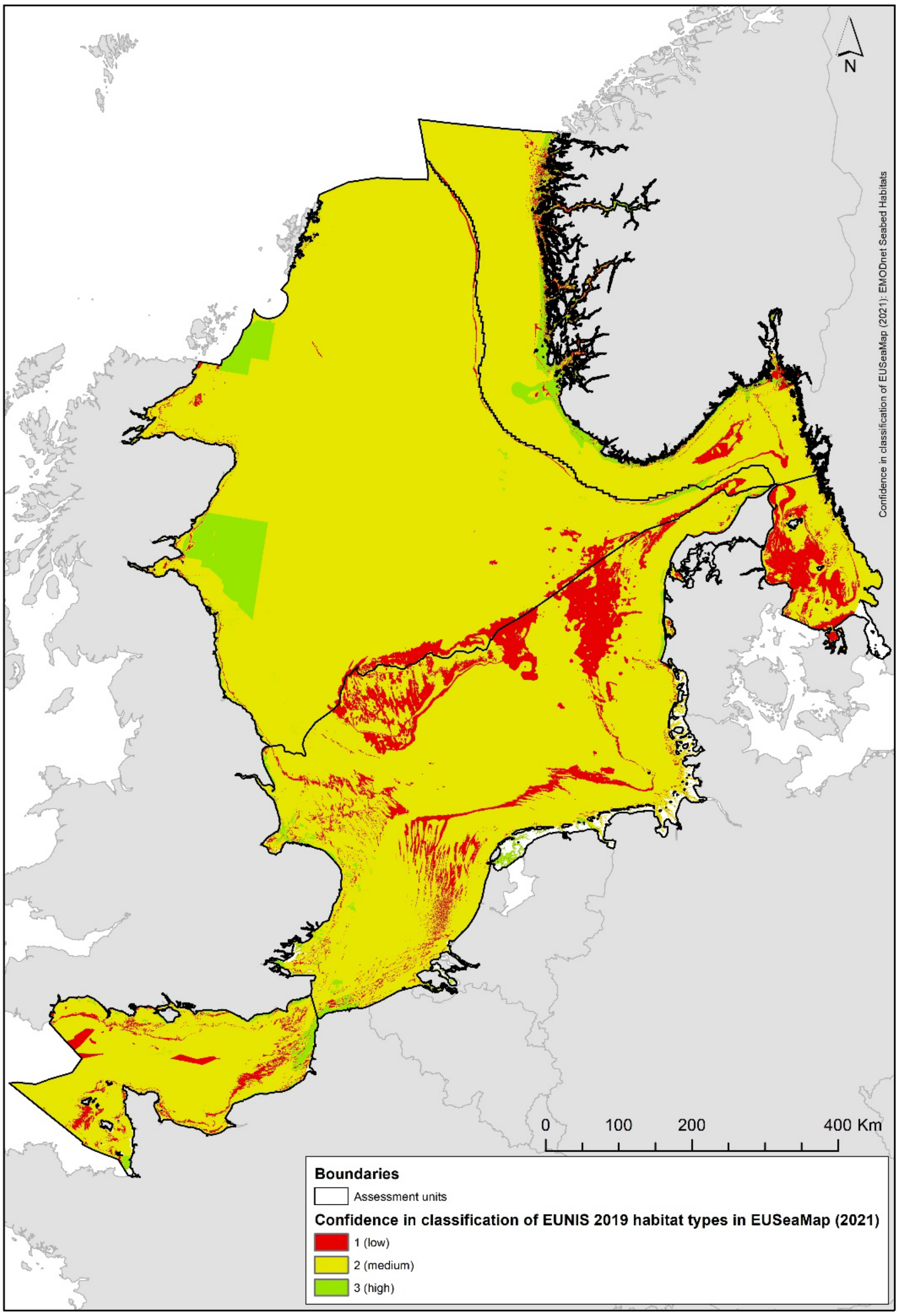

Figure j: Confidence in classification of EUNIS 2019 habitat types in EUSeaMap 2021

Conclusion

Activities for energy production that cause sealing of the seabed are concentrated in the Southern North Sea. The Central North Sea is another focus area for oil and gas production. In the past years, the area sealed has slightly increased due to the construction of offshore wind farms for renewable energy production.

While the overall extent of bottom trawling has decreased between the two assessment periods (2009-2014 and 2015-2020) by approximately 2%, the pressure has further increased in areas that are already intensively trawled and in habitat types with a higher susceptibility to severe sediment changes. Seabed habitats may further be threatened by aggregate extraction activities, however, the extent of risk cannot be estimated with the available data.

At the level of habitat types, biogenic habitats are threatened most by habitat loss due to their small extent and their typically low resistance to and recoverability from impacts. All other broad habitat types assessed are considered to be not endangered by sealing with offshore structures, as the proportion of affected habitat area is less than 0,03% per habitat type and assessment unit. The risk of loss by trawling is assumed to increase for mud in the upper depth zones and for coarse sediments in the deeper zones with lower energy.

Conclusion (extended)

Although the proportion of area estimated as sealed by offshore structures is still quite small, there is an increasing concern about future developments in the Greater North Sea, particularly with regard to the expansion of renewable energies. While this assessment focuses on physical changes to the seabed, soft sediment biotopes may be impacted on a much larger area by alterations of the species composition, the food web structure, local current regime and introduction of new species. Such changes could be classified as physical disturbance and may be included in a future assessment of indicator BH3 on the Extent of physical disturbance to benthic habitats.

The analysis of trawling risk at the level of the assessment units has shown that the impact on some habitats is high and has further increased in the current assessment period. This is especially the case for mud habitats in the Channel, the Southern and the Central North Sea, where core fishing zones are located. Trawling impact has further intensified in these habitats, with a shift of fishing pressure from habitat types less subject to risk of loss like sand to more vulnerable habitat types like mud and coarse sediments.

Knowledge Gaps (brief)

This pilot assessment presents the first attempt to estimate risk of habitat loss by sealing and sediment alterations in the Greater North Sea. Currently, the assessment is limited to some offshore structures, trawling and aggregate extraction. Other activities, such as capital dredging, disposal of sediments, coastal defence structures or shipping infrastructure, that may be an important factor in coastal areas, have not been regarded yet. The method for the assessment of sealed loss has been applied before in similar analyses, whereas the method for estimating the risk of habitat loss due to sediment changes has been newly developed for this indicator. The outcomes rely on the available information and could improve with newer and more accurate data on habitat types and activities.

Knowledge Gaps (extended)

The risk indicator pilot assessment has been based on the best available data, however, there are still gaps regarding information on the distribution and intensity of activities and habitat types. Particularly for aggregate extraction, the accessible data is currently not sufficient to produce a risk assessment. The further establishment of an aggregate database by ICES WGEXT may support future assessments. The risk assessment of bottom trawling may likewise improve when smaller fishing vessels are included in the data and with an increased spatial resolution.

Methodological improvements could include the calibration of categories proposed for trawling and dredging intensities. This process could be supported by ground truthing of sites with estimated high risk or the evaluation of sediment changes due to different intensities of fishing or extraction. Hydrographical models that account for severe sediment alterations may be useful to improve the accuracy of buffers used for the estimation of loss by offshore structures. More detailed evidence on substrate changes may also enable to include further factors like depth in the assessment method and allow for a more specific assessment.

Evidence on broad habitat types relied on the broad-scale predictive map, EUSeaMap (Vasquez *et al*., 2021) which is mostly a result of a combination of predictive modelling (for the biological zones) and interpolation of sparse sediment observations over long distances (for the substrate types). Furthermore, there is a knowledge gap about how the broad habitats have changed over time, with the substrate data in EUSeaMap being a compilation of data collected over many decades. Further work on a regional level should focus on clear definitions of EUNIS habitats and a harmonisation of the broad habitat classification at least throughout the Greater North Sea. This may also lead to changes in the classification for probability of loss by bottom trawling and aggregate extraction.

Likewise for the threatened and/or declining habitats data product (OSPAR 2020 a,b), there are large spatial gaps caused by a lack of survey data. Additionally, unlike EUSeaMap, there is no attempt to fill the gaps with predictions so there is likely to be an underestimate of the extent and distribution. There are many more point observations than polygons within the data product too, meaning that the spatial extent of the habitats, even where they are known to be present, is not always known. Similarly to the sediment data in EUSeaMap, this data product is a compilation of data spanning many decades, meaning that changes over time cannot be determined. With further survey effort and dedicated monitoring programmes, an improved knowledge on the distribution of broad and protected habitats could ensure that future assessments are reliable.

Threshold values have not yet been proposed for this indicator. The maximum allowable extent of loss should be expressed as a proportion of the total natural extent of the habitat type. For small-scale and particularly sensitive habitat types such as biogenic habitats, a stricter threshold value should be applied and a maximum extent of loss in km^2 may also be discussed. Proposals on threshold values should reflect the recommendations developed in TG Seabed for the corresponding criterion D6C4 'Extent of loss' of the Marine Strategy Framework Directive (MSFD).

For future assessments, data availability on further activities causing sealed and unsealed loss in the Greater North Sea and other OSPAR Regions shall be evaluated in order to extend the assessment. The possibility to run an assessment of historic biogenic loss shall also be explored.

References

BfN (2022): Sand- und Kiesabbau – Minimierung der Belastungen. https://www.bfn.de/minimierung-der-belastungen-1

De Jong M. (2016): The ecological effects of deep sand extraction on the Dutch continental shelf. Implications for future sand extraction. PhD Thesis, Wageningen University, Wageningen.

Desprez M. (2012): Synthèse bibliographique. L'impact des extractions de granulats marins sur les écosystèmes marins et la biodiversité. Les études de l'UNPG - Nature et paysage.

Eastwood P.D., Mills C.M., Aldridge J.N., Houghton C.A. & Rogers S.I. (2007): Human activities in UK offshore waters: an assessment of direct, physical pressure on the seabed. ICES J Mar Sci 64:453–463

Esteban M.D, López-Gutiérrez J.S. & Negro V. (2019): Gravity-Based Foundations in the Offshore Wind Sector J. Mar. Sci. Eng. 7:64.

EWEA (2019): The European Offshore Wind Industry - Key Trends and Statistics 2018. European Wind Energy Association.

Fariñas-Franco, J.M., Pearce, B., Porter, J., Harries, D., Mair, J.M., Woolmer, A.S. & Sanderson, W.G. 2014. Marine Strategy Framework Directive Indicators for Biogenic Reefs formed by Modiolus modiolus, Mytilus edulis and Sabellaria spinulosa. Part 1: Defining and validating the indicators, JNCC Report No. 523, JNCC, Peterborough

Foden J., Rogers S. I., & Jones A. P. (2011): Human pressures on UK seabed habitats: a cumulative impact assessment. Marine Ecology Progress Series, 428: 33–47.

Foden J., Rogers S.I. & Jones A.P. (2009): Recovery rates of UK seabed habitats after cessation of aggregate extraction, Mar. Ecol. Prog. Ser., 390, 15–26

HELCOM (2017): State of the Baltic Sea – Holistic Assessment. The assessment of cumulative impacts using the BSPI and BSII. Supplementary Report to the First Version of the 'State of the Baltic Sea' Report 2017

Hill J.M., Marzialetti S. & Pearce B. (2011): Recovery of seabed resources following marine ag-gregate extraction. Marine Aggregate Levy Sustainability Fund (MALSF). Science Monograph Series No. 2._first_version_2017.pdf

Hintzen N.T., Aarts G., Poos J.J., Van der Reijden K.J. & Rijnsdorp A.D. (2021): Quantifying habitat preference of bottom trawling gear. ICES Journal of Marine Science, Volume 78(1):172–184

ICES (2017): OSPAR request on the production of spatial data layers of fishing intensity/pressure. In Report of the ICES Advisory Committee, 2017. ICES Advice 2017, ICES Technical Service, sr.2017.17. 8 pp.

ICES (2019a): Workshop on scoping of physical pressure layers causing loss of benthic habitats D6C1 – Methods to operational data products (WKBEDLOSS). ICES Scientific Reports, Volume 1 Issue 15

ICES (2019b): Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT).

ICES EUTRADE (2021). ICES data outputs of EU request on how management scenarios to reduce mobile bottom fishing disturbance on seafloor habitats affect fisheries landing and value. (https://doi.org/10.17895/ices.data.8192).

ICES (2022): Development of an ICES Aggregate Dredging Dashboard. https://sway.office.com/orluJoHSruYfhy09?ref=Link

Kaiser M.J., Hormbrey S., Booth J.R., Hinz H. & HIDDINK J.G. (2018): Recovery linked to life history of sessile epifauna following exclusion of towed mobile fishing gear. - Journal of Applied Ecology 55: 1060-1070

Jennings S. & Kaiser M.J. (1998): The effects of fishing on marine ecosystems. Adv. Mar. Biol. 34

LKN-SH (2021): Fachplan Küstenschutz Sylt, Grundlagen – Sandentnahmen. Stand 28.04.2021. https://www.schleswig-holstein.de/DE/Fachinhalte/K/kuestenschutz_fachplaene/Sylt/2_0_grundlagen.html

Mengual B., Cayocca F., Le Hir P., Draye P., Laffargue P., Vincent B. & Garlan T. (2016): Influence of bottom trawling on sediment resuspension in the 'Grande-Vasière' area (Bay of Biscay, France). - Ocean Dynamics 1181-1207

Mielck F., Michaelis R., Hass H.C., Hertel S., Ganal C. & Armonies W. (2021): Persistent effects of sand extraction on habitats and associated benthic communities in the German Bight. Biogeosciences, 18, 3565–3577

Morato T, González-Irusta J-M, Dominguez-Carrió C, *et al.* (2020): Climate-induced changes in the suitable habitat of cold-water corals and commercially important deep-sea fishes in the North Atlantic. Glob Change Biol. 26: 2181– 2202. https://doi.org/10.1111/gcb.14996

Negro V., López-Gutiérrez J.S., Esteban M.D., Alberdi P., Imaz M. & Serraclara J.M. (2017): Monopiles in offshore wind: Preliminary estimate of main dimensions. Ocean Engineering 133:253-261

Newell R.C. & Woodcock T.A. (2013): Aggregate Dredging and the Marine Environment: an overview of recent research and current industry practice. The Crown Estate.

Oberle F.K.J., Swarzenski P.W., Reddy C.M., Nelson R.K., Baasch B. & Hanebuth T.J.J. (2016): Deciphering the lithological consequences of bottom trawling to sedimentary habitats on the shelf. Journal of Marine Systems 159:120–131

OSPAR (2011): Intersessional Correspondence Group on Cumulative Effects – Pressure list and descriptions. OSPAR Commission, London

OSPAR (2020a): OSPAR Habitats in the North-East Atlantic Ocean - 2020 Polygons. Data available from https://www.emodnet-seabedhabitats.eu

OSPAR (2020b): OSPAR Habitats in the North-East Atlantic Ocean - 2020 Points. Data available from https://www.emodnet-seabedhabitats.eu

Perry F., Tyler-Walters H., & Garrard S. L. (2020): Ostrea edulis beds on shallow sublittoral muddy mixed sediment. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: https://www.marlin.ac.uk/habitat/detail/69

Petersen J.K. (ed.), Holm A-P.S., Christensen A., Krekoutiotis D., Jakobsen H., Sanderson H., Andreasen H., Gislason H., Strand J., Behrens J., Hansen J.W., Svendsen J.C., Timmermann K., Møller L.F., Bach L., Larsen M.M., Zrust M.O., Nielsen M.M., Eigaard O.R. & NielsenT.G. (2018): Menneskeskabte påvirkninger af havet - Andre presfaktorer end næringsstoffer og klimaforandringer. Institut for Akvatiske Ressourcer, Danmarks Tekniske Universitet. DTU Aqua-rapport Nr. 336-2018

Populus J., Vasquez M., Albrecht J., Manca E., Agnesi S., Al Hamdani Z., Andersen J., Annunziatellis A., Bekkby T., Bruschi A., Doncheva V., Drakopoulou V., Duncan G., Inghilesi R., Kyriakidou C., Lalli F., Lillis H., Mo G., Muresan M., Salomidi M., Sakellariou D., Simboura M., Teaca A., Tezcan D., Todorova V. & Tunesi L. (2017): EUSeaMap, a European broad-scale seabed habitat map. 174p

Roberts J.M., Harvey S.M., Lamont P.A. & Gage J.A. (2000): Seabed photography, environmental assessment and evidence for deep-water trawling on the continental margin west of the Hebrides. Hydrobiologia 44, 173-183.

Roberts C., Smith C., Tillin H. & Tyler-Walters H. (2010): Review of existing approaches to evaluate marine habitat vulnerability to commercial fishing activities. Report: SC080016/R3, Environment Agency, Bristol.

Schratzberger M. & Jennings S. (2002): Impacts of chronic trawling disturbance on meiofaunal communities. - Marine Biology 141 (5): 991-1000

Strain E.M.A., Allcock A.L., Goodwin C., Maggs C.A., Picton B.E. & Roberts D. (2012): The long-term impacts of fisheries on epifaunal assemblage function and structure, in a Special Area of Conservation. Journal of Sea Research 67: 58-68.

Tillin H.M., Houghton A.J., Saunders J.E., Drabble R. & Hull S.C. (2011): Direct and Indirect Impacts of Aggregate Dredging. Marine ALSF Science Monograph Series No.1. MEPF 10, 41p

Tillin H.M. (2016): Modiolus modiolus beds on open coast circalittoral mixed sediment. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: https://www.marlin.ac.uk/habitat/detail/342

Tillin H.M., Marshall C., Gibb N. & Garrard S. L. (2020): Sabellaria spinulosa on stable circalittoral mixed sediment. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: https://www.marlin.ac.uk/habitat/detail/377

Trimmer M., Petersen J., Silyer D.B., Mills C., Young E. & Parker E.R. (2005): Impact of long-term benthic trawl disturbance on sediment sorting and biogeochemistry in the southern North Sea -Marine Ecology Progress Series 298: 79-94

Tyler-Walters H., Garrard S.L. & Perry F. (2019): Lophelia reefs. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [online]. Plymouth: Marine Biological Association of the United Kingdom. Available from: https://www.marlin.ac.uk/habitat/detail/294

Vasquez M., Allen H., Manca E., Castle L., Lillis H., Agnes, S., Al Hamdani Z., Annunziatellis A., Askew N., Bekkby T., Bentes L., Doncheva V., Drakopoulou V., Duncan G., Gonçalves J., Inghilesi R., Laamanen L., Loukaidi V., Martin S., McGrath F., Mo G., Monteiro P., Muresan M., Nikilova C., O'Keeffe E., Pesch R., Pinder J., Populus J., Ridgeway A., Sakellariou D., Teaca A., Tempera F., Todorova V., Tunesi L. & Virtanen E. (2021): EUSeaMap 2021, A European broad-scale seabed habitat map, Technical Report.

Assessment Metadata

Field	**Data Type**	
Assessment type	List	Pilot Assessment
SDG Indicator	List	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
Thematic Activity	List	Biological Diversity and Ecosystems - Targeted actions for the protection and conservation of species, habitats and ecosystem processes
Relevant OSPAR Documentation	Text	OSPAR CEMP Guideline (In Preparation): Area of habitat loss (BH4) (not yet published)
Date of publication	Date	2023-06-30
Conditions applying to access and use	URL	https://oap.ospar.org/en/data-policy/
Data Source	URL	https://www.emodnet-seabedhabitats.eu https://www.emodnet-humanactivities.eu https://odims.ospar.org

Field	Data Type	
		https://ices-library.figshare.com/articles/dataset/Data_for_OSPAR_request_on_the_production_of_spatial_data_layers_of_fishing_intensity_pressure/18601508

OSPAR's Quality Status Report 2023

OSPAR COMMISSION

OSPAR Secretariat
The Aspect
12 Finsbury Square
London
EC2A 1AS
United Kingdom

t: +44 (0)20 7430 5200
f: +44 (0)20 7242 3737
e: secretariat@ospar.org
www.ospar.org

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: 953/2023