  

Impact of demersal & seine fisheries in the Natura 2000-area Cleaver Bank

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A review of literature and available data

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Summary

The Netherlands have designated the Natura 2000 site Cleaver Bank under the Habitats Directive (92/43 EEC). The overall aim is to ensure the adequate protection of reefs (habitat type H1170) in accordance with the Habitats Directive.

The conservation objectives for H1170 are to maintain the distribution and surface area of the habitat, and to *improve its quality*. An improvement in quality is needed because the present-day quality of the habitat is currently assessed as unfavourable/inadequate (Jak et. al. 2009).

Therefore, the Dutch Government wants to reduce the pressures on the benthic habitat from bottom-contacting fishing gear. To this end the Netherlands have drafted a proposal for fisheries measures (Version 12, 4 December 2017), which the Netherlands intend to submit to the European Commission as a Joint Recommendation under articles 11 and 18 of Regulation (EU) 1380/2013) on the Common Fisheries Policy (CFP).

According to the proposal, the realisation of the conservation objectives of the habitat should result from the following measures:

- A zoning system dividing the area in 4 management zones and 1 (continuous) open zone.
- Closure of the management zones to mobile bottom contacting fishing gear types (< six knots): beam trawl, bottom otter board trawl, dredges and demersal seines (Scottish seines -also called fly-shoot- and Danish anchor seines).

In this literature review, carried out by ZiltWater, Kroes Consultancy and NIOZ, the impact of the aforementioned mobile bottom contacting fishing gear types on conservation objectives H1170 is investigated. For the Natura 2000-area Cleaver Bank, the main question that the commissioning party, WWF Netherlands, would like to have answered is:

ToR – Main question 1

Can it be concluded with certainty, leaving no reasonable scientific doubt, that in case any of the mobile bottom contacting fishing gears (for which the management zones of Natura 2000 site Cleaver Bank will be closed according to the joint recommendation, draft version December 2017), would be allowed in the management zones, the delivery of the conservation objectives of this site would not be jeopardized, in keeping with Article 6 of the Habitats Directive 92/43 EEC?

And

ToR – Main question 2

Can it be concluded with certainty, leaving no scientific doubt, that allowing bottom-impacting fisheries in the remaining area of Natura 2000 site Cleaver Bank outside the management zones, would not jeopardize the delivery of the conservation objectives of this site, in keeping with Article 6 of the Habitats Directive 92/43 EEC?

The results of this study can be used as a "second opinion" on the draft Background Document to the Joint Recommendation for offshore fisheries management on the Cleaver Bank (BD, in preparation).

The criteria we used to give a second opinion on the BD are based on the accepted methodology for an appropriate assessment.

The following sub-questions were formulated:

- Does the BD contain the relevant subjects?
- Does it give sufficient insights in the activity?
- Is the best available knowledge applied?
- Is the impact assessment complete?
- Have autonomous developments sufficiently been taken into account?
- In what way have knowledge gaps and uncertainties been dealt with?
- Is the selection of activities considered in cumulation complete?

Regarding the first question (ToR – Main question 1) the conclusion of this literature review is that in the case that mobile bottom contacting fishing gears would be allowed in the management zones of the Natura 2000-site Cleaver Bank, the vulnerable fauna elements are negatively impacted and the delivery of the conservation objectives (especially the improvement of habitat quality) can be jeopardised. This is the case for gears with a sub-surface impact (beam trawl), but perhaps even more so for gears with a shallow surface impact and larger area footprint (seines), since the most typical H1170-features of the Cleaver Bank protected area are the vulnerable (long-lived), filter-feeding, sessile epifauna, growing on the hard substrates. The significance of the effects should be investigated and assessed in an Appropriate Assessment (cf. HD Art. 6).

The proposal of the closed areas now is very much focused on the (rather narrow) habitat specifications of H1170. With that, characteristics such as 'a mosaic of sediments' are not fully protected. In the FIMPAS project, it was proposed to allow bottom mobile fishing gear in a corridor that encompasses (surrounds) areas where red algae occur. Such a choice is unfortunate in order to conserve this as a "typical" and characteristic species in the Habitat Directive (Duineveld et al., 2013). The red algae are very vulnerable to bottom disturbance, especially the reversal (overturning) of stones (which they need as substrate) and increased resuspension and sedimentation that decrease the clarity of the water and diminuishes the available light which is needed for photosynthesis. The effect of overturning of substrate for these species is evident. Resuspension of fine sedimentary material reduces the light penetration which will limit or prevent growth of these algae. Sedimentation of fine sediments on the algae has the same effect.

Regarding the second question (ToR – Main question 2), we like to draw the attention to the fact that the whole Cleaver Bank has been designated as Habitat type H1170 under Natura 2000. However, the MPA-boundaries are mainly based on the distribution of boulders > 30 cm and the gravel, gravelly sand and biodiversity in the near surroundings. The BD (following Jak et al., 2009) distinguishes 3 size classes of hard compact substrata that are (1) and can be (2, 3) part of the habitat type H1170:

1. Hard compact substrata with a cross-section of at least 64 mm (rocks, boulders or cobbles of ‘generally >64 mm’) is included in the habitat type.

2. Hard compact substrata (gravel and cobbles with sessile benthos) with a cross-section of 8 to 64 mm.

3. Hard compact substrata with a cross-section smaller than 8 mm. This finer gravel fraction (and possibly even finer sediments, including sand) can only form part of the habitat type if (1) these sediments form only a thin, mobile layer over cobbles and coarse gravel on which organisms live that are dependent on hard compact substrata, or (2) if they occur in mosaic with the habitat type.

Much of the substrates as described in 2 and 3 are not incorporated in the current boundaries of the management zones. The finer sediments, like gravel and sand outside the chosen boundaries, can also be colonised by sessile Reef Associated Species and thus become part of (and extend) the reef habitat (Sheenan et al., 2013). Furthermore, the highly permeable coarse sands on the Cleaver Bank can be inhabited by very special species, among which is the chordate *Branchiostoma lanceolata* (Van Moorsel, 2003).

Firm sediments may also be covered by a top-layer of finer sediments, and not show on the SSS as hard compact substratum, but still be suitable for species to attach to the underlying hard layer (Lavaleye, 2014). Lavaleye (2014) also suggests that a top layer of soft sediment on Cleaver Bank areas near the Botney Cut can originate from the deep by resuspension as a result of fishery activities in that channel. In the current proposal, however, the Botney Cut is left outside the borders of the closed area.

Resuspended sediments can further have negative effects on fauna not adapted for chronic high levels of turbidity. Decreased light intensity and smothering, or interference with filtering structures has negative effects on such fauna. With its depth of ~ 40 meter and coarse sands the Cleaver Bank hosts a community not adapted to high suspended matter loads and is likely to be sensitive to a chronic elevation of SPM caused by fisheries. Also, the transition of the flat Cleaver Bank to the deep Botney Cut channel is left out of the considerations, although the BD mentions on p. 28 that the bottom structure is more important on the depth-gradient to the deeper, silt-rich sea bed than for shallower sandy parts (Jak et al, 2009, referred to in Slijkerman 2013).

Therefore, is it likely that only closing the current proposed management zones will not provide the required certainty that the delivery of the conservation objective for H1170 in the Cleaver Bank would not be jeopardized.

The following recommendations are given as input for the background document.

Subject	**Recommendation**
Description of H1170 and explanation of typical values and species	Supported by the overview in Table 3.1, we recommend to revise Table 11.1 in the Background Document and add a clear(er) rationale for the applied indicator selection.
Available surveys	It appears that NIOZ conducted several surveys as part of their North Sea research program, but that not all of the survey data have been analysed or reported. There may be more unpublished data from other surveys (e.g. in the DISCLOSE-project) which may be worthwhile to include in the BD.
Status of the Cleaver Bank	The BD should make clear how the selected indicators can help to assess the ecological quality of H1170, which should improve (according to the Natura 2000 objectives). It is recommended to add or develop derived indicators such as the number of trawl marks observed in surveys, or the percentage of the area that is (un)trawled.
Improve knowledge on the Cleaver Bank	The spatial and temporal coverage of the monitoring is restricted. Large areas were not surveyed. Given that, and the fact that the indicators of quality improvement are not clear, the actual conservation status in terms of quality of the habitat cannot be assessed adequately and is largely unknown.
Description of demersal gear types and footprint	Further quantification of the footprint is only possible with more detailed information on the fishery intensity and the individual gear specifications. Such a quantification is recommended for an impact assessment.
Sensitivity of typical species to physical and biological pressures	On the Cleaver Bank, sessile epifauna is the most vulnerable for both surface and subsurface mobile bottom contacting fishing gear. In order to assess the vulnerability of species we also need to take into account the life stage of species. The BD-document does not distinguish lifepe stages of characteristic species when assessing the impacts of mobile bottom contacting fishing gear.
Impact on conservation objectives H1170	Most sessile epifauna depend on filter feeding and are sensitive to an increase in turbidity. There is little information available on the effect of smothering/turbidity on fauna in the Cleaver Bank caused by trawling gear in the Botney Cut.

Furthermore, the BD should provide the evidence (without reasonable scientific doubt) needed within the legal framework of the Habitats' Directive to support the management decisions and therefore must be set up taking into account the mandatory criteria for assessing the quality of H1170. This seems currently not the case.

1 Introduction

1.1 Background Cleaver Bank

The Dutch Government has designated the Natura 2000 site Cleaver Bank under the Habitats Directive (92/43 EEC), which forms the legal framework. The overall aim is to ensure the adequate protection of reefs (habitat type H1170) in accordance with the Habitats Directive.

The conservation objectives for H1170 are to maintain the distribution and surface area of the habitat, and to *improve its quality*. An improvement in quality is needed because the quality status of the habitat (at the moment of designation in 2016) was assessed as moderately unfavourable (see the Dutch Profile Document of Habitat type H1170, version of 2014; https://www.synbiosys.alterra.nl/Natura2000/documenten/profielen/habitattypen/Profiel_habitattype_1170_2014.pdf).

Box: Legal Framework Habitats' Directive

The BD aims to provide the necessary background information to the Draft Joint Recommendation for offshore fisheries management on the Cleaver Bank, with a request to regulate the fisheries in part of this area to ensure a key contribution to achieving Natura 2000 conservation objectives for reefs (H1170) and to ascertain that the integrity of the site will not be adversely affected. All this is in keeping with Articles 6.2 and 6.3 of the Habitat Directive 92/43EEC. In this framework, the Cleaver Bank is a Site of Community Importance (SCI), located in the EEZ of the Netherlands and was officially designated as HD area for reef protection on 27 May 2016.

According to article 1 sub e of the Habitats Directive 'the conservation status of a natural habitat means the sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species within the territory (…). The conservation status of a natural habitat will be taken as 'favourable' when (…), the specific structure and functions which are necessary for its long maintenance exist and are likely to continue for the foreseeable future, and the conservation status of its typical species is favourable'. Following article 1 sub i Habitats Directive 'the conservation status of a species (including the typical species) means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations'. The conservation of the typical species will be taken as favourable when: population dynamics on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and the natural range of the typical species is neither being reduced, nor is likely to be reduced for the foreseeable future (…)' (article 1 sub i Habitats Directive).

Interpretation manual of European Union Habitats, version EUR 28, April 2013:

Reefs can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions. Plants that are associated with reefs are (in the North Atlantic including North Sea and Baltic Sea): - A large variety of red, brown and green algae (some living on the leaves of other algae). Animals and reef forming species are Polychaetes (e.g. *Sabellaria spinulosa*, *Sabellaria alveolata*, *Serpula vermicularis*), bivalves (e.g. *Modiolus modiolus*, *Mytilus* sp.) and cold water corals (e.g. *Lophelia pertusa*). Non reef forming species are in general sessile invertebrates specialized on hard marine substrates such as sponges, anthozoa or cnidaria, bryozoans, polychaetes, hydroids, ascidians, molluscs and cirripedia (barnacles) as well as diverse mobile species of crustaceans and fish.
This document does not give further criteria for reefs.

To improve the habitat quality of H1170, the Dutch Government wants to reduce the pressures on the benthic habitat from bottom-contacting fishing gear. To this end the Netherlands have drafted a proposal for fisheries measures (we used the draft version joint recommendation of 7

December 2017), which the Netherlands intend to submit to the European Commission as a Joint Recommendation under articles 11 and 18 of Regulation (EU) 1380/2013) on the Common Fisheries Policy (CFP).

According to the proposal, the realisation of the conservation objectives of the habitat should result from the following measures:

- A zoning system dividing the area in 4 management zones and 1 (continuous) open zone.
- Closure of the management zones to mobile-bottom contacting fishing gear types (< six knots): beam trawl, bottom otter board trawl, dredges and demersal seines (Scottish seines -also called fly-shoot- and Danish anchor seines).

The four zones (see figure 1.1 below) aim to provide a robust protection of the habitat H1170 of c. 700 km^2 in total (70.000 ha), comprising 45% of the entire N2000 Cleaver Bank area (154.058 ha).

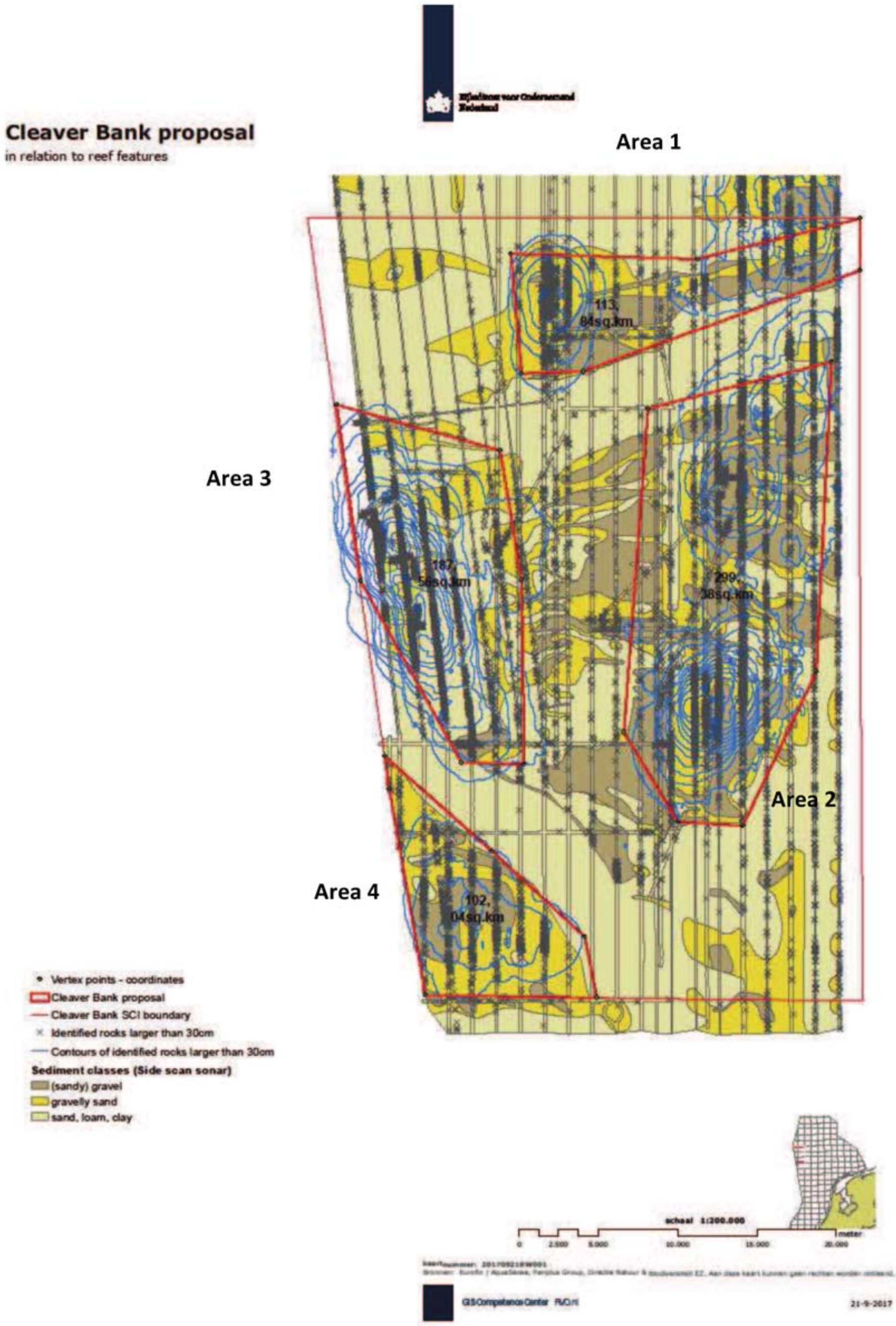

Figure 1.1 Proposed closures (management areas) in relation to the habitat feature H1170 according to the different layers of the additional research (Cleaver Bank Background Document, draft of 4 December 2017). Area 1=11364 ha, area 2=9416 ha, area 3=18756 ha, area 4=10602 ha.

1.2 Aim of the assignment

Following the procedure of article 11 of the Common Fishery Policy (CFP) and before submitting the joint recommendations for approval to the European Commission, the Netherlands aim to reach an agreement on the proposed fisheries management measures with member states with a 'direct management interest' Belgium, France, Germany, Sweden, United Kingdom and Denmark.

WWF Netherlands would primarily like to have researched the impacts that demersal seines have on habitat type H1170 of the Cleaver Bank and on its conservation objectives. However, the impacts of the other bottom impacting gears, beam trawl, bottom otter board trawl and dredges on the conservation objectives for Natura 2000 site Cleaver Bank are to be included as well.

1.3 Research question

For the Natura 2000-area Cleaver Bank, the main question which commissioning party, WWF Netherlands, would like to have answered is:

1. *'Can it be concluded with certainty, leaving no reasonable scientific doubt, that in case any of the mobile bottom contacting fishing gears to which the management zones of Natura 2000 site Cleaver Bank will be closed according to the joint recommendation, draft version December 2017, would be allowed in the management zones, the delivery of the conservation objectives of this site would not be jeopardized, in keeping with Article 6 of the Habitats Directive 92/43 EEC?'*

The findings in the report on the effects of bottom disturbing fisheries also incorporate areas in the Cleaver Bank outside the management zones. Therefore the following second main question is formulated:

2. *"Can it be concluded with certainty, leaving no scientific doubt, that allowing bottom-impacting fisheries in the remaining area of Natura 2000 site Cleaver Bank outside the management zones, would not jeopardize the delivery of the conservation objectives of this site, in keeping with Article 6 of the Habitats Directive 92/43 EEC?"*

2 Methodology

In this literature review the possibility of significant effects are related to the question whether the delivery of the conservation objectives for habitat H1170 will be jeopardized in the light of the characteristics and the specific environmental conditions of the Natura 2000 site if demersal (mobile bottom contacting) fishing gear is allowed within the management zones of the Cleaver Bank.

The following points of concern are addressed (Terms of Reference literature review Cleaver Bank by Thomas Rammelt, WNF, 4 September 2017).

Methodology

1. The aforementioned question will be answered on the basis of all literature and the best available data concerned.
2. Is there sufficient literature available to support the conclusion that the favourable conservation status of the Natura 2000 site is ensured in case of a management regime which allows the aforementioned bottom impacting gears in the management zones?
3. In the literature review the question will be answered if in the Cleaver Bank Background Document, draft of 4 December 2017, attachment 2) selective use has been made of available literature.

a. Was recent literature concerning the effects of the afore mentioned bottom impacting gears on reefs, habitat type H1170, left out of the impact analysis in the Background Document, p. 28-32?

b. Were conclusions of research, which have been used in the Cleaver Bank Background Document – also including the studies by Rijnsdorp et al (2016), and by Eigaard et al. (2016) - correctly reproduced?

Assessment of effects

1. Is a management regime, which allows the aforementioned bottom impacting gears in the management zones of the Natura 2000 site, scientifically justified on the basis of pressures in the occurrences of habitat type H1170 and hence does it meet the conservation status of the habitat?
2. In the literature review the possibility of significant effects will be related to the question whether the delivery of the conservation objectives for habitat H1170 will be jeopardized in the light inter alia of the characteristics and the specific environmental conditions of the site.
3. The literature review will, inter alia, research the effects of bottom impact and bycatch of the afore mentioned bottom impacting gears on habitat type H1170 as described in the Profile Document of H1170. The effects on the seabed and associated species will include the effects on fish (target and non-target species), benthos, shell fish and other bottom dwelling species. The research will also focus on slow-growing and long-lived species and other effects on the food web. If possible, long term effects will be taken into account. The effects on typical species as mentioned in the profile Document H1170, and on the indicator species as listed on p. 53 of the Background Document are part of this assessment.
4. In the assessment of the effects of the bottom impacting gears, the footprint per hour fishing of the gears should be compared.
5. In the assessment the study, commissioned by the Danish government, by DTU Aqua into the impacts of demersal seines (possibly focused on the Frisian Front and Central Oyster Grounds seabed), will be taken into account as well. This research is not yet available and is expected in September 2017.

Cumulative effects

1. Do impact assessments that support the draft proposal for the Cleaver Bank, include an assessment of the cumulative effects before they are related to characteristics, the specific environmental conditions and conservation objectives of the site?
2. Have other plans and activities been included in an assessment of cumulative effects?
3. Have 'external' activities taking place outside the borders of the Natura 2000 site Cleaver Bank, sufficiently been taken into account in the assessment of the effects inside the site?

In the Cleaver Bank background document, several bottom contacting fishing activities are listed. These gears, to be banned in the management zones, are: beam trawl, bottom otter board trawl, dredges and demersal seines (Table 2.1 below; Table 9.1 of the BD). Because of recent developments we added some considerations on the pulse beam trawl as well.

Table 2.1 Overview of bottom contacting gears that are part of the literature review

Gear groups that are banned in the closed zones	Gear Code Annex XI in EU Regulation 404/2011	International Standard Classification of Fishing Gears (ISSCFG)
Beam trawl	TBB	03.1.1
Bottom Otter Board Trawl	OTB, OTT, PTB, TBN, TBS, TB, BTM	03.1.2 , 03.3.0, 03.1.3, 03.1.9
Dredges	DRB, HMD	04.1.0, 04.2.0, DRM, DRX
Demersal seines	SDN, SSC, SPR, SV, SX	SPR, SDN, SSC, SV, SX

A literature survey was done to assess the current impact of mobile bottom contacting fishing gear on the status of certain indicator species. It was soon apparent that it is impossible to carry out a full review of 'all' literature, because of the large amount of studies that have been carried out since a long period and in recent years. For this study we used the most recent and relevant sources, and in addition it was possible to access unpublished data of NIOZ-surveys on the Cleaver Bank. Because of a lack of literature on the effect of specific gear (e.g. Danish seine) on specific substrates (e.g. gravel), we also approached the matter starting from the sensitivity of indicator species to the impacts of fishery. Sources of information on species were www.marlin.ac.uk, www.genustraithandbook.org.uk, and the (grey) literature available at NIOZ and in the public domain (including the relevant studies commissioned by the Dutch Government).

The full list of cited and consulted literature is listed in **Annex 1**. Author, year and title are presented per reference. Also, a brief description is given of the area of concern.

3 Conservation status of H1170

The typical values and characteristic species of the Cleaver Bank are described in the draft Background Document to the Joint Recommendation for offshore fisheries management on the Cleaver Bank (BD, DRAFT 12 of 4 December 2017; in preparation).

3.1 Description of H1170 and explanation of typical values and species

In 2016, 27th May, the Dutch part of the Cleaver Bank was designated as habitat type 1170 'Open-sea reefs' which is characterised by geomorphological features that are considered to be reef structure (Jak et al., 2009). The Cleaver Bank site (30-50 m depth) consists of a northern and southern part that are separated by the 60 m deep and silt-rich Botney Cut, which intersects the area.

Conservation objectives for H1170 are: maintain distribution, maintain surface area and improve quality of H1170 (see the Dutch Natura 2000 legal framework). An improvement in quality is needed because the quality of the habitat is currently assessed to be unfavourable or inadequate because of the presence of numerous trawl marks on the seabed, which showed up in several surveys that have been conducted over the past decennia (based on Jak et al., 2009), see par. 3.4.

3.1.1 Typical values

The presence of large cobbles and/or coarse gravel is a characteristic feature of habitat type H1170. Gravel and cobbles on the Cleaver Bank originate from the last Ice Age (Schwarzer and Diesing, 2003, from Jak et al., 2009). One additional characteristic is the presence of a mosaic of coarse sediment types that, in addition to cobbles and gravel, consists of various gravel and sand fractions (based on Laban, 2004). Places with gravel and boulders alternate with coarse sand and places with old shell material. Here and there, boulder clay rises to the surface.

The gravel and cobbles offer habitat for sessile epifauna to settle. Gravel with a grain size larger than 30 mm can already be covered with sessile fauna. This suggests that the mobility of these sediments is minimal. Sessile organisms are important because these organisms can aggregate loose elements on the seafloor together (Collie et al., 1997), resulting in a seafloor which is less sensitive to the effects of water movement. The presence of, and accretion by, these sessile organisms is responsible for the development of the three-dimensional structure of the habitat type, giving it complexity. This complex, three-dimensional structure creates new niches that become occupied by specialised organisms and that offer shelter to juvenile mobile fauna such as fish (Rabaut et al, 2013). This leads to increasing biodiversity and additional ecosystem services (based on Jak et al., 2009).

<u>The coarse permeable sands</u> form a specific habitat for species such as the lancelet *Branchiostoma* and sand smelt *Ammodytes sp*. and thick-shelled bivalves, such as *Arcopagia crassa*, *Dosinia exoleta* and *Aequipecten opercularis*.

Because of the considerable depth (~40m) of the Cleaver Bank, the sand and finest gravel fractions on the bottom are disturbed by wave action only in extremely heavy weather. By comparison with the Oyster Grounds, which are of comparable depth, an estimate by Thompson et al. (2011) showed that natural resuspension events at this depth occur during 8% of the time (see also section 6.2 in this report). As a consequence of the glacial origin and the hydrography, the gravel is relatively poor in silt. The visibility is so high that light penetrates to a depth of 40 m, which is sufficient to enable the growth of crustose calcareous red algae (van Moorsel, 2003).

The mosaic pattern and the low mobility of a large part of the sediments in combination with the clarity of the water make the Cleaver Bank unique in the Dutch EEZ, although this combination of features is less rare in other parts of the North Sea (Jak et al, 2009).

3.1.2 Typical species

The description of the Natura 2000-habitat type of the Cleaver Bank includes a list of characteristic or exclusive typical species (see Profielendocument H1170). With the aim of selecting smart indicator species to evaluate the quality status of protected areas on the DCS (Dutch Continental Shelf) in the context of both the Habitats' Directive (Natura 2000) and the Marine Strategy Framework Directive (MSFD), we added smart species to the list of typical species, as defined by Natura 2000 (Wijnhoven et al., 2013). The MSFD is concerned with the quality of marine ecosystems. MSFD-descriptors or indicators of habitat quality are: bottom integrity and healthy populations of infauna and epifauna, including long living species. In order to improve the habitat quality, the reduction of mortality and increase of survival of organisms need special attention. The purpose of these descriptors or indicators is to assess the quality status of the habitat type and to enable the detection of the effectiveness of measures.

The draft Background Document of the Cleaver Bank (Table 11.1) presents a list of indicator species, containing some but not all of the typical species of H1170, together with additional indicator species (see Table 3.1 below, column "Table 11.1"). These additional indicator species are all benthic species (epi- and infauna) and they are considered to represent the relevant quality aspects of the habitat as mentioned above. Mobile species, such as fish, and rare species are excluded as such species cannot be reliably sampled quantitatively, which prevents the detection of long term trends in their population development. These species will, however, be reported whenever found in video samples. Of the suggested smart indicators (Wijnhoven et al., 2013), the bivalve *Dosinia exoleta* was not included in the list of indicator species in the BD.

In several previous studies, indicator species were selected that are characteristic of the Cleaver Bank. Table 3.1 presents an overview of indicator species that were suggested in the different studies (Wijnhoven et al., 2013, Lengkeek et al., 2013); www.synbiosys.alterra.nl/Natura2000/Profiel_habitattype_1170_2014.pdf).

Tabel 3.1. Overview of selected typical species for the Cleaver Bank appointed by N2000 and in the BD, but also in several studies. Explanation: Indicator T+S = Indicates 'Typical species' and Smart species. Ca = Indicator abiotic, Cab = Indicator biotic structure, K = Characteristic for habitat, E = Exclusive for habitat. Prim = primary indicator, Sec = secondary indicator, Reg = registration species. Distinctive species are the predominant species of the gravel beds, that are typical of the area in that they are not, or only scarcely, found in adjacent regions.

spec	Species	NL name	EN name	BD Table 11.1	T Natura 2000	KRM: Wijnh	Leewis	Lengkeek	Sips&Waardenburg 1989
Anthozoa	Alcyonium digitatum	dodemansduim	dead man's finger	+	Cab	Cab	T + S	Prim	distinctive
Anthozoa	Cerianthus lloydii	viltkokeranemoon		+					
Anthozoa	Urticina sp.	zeedahlia	sea dahlia	+	Cab		T + S		
Bivalvia	Aequipecten opercularis	wijde mantel	queen scallop	+	Cab		T	Reg	
Bivalvia	Arcopagia crassa (Acropagia crassa?)	stevige platschelp		+	Cab	Cab	T	Reg	distinctive
Bivalvia	Arctica islandica	noordkromp	ocean quahog	+					
Bivalvia	Pododesmus sp./patelliformis	zadeloester		+	K + Ca	K + Ca	T + S	Sec	
Bivalvia	Polititapes rhomboides	gevlamde tapijtschelp		+					
Bivalvia	Timoclea ovata	ovale venusschelp		+					
Echinoidea	Echinocyamus pusillus	zeeboontje	pea urchin	+					
Florideophyceae	Lithothamnion sonderi & Phymatolithon sp.	kalkroodwieren		+	K	K	T + S	Reg	
Gastropoda	Aporrhais pespelecani	pelikaansvoet		+	Cab		T	Sec	
Gastropoda	Buccinum undatum	wulk	dog whelk	+	Cab	Cab	T	Sec	
Gastropoda	Simnia patula = Xandarovula patula!	stiefelslak		+	Cab		T	Reg	
Malacostraca	Galathea intermedia	oprolkreeftje		+	E	E	T + S	Sec	
Malacostraca	Liocarcinus sp.	zwemkrab		+					
Malacostraca	Paguridae			+					
Malacostraca	Pagurus cuanensis	Harige heremiet greeft		+					
Malacostraca	Upogebia deltaura	molkreeftje		+					
Polychaeta	Aonides paucibranchiata	?	a bristleworm	+					
Polychaeta	Chone duneri	?	?	+	K	K	zie C. inf.	Prim	distinctive
Polychaeta	Chone infundibiliformis						T + S	Prim	
Polychaeta	Goniadella bobrezkii	?	?	+					
Polychaeta	Protodorvillea kefersteini	?	a polychaete worm	+					
Polychaeta	Sabellaria spinulosa		Ross worm	+	K + Ca	K + Ca	T + S	Reg	
Polychaeta	Spiophanes kroyeri			+					
Polychaeta	Spirobranchus triqueter / Pomatocerus triqueter	driekantige kalkkokerworm		+		Ca		Reg	
Polychaeta	Terebellides stroemii			+					
Porifera	undefined phylum			+				Prim	
Porifera	Haliclona oculata	geweispons	Mermaid's Glove		Cab		T	Prim	
Bivalvia	Dosinia exoleta	Artemisschelp	Rayed Artemis		Cab	Cab	T	Reg	distinctive
Pisces	Micrenophrys lilljeborgi / Taurulus lilljeborgi	Dwergzeedonderpad			E		T	Reg	
Pisces	Diplecogaster bimaculata	Zuignapvis			E		T	Reg	
Pisces	Lophius piscatorius	Zeeduivel			Cab		T	Reg	
Cnidaria	Hydrozoa						S	Prim	
Nudibranchia		Naaktslakken of eieren	Slugs/snails					Sec	
Pisces		Roggen/haaien	Rays, skates and sharks					Reg	
Chordata	Branchiostoma	Lancetvisje	Lancet						distinctive
Amphipoda	Urothoe marina	bulldozerkreeftje							
Polychaeta	Typosyllis cornuta								
Bivalvia	Modiulus modiolus	paardenmossel	horse mussel						
Malacostraca?	Callianassa subterranea	slibburcht kreeftje							
Echinoidea	Psammechinus miliaris	Kleine zeeappel							distinctive
Anthozoa	Metridium senile	Zeeanjelier							distinctive
Anthozoa	Urticina felina (Tealia)	Zeedahlia							distinctive
Pisces	Ammodytes	zandspiering	sand smelt						+

Table 11.1 of the BD includes more than the typical species (as defined in the framework of Natura 2000), and contains a different set of species than in several other documents. The basis for selecting a particular subset of all relevant indicators in Table 11.1 of the Background Document is unclear: the document does not explain the criteria or sources from which the indicators were derived. Note that there are some errors in the Table (some Bivalves occur in the table as Bivalve and as Gastropod as well).

3.2 Available surveys

There is an international obligation to report on the status of the Natura 2000-areas at regular time intervals (every 6 years). The Dutch national monitoring program MWTL (Monitoring van de Waterstaatkundige Toestand des Lands) only has one sampling location at the outer western edge of the Cleaver Bank. MWTL is carried out once every 3 years, using a box-core and 'Triple-D'. However, these methods are not suitable to sample gravel/cobbles/boulders as present on the Cleaver Bank, because on this type of substrates a combination of Hamon grab, video/photo and Side Scan Sonar is required.

Because of the shortcomings of the national monitoring (MWTL) on the Cleaver Bank, and the EU-obligations to report on its status regularly, RWS is working on improving the monitoring. The figure below (Figure 3.1) shows the proposed monitoring stations on the Cleaver Bank that should enable a better assessment of the status of the Cleaver Bank including habitat type H1170 in future (Troost et al., 2013). For this area, a combination of video sampling and Hamon grab is recommended. The northern and south-eastern parts of the Cleaver Bank SCI are not covered by monitoring stations, the reason is not clearly explained in Troost et al. (2013).

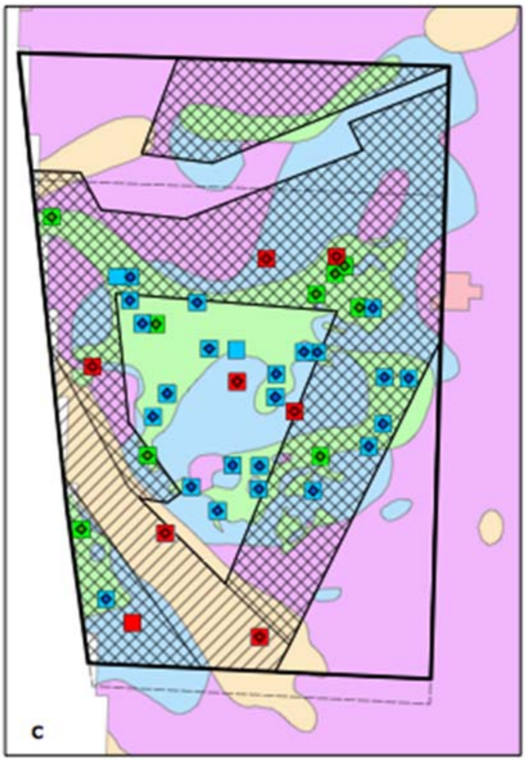

Figure 3.1. Proposed monitoring stations Cleaver Bank (Troost et al. 2013). Square symbols indicate Hamon grabs, diamonds indicate video sampling. Troost et al. (2013).

To assess the current status of the Cleaver Bank, as said, the (practically non-) existing MWTL-monitoring (in this area) cannot be used and for now we have to rely on incidental surveys and studies. Investigative surveys, applying different methods to map the geological and ecological status of the Cleaver Bank, were carried out in this area since 1983 until recent dates. The table below (Table 3.2) provides an overview of the different surveys and the methods applied.

Table 3.2. Overview of surveys carried out on the Cleaver Bank

year	who	geologisch	ecologisch	SSCS	Hamon	ROV	Core	Citation	Opdrachtgever	Gebruikt in BD
1983	De Groot?							genoemd in Moorsel 2003		nee
1985	BuWa	+	+		+			Sips, H.J.J. en H.W. Waardenburg, 1988	RWS, NZ	nee
1988	BuWa	(+)	+	+	+	+	+	Sips & Waardenburg, 1989	RWS, NZ	nee
1989	BuWa							Van Moorsel & Waardenburg 1990		nee
1990	BuWa							Van Moorsel & Waardenburg 1991		nee
1991	BuWa							Van Moorsel, 1993		nee
2002	EcoSub		+	+	+	+		Van Moorsel, G., 2003	RIKZ	ja
2002	TNO							Laban, 2004		ja
2014	NIOZ			+	+	+		Lavaleye, 2014	RWS, NZ	nee
2015	Periplus, Eurofins/Aquasense	+	+	+	+	+		Leewis et al., 2016. Periplus Report 16C021-01	MinEZ	ja
2016	Fugro	+	+	+	+	+	etc.	Fugro, 2016 in VikingLink Aanvraag compleet.pdf	VikingLink	nee
2013	NIOZ		+		+	video		Witbaard et al, 2013- Cruise report		
								Duineveld et al, 2014-Report for RWS		

The status description in the BD is based on the state of the art available reports (Van Moorsel 2003, Laban 2004, Leewis et al., 2016). The cited reports of Jak et al. (2009) and Lindeboom et al. (2005, 2008) are merely desk studies, mainly based on the survey data by Van Moorsel 2003 and Laban 2004.

Older references, not cited in the BD directly, are: Sips & Waardenburg (1988, 1989,) Van Moorsel & Waardenburg (1990, 1991), Van Moorsel (1993, 1994). More relevant and recent references, uncited in the BD, are: Duineveld et al. (2013), Lengkeek et al. (2013), Lavaleye, 2014, Leewis & Verduin 2015, Fugro, 2016 (cited in VikingLink, 2017).

Lengkeek et al. (2013) report incidental observations made during a North Sea diving expedition.

Recently, data (by Side Scan Sonar (SSS), video-collections (ROV) and Hamon grabs have been acquired and analysed by RWS/Periplus/Eurofins/NIOZ. These were (sometimes only partly) reported in Duineveld et al., 2013, Lavaleye, 2014, Leewis & Verduin 2015 and Leewis et al., 2016. The NIOZ survey was conducted in September 2013 and had a follow-up in the next year (2014) in cooperation with RWS (video and multibeam survey), reported (partly) by Lavaleye (2014).
In the VikingLink (2017) impact assessment for a transnational communication cable, reference is made to Periplus (2015) (but this reference is not listed in the report; it is probably the same as Leewis & Verduin, 2015) and Fugro (2016). It remains unclear if VikingLink was based on the surveys mentioned before, or if they independently also collected their own data (Fugro, 2016).

In 2017, researchers from TU Delft, Groningen University, and NIOZ, joined an Oceana Foundation expedition from 3 to 15 August 2017. The expedition sailed from the Borkum Stones westwards, towards the Dogger Bank. Its mission, called project DISCLOSE, was to get information on the seafloor in order to identify vulnerable areas. As part of this, TU Delft (L. Koop) produced a very detailed map (based on Side Scan Sonar data of RWS) of the sediments of the Cleaver Bank, which can be found on (Figure 3.2).

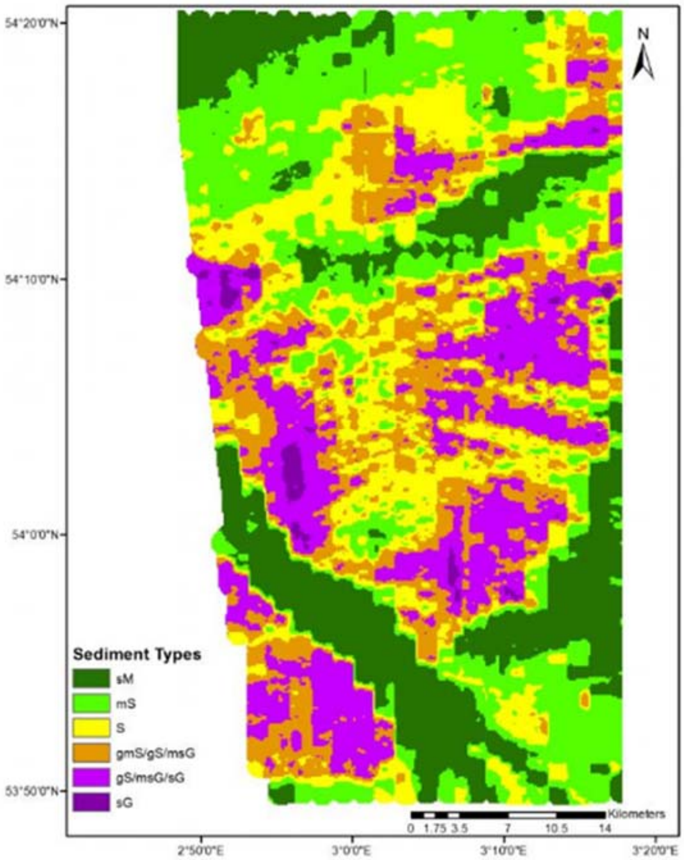

Figure 3.2. Sediments, based on SSS of a 25-30 km wide track of the Cleaver Bank. Colours indicate the soil composition (purple-pink-orange = gravely sediments, yellow = sandy sediments, greens = muddy sediments). Image: Leo Koop/TU Delft, DISCLOSE project.

In addition to the benthic surveys described above, several fish surveys are carried out annually by IMARES to collect information for fish stock assessments in the North Sea. Bos et al. (2012) provided summary sheets per species based on surveys are the IBTS, BTS, SNS and DFS, in which the distribution and trends of each species in the Dutch part of the OSPAR area is shown.

3.3 Status of the Cleaver Bank

The high biodiversity of the Cleaver Bank is due to the diverse composition of the substrates at a relatively large depth. All components (cobbles, pebbles, coarse sediments with shell remains, coarse permeable sands) contribute to the diverse fauna. Furthermore, the intersecting deep and muddy channel Botney Cut provides conditions for even more and different groups of organisms.

According to Van Moorsel (2003), the characteristic species of the Cleaver Bank are the species that are bound to coarse sand, gravel and pebbles. Van Moorsel (2003) concludes that the typical species occurring on the Cleaver Bank fall into three main groups:

- sessile epifauna, growing on cobbles (*Alcyonium*, *Lithothamnion*, *Phymatolithon*, *Spirobranchus, Pododesmus*, *Hiatella arctica* = rock boring mollusc),
- infauna related to highly permeable coarse sands (*Branchiostoma*, the pea-urchin *Echinocyamus pusillus*, worms *Aonides paucibranca, Typosyllis cornuta*, *Goniadella brobetzkii,* gammarid *Urothoe marina*), and
- organisms that are adapted to living on or in coarse sediments such as the thick-shelled bivalves i.e the rayed artemis (*Dosinia*), blunt tellin (*Arcopagia*) and ocean quahog (*Arctica islandica*). They are adapted to deal with occasional mobility of pebbles by natural causes.

There is also potential habitat for the long-lived horse mussel *Modiolus modiolus* and the common whelk *Buccinum undatum* (needs hard substratum to deposit egg-cases).

The growth of crustose red algae (potentially forming 'maerl') at depth on the Cleaver Bank is unique for the NCP and only possible due to the clarity of the water in combination with the presence of hard substratum. These algae need light for photosynthesis and can be found up to 39 m in the clearest waters, because of the light limitation at greater depths (Van Moorsel, 2003). Since the shallow parts of the Cleaver Bank are around 30 m, the red algae only have growth potential in a narrow depth zone on the bank (implicating that, if water clarity would decrease, a distribution shift to shallower waters with sufficient light is not possible within Cleaver Bank).

Additionally, Van Moorsel (2003) describes the presence of deep water northern species such as the gastropods *Neptunea antiqua*, *Colus gracilis*, the sea urchin *Spatangus purpureus*, the squat lobster *Galathea*, the worms *Glycera lapidum*, *Chone duneri*, *Laonice bahusiensis* and the fish species *Taurulus (syn. Micrenophrys) lilljeborgii.* These occur on the Cleaver Bank at their southern distribution limit. Another fish species special to the Cleaver Bank is *Diplecogaster bimaculata*, clinging to (the underside of) stones.

The burrowing crustacean species *Callianassa* and *Upogebia* were found at the edge of, or in, the deep and silt-rich channel Botney Cut. They are not considered as typical species for the habitat H1170 (Jak et al., 2009). However, they may serve as food for skates and rays and other fish.

Bos et al. (2012) found a high fish species diversity on the Cleaver Bank. Van Moorsel (2003) reported 25 fish species (in diving and video observations and beam trawl hauls) on the Cleaver Bank. Gobies (*Pomatoschistus sp.*) were the most common species, and solenette (*Buglossidium luteum*), scaldfish (*Arnoglossus laterna*) and dragonet (*Callionymus lyra*) appeared in the Cleaver Bank in high densities of locally more than 10 individuals per 1000 m^2. Some new species (for the DCS) were found, for instance the Northern rockling (*Ciliata septentrionalis*), that never showed up in the IBTS monitoring of 2000 (Van Moorsel, 2003).

Both the Norway Bullhead (*Taurulus lilljeborgii*) and the Two Spotted-clingfish (*Diplecogaster bimaculata*) were unknown for the Cleaver Bank (were not included in the Dutch species database Biobase) and are rare to the Dutch fish fauna. However, all fish species listed above appeared in most sampling transects within the Cleaver Bank and prefer cobbles as a habitat (Van Moorsel, 2003).

The reef structure of the Cleaver Bank not only offers habitat for "rare" species but can also offer space to the larval and juvenile stadia of fish (see Rabout et al 2013). An example of this is the herring *Clupea harengus*, a pelagic species with benthic eggs, that in the past used the Cleaver Bank gravel substrata as a spawning area. The Cleaver Bank is an important spawning ground, in particular for cod and possibly for whiting, of which the stock is currently well below target. Closing this area would lead to less disturbance of the seabed, potentially enhancing cod spawning, which could contribute to rebuilding of the cod stock (Van Kooten et al., 2015b).

Fish-eating birds like the common guillemot (*Uria aalge*) and the razorbill (*Alca torda*), but also the harbour porpoise (*Phocoena phocoena*) and the minky whale (*Balaenoptera acutorostrata*) are attracted by the large schools of fish that migrate via the Botney Cut (Jak et al., 2009).

Duineveld et al (2013) made an inventory (as part of the NIOZ North Sea monitoring 2011-2012) of the density of indicator and typical species in the Cleaver Bank and Dogger Bank, based on video monitoring. Figure 3.4 presents the distribution of a number of 'typical' and / or 'indicator types for the Cleaver Bank. The figure shows that, rather unexpectedly, relatively high densities of indicator species were found on the stones in the muddy sandy slope at the transition between Cleaver Bank and the Botney Cut.

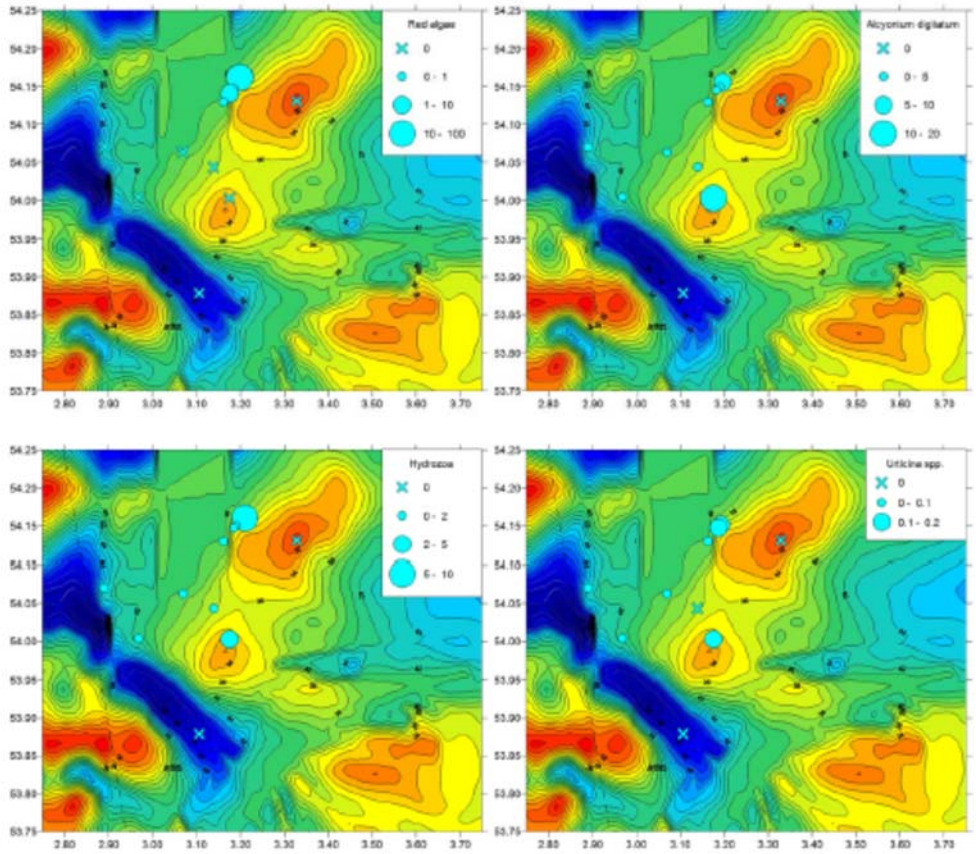

Figure 3.3. Distribution and density (Ind./20m²) of some 'typical' and/or 'Indicator' species. Upper left: calcarious red algae growing on stones and (a.o.) belonging to the genus *Lithothamnion*. Upper right: *Alcyonium digitatum*, a soft coral species that grows on stones. Bottom left: *Hydrozoa* or Hydroid polyps (branched colonies of nettle animals), growing on hard substrate. Bottom right: *Urticina* spp., a large sea anemone. Source: Duineveld et al., 2013.

The VikingLink (2017) reports that the area was mapped in low resolution (due to budget restrictions) and that ecological samples were taken at 42 locations, of which 39 were also observed by ROV. The western part of Cleaver Bank consists of cobbles and silty sediments, and the eastern part of cobbles and gravel and other coarse sediments. There was a rich infauna, but the epifauna on cobbles had a relatively low diversity, typical of coarse sediment areas (Periplus, 2015; Figure 3.4). The SSS-data, with limited ground-truthing by the ROV-survey, localised the areas with cobbles with a diameter of 30 cm or more. The cobbles seemed to occur in clusters, which are indicated in a map. The sessile epifauna that was observed consisted of the octocorrallium *Alcyonium digitatum*, *Serpulidae*, *Hydrozoa*, *Urticina sp*. The mobile epifauna encompassed the North Sea crab, *Cancer pagurus*, the swimming crab (*Liocarcinus* species), whelk (*Buccinum undatum*), queen scallop (*Aequipecten opercularis*) and brittle stars (*Ophiuridae*).

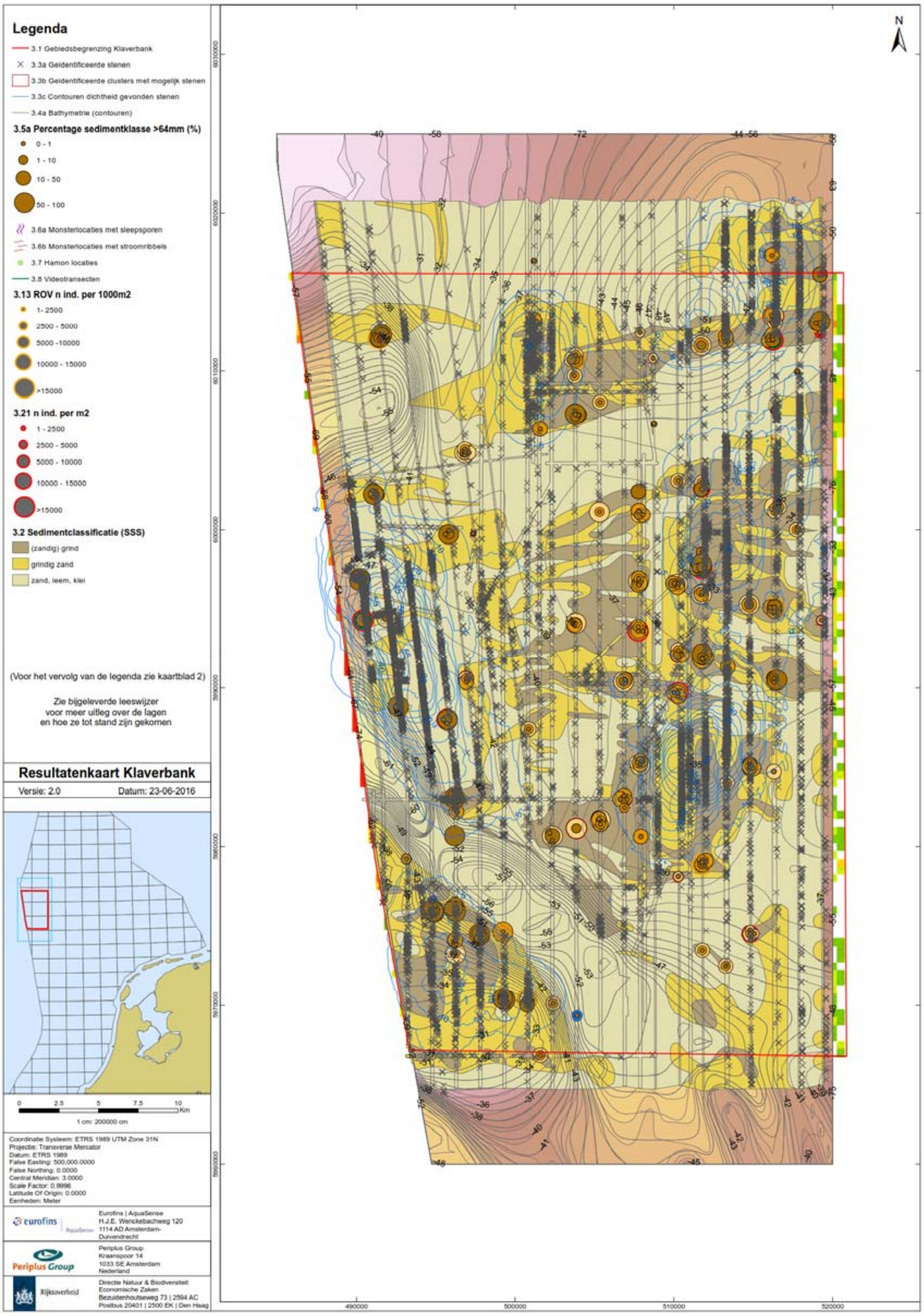

Figure 3.4. Integrated geological and ecological data of 2014/2015 Side Scan Sonar (SSS), video-collections (ROV) and Hamon grabs in the Cleaver Bank by Leeuwis et al., 2016.

3.4 Traces of fishery

An analysis on the value of the fishing activities of European fishing fleets on the proposed closed areas on the Cleaver Bank and Frisian Front showed that the majority of the fishing activities on the Cleaver Bank is carried out by Dutch vessels, followed by Belgian, British and German fleets (Hamon et al., 2017). The fishing occurs mainly by beam trawls and otter-board trawls.

The Dutch fleet also operates seines (fly-shoot) in the area. The main species targeted by the beam-trawl fleet on the Cleaver Bank is plaice. The other demersal gears catch a combination of species such as mackerel, plaice, cod and whiting. Some sole and Nephrops are caught as well. All other species have much lower landings with the notable anomaly of the Danish fleet in 2014 that caught anchovy and sprat (Hamon et al., 2017).

A television broadcast named 'Hollandse Vissers' ('Omroep MAX', 2014), showed the actual activity of a traditional beam trawler on the Cleaver Bank, catching (among others) common whelk (*Buccinum undatum*) and stones with sessile epifauna attached (Figure 3.5).

Figure 3.5. Screenshot of the broadcast 'Hollandse Vissers ('Omroep MAX', 2014) showing the catch of a t beam trawler on the Cleaver Bank.

Trawling marks were already observed by Side Scan Sonar (SSS) in the Cleaver Bank surveys conducted in 1979, 1983 and 2002 (reported by Van Moorsel 2003 and Laban 2004). Lavaleye (2014) also noted numerous and clear beam trawl marks, visible on the SSS-images. Lengkeek et al. (2017) documented recent bottom contacting activities on the Cleaver Bank, and describe its visible traces as observed during a diving expedition. Even the few stations on the Cleaver Bank where large cobbles with red algae were found - see Figure 3.6a - are actively fished (Duineveld et al., 2013, Lengkeek et al. 2013); this was concluded by comparing the 2011 and 2012 NIOZ-surveys that showed clear bottom disturbance (e.g. broken and reversed stones, see Figure 3.6b,c).

On the basis of these type of observations, Jak et al. (2009) concluded that the structure and function of the habitat (H1170) must have fundamentally deteriorated due to repeated disturbance of the bottom, compared to an undisturbed situation.

a.

b, c.

Figure 3.6. Pictures of the damage to the epifauna community of the Cleaver Bank in June 2017 (Lengkeek et al., 2017).

a. A track of demersal fishing gear in the bottom substrate in 2017. A second track, not visible on the photo, was about 10 meters further (photo: P. Van Rodijnen). b, c.. Detailed pictures of damage to dead man's finger in 2017. b. Dead man's finger in bad condition, partly under a stone. c. A loose piece of dead man's finger visible between stones with a fractured surface (pictures: Udo van Dongen).

4 Impact of demersal fisheries

4.1 Description of demersal gear types and footprint

The impact analyses of towed fishing gear on H1170 is based on Deerenberg et al. (2010) and the BENTHIS study (e.g. Rijnsdorp, 2016, Eigaard et al., 2016). BENTHIS provided information on the surface area impacted by the various mobile bottom contacting metiers.

Towed nets may affect the sea floor in various ways (figure 4.1 Eigaard et al., 2016). The cables and ground ropes that are dragged over the sea bed may homogenize the texture of the sea bottom, destroy hard structures and move or turn stones or shells. Heavy gear components such as the otter boards or tickler chains will penetrate into the sea bed and disturb the vertical structure of the sediment (Rosenberg et al, 2003) or compact the sediment. Sediment is brought into suspension by the turbulence generated in the wake of the gear (O'Neill and Ivanovich, 2016; Pusceddu et al., 2005) and affect nutrient exchange (Couceiro et al., 2013).

It is necessary to estimate the seabed pressure, using the area and severity of gear impact of different fishing methods on the seabed as a measure. Eigaard et al. (2016) developed a generic method to compare the 'footprint' of different fishing gears, taking into account the overall size of the gear (e.g. door spread of otter trawls OT) and the relative contribution of different gear elements to the footprint. Eigaard derived the penetration depth of individual gear components from literature. The different towing principles of demersal seines, otter trawls, beam trawls and dredges are illustrated by the figure below (from Eigaard et al., 2016).

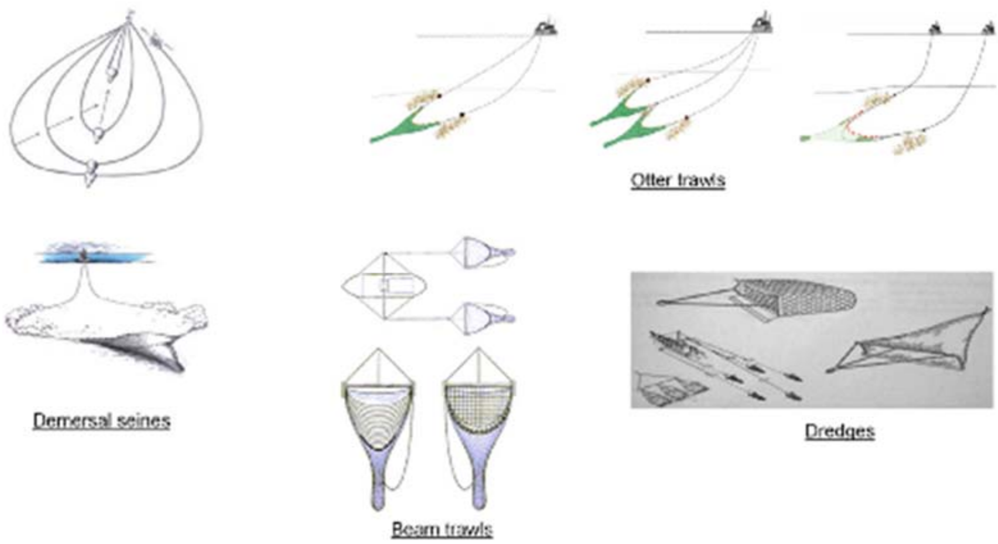

Figure 4.1. Towing principles of the four main high-impact demersal gear groups identified: DSs (left), OTs(top right), DRBs (bottom right), and TBBs (centre, bottom). Illustrations from FAO: http://www.fao.org/fishery/geartype/search/en. This figure is available in black and white in print and in colour at ICES Journal of Marine Science online.

Different gear elements have different properties, therefore a distinction is made in trawl shoes/doors, ground gear/tickler chains, ropes and bridles. And whether the penetration depth is less than 2 cm (surface) or deeper (sub-surface). Eigaard et al. (2016) distinguish between surface abrasion by all gear components that have bottom contact, and subsurface abrasion by gear components that penetrate more than about 2 cm into the sediment.

Metiers differ widely in the surface area swept per hour of trawling (Eigaard et al., 2016). Flyshoot and otter trawls, in particular twin trawls, have a large surface footprint as compared to for instance beam trawls used in the flatfish fishery. The flatfish beam trawls, however, have a relatively large subsurface footprint because all gear components penetrate into the seabed (Figure 4.2 below).

In the last decennium there has been a rapid transition from traditional tickler chain beam trawls (using mechanical stimulation) to pulse trawls and to sumwing-pulse trawls (using electrical stimulation), which is evident from the effort statistics. In 2008, beam trawl fisheries still represented 77% of the total effort in terms of horse power days. In 2014, this percentage had decreased to only 2 percent whereas the sumwing method + pulse fisheries had increased to 68% (Turenhout et al, 2016).

Although pulse fishing is strictly regulated and is officially forbidden within the EU, at present there are 82 exemptions (for NL) from this EU-ban on electrical fishing, which is (with different specifications) used both in coastal shrimp fisheries as well as in offshore flatfish fisheries. In pulse fishing for flatfish the tickler chains have been replaced by a system which activates, stimulates and/or paralyzes the target species so that they end up in the net. All gear varieties still have a ground rope and on basis of photographs (Polet & Depestele, 2011) it is suggested that various combinations of pulse lines/ropes and ticklers might be present.

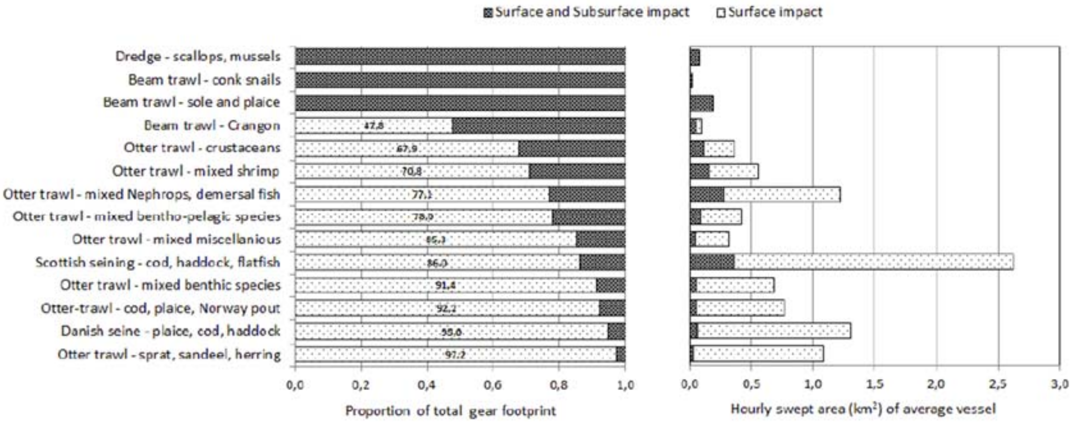

Figure 4.2. Proportion of total gear footprint (a) and the area of seabed swept in 1 h of fishing with an average-sized vessel (b) with impact at the surface level and at both the surface and the subsurface level for the 14 BENTHIS metiers (Eigaard et al., 2016).

4.2 Sensitivity of typical species to physical and biological pressures

In this paragraph, the sensitivity of the fauna to different types of pressure is assessed in terms of resistance or intolerance and resilience or recoverability.

MarLIN defines a species (or population) as 'very sensitive' when it is easily adversely affected by human activity (e.g. low resistance) and recovery is only achieved after a prolonged period, if at all (e.g. low resilience or recoverability)" (OSPAR, 2008; Laffoley et al., 2000).

The original genustrait handbook (genustraithandbook.org.uk) intended to assist in the assessment of the impacts of marine aggregate dredging on benthic resources as well as in the prediction of the potential that individual genera have to recolonise and the time that may be required for restoration of the biomass by growth of the colonising individuals. 'Genustrait' defines the sensitivity of species based on life trait characteristics, such as motility of adults, motility of larvae and longevity, a.o..

Table 4.1 presents the sensitivity for mobile bottom contacting fishing gear per functional group of indicator species (cobbles, gravel, course sand), based on the genustrait handbook (Marine Ecological Surveys Ltd., 2008). Of the listed species, 7 are assessed as 'vulnerable', 9 as 'robust', 9 as 'intermediate' and 22 species were not assessed (blank). The sensitivity is assessed based on the ecological traits, but without giving strict definitions (Marine Ecological Surveys Ltd., 2008).

Table 4.1 Genustrait assessment of the sensitivity of selected species to bottom contacting fishery (http://www.genustraithandbook.org.uk, Marine Ecological Surveys Ltd., 2008).

Faunaclass	Species	Biota/sediment	Faunatype		Lifespan	Sensitivity
			juveniel	*adult*		
Amphipoda	Urothoe marina	Coarse sand			1-2 yr	Intermediate
Anthozoa	Alcyonium digitatum	cobbles and stones	Sessile epifauna	Sessile epifauna	>10 yr	Vulnerable
Anthozoa	Cerianthus lloydii	sand, gravel mud	Sessile epifauna	Sessile epifauna	>10 yr	Vulnerable
Anthozoa	Urticina sp.	cobbles and stones	Sessile epifauna	Sessile epifauna	?	
Anthozoa	Metridium senile	gravel			?	
Anthozoa	Urticina felina (Tealia)	gravel			?	
Bivalvia	Aequipecten opercularis	coarser sediments	Sessile epifauna	mobile epifauna	3-10 yr	Intermediate
Bivalvia	Arcopagia crassa (Acropagia crassa?)	Coarse sediment	shallow infauna	deep infauna	5-10 yr	Vulnerable
Bivalvia	Arctica islandica	Coarse sand	shallow infauna	deep infauna	>10 yr	Vulnerable
Bivalvia	Pododesmus sp./patelliformis	cobbles and stones	Sessile epifauna	Sessile epifauna	?	
Bivalvia	Polititapes rhomboides	soft sediments	shallow infauna	deep infauna	5-10 yr	
Bivalvia	Timoclea ovata	sandy gravel	shallow infauna	-	3-10 yr	Intermediate
Bivalvia	Dosinia exoleta	Coarse sediment			5-10 yr	Intermediate
Bivalvia	Modiulus modiolus	Coarse sand			>10 yr	Intermediate
Chordata	Branchiostoma	Coarse sand			?	
Cnidaria	Hydrozoa				?	
Echinoidea	Echinocyamus pusillus	Coarse sand	shallow infauna	-	1-2 yr	Intermediate
Echinoidea	Psammechinus miliaris	gravel			3-10 yr	Robust
Florideophyceae	Lithothamnion sonderi & Phymatolithon sp.	cobbles and stones	Sessile epifauna		?	
Gastropoda	Aporrhais pespelecani	mud-muddy sand	mobile epifauna		?	
Gastropoda	Buccinum undatum	Coarse sediment	mobile epifauna	mobile epifauna	3-10 yr	Vulnerable
Gastropoda	Simnia patula = Xandarovula patula!	on Alcyonium	mobile epifauna		?	
Malacostraca	Galathea intermedia	coarse sediments?	mobile epifauna		3-10 yr	Vulnerable
Malacostraca	Liocarcinus sp.	mud-gravel	mobile epifauna		3-10 yr	Robust

Malacostraca	Paguridae	mud-gravel	mobile epifauna		>10 yr	Vulnerable
Malacostraca	Pagurus cuanensis	mud-gravel	mobile epifauna		3-10 yr	Robust
Malacostraca	Upogebia deltaura	Botney Cut	shallow infauna	deep infauna	3-10 yr	Robust
Malacostraca?	Callianassa subterranea	Botney Cut			(1-10 yr)	Robust
Nudibranchia						
Pisces	Micrenophrys lilljeborgi / Taurulus lilljeborgi				?	
Pisces	Diplecogaster bimaculata				?	
Pisces	Lophius piscatorius				?	
Pisces		eat Upogebia				
Pisces	Ammodytes				?	
Polychaeta	Aonides paucibranchiata	Coarse sand	freeliving ?		<1 yr	Intermediate
Polychaeta	Chone duneri	coarse sand gravel	shallow infauna		?	
Polychaeta	Chone infundibiliformis	-	-		?	
Polychaeta	Goniadella bobrezkii	Coarse sand	-		?	
Polychaeta	Protodorvillea kefersteini	coarse sand gravel	-		1-2 yr	Robust
Polychaeta	Sabellaria spinulosa	coarse sand gravel	Sessile epifauna		3-10 yr	Robust
Polychaeta	Spiophanes kroyeri	muddy sand	sessilie infauna		1-2 yr	Intermediate
Polychaeta	Spirobranchus triqueter / Pomatocerus triqueter	cobbles and stones	Sessile epifauna		3-10 yr	Robust
Polychaeta	Terebellides stroemii				?	
Polychaeta	Typosyllis cornuta	Coarse sand			1-2 yr	Robust
Porifera	undefined phylum				3-10 yr	Intermediate to Vulnerable
Porifera	Haliclona oculata					

Sessile epifauna

Sessile epifauna, which can be slow growing and forming 3D-structures above the bottom, is attached to stones and need hard substratum and undisturbed areas. In general, it can be concluded that sessile epifauna are often filter-or suspension feeding, long-lived species that are very vulnerable to physical disturbance of the substratum or by smothering after resuspension events. Some characteristic sessile species (that are listed as indicator species in Table 11.1 of the BD) are highlighted below.

Crustose red algae (*Lithothamnion sp.* and *Phymatolithon sp.*) grow on large stones in the Cleaver Bank. Beside a crustose form, they can grow in the form of so-called maerl. They are highly sensitive for abrasion/disturbance of the surface of the substratum or seabed, penetration or disturbance of the substratum subsurface and smothering and siltation rate changes (light). The crustose red algae Lithothamnion at Cleaver Bank are very special because they grow at such depth due to the extreme clarity of the water.

Large stones are overgrown with polychaetes like *Spirobranchus* and *Sabellaria spinulosa* in between. These species are considered as eco-engineers of the reef, because they can cement substratum and provide the reef of another texture. *Spirobranchus* is (moderately) sensitive to substratum loss and smothering. *Spirobranchus* is attached permanently to rocks, boulders or shingle. Removal of substratum will remove calcareous tubes and animals contained in them. Smothering with a 5 cm layer of sediment would completely cover the tubes of *Spirobranchus* that usually lie flat against the surface of the rock. It is also likely that too much sediment on the surface of rocks or shells would prevent settlement of larvae and impair the long-term survival of populations.

A common species of the genus Alcyonium in the Cleaver Bank is *Alcyonium digitatum*, that lives on large stones. *Alcyonium digitatum* is highly sensitive for removal and displacement. The species is permanently attached to the substratum and once displaced does not have the ability to re-establish its attachment. Removal of the substratum would also remove this species within the area under consideration and mortality is judged to be high.

Hydrozoa already grow on stones of approx. 30 mm on the Cleaver Bank.

The stones and cobbles function as a spawning substratum on which eggs deposit (e.g. common whelk *Buccinum undatum* and fish species like e.g. herring *Clupea harengus*). Displacement or turning of stones and smothering can be lethal for eggs because of oxygen shortage.

Mobile epifauna

Most mobile epifauna is associated to cobbles and gravel because of foraging or as hiding area in holes (e.g. large crustacea, demersal fish species like gobies or Malacostraca like *Liocarcinus depurator*). The latter species is moderately sensitive for abrasion and physical disturbance. The species was observed to be frequently injured and killed as a result of capture in a commercial 4 m-beam trawl (Kaiser & Spencer, 1995) and so a high intolerance has been recorded. Recovery should be good because *Liocarcinus depurator* has planktonic larvae and is able to reproduce several times a year (Wear, 1974).

Infauna

Infauna can be grouped into:

- Shallow burrowing species (<2 cm): mostly juvenile stadia of several groups of species, e.g. the pea-urchin (*Echinocyamus pusillus*)
- Deep burrowing species (>2 cm): adult bivalves (*Arcopagia*, *Dosinia*), worms, digging crustacea, lancelet (*Cephalochordata*), sand smelt (*Ammodytes sp.*)

An example of both shallow and deep living species is the bivalve *Arctica islandica.* The adult large, deep living shells start as small juveniles that live in the upper sediment layers. Settlers of *Arctica* start at a size of ~200 um and it takes them several years to attain a shell height of 5 cm. In the juvenile phase shells are thin and easily damaged being evident from the size strength relationship as reported by Witbaard and Klein (1990, 1994). *Arctica islandica* can be damaged by abrasion due to mobile fishing gear, e.g. beam trawls and otter trawls often leading to direct mortality. In addition, the decline in the population of *Arctica islandica* in the southern North Sea may correspond with the intensity of beam trawling (OSPAR, 2009c).

An example of a deep burrowing species is the lancelet. The lancelet (*Branchiostoma* sp.) has a life span of 2-5 yrs and individuals can regenerate and recover from injuries to some extent. Recovery of impacted populations may occur through recovery of damaged individuals, migration of adults or by colonisation by planktonic larvae (found in the plankton for three months) (Tillin, 2016).

4.3 Impacts of demersal fishing gear

In this paragraph, the impact on the typical species and habitats is described per type of mobile bottom contacting fishing gear.

Aspects of fisheries, based on the categories in Deerenberg et al. (2010) and MarLIN (see Table 4.2), are related to pressures of dredge-beam trawl-otter trawl-Scottish seine/fly-shoot- Danish seine. In this summing-up the fishing gears are ranked from gear with a small but deep footprint (dredge) to gear with large but superficial footprint (Danish seine), and all intermediate forms.

Table 4.2 Impact categories of demersal fishing gear on the fauna and abiota (Deerenberg et al., 2010 versus MarLIN http://www.marlin.ac.uk) and the type of effect for different fishing gears, based on literature in combination with our own expert judgement

Type of effect	Aspect	Description	Dredge	Beam Trawl	Otter trawl	Scottish seine	Danish seine	Pulse (wing)
Damage	Abrasion & physical disturbance	This factor includes mechanical interference, crushing, physical blows against, or rubbing and erosion of the organism of interest. Protrusive species may be crushed, and delicate organisms with a fragile skeleton or soft bodies may be physically damaged or broken (snapped).	high	high	high	medium	medium	medium
	Abrasion/disturbance of the surface of the substratum or seabed	Damage to surface features (e.g. species and physical structures within the habitat)	high	high	high	high	medium	medium
	Displacement	Physical removal or transportation of the species or community of interest. The community, colony or organism may be removed from its natural habitat but remain in the vicinity.	high	high	high	high	medium	medium
	Penetration or disturbance of the substratum subsurface	Damage to sub-surface features (e.g. species and physical structures within the habitat)	high	high	high	high	medium	medium
Structure of substrate	Habitat structure changes - removal of substratum (extraction)	Extraction of substratum to 30 cm (where substratum includes sediments and soft rocks but excludes hard bedrock)	high	high	high	medium	low	low
	Physical change (to another seabed type)	If rock was replaced with sediment, this would represent a fundamental change to the physical character of the biotope and the species would be unlikely to recover. The biotope would be lost.	low	low	low	low	low	low
	Physical change (to another sediment type)	1) Change in sediment type by one Folk class (based on UK SeaMap simplified classification). 2) Change from sedimentary or soft rock substrata to hard rock or artificial substrata or vice-versa.	low	low	low	low	low	low
	Substratum loss	The physical removal of the substratum inhabited or required by the species or community in question.	high	high	high	high	medium	low
Turbidity	Increase in suspended sediment	A change in one rank on the WFD (Water Framework Directive) scale e.g. from clear to intermediate for one year.	Medium	Medium	Medium	medium	medium	low
	Increase in turbidity	The turbidity (clarity or opacity) of water is dependent on the concentration of substances that absorb or scatter light; for example, inorganic or organic particulates (suspended matter), plankton and dissolved substances.	Medium	Medium	Medium	medium	medium	low
	Smothering	The physical covering of the species or community and its substratum with additional sediment (silt), spoil, detritus, litter, oil or man-made objects. Overgrowth by other species such as encrusting ascidians is also included here.	Medium	medium	high	medium	low	low
	Smothering and siltation rate changes (heavy)	'Heavy' deposition of up to 30 cm of fine material added to the habitat in a single discrete event	high	high	high	medium	low	low
	Smothering and siltation rate changes (light)	'Light' deposition of up to 5 cm of fine material added to the habitat in a single, discrete event	high	high	high	medium	low	low
Removal/Discards	Extraction of this species	If 50% of the population or biotope is removed then sensitivity is automatically assessed as intermediate. Potential for recovery after a very efficient extraction has been undertaken can also be assessed using this definition.	high	high	high	medium	low	low
	Removal of target species	Removal of species targeted by fishery, shellfishery or harvesting at a commercial or recreational scale.	high	high	high	medium	low	low
	Extraction of other species	A species that is a required host or prey for the species under consideration (and assuming that no alternative host exists) or a key species in a biotope is removed.	high	high	high	medium	low	low
	Removal of non-target species	Removal of features or incidental non-targeted catch (by-catch) through targeted fishery, shellfishery or harvesting at a commercial or recreational scale.	high	high	high	medium	low	low

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4.3.1 Removal and damage

Dredges used for catching molluscs (such as scallops, mussels, and oysters). The impact caused by the dredge is expected to produce a homogenous gear path (Eigaard et al., 2015). This does, however, depend on the presence/absence of dredge teeth, which are always used in scallop fishing and produce a more uneven sediment furrow (O'Neill et al., 2013). Standard dredges have been demonstrated to create furrows of up to 6 cm depth in soft sediments (Pravoni et al., 2000) and the dredges used for infaunal bivalves in the Adriatic Sea have been demonstrated to create furrows in the sediment up to 15 cm deep (Lucchetti and Sala, 2012).

Valentine and Lough (1991) (in: Johnson, 2002) used side scan sonar and a submersible to describe the effects of scallop dredges and trawls on sand and gravel bottom habitats on eastern Georges Bank. They noted that the most evident signs of disturbance occurred on gravel pavement, where long, low mounds of gravel had been formed by trawling and dredging. In some areas the sea bed was covered by trawl and dredge tracks. Gravel areas which were unfished (due to the presence of large boulders) had a biologically diverse community with abundant attached organisms. Conversely, the attached epifaunal community was sparse and the bottom was smoother in areas that had been disturbed by dredging and trawling.

The horse mussel (*Modiolus modiolus*) has been indicated in several studies as a species that is sensitive to bottom fishing disturbance in general (Macdonald et al., 1996 in Collie et al., 2000). The disturbed sites were characterized by scavenger species such as hermit crabs and the waved whelk (*Buccinum undatum*) which are known to be relatively insensitive to disturbance (Collie et al., 2000).

The beam trawl fishery is directed at flat fish species and characterised by high percentages of by-catch (71-95%, Lindeboom & De Groot 1998). Kaiser et al. 2006 report 42% initial reduction in abundance of benthic taxa after experimental trawling. There are no studies carried out in biogenic habitats. High mortality rates mainly affect long-lived species (four of the typical species of H1170).

Traditional beam trawls (with multiple tickler chains) were found to be detrimental to large molluscs among which is *Arctica islandica* (Witbaard & Klein, 1994) and *Buccinum undatum* (Mensink, 2000). But also other species (*Dosinia lupinus*, *Acanthocardia echinata*, *Chlamys opercularis*) have been found with big scars on the shells as well. For some species (*Dosinia*, *Acanthocardia*) a marked difference in size distribution, with smaller size classes in heavily fished areas and larger sizes in lightly fished areas, within the Oyster Grounds was found (van Kooten et al, 2015). This, in combination with the observations of scars in these species, suggests a size dependent mortality potentially related to fishing intensity.

Rijnsdorp (2015) refers that *Arctica islandica* is one of the larger robust molluscs that are better protected against physical damage by passing fishing gear (components). Witbaard and Klein (1994), however, observed that about 90 % of the shells (doublets) caught as by-catch were damaged and 80 % of the damage found was at the siphon side (sediment-water interface) of the shell. Although *Arctica islandica* has a robust appearance, the low percentage of organic matter in its shell makes it fragile. Observations of this species from by-catch showed that numerous shells had internal damage in the hinge, often evidenced as malformations (Witbaard & Klein, 1993, Witbaard & Klein 1994).

Duineveld et al. (2007) who sampled in the 500 m-protected zone around a gas platform, observed marked differences in densities of larger species (such as *Callianassa subterranea*, *Upogebia deltaura*, and fragile bivalves e.g. *Arctica islandica*, *Thracia convexa*, *Dosinia lupinus*, *Abra nitida*, *Cultellus pellucidus*) within (unfished) and outside (fished) the zone, which suggests an effect of fishing on survival and mortality of these species.

The otter board trawl fishery is directed at roundfish species and Nephrops and characterised by high percentages (67-86%) of by-catch (Lindeboom & De Groot 1998). Specific mortality caused by otter board trawling in open-see reef habitat or similar habitats has not been assessed. High mortality rates mainly affect long-lived species (four of the typical species of H1170).

Otter board trawling in sum mainly causes reduction in abundance of its typical species, of which several contribute to a complex biogenic structure. Initial impact appears severe and recovery is unknown, but expected to be slow owing to the stable nature characterised by diverse communities. Any otter board trawl activity causes a long-term state of disturbance of the habitat.

The demersal purse seine is a preferred technique for capturing all kinds of fish species which live close to the sediment surface, such as cod, plaice, haddock, red mullet. Seines are used when there are flat but rough sea beds, which are not trawlable. Danish seining or 'snørrevåd' is a semi-static fishing method based on the herding effect of cables running over the sea bed. Floats keep the net open vertically and this is attached to the footrope that is generally rigged much lighter than that of a trawl, but is sufficiently weighted to keep the lower edge of the net mouth in contact with the seabed. Seines cannot work on such rough grounds as otter trawls. The Scottish Seine or fly-shoot fishery uses long lengths of seine rope to herd fish into the path of the net as the gear is hauled. Removal and damage of non-target species is likely, but unknown. The shallow-living infauna will also be impacted by the fly-shoot and Danish seine. Shallow-living infauna may also comprise the larval and juvenile stages of benthos whose adults live at greater depths. According to Van Moorsel (2003) many of the species that are typical to coarse sand, pebbles and cobbles are adapted to the high natural dynamics of this type of sediments. However, contact with the ground gear and trawl doors or -shoes may be out of the natural range of impact. Based on three studies (Collie et al. 1997, 2000 and Auster et al. 1996), the use of different types of mobile gear on gravel habitat results in a reduction in epifaunal abundance and cover, similar to effects of individual mobile gear on gravel habitats (Johnson, 2002).

4.3.2 Discards and by-catch

Depending on the type of fishing gear, the mesh size, target species and fishing area, the discards and by-catch percentages may vary widely. Below we give some indications for the different gear types as found in literature.

The beam trawl fishery is characterised by a high percentage of discards (71-95%, Lindeboom & De Groot (1998); 40-60% STECF, Dutch fleet in 2008: 35%, Van Helmond & Van Overzee, 2010). A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002).

The otter board trawl fishery is characterised by a modest percentage of discards (67-86% according to Lindeboom & De Groot 1998; up to 28%, Kelleher 2005). However, the fishery directed at sandeel (and Norway pout) has a discard rate of <1% (Kelleher 2005). The fishery directed at flatfish has a higher discard rate (51%, Kelleher 2005). The otter boards trawl fishery directed at Nephrops (by the Dutch fishery, concentrating in the Botney Cut of the Cleaver Bank) has a discard rate of 60% (Van Helmond & Van Overzee 2009). (many small-sized Nephrops are discarded). A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002).

The seine fishery has low discards rates of less than 5% (Kelleher 2005). Given the high catches, this still amounts to large volumes of discarded fish and benthos. A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002). In the northeast Atlantic (south of Portugal) discards in seine fisheries consist mainly of pelagic species and juveniles of the target species (Gonçalves et al. 2008).

4.3.3 Impact on substrate

Rijnsdorp et al. (2016) assess the physical impact of towed nets as follows:

- Cables and ground rope: homogenise texture of sea bottom, destroy hard structures, move stones or shells
- Otter boards or tickler chains: penetrate into the seabed and disturb the vertical structure of the sediment

In summary the following physical impacts can be distinguished: 1. penetration into the seabed (depending on shape and mass of the gear; higher towing speed implicates heavier gear); 2. collision with (hard) structures (depending on mass of the gear component and the speed at which the gear is dragged); 3. re-suspension of sediments (determined by the grain size of the sediment and the hydrodynamic resistance (which is a function of the surface area of the gear and the square root of the speed).

Six studies of toothed scallop dredges on gravel were reviewed in Johnson, 2002 (Bradshaw et al. 2000, 2001, 2002; Caddy 1973, Kaiser et al., 1996, Veale at al. 2000): dredging produced tracks in sediments, and disrupted and overturned gravel and boulders. Dredging also reduced the abundance of some infauna and epifauna, although some species were less abundant in a closed area, while others were more abundant. Many epifauna taxa recovered 5-9 years after the area was closed, but not before. Longterm changes in benthic communities exposed to varying degrees of fishing effort could not be related solely to increased fishing activity; some sessile epifauna were more abundant in low effort fishing grounds, while others were more abundant in high effort grounds (Johnson, 2002).

A single study of the effects of dredging on maerl beds showed that a single tow ploughed the seafloor, destroyed and buried living maerl, overturned boulders, erased bottom features, and suspended sediment (Hall-Spencer & Moore, 2002 reviewed in Johnson, 2002). Dredge tracks were visible for 0.5-2.5 years depending on depth and exposure to wave action. Biological effects included removal or mortality to infauna and large epifauna, and attraction of invertebrate predators and scavengers. The benthic community recovered completely at a previously dredged site within 2 years, but some species at a previously undredged site still had not recovered after 4 years (Johnson, 2002).

The classic beam trawl with 10-12 tickler chain penetrates a gravel substrate about 1-8 cm (Paschen et al., 2000), removing the large physical features and reducing the structuring biota (e.g. ICES 2007a, b). The structure of features that arise from the bottom, the mosaic pattern of variation in sediment and the seabed stability are key features of the open-sea reef habitat of the Cleaver Bank (Jak et al. 2009).

Both tickler chains and beam shoes have been demonstrated to Eigaard et al., 2015 generate furrows of up 10 cm depth in the sediment (Paschen et al., 2000; Depestele et al., 2015). The footprint (Eigaard et al., 2016) is estimated for subsurface and surface 0.2 km^2 per h fishing with average-sized vessel, penetration depth on coarse sediment: <5-10cm (shoes), <3-10 cm (tickler chains).

Although there is a vast list of studies on the impact of beam trawl on soft sediments, no studies with this gear on gravel or a mixture of sediment types were reported in the review of Johnson (2002). Field studies in the Cleaver Bank area repetitively found trawl marks on the seabed illustrating the presence of beam trawling with its physical effects in this type of habitat (Jak et al., 2009; Lavaleye, 2014; Leewis et al., 2015; Lengkeek et al., 2017.

Box: Pulse and pulse wing bottom trawls

Since 2009, there has been a rapid transition by Dutch fishermen from traditional beam trawling to pulse trawling. Beam trawling works by dragging tickler chains across the seabed to startle the fish and make them leap into the net. The most commonly used pulse trawling technic are the 'pulskor' (pulse trawl) and 'pulswing' (pulse wing). Both are based on a system which emits short electric pulses on a part of the seabed. This makes the muscles of the fish contract, whereupon the fish detach from the seabed and land in the net. The pulse trawl is lighter than the traditional beam trawl, so it does not penetrate as deeply into the seabed (but it still touches the bottom). In addition, as the fishing speed of pulse trawlers is slower, the trawled distance per hour is shorter and the overall fished surface is smaller.

It is unclear what these gears do to the benthic ecosystem (ICES WG Electra 2017), but based on the lower fishing speeds and the lighter fishing gears and the reported volumes of by-catch, the pulse and pulse wing bottom trawls are thought to have less impact on the seabed and its fauna than the traditional beam trawl. Pulse trawls are thought to penetrate less deep in the bottom and the bycatch of undersized fish and benthos is distinctly lower (30-50% fewer fish discards, 48-73% fewer benthic species) (Quirijns et al, 2015).

Effects in the trawl track itself are still unclear. A few laboratory studies indicate that some benthic species respond to the pulse and others do not respond. Long term effects on benthos of being exposed to a pulse are largely unknown. The electrical pulses might affect the sediment water exchange either directly, or by influencing bio-irrigating and bioturbating fauna (ICES WG Electra 2017). From the available literature on the impact of these new types of (pulse) fisheries it is not always clear whether it deals with traditional beam trawl-pulse or with sum-wing-pulse or a sumwing with ticklers, which hampers the interpretation of the results.

Currently, these aspects are being investigated by Wageningen Marine Research as part of the PULSEFISHING project (Effecten van de platvisvisserij met de pulskor op het ecosysteem; 2016-2019), financed by the Ministry of Economic Affairs (EZ), but no reports are available yet. An overview of European pulsefishing research is found in the final report of the ICES working group on electrical trawling (ICES WG Electra 2017). WG Electra (2017) note that no studies have been done on the effect of pulse stimulation on the functioning of the benthic ecosystem and nutrient dynamics. They conclude that in ecological terms, the replacement of the tickler chain beam trawl with pulse trawl with electrodes diminish the mechanical impact of trawling on the North Sea benthic ecosystem. Although the irreversible effects of electrical stimulation seem to be restricted to the vertebral fractures in cod and whiting, further research on the effects of electrical stimulation on marine organisms and ecosystem functioning is needed to assess the effects on the scale of the North Sea.

The otter boards penetrate a gravel substrate about 1-25 cm to resuspend the sediment and chase the target fish species, whereas the ground-ropes glide or hop over the seabed and penetrate 0.5-6.5 cm depending its construction (van Marlen et al., 2010). Depending on the sediment type, the trawl doors can dig up a trench/furrow of up to 35 cm deep and transfer large amounts of sediments onto either side of their path (Lucchetti and Sala, 2012, in Eigaard et al. (2015)). Deerenberg et al (2010) surmise that disturbance of the structure of H1170 is potentially high, owing to typical and vulnerable biogenic structure elements of habitat H1170.

The impact of several types of fisheries on different substrates were reviewed by Johnson (2002). Only two papers on the effects of otter trawls to gravel habitat were available, both of which were observational. These studies showed that trawling on gravel habitats removes fine sediments, moves stones and boulders, and decreases abundance of epibenthic macro-fauna and reduces the cover they provide (Johnson, 2002). Four papers observed effects of otter trawls on habitats with a mixture of sediment types. Physical effects mirror those reported for sections above, including the overturning of stones, tracks in sediment, sediment re-suspension, and smoothing of seafloor. The one paper that addresses biological effects reports that trawling results in a decrease in epibenthic macro-fauna, and an increase in opportunistic infauna. One paper that addresses chemical effects of trawling found no significant effects. No information is provided on recovery (Johnson, 2002).

There are hardly any field studies on the benthic impact of Danish seine or Scottish seine (fly-shoot) fishery. According to Huse et al. (2003), traditionally the seine net fishery took place on very smooth and sandy bottom, but in later years also on gravel and to some extent on stony bottom. Consequently, the gear has to touch bottom with some or all of its components, which means ground rope and herding ropes. The ground-gear will have some effect on the substrate by shifting small amounts of sand and gravel (Huse et al., 2003). For Danish seining, which is suggested to be more low-impact than fly-shooting, there is likely a difference in the gear configurations between the coastal fleet (from which most of the scientific evidence was derived) and the larger-scale offshore Danish seiners. The former use thin rope while the offshore fleet likely use heavier, thicker ropes (pers. comm. Thomas Kirk Sørensen WWF-DK to Thomas Rammelt).

Schückel, et al., 2017 assessed in a predictive study the seine fishing effects on the biotope type “species-rich gravel, coarse sand and shell layers”. They found that the habitat type has overall proven to be sensitive to seine fishing due to its inventory of sessile Epifauna-species. However, it is plausible that additionally due to this fishing method, a part of the Endofauna of the KGS-areas is affected as well (Schückel et al., 2017).

Fly-shoot towing speed is low at the start, but increases to the end of the tow and is then comparable to other bottom trawl gears (Rijnsdorp 2016). The fly-shoot, of all mobile bottom contacting gears, has the largest surface footprint (1.6 km2/h for an average vessel, compared to 0.3 km2/h for a beam trawl or dredge; Eigaard et al., 2016).

Adverse effects are expected on fragile biogenic habitat (soft corals, sponge gardens, etc.) and fragile benthic taxa that live on the sea bed and are attached to hard objects (stones, shells, etc.). Examples of these species are soft corals (dead men's fingers), sea pens, reef building species such as *Sabellaria* (tube worms), *Modiolus modiolus* (horse mussels) and *Bryozoa*. We also expect that the recovery of these sensitive species will be hampered by fly-shooting as the ropes may break down the first stages of the biogenic structures or damage or kill the recruits of fragile epibenthic species. (Rijnsdorp, 2015).

4.3.4 Turbidity / suspended matter / smothering

Fisheries data show that beam trawl fishing takes place on the Cleaver Bank (with chain mats on stony parts), and that in the Botney Cut the principle fishing method is otter trawling (see Lindeboom et al., 2008).

Apparent discrepancies between the observed stones and the hardness of the bottom (especially in areas near the Botney Cut) as indicated by the SSS-surveys, were explained by the possible coverage of the boulder and gravel bottom by a thick and loose silt-layer on top. This silty material could originate from the Botney Cut, where intensive fishery could have resuspended fine sediments and cause extra deposition on the bordering parts of the Cleaver Bank (Lavaleye, 2014). The latter remark is interesting and indicates that, if true, the fishery in the Botney Cut can have indirect impacts on the neighbouring Cleaver Bank areas by causing extra sedimentation and possible smothering of the coarse sediments and its typical fauna and calcareous algae. In the current proposals for zoning, the Botney Cut remains accessible to bottom contacting fishery.

The concentrations of suspended material on the Cleaver Bank are low, enabling light to penetrate to the bottom enabling growth of e.g., calcareous red algae (and seven other typical species of H1170). H1170 is of low energetic nature, suggesting that resuspended material may take some time to settle.

O'Neil and Ivanovic (2016) reviewed research on the mechanical impact of towed bottom fishing gears with the aim to come to predictive models and refer to the numerous field studies demonstrating such effect. Swinghammer et al. (1998) reported on the observed changes of the seabed and sediment properties of trawled areas (otter) in comparison to untrawled areas. Sediment topography and roughness changed and reduced the superficial biogenic sediment structure and the presence of flocculated organic material. The study of Martín et al. (2014) showed that turbidity in a submarine canyon in the Mediterranean was dominated both in magnitude and in temporal patterns by resuspension caused by fisheries and caused intermediate nephloid layers and peak suspended particulate matter (spm) concentrations of >200 mg/l. An experimental study in the Bay of Biscay similarly demonstrated the resuspension effect of trawl doors and its effect on sediment granulometry, i.e. a gradual coarsening of the sediments in the most heavily fished area between 1967 and 2014 (Mengual et al., 2016). A French study (Deprez, 2000) found the opposite, i.e. a gradual fining of the sediments caused by the release and sedimentation of mud in dredging tracks within an area of gravely coarse sediments. This led to a change in community composition from species characteristic for coarse sands (such as *Branchiostoma*) to species characteristic for fine sedimentary habitats. There are also studies which report on the absence of a change in sediment characteristics or fauna (Simpson and Watling, 2006).

These contrary results suggest that the ultimate effects of resuspension probably depend on the hydrographical conditions and will be hard to predict. Despite this uncertainty it is evident that resuspended sediments have negative effects on fauna not adapted for chronic high levels of turbidity. Decreased light intensity and smothering, or interference with filtering structures has negative effects on such fauna. With its depth of ~ 40 meter and coarse sands the Cleaver Bank hosts a community not adapted to high suspended matter loads and is likely to be sensitive to a chronic elevation of SPM caused by fisheries.

There is little or no information about potential effects of seine fisheries on benthic habitats and gravel substrates in particular. Key issue is the nature of the contact between fishing gear and sea bottom, which is surmised to be light, although a moving footrope can be expected to affect the epifauna and cause resuspension. For both the Scottish seine/fly-shoot and the Danish seine, Deerenberg et al. (2010) surmise that induced turbidity is low due to the relatively light contact of the footrope with the sea bottom.

4.4 Impact on conservation objectives H1170

The conservation objectives of H1170 are: to maintain the distribution and surface area of the habitat, and to *improve its quality*. The quality is expressed by a number of indicator species, called 'Typical species' (see Table 4.1 and Table 3.1, column 'T Natura 2000').

Table 4.1. Typical species H1170, type of indicator and type of fauna.

Typical species H1170	Type of indicator	Type of fauna
Alcyonium digitatum	Cab	Sessile epifauna
Urticina sp.	Cab	Sessile epifauna
Aequipecten opercularis	Cab	Sessile epifauna
Arcopagia crassa (Acropagia crassa?)	Cab	Shallow infauna
Pododesmus sp./patelliformis	K + Ca	Sessile epifauna
Lithothamnion sonderi & Phymatolithon sp.	K	Sessile epifauna
Aporrhais pespelecani	Cab	Mobile epifauna
Buccinum undatum	Cab	Mobile epifauna
Simnia patula = Xandarovula patula!	Cab	Mobile epifauna
Galathea intermedia	E	Mobile epifauna
Chone duneri	K	Shallow infauna
Sabellaria spinulosa	K + Ca	Sessile epifauna
Haliclona oculata	Cab	Sessile epifauna
Dosinia exoleta	Cab	Shallow infauna
Micrenophrys lilljeborgi / Taurulus lilljeborgi	E	Mobile epifauna
Diplecogaster bimaculata	E	Mobile epifauna
Lophius piscatorius	Cab	Mobile epifauna

Bottom contacting fishing gears will have distinctly different impacts on epifauna compared to infauna. The latter, especially deeply burrowed species, profit from protection given by their way of life. Epifauna is vulnerable to all types of bottom contacting fishing gear as they live exposed at the sediment surface.

Results of Collie et al (2000) indeed confirm the hypothesis that gravel habitats are very sensitive to physical disturbance by bottom fishing and that the primary impact is the removal of emergent, epifaunal taxa (Anon., 1996) (see also Freese et al, 1999). In a study in the western Gulf of Maine, Grizzle et al (2009) showed that the recovery from fishing effects (gillnet-otter trawls) depended on sediment type. The conclusion was that the epifauna in especially boulder and gravel areas were affected, while effects on infauna were minimal.

When comparing different types of seine nets, the Scottish seine (or fly-shoot) is expected to have a relatively larger impact than the Danish seine due to its weight, thicker ropes, and larger area affected. All types of bottom-contacting fishing gear are considered to be destructive to these epifauna species.

The typical infauna of coarse sands and pebbles is perhaps resilient to natural dynamics (e.g. *Branchiostoma*, thick-shelled molluscs) but may be more easily damaged by bottom contacting gear. Sensitivity of a species are different during their life phases. Large mollusc species which are regarded as less sensitive (Rijnsdorp, 2016) all have juvenile phases in which they have thin shells and live in the superficial sediment layers thus even within the range of a gear component with a relatively shallow bottom penetration.

There are also differential effects of compacting and contacting forces (Vasconselas et al, 2011). Small-shelled specimens were found to be less sensitive to compaction while large shells are more vulnerable to compacting forces. Several studies show that for a number of large species a significant percentage of the caught specimens are seriously damaged (Witbaard en Klein, 1994, Mensink et al, 2000). Other studies showed clear differences in mortality between species (Bergman et al 2001).

Smaller infauna such as worms and burying crustaceans may be less impacted. Especially the deeper burrowing species live beneath the penetration depth of the fishing gears. The extent to which these species are affected by structural and biogeochemical changes of the sediments is unknown, as Duineveld et al (2007) found higher abundance of these species in the fishing exclusion zone around a gasplatform. This suggests that they are affected by trawling despite their relative protected mode of life.

It is well known that in trawl tracks elevated numbers of scavenging species are found (Groenewold, 2000). Fishermen know this and tend to fish the same line several times. The scavengers use the freshly exposed food source of damaged animals, discarded dead remains and otherwise buried animals such as polychaetes (Groenewold & Fonds, 2000).

The two fish species that are typical for Cleaver Bank are small and may escape through wider meshed fishing nets, but this will highly depend on the behaviour of these species in response to the approach of the net. A hiding behaviour might increase their vulnerability when they end up in the cod end with stones and other debris. As they live between/under gravel/pebbles/rocks, bottom disturbance may impact them. Removal or dislodgement of stones will at least lead to a temporal habitat change or may complete loss. If the habitat is critical to the species as nursery area significant effects are to be expected.

Within the Marine Strategy Framework Directive, several indicators of habitat quality are given. In the context of bottom trawling and benthic fauna the descriptors: bottom integrity and healthy populations of infauna and epifauna, including long living species are important.

From above overview i.e. the present conservation status, the effects on bottom ecosystems of the various fishing methods and the vulnerability of the listed indicator species it is evident that bottom trawling in whatever form has strong negative effects on especially the sessile epifauna in the Cleaver Bank.

Given the fact that Jak et al. (2009) estimated the conservation status of the area as being insufficient, mainly based on the recurrent presence of trawl marks in the area, an improvement of the habitat quality can be made by reducing mortality and by increasing survival of organisms. This can be achieved by the introduction of management zones in the area from which all types of bottom contacting fishing gears are banned. Despite the supposedly light impact of the various types of seine fisheries, its impact is deemed significant on especially the sessile epifauna growing on the hard substrate (boulders & gravel), characteristic for the area.

5 Cumulative effects

The North Sea is of a great economic importance. Some economic activities are directly related to the sea (eg. oil and gas extraction, fishing), others indirectly (such as ports, industry and recreation). The North Sea is also important for transport activities (shipping, telecommunications, energy supply) and functions for which there is insufficient space on land (wind energy, sand extraction). Below, a short description is given of the relevant activities and their cumulative effects based on the integrated management plan of the North Sea (Anon, 2015).

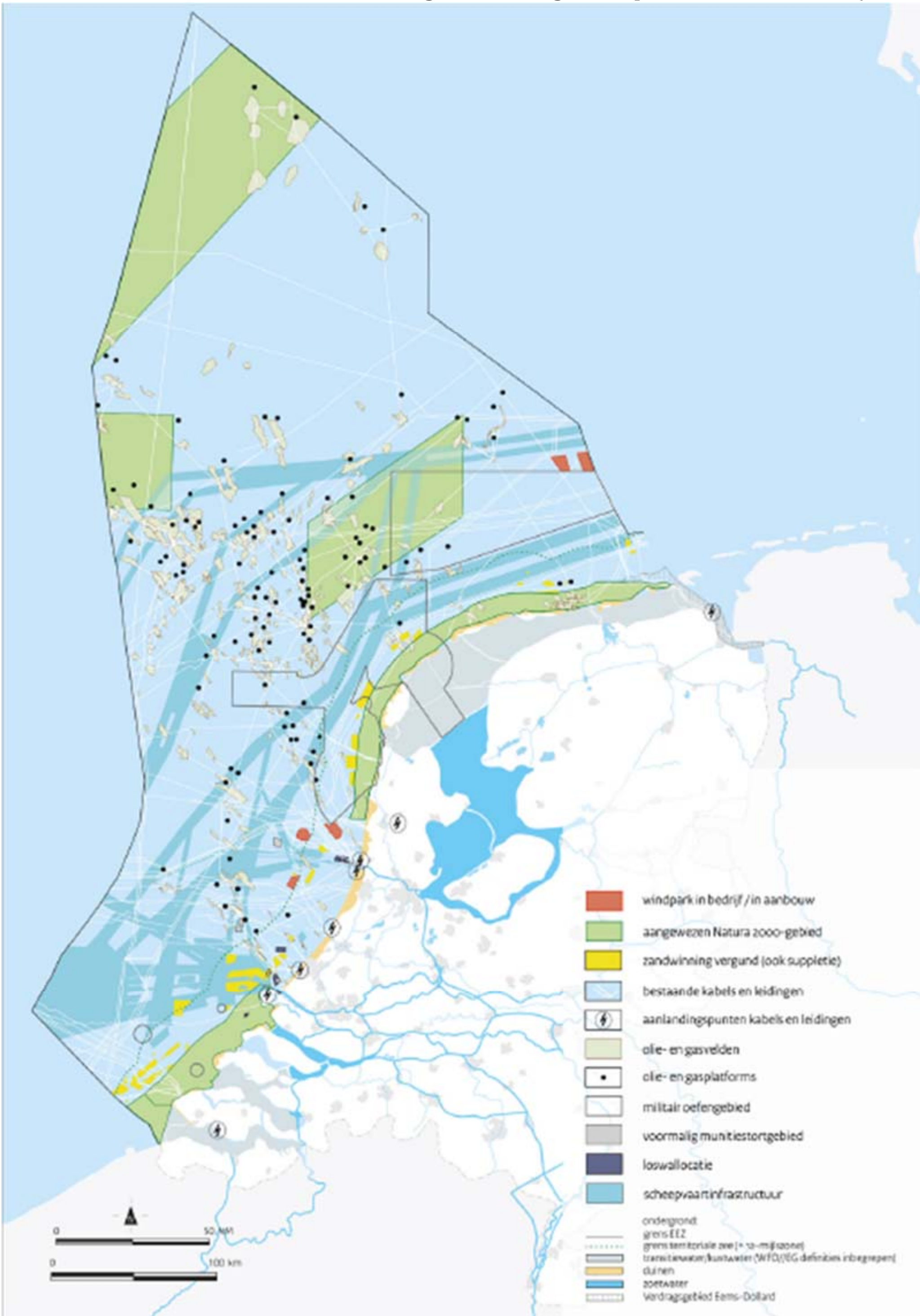


Figure 5.1. Activities in the North Sea (Beleidsnota Noordzee 2016-2021)

Shipping

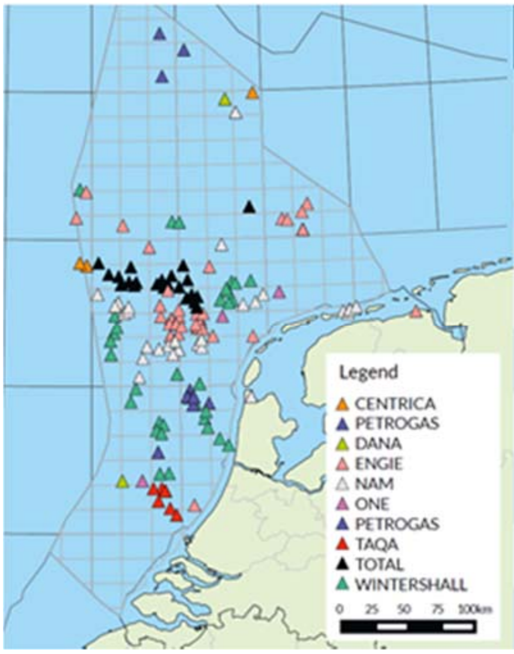
The North Sea poses very busy shipping lanes. Figure 5.1 gives an impression of the shipping intensities. The Dutch seaports are junctions for international trading and a location for industry and services. Possible cumulative effects of shipping are: its contribution to underwater sound and visual disturbance, and shipping is a source of pollution. The effects of shipping on bottom integrity and benthos fauna are neglectable.

Military use

The North Sea is important for the armed forces, for training and exercising purposes. The space requirement for these activities is laid down in a separate key planning decision, named Second Structure Plan Military Grounds. In this plan the areas are designated for these activities. In the absence of exercises these areas are available to other users. There are a number of dumping areas for ammunition in the North Sea, but dumping has been banned for some time now. Cumulative effects on bottom integrity and benthos fauna are not expected.

Energy

Extraction and exploration of oil and natural gas reserves has always been an important economic activity on the North Sea. This industry is, however, under pressure by the low oil and gas prices and the transition to an economy based on the use of sustainable energy. The cessation of production and the decommissioning of old platforms are issues that will become increasingly relevant in the near future, much depending on the development of the oil and gas prices.
In the western part of the Cleaver Bank area (near UK border) one fixed platform for exploitation of oil/gas is situated (van der Burg et al., 2012).
Beside the exploitation of the current platform, explorative activities (e.g. seismic research) and drilling activities also take place in the areas. New developments are the system integration of different sources of offshore energy but the implications of that for the ecosystem are as yet not known. A recent prospectus of EBN, the institution that invests in the exploration for and production of oil and natural gas AO, gives some insight in the envisaged developments (EBN, 2016: Focus Dutch Oil and Gas 2016).



Operator	Integrated	Satellites
Centrica	2	1
Dana	2	0
ENGIE	12	24
NAM	12	17
ONE	1	1
Petrogas	5	7
TAQA	2	5
Total	9	20
Wintershall	9	17

Figure 5.2 Overview of platforms in the DCS. Source: https://www.ebn.nl/wp-content/uploads/2016/12/Focus-Dutch-Oil-and-Gas-2016.pdf.

Compared to the scale of bottom fishing, the footprint of these activities is relatively small. Direct effects on the seabed and the benthic fauna are related to habitat change or habitat loss at the site of the platform. The impact on the targets of indicator species depends on the scale of extraction (amount of facilities) in the area. With the current number of facilities in the areas, the estimated area of habitat change or loss is small.

Within a zone of 500 m surrounding the platforms, other activities are excluded because of safety considerations. In this way, a closed area for fisheries exists which can function as a sanctuary for bottom fauna. The pile foundations of platforms locally alter the habitat from soft bottom to hard substrate, which is relative scarce in the North Sea. Effects of this change towards hard substrate on the ecosystem functioning has been studied for one platform within the INSITE project. Bottoms closely around the wells of older platforms are often polluted with oil based drill cuttings.

Drilling of (bore)holes disturbs the bottom substrate by placement of pipes, the drilling itself and the release of cement and spacers. A surplus of cement can smother bottom fauna. The surface with a smothering layer of more than 1 mm is expected to be less than 1 ha (Tamis et al., 2011).

Cables and pipes

Four pipelines currently transect the SCI: North-South from Norway towards Belgium and Norway to France and the NGT-pipeline, which transports gas to the Dutch coast. Furthermore, from 2014 there is a pipeline transporting gas from the platform in the Northwest of the SCI and one from 2006 that crosses the SCI from a UK platform in the West to a platform North of the SCI. A fifth pileline is foreseen in 2019, which will connect the UK with Denmark. It will cross the Cleaver Bank slightly in the North West corner (Figure 5.3).

Whilst placing pipelines, the sediment is disturbed approximately 10 m on each side of the pipeline (Tamis et al., 2011). Placement or replacement can lead to raised turbidity and bottom fauna in the tracing, or living downstream of it, is affected locally. After placement a fast recovery of the bottom structure is expected. For cables the effects are similar (Slijkerman et al., 2013). Electric and/or magnetic fields occur when cables are being used, the impact is unclear.

In 2017, an initiative was presented to make a new High-Voltage Direct-Current (HVDC) cable (1400 MW capacity) between the UK and Denmark. This cable would cross the Dutch Economic Zone over a length of 170 km, and it crosses the Northern part of the Cleaver Bank (VikingLink, 2017). This cable adds to the four cables that are already in place.

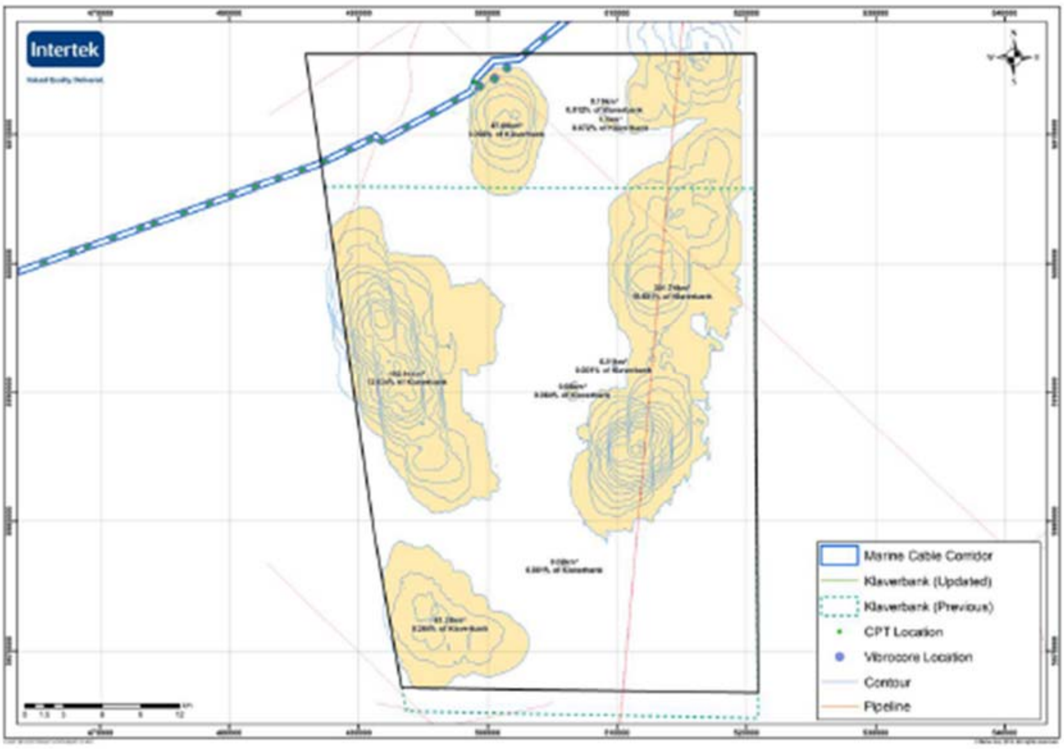


Figure 5.3. Natura 2000 area Cleaver Bank (black rectangle) with boulder concentrations depicted, including the track of the Viking Link Interconnector.

Wind farms

Offshore wind energy has developed in the past years, with a number of three nearshore wind farms that are operational. The turbine parks Egmond at Zee (EAZ) and Prinses Amalia Windpark (PAW), outside the 12-mile zone, have a surface of 26,8 and 16,6 km^2, respectively (including 500 m safety zone). 'Windpark Luchterduinen' in the Dutch Coastal area (in the 12 NM-zone) has a surface of 25km^2. The Gemini Offshore Windpark (on 34 NM) in the northern area of the Wadden islands is currently under construction. The surface is approx. with a surface of 68 km^2. Expansion of offshore wind energy to waters north of the Wadden islands and to the relatively shallow Dogger Bank in the North Sea. The government strives to install 4,450 MW of wind energy on the North Sea operational by 2023 (SER, 2017 - Nationaal Energieakkoord). Also objectives within the wind energy areas of Borssele, Zuid-Holland and Noord-Holland are made, because closer to the coast the realization of wind energy is cheaper than further at sea. The government wants to add a strip of a maximum of two nautical miles to the areas of South and North Holland within the 12-mile zone, making the area more spatially and cost-efficient to use. The decision to designate will be elaborated in a partial revision of the National Water Plan 2016-2021. To this end, an environmental impact report will be drawn up in which alternatives are considered. An Appropriate Assessment will also be drawn up. None of the current or planned parks are situated in the Cleaver Bank, therefore the cumulative effects of wind farms can be left out of scope.

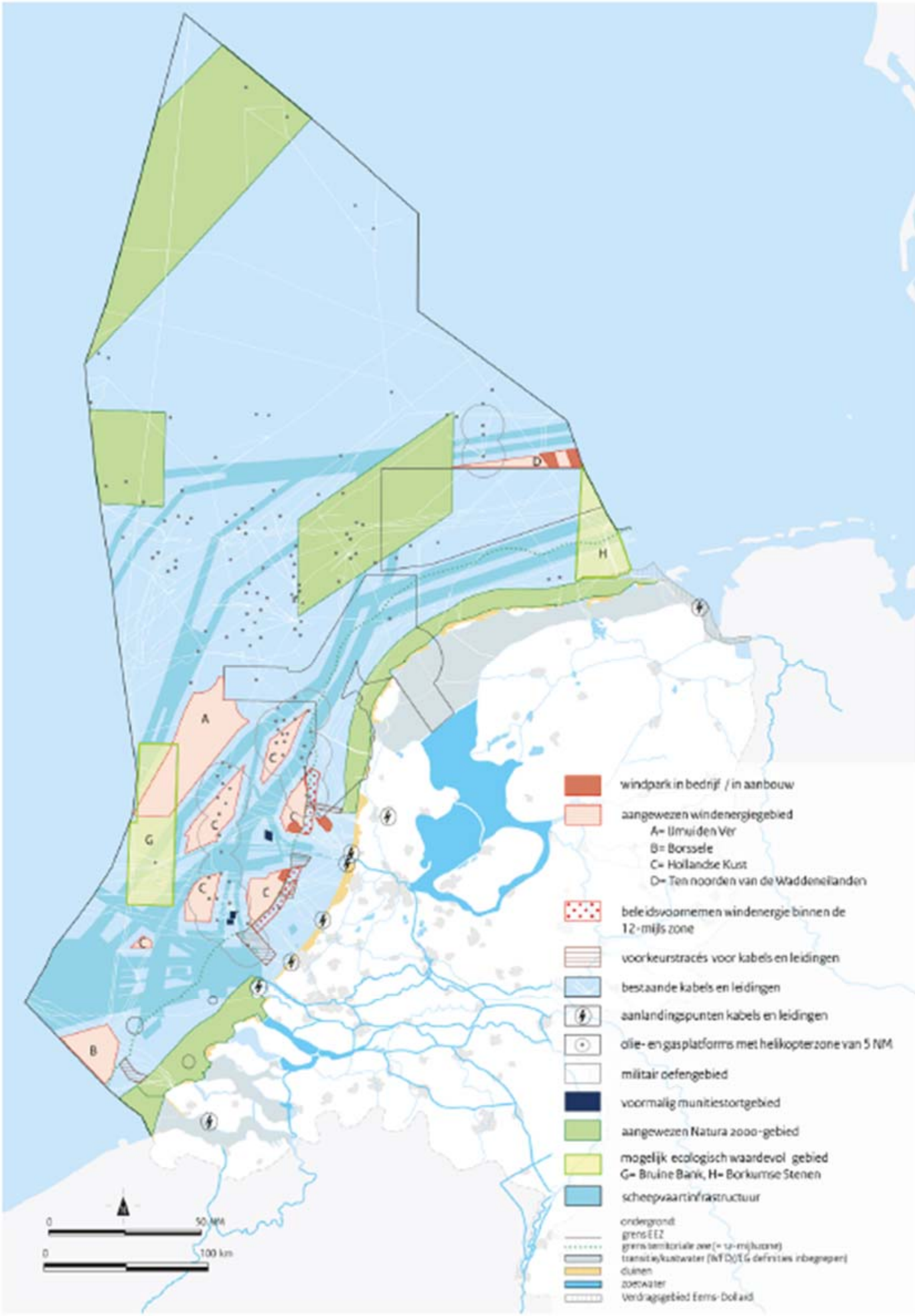


Figure 5.4 Wind energy in the EEZ (Beleidsnota Noordzee 2016-2021)

Extraction of surface minerals and sand

The sand and gravel rich areas of the Cleaver Bank gained a lot of interest for extraction in the past (Van Moorsel, 2004). Currently, no extraction of surface minerals is taking place. Cumulative effects of sand and gravel extraction are not relevant for the Cleaver Bank since none of these activities take place in the areas.

6 Conclusion and recommendations

In this chapter an overview is presented of the most important conclusions in our second opinion on the background document. Also recommendations are given for the content of the background document.

6.1 Scientific certainty

ToR – Main question 1

Can be concluded with certainty, leaving no reasonable scientific doubt, that in case any of the mobile bottom contacting fishing gears to which the management zones of Natura 2000 site Cleaver Bank will be closed according to the joint recommendation, draft version December 2017, would be allowed in the management zones, the delivery of the conservation objectives of this site would not be jeopardized, in keeping with Article 6 of the Habitats Directive 92/43 EEC?

In case that mobile bottom contacting fishing gears would be allowed in the management zones of the Natura 2000-site Cleaver Bank, the vulnerable fauna elements are negatively impacted and the delivery of the conservation objectives (especially the improvement of habitat quality) can be jeopardised. This is the case for gears with a sub-surface impact (beam trawl), but perhaps even more so for gears with a shallow surface impact but larger area footprint (seines), since the most typical H1170 features of the Cleaver Bank protected area are vulnerable (long-lived), filter-feeding, sessile epifauna, growing on the hard substrates. The significance of the effects should be the subject of an Appropriate Assessment (compliant with Art 6 Habitats Directive).

The proposal of the closed areas now is very much focused on the (rather narrow) habitat specifications of H1170. With that, characteristics such as 'a mosaic of sediments' are not fully protected. It was proposed to allow bottom mobile fishing gear in a corridor that encompasses (surrounds) areas where red algae occur. Such a choice is unfortunate if the aim is to conserve this as a "typical" and characteristic species in the Habitat Directive (Duineveld et al., 2013). The red algae are very vulnerable to bottom disturbance, especially the reversal (overturning) of stones (which they need as substrate) and increased resuspension and sedimentation. The effect of overturning of substrate for this species is evident. Resuspension of fine sedimentary material reduces the light penetration which will limit or prevent growth of these algae. Sedimentation of fine sediments on the algae has the same effect.

ToR – Main question 2

Can it be concluded with certainty, leaving no scientific doubt, that allowing bottom-impacting fisheries in the remaining area of Natura 2000 site Cleaver Bank outside the management zones, would not jeopardize the delivery of the conservation objectives of this site, in keeping with Article 6 of the Habitats Directive 92/43 EEC?

The whole Cleaver Bank has been designated as Habitat type H1170. The boundaries of the management zones are mainly based on the distribution of boulders > 30 cm (blue lines) and the gravel, gravelly sand and biodiversity in the near surrounding. For H1170 the BD (via Jak et al., 2009) distinguishes 3 size classes of hard compact substrata that are (1) and can be (2, 3) part of the habitat type:

1. Hard compact substrata with a cross-section of at least 64 mm (rocks, boulders or cobbles of 'generally >64 mm') is included in the habitat type.

2. Hard compact substrata (gravel and cobbles with sessile benthos) with a cross-section of 8 to 64 mm.

3. Hard compact substrata with a cross-section smaller than 8 mm. This finer gravel fraction (and possibly even finer sediments, including sand) can only form part of the habitat type if (1) these

sediments form only a thin, mobile layer over cobbles and coarse gravel on which organisms live that are dependent on hard compact substrata, or (2) if they occur in mosaic with the habitat type.

Much of the substratum as described in 2 and 3 is not incorporated in the current boundaries of the management zones. The finer sediments, like gravel and sand outside the chosen boundaries, can also be colonised by sessile Reef Associated Species and thus are part of (and extend) the reef habitat (Sheenan et al., 2013). Furthermore, the highly permeable coarse sands on the Cleaver Bank are inhabited by very special species, among which is the chordate *Branchiostoma lanceolata* (Van Moorsel, 2003).

Firm sediments may also be covered by a top-layer of finer sediments, and not show on the SSS as hard compact substratum, but still be suitable for species to attach to the underlying hard layer (Lavaleye, 2014). Lavaleye (2014) also suggests that a top layer of soft sediment on Cleaver Bank areas near the Botney Cut can originate from the deep by resuspension as a result of fishery activities in the Botney Cut channel. In the current proposal, however, the Botney Cut is left outside the borders of the closed area.

Resuspended sediments can further have negative effects on fauna not adapted for chronic high levels of turbidity. Decreased light intensity and smothering, or interference with filtering structures has negative effects on such fauna. With its depth of ~ 40 meter and coarse sands the Cleaver Bank hosts a community not adapted to high suspended matter loads and is likely to be sensitive to a chronic elevation of SPM caused by fisheries.

Also, the transition of the flat Cleaver Bank to the deep channel is left out of the considerations, although the BD mentions on p. 28 that "the bottom structure is more important on the depth-gradient to the deeper, silt-rich sea bed than for shallower sandy parts" (Jak et al, 2009, referred to in Slijkerman 2013).

Therefore, is it likely that only closing the current proposed management zones will not provide the required certainty that the delivery of the conservation objective for H1170 in the Cleaver Bank would not be jeopardized.

6.2 Is the best available knowledge applied?

Q2. Sufficiency of literature
ToR: Is there sufficient literature available to support the conclusion that the favourable conservation status of the Natura 2000 site is ensured in case of a management regime which allows the afore mentioned bottom impacting gears in the management zones?

There is an immense amount of literature on the impact of bottom fisheries, however there are only few studies that looked at the impact on hard and gravely substrates such as on the Cleaver Bank H1170. On specific gears such as Danish seine and Scottish seine (fly-shoot) there are not many studies available. In general, it can be concluded that sessile epifauna are often filter-or suspension feeding, long-lived species that are very vulnerable to physical disturbance of the substratum or by smothering after resuspension events. Most mobile epifauna is associated to cobbles and gravel because of foraging or as hiding area in holes. The third component are the infauna, a.o. consisting of long lived molluscs that live shallow as juveniles and deeper in the sediment as an adult. These infauna components are vulnerable to both surface and sub-surface bottom disturbance.

The impacts of bottom contacting fisheries are, dependent on the gear component (Rijnsdorp et al. 2016): homogenisation of the texture of sea bottom, destruction of hard structures, displacement of stones and shells (by cables and ground rope), or the penetration of the seabed and disturbance of the vertical structure of the sediment (in case of otter boards or tickler chains) - including collisions with (hard) structures, and re-suspension of sediments.

Adverse effects are expected on fragile biogenic habitat (soft corals, sponge gardens, etc.) and fragile benthic taxa that live on the sea bed and are attached to hard objects (stones, shells, etc.). We expect that the recovery of these sensitive species will also be hampered by fly-shooting. All types of bottom-contacting fishing gear are considered to be destructive to these epifauna species.

Q3. Selective use of literature

ToR: In the literature review the question will be answered if in the Cleaver Bank Background Document, draft of 7 July 2017, attachment 2) selective use has been made of available literature.

a. Was recent literature concerning the effects of the afore mentioned bottom impacting gears on reefs, habitat type H1170, left out of the impact analysis in the Background Document, p. 28-32?
b. Were conclusions of research, which have been used in the Cleaver Bank Background Document – also including the studies by A. Rijnsdorp et al (2015), and by Eigaard et al (2016)- correctly reproduced?

Ad a.

Literature is available on direct and indirect impacts of trawling on reef habitat and the recovery of habitat and fauna due to cessation of fisheries. This knowledge of impacts of trawling as well as knowledge on recovery after cessation of fisheries is not incorporated in the BD.

Hermsen et al. (2003) found that cessation of mobile fishing on the gravel pavements on the Georges Bank has resulted in a marked increase in benthic megafaunal production. After the prohibition of bottom fishing at one site, both colonial and noncolonial species increased in abundance. Populations of most taxa took two years or more to increase after the fishing closure. Bottom fishing needs to be reduced to infrequent intervals to sustain the benthic species composition of Georges Bank at a high level of biodiversity and abundance (Asch et al., 2008).

Tillin et al. (2006) investigated the effects of chronic trawling disturbance on the functional composition of faunal benthic invertebrate communities in 4 constrasting regions of the North Sea (6-13 sites) and found that changes in the functional structure of the community due to the effects of long-term trawling were identified in 3 of the 4 areas sampled. Filter-feeding, attached and larger animals were relatively more abundant in lightly trawled areas, while areas with higher levels of trawling were characterised by a higher relative biomass of mobile animals and infaunal and scavenging invertebrates. Univariate analysis of selected traits confirmed the patterns observed in multivariate analysis. These results demonstrate that chronic bottom trawling can lead to large scale shifts in the functional composition of benthic communities, with likely effects on the functioning of coastal ecosystems.

Ad b.

A subset of the conclusions of Rijnsdorp et al. (2016) and Eigaard et al. (2016) is correctly reproduced. However, there are some remarks. The BD states: "As a result of fisheries impact, the sea floor is homogenized, having a negative impact on deep digging species such as shrimps. Those species are important for the structure, chemical conditions, mineralization of the sea floor, enhancing the distribution other species (Slijkerman, 2013)." This impact is characteristic for grounds with soft substratum like Frisian Front and Oyster Grounds instead of reef habitat like H1170. Rijnsdorp et al. (2016) conclude in their preliminary results that the Sublittoral mud (EUNIS A5.3) is affected the most due to the combined effect of intensive fishing and large proportions of long-lived taxa.

We note that the BD is not dealing with the impact of raised turbidity by resuspension of the substrate through fisheries.

With respect to Eigaard et al. (2016), it can be noted that the depth at which bottom disturbance is taking place (surface, sub-surface) is not determining the entire effect. The impact of similar disturbance depths can have different consequences on one type of substratum (e.g. 2 cm disturbance depth on a sandy sediment in the shallow coastal zone) or another (e.g. the same on a fine sediment or gravel offshore at 50 m depth). In other words: the different sensitivity of different substrates is left out of the consideration by Eigaard et al. (2016). Eigaard et al. (2016) did not include gravel and hard substrates in their review.

A paper by Thompson et al. (2011) shows that, dependent on the area (depth), short-term natural resuspension events occur on the Oyster Grounds during 8% of the time. These events are caused by tide- and wave-induced raised current velocities. In much shallower sites (e.g. Sean

Gasfield), these events can increase to 50% of the time. Therefore, natural resuspension events by natural causes do occur in the open sea. In the deeper parts of the North Sea, these events have a strongly seasonal character (more wind and waves during winter). Resuspension by fishery is less seasonal, although the fishing effort also shows seasonal patterns. With respect to the depth, the Cleaver Bank compares with the Oyster Grounds. On this ground, it can be assumed that on the Cleaver Bank natural resuspension events occur during 8% of the time as well. However, due to the coarser type of sediment, the resuspension is expected to reach lower concentrations and it is assumed to resettle quickly after disturbance.

Furthermore, the BD mentions that: "Bottom structure is more important on the depth gradient to the deeper, silt-rich sea bed than for shallower sandy parts (Jak et al, 2009, referred to in Slijkerman, 2013)." These areas are currently not protected in the proposed management zones.

6.3 Is the impact assessment complete?

Q1. Scientific justification of chosen management regime
ToR: Is a management regime, which allows the aforementioned bottom impacting gears in the management zones of the Natura 2000 site, scientifically justified on the basis of pressures in the occurrences of habitat type H1170 and hence does it meet the conservation status of the habitat?

The monitoring data on the Cleaver Bank are, despite project monitoring in the past years, still rather limited and not covering the entire area. There are several maps of the Cleaver Bank, but what is missing in the BD is an 'overview' map indicating the presence of the most typical features of the Natura 2000 area.

Mobile fishing gear reduces seafloor habitat complexity through the removal of structure-building fauna, e.g. emergent organisms that create pits and burrows, as well as by smoothing of sedimentary bedforms (e.g. sand ripples). Lindholm et al. (2004) compared the relative abundance of microhabitat features (the scale at which individual fish associate with seafloor habitat) inside and outside of a large fishery closed area (6917 km2) on Georges Bank (an area with a comparable seabed habitat as Cleaver Bank). Results showed significant differences in the relative abundance of the shell fragment and sponge microhabitat types between fished and unfished areas.

Natura 2000 is the implementation of the Habitats Directive, which works according to strict criteria and assessment protocols. The BD aims to provide the necessary background information to the Draft Joint Recommendation for offshore fisheries management on the Cleaver Bank, with a request to regulate the fisheries in part of this area to ensure a key contribution to achieving Natura 2000 conservation objectives for reefs (H1170) and to ascertain that the integrity of the site will not be adversely affected. However, the BD is not set up as an appropriate assessment (cf. HR Article 6).

An important question is whether the BD has sufficiently taken into account the Habitats Directive criteria for habitat quality and as specified for habitat H1170 in the '*profieldocument H1170*', and also of the Interpretation Manual on the European Habitats, version EU28 of april 2013. A negative answer on this question would not give the certainty, leaving no reasonable scientific doubt, that a) allowing any of the bottom-impacting fisheries in the management zones, and b) the proposed management regime (specific location of management zones, and allowing bottom impacting fisheries in the rest of N2000 area Cleaver Bank) will have no adverse effects on the site integrity. The BD should provide the evidence (without reasonable scientific doubt) needed within the legal framework of the Habitats' Directive to support the management decisions and therefore must be set up taking into account the mandatory criteria for assessing the quality of H1170. This seems currently not the case.

6.4 In what way have knowledge gaps and uncertainties been dealt with?

Q2. Risk of not meeting the conservation objectives
ToR: In the literature review the possibility of significant effects will be related to the question

whether the delivery of the conservation objectives for habitat H1170 will be jeopardized in the light inter alia of the characteristics and the specific environmental conditions of the site.

We related the vulnerability of indicator species to bottom disturbance by mobile bottom fishing gear. Every form of bottom disturbing contact impacts the fauna that depends on the reef habitat, e.g. sessile epifauna, growing on cobbles, infauna related to highly permeable coarse sands and the organisms that are adapted to living on or in coarse sediments.

Pressures are: removal and damage, discards and by-catch, turbidity/suspended matter/ smothering and changes to structure of substrate. Information is available on the impact of most pressure aspects on fauna. Precaution is needed for turbidity/smothering of the reef caused by bottom disturbing in the nearby area (e.g. Botney Cut). Sessile epifauna is vulnerable for smothering and/or a decreasing water clarity. A distinction of the turbidity effect is whether it impacts photosynthesis or filter feeding.

In general, it can be concluded that sessile epifauna are often filter-or suspension feeding, long-lived species that are very vulnerable to physical disturbance of the substratum or by smothering after resuspension events. Adverse effects are expected on fragile biogenic habitats and fragile benthic taxa that live on the sea bed and are attached to hard objects. We expect that the recovery of these sensitive species will be hampered by bottom contacting fishing gear, including fly-shooting. All types of bottom contacting fishing gear are expected to be destructive to these epifauna species and the allowance of these types of fisheries in the Natura 2000 area Cleaver Bank, both inside and outside the management zones, poses a risk of not meeting the conservation objectives.

6.5 Does the BD give sufficient insight in the activity?

Q3. Literature review of fishery impact
ToR: The literature review will, inter alia, research the effects of bottom impact and bycatch of the afore mentioned bottom impacting gears on habitat type H1170 as described in the Profile Document of H1170[1]. The effects on the seabed and associated species will include the effects on fish (target and non-target species), benthos, shell fish and other bottom dwelling species. The research will also focus on slow-growing and long-lived species and other effects on the food web. If possible, long term effects will be taken into account. The effects on typical species as mentioned in the profile Document H1170, and on the indicator species as listed on p. 53 Background Document are part of this assessment.

The BD concludes that for the Cleaver Bank habitat with a relatively high gravel content and a low level of natural disturbance, the benthos is expected to have a higher sensitivity to trawl disturbance as compared to the sandier habitats that are exposed to higher bed shear stress. The reef habitat type H1170 is therefore assessed as being highly sensitive to all types of bottom contacting gear, even gears with small subsurface impact, and larger surface impact.

The BD appears to refer to the most up-to-date information on the typical values of the Cleaver Bank. However, structural monitoring (of H1170 and its specific quality elements) is currently lacking. The BD does not present a complete overview of monitoring and studies that were carried out on the Cleaver Bank in recent years.

Connected with the different types of bottom contacting fisheries and their footprints (Eigaard et al., 2016), it is relevant to get insight in the life-cycles of the different species belonging to the typical fauna of H1170 (not only the adults, but also the egg and larval stages and juveniles), because the demands of the different life stages may differ during the ontogeny of a species. It is also necessary to distinguish the typical fauna in: epifauna, near-surface infauna, and sub-surface infauna. These considerations are currently missing in the background document, but they are needed to assess the impact of different types of bottom contacting gears.

By-catch of fish in the demersal fisheries can have severe consequences for the fish fauna. The BD does not give a description of the current fish fauna of the Cleaver Bank.

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[1] See the Dutch Profile Document of Habitat type H1170, version of 2014.

The current status of the Cleaver Bank 'quality' is not well known. This is problematic if an improvement in quality of the habitat type H1170, which is the objective, is to be demonstrated. To assess the quality status and detect the effectiveness of measures, a list of indicator species (to monitor the improvement of habitat type H1170) was drawn up in the BD (but contains some errors, e.g. a doubling of the species *Pododesmus* and *Polititapes* – both Bivalves, but erroneously also listed as Gastropods).

Furthermore, the status of the presented list of indicator species that represent the good status of H1170 Cleaver Bank is unclear. Table 11.1 does not give references of how the table is composed, or which are the criteria and the sources of information.

The typical species and smart indicators are not monitored in the current MWTL (Wijnhoven et al., 2013). Therefore, it is impossible to assess the current status from the MWTL-data.

Q4. Footprint considerations
ToR: In the assessment of the effects of the bottom impacting gears, the foot print per hour fishing of the gears should be compared.

For a comparison of the footprint, reference is made to Eigaard (2015). Within each type of mobile bottom contacting gear, a wide range in configurations of individual fishing vessels is possible. Therefore, a more realistic comparison of footprint can only be made on the basis of realistic fishing effort data of the area.

6.6 Is the selection of activities considered in cumulation complete?

Q1.
ToR: Do impact assessments that support the draft proposal for the Cleaver Bank, include an assessment of the cumulative effects before they are related to characteristics, the specific environmental conditions and conservation objectives of the site?

Shipping, cables and pipelines, oil and gas extraction and oil pollution have been considered, beside fisheries, as human activities in the management zones. Cumulative effects of other activities were assumed to be low or absent. Although the relevant cumulative effects have been included, the information in the BD may need an update with the most recent policy documents that exist for activities in these areas. A description of current and planned activities is given in the Beleidsnota Noordzee 2016-2021.

Q2.
ToR: Have other plans and activities been included in an assessment of cumulative effects?

We found a recent (2017) impact assessment for the VikingLink cable that crosses the northern edge of the Cleaver Bank.

No other plans/activities are included in an assesment of cumulative effects.

Q3.

ToR: Have 'external' activities taking place outside the borders of the Natura 2000 site Cleaver Bank, sufficiently been taken into account in the assessment of the effects inside the site?

No external activities outside the Natura 2000 site Cleaver Bank have been taken into account.

6.7 Recommendations

Description of H1170 and explanation of typical values and species

The description of the current status of the habitat H1170 is hampered by a lack of area-covering monitoring data on the Cleaver Bank. In the BD, a total of 28 typical species are listed as indicator species for the conservation objectives of the H1170 Cleaver Bank Natura 2000 site, including species of Anthozoa (soft coral), Florideophyseae (red algae), Gastropoda, Malacostraca, Polychaeta and Bivalvia.

The list of indicator species to monitor the development of (the quality of) H1170 on the Cleaver Bank (Background Document, Table 11.1) is more extensive than the list of Typical Species of H1170 within Natura 2000, or the list of 'smart indicators' (derived for the Marine Strategy Framework Directive). Furthermore, it contains a different set of species than in several other documents. The basis for selecting a particular subset of all relevant indicators in Table 11.1 of the BD is unclear. It should be explained in the BD which species list is used to assess the impacts, and based on which criteria this list has been composed.

Supported by the overview in Table 3.1, we recommend to revise Table 11.1 in the Background Document and add a clear(er) rationale for the applied indicator selection.

Furthermore, the BD should provide the evidence (without reasonable scientific doubt) needed within the legal framework of the Habitats' Directive to support the management decisions and therefore must be set up taking into account the mandatory criteria for assessing the quality of H1170. This seems currently not the case.

Available surveys

It appears that NIOZ conducted several surveys as part of their North Sea research program, but that not all of the survey data have been analysed or reported (pers. comm. Rob Witbaard). There may be more unpublished data from other surveys (e.g. in the DISCLOSE-project) which may be worthwhile to include in the BD.

Status of the Cleaver Bank

Several surveys observed trawling marks in the Cleaver Bank, as reported by Van Moorsel (2003), Laban (2004), Lavaleye (2014), Lengkeek et al. (2017), Duineveld et al. (2013). The current status can be considered as a result of decennia of fisheries with demersal mobile fishing gear.

The BD should make clear how the selected indicators can help to assess the quality of H1170, which should improve (according to the Natura 2000 objectives). It is recommended to add or develop derived indicators such as the number of trawl marks observed in surveys, or the percentage of the area that is (un)trawled.

The spatial and temporal coverage of the monitoring is restricted. Large areas were not surveyed. Given that, and the fact that the indicators of quality improvement are not clear, the actual conservation status in terms of quality of the habitat cannot be assessed and is largely unknown.

Description of demersal gear types and footprint

Eigaard et al. (2016) distinguish between surface abrasion by all gear components that have bottom contact, and subsurface abrasion by gear components that penetrate more than about 2 cm into the sediment.

Metiers differ widely in the surface area swept per hour of trawling (Eigaard et al., 2016). Flyshoot and otter trawls, in particular twin trawls, have a large surface footprint as compared to for instance beam trawls used in the flatfish fishery. The flatfish beam trawls, however, have a relatively large subsurface footprint because all gear components penetrate into the seabed
The pulse gear has the capacity to reduce the mechanical impact of trawling on the benthic ecosystem, but there are still considerable knowledge gaps on how the electrical stimulation affects marine organisms and ecosystem functioning.

Further quantification of the footprint is only possible with more detailed information on the fishery intensity and the individual gear specifications. Such a quantification is recommended for an impact assessment.

Sensitivity of typical species to physical and biological pressures

Sessile epifauna is the most vulnerable for both surface and subsurface mobile bottom contacting fishing gear. In order to assess the vulnerability of species we also need to take into account the life stage. The BD-document does not distinguish life stage of characteristic species when assessing the impacts of mobile bottom contacting fishing gear.

Impact on conservation objectives H1170

All mobile bottom contacting gears have a negative impact on the substratum or turbidity and thus on the vulnerable sessile epifauna and conservation goals of H1170. This is especially the case for gears with a large surface impact like demersal seines.

Surface disturbance over a large area is more damaging to the characteristic epifauna than a deeper sub-surface disturbance over a small area.

Most sessile epifauna depend on filter feeding and is sensitive to an increase in turbidity. There is little information available on the effect of smothering/turbidity on fauna in the Cleaver Bank caused by trawling gear in the Botney Cut.

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Annex 1. List of consulted literature on impact of mobile bottom contacting fishing gear on the status of indicator species

Author	Year	Subject	Title	Journal
Abstract Broadhurst et al	2006	Species specific effects	Estimating collateral damage of bottom trawling.pdf	Fish and Fisheries. 7: 180–218.
Abstract Brouwer et al	2016	Processes Policy and Management	Public willingness to pay for alternative management regimes of remote marine protected areas etc.pdf	Marine policy 68: 195-204
Abstract Castega et al	2016	Recovery and restoration	First results of fauna community structure and dynamics on two artificial reefs in the south etc.pdf	Estuarine Coastal and shelf Science 179: 172-180.
Abstract Freese	1999	Community effects Gravel	Effects of trawling on seafloor habitat and associated invertebrate taxa in the gulf of Alaska.pdf	Marine Ecology Progress series 182: 192-126.
Abstract Prena et al	1999	Ecosystem effects Sand bottom	Experimental otter trawling on a sandy bottom ecosystem of the Grand Banks MEPS 181 107-124.pdf	Marine Ecology Progress series 181: 107-124.
Abstract Ramsey et al	2001	Species specific effects	causes of shells scarring in dog cockles.pdf	Journal of Sea research 45(2): 131-139
Abstract Schratzberger et al	2014	-	Role of sedimentary regime in shaping the distribution in a subtidal sandbank environment.pdf	PLOS1 9 (10)
Abstract Siddhi et al	2017	Processes mobile sands	Mobility of maerl and coarse sediments in waves.pdf	Estuarine Coastal and Shelf Science 189: 173-188
Abstract Smit et al	2008	Species specific effects resuspension	Species sensitivity to suspended clays, burial etc.pdf	Environmental Toxicology and Chemistry 27(4):1006-1012
Abstract Stottrup et al	2017	Recovery and restoration	Restoring a boulder reef in temperate waters.pdf	Ecological engineering 102: 468-482.
Abstract van Marlen	2013	Fishing technique effects	Catch comparison of flatfish pulse trawl and beam trawl.pdf	Fisheries Research 151: 57-69.
Abstract Vos & Mol	2010	Processes Policy and Management	Changing trust relations within the Dutch fishing industry the case of national study groups.pdf	Marine policy 34(5) : 887-895
Abstract Wilson et al	2014	Species specific effects bycatch	Looking beyond mortality of bycatch: sub-lethal effects of incidental capture on marine animals.pdf	Biological Conservation 171: 61-72
Abstract_James et al	2015	effects on individual species Resuspension	Sediment impacts on marine sponges.pdf	Marine Pollution Bulletin 94: 5-13.
Abstract_Oberele et al	2015	Physical effects bottoms	Deciphering the lithological consequences of bottom trawling to sedimentary habitats on the shelf.pdf	Journal of Marine systems 199: 120-131.
Anonymous	2014	Processes Policy and Management	Mariene strategie voor het nederlandse deel van de noordzee 2012-2020, deel 2 krm-monitoringprogramma	-
Anonymous	****	Processes Policy and Management	Mafcons report-Chapter08Annex3Disturbance.pdf	-
Anonymous	****	Processes Policy and	Natura 2000 doelendocument[1].pdf	-

		Management		
Auster et al	1996	Physical effects bottoms	Effects mobile fishing gear gulf of maine.pdf	Reviews in Fisheries Science (4) 2: 185-202
Beers et al	2013	Fishing techniques	Themabeschrijving verduurzaming in nederlandse visserij-flyshoot	BO-12.04 Document beleidsondersteunend onderzoek
Bergmann et al	2001	Species specific effects bycatch	Damage sustained by epibenthic invertebrates discarded in the nephrops fishery of the Clyde sea area Scotland.pdf	Journal of Sea Research 45:105-118
Boedeker et al	****	-	Chapter03-sandbank-reef.pdf	-
Bolam et al	2017	Community effects Trait analyses	Differences in biological trait composition of benthic assemblages between unimpacted habitats.pdf	Marine Environmental Research 126: 1-13
Bos et al	2011	Community effects Trait analyses	Biodiversity Hotspots on the Dutch continental shelf	WUR-IMARES report C071/11 145pp
Braeckman et al	2014	Processes Policy and Management	Protecting the commons the use of subtidal ecosystem engineers in marine management.pdf	Aquatic conservation Marine and freshwater ecosystems
Breen et al	2015	Species specific effects MPAs	Temperature marine protected areas and highly mobile fish a review.pdf	Ocean and Coastal management 105: 75-83
Brey et al	1990	-	Arctica islandica in Kiel Bay growth production and ecological significance	Journal Experimental Marine Biology and Ecology 136:217-235
Collie et al	2005	Community effects recovery	Effects of fishing on gravel habitats assessment and recovery of benthic megafauna on Georges Bank.pdf	Marine ecology progress series 155:159-172
Collie et al	1997	Community effects recovery	Effects fishing on the benthic megafauna of georges bank	American fisheries society symposium 41:325-243
Coolen et al	2015	-	Reefs and Reeflike structures in the North Sea	Journal of Sea research 103: 84-92
Couceiro et al	2013	Ecosystem effects resuspension	Impact of resuspension of cohesive sediments at the Oyster Grounds North Sea on nutrient exchange .pdf	Biogeochemistry 113: 37-52
Dankers et al	2003	Processes Policy and Management	Vogel en Habitat richtlijn op de Noordzee	Alterra rapport 695 92 pp.
Dannheim	2017	Community effects recovery	Macrozoobenthic response to fishery-PhD AWI 2007.pdf	Dissertation zur erlangung des akademische Grades Dr. re. nat. Bremen. 226pp
Davies et al	2001	Processes Policy and Management	marine monitoring-handbook March 2001	Joint Nature Conservation Committee, isbn 1 861075243, 405pp
Dellapenna et al	2006	Ecosystem effects resuspension	Impact of shrimp trawling and associated sediment resuspension in mud dominated shallow estuaries.pdf	Estuarine Coastal and Shelf Science 69: 519-530
Depestele et al	2016	Physical effects Sandy bottom	Measuring and assessing the physical impact of beam trawling.pdf	Ices Journal of Marine Science 73:suppelement 1: i15-126.
Desprez	2000	Ecosystem effects gravel resuspension	Physical and biological impact of marine aggregate extraction along the French coast of the English channel.pdf	Ices Journal of Marine Science 57: 1428-1438
deVries et al	2011	-	Scaling human induced pressures to population level impacts in the marine	Wot working document 285: 80 pp.

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Dieter et al	2003	Bibliography Review	Mobile fishing gear effects on benthic habitats a bibliography.pdf	NOAA Technical memorandum NMFS-AFSC-135. US Department of Commerce: 206pp
Dijksma	2014	Processes Policy and Management	Start aanwijzings procedure Natura 2000 gebieden	Tweede Kamer der Staten-Generaal Vergaderjaar 2013-2014 32 670 nr 90, brief.
Duineveld et al	2007	Community effects Species specific effects	Mining Platform - differences	Ices Journal of Marine Science64: 899-908
Duineveld et al	2013	Description of the Cleaver Bank	Project 4073.1- Duineveld et al. Rapport Video Surveys Klaverbank en Doggersbank.pdf	NIOZ report, unpublished.
Eastwood et al	2007	effects spatial estimation	Human activities in UK offshore waters an assessment-ICES J Mar Sci	Ices Journal of Marine Science64: 453-463.
Eigaard et al	2016	effects spatial estimation	Estimating seabed pressure on basis of gear design ICES J. Mar. Sci.-2016-Eigaard-i27-43.pdf	Ices Journal of Marine Science 73 Supplement 1): i27-i43.
Eigaard et al 2016b	2016	effects spatial estimation	A Correction to Estimating seabed pressure (1).pdf	Ices Journal of Marine Science 73 Supplement 1): i27-i43.
Ellis et al	2014	effects spatial estimation	Scaling up experimental trawl impact results to fishery management scales etc.pdf	Canadian Journal of fisheries and aquatic Sciences 71: 733-746
Engel en Kvitek	1998	Community effects otter trawling	Effects of otter trawling on a benthic community in Monterey bay national marine sanctuary.pdf	Conservation Biology 12 (6): 1204-1214.
Engelhard et al	2016	-	Ices meets marine historical ecology	Ices Journal of Marine Science 73(5)1386-1403.
Fahe et al	2003	-	Fisheries associated changes in the whelk Buccinum undatum in the south west Irish Sea.pdf	Irish Fisheries Investigations 15: 26pp,
Fiedrich et al	1990	Physical effects bottoms	Sedimentologische auswirkungen der grund fischerei in der Kieler Bucht.pdf	Meyniana 42: 123-151.
Foden et al	2011	Cumulative effects recovery	cumulative impact human activities North Sea.pdf	Marine Ecology Progress series 428: 33-47
Freese et al	2001	Species specific effects epifauna	Trawl induced Damage to Sponges Observed from a REsearch submersible.	Marine Fisheries review. 63 (3): 7-13.
Gilkinson et al	1998	Community effects otter trawling	Impacts of trawl door scouring on infaunal bivalves etc.pdf	Journal of Experimental Marine Biology and Ecology 224: 291-312.
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Grizzle et al	2009	Community effects recovery	Effects of a large fishing closure on benthic communities in the.pdf	Fisheries Bulletin 6: 308-317
Groenewold & Fonds	2000	Ecosystem effects beam trawl	Effects on benthic scavengers of discards and damaged benthos produced by the beam-trawl fishery in the southern North Sea.pdf	Ices Journal of Marine Science 57: 1395-1406.
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Hermsen et al	2003	effects on community structure and processes	Georges bank megafaunal production and fishing.pdf	Marine Ecology Progress series 97: 97-108
Hiddink et al	2006	effects on community structure and processes	Cumulative impacts of seabed trawl disturbance on benthic biomass production etc.pdf	Canadian journal of fisheries and aquatic sciences. 63: 721-736.
Hiscock et al	2004	-	Identification of seabed indicator species from time series	Report to the joint nature conservation comittee and the Environment Agency from the marine biological association Plymouth Marine Biological Association JNCC Contract F90-01-705. 109pp
IJlstra	2017	-	Report Ad hoc informal Scheveningen Group June 20 2017.pdf	Report Ad hoc informal Scheveningen group. 5pp.
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Jessen et al	2011	-	Science based guidelines for MPAs and MPA networks in Canada.pdf	Canadian Parks and Wilderness Society 58pp.
Kaiser	1998	effects fishing relative to natural disturbance	Significance of bottom fishing disturbance.pdf	Conservation Biology 12(6): 1230-1235.
Kenchington et al	2001	Community effects otter trawling	Effects of experimental otter trawling on the macrofauna of a sandy bottom.pdf	Canadian Journal of Fisheries and Aquatic Sciences 58: 1043-1057.
Kerckhof et al	2006	-	The veined whelk Rapana venosa has reached the North Sea.pdf	Aquatic invasions 1(1): 35-37.
Kraan et al	2013	-	Monitoring of Cod catches in ottertrawls and seines	Imares Wageningen UR rapport C077.13: 24pp.
Kuhlman and Oosterbrugge	2014	Fishing methods Transition	Bodemberoerende visserij op de Noordzee. Huidige situatie en toekomst scenarios.pdf	Report LEI 2014-024.54pp.
Laban	2002	Description of the Cleaver Bank	Geologie klaverbankrapport.pdf	TNO rapport NITG 01-003-A.
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Lengkeek en Bouma	2010	Bibliography Review	Impact of beamtrawl fisheries in the North Sea. A summary in fifty five publications.	Bureau Waardenburg bv. Rapport 10-048: 46pp.
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Polet	2015	Review Fishing for Plaice	Pladijs vanuit biologisch en visserijtechnisch perspectief	Instituut voor landbouw en Visserijonderzoek. Vissen in het verleden sessie 3: 10pp
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The background photo of the cover shows a typical gravel sediment sampled in 2013. The insets show fauna components as can be found at the Cleaver Bank.

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