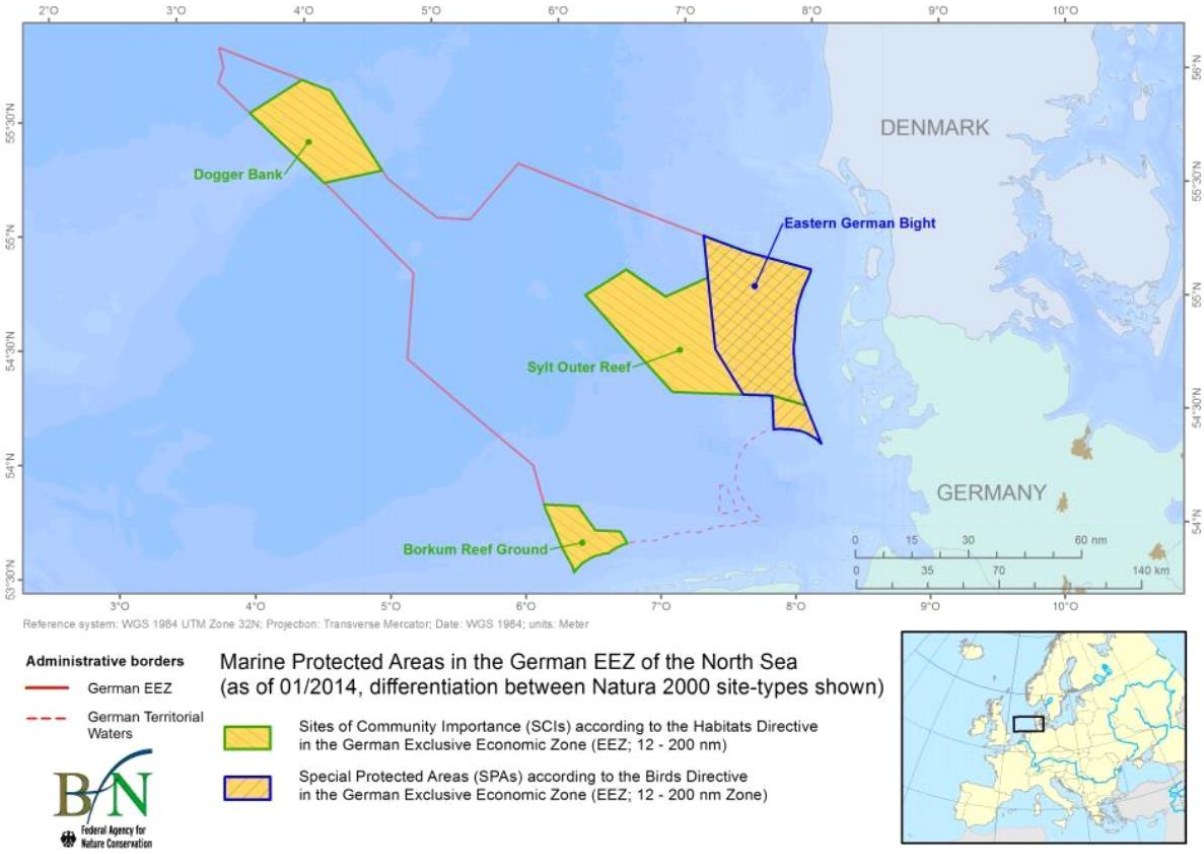
How does sandeel fishery impact the marine ecosystem in the southern North Sea and the achievement of the conservation objectives of the marine protected areas in the German EEZ of the North Sea?



Dr.Thurid Otto, Dr.Silvia Opitz, Dr.Rainer Froese
GEOMAR - Helmholtz-Centre for Ocean Research Kiel
2019

GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

Authors‘ address:

GEOMAR
Helmholtz-Centre for Ocean Research Kiel
Düsternbrooker Weg 20
24105 Kiel

Cover Page
Map: Federal Agency for Nature Conservation (BfN)

Funded by Federal Agency for Nature Conservation (BfN)

Table of contents

1. Background

Under Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora (Habitats Directive), EU member states (MS) are obliged to establish a consistent network of protected areas for their terrestrial and marine areas (including the Exclusive Economic Zone, EEZ). Together with the protected areas under the Birds Directive (Directive 79/409/EEC on the Conservation of Wild Birds) the protected areas under the Habitats Directive form part of the marine Natura 2000 network. After inclusion in the Community list of the EU Commission (EU-COM), EU-MS are required to develop measures in accordance with the Habitats Directive to ensure maintaining or restoring of the favourable conservation status of species and habitats. Establishment and implementation of measures for regulation of the commercial fisheries in marine Natura 2000 sites in the EEZ of a EU-MS can be conducted solely in the framework of the Common Fisheries Policy (CFP, Regulation (EU) No 1380/2013). In 2013, the CFP was fundamentally revised and has applied since 1.1.2014 in all EU waters. The core objective of the reformed CFP is the implementation of a sustainable, ecosystem-friendly use of marine resources particularly in relation to the achievement of a good environmental status of the European oceans until 2020 according to the MSFD. Fish stocks in EU waters shall be exploited in accordance with the MSY principle (MSY: „Maximum Sustainable Yield“), e.g. stocks shall be managed in such a way that they are restored to and maintained at levels capable of producing maximum sustainable yield.

Taking the initial assessment of the German North Sea in 2012 in the framework of the MSFD (MSFD Art. 8, BMUB 2012) as a basis, it can be stated that the cumulative pressure of the various human activities in the German North Sea is too high and the good environmental status of species and biotopes in the North Sea is not reached. Thus, Germany has set out specific operational environmental targets for the German North Sea, which were agreed between the Federal Government and the coastal federal states and communicated to the European Commission in 2012[1]. These targets should help to achieve a good environmental status (GES) for all German marine areas in 2020. For benthic habitats, the following environmental targets are of key relevance in this regard:

- Environmental target 3.1: In terms of space and time periods, there are adequate zones for retreat and resting for ecosystem components. To protect marine life from anthropogenic disturbances, for example, areas and periods of time where fishing is prohibited and/or restricted (no-take zones and no-take times based on the CFP rules) are established (cf. for example MSFD Recital 39).
- Environmental target 3.2: Bycatch, discards and bottom-trawl fishing gears do not adversely affect the structure and function of food webs and marine habitats. Germany will work towards the regeneration of ecosystem components already damaged by human interventions. The functional groups of the biological features (Annex III Table 1 of the MSFD) or their forage base are not jeopardised.
- Environmental target 4.3: Fisheries do not disturb other ecosystem components (non-target species and benthic communities) to the extent that they compromise the achievement or maintenance of their respective specific good environmental status.

[1] BMUB 2012(Publisher) http://meeresschutz.info/berichte-art-8-10.html

To implement the objectives of the Habitats Directive, the Birds Directive and the MSFD, Germany has developed a Joint Recommendation (JR) regarding fisheries management measures under Article 11 and 18 of the CFP Regulation within the Natura 2000 sites in the German EEZ of the North Sea. As referred to in Article 11 and 18 of the CFP regulation, Germany had to submit the draft JR to the EU-MS having direct management interest in the fishery in the German EEZ and had to reach an agreement with them in the official so-called "Scheveningen-Process" within six months. The JR contains, inter alia, proposals for the exclusion of all mobile bottom-contacting gear in parts of the Natura 2000 site Sylt Outer Reef (SAR, "Sylter Außenriff") and in the Natura 2000 site Borkum Reef Ground (BRG, "Borkum Riffgrund") to protect the occurring habitat and biotope types with their characteristic species. In the course of negotiations on the JR with all EU-MS having direct fisheries management interests, Germany had to accept several compromises in order to achieve a consensus on the proposed measures according to the requirements of the CFP. Particularly demanded by Denmark, Germany had to make compromises in the final negotiation phase (2018) for the Natura 2000 sites SAR and BRG concerning the sandeel fishery, which is mainly conducted with bottom trawls in the North Sea. The Danish government saw a substantial economic disadvantage for the Danish sandeel fishery through the proposed exclusion zones and therefore did not agree to the initial proposed measures. The compromise found in the end envisages the establishment of two corridors in the Natura 2000 site SAR, in which fisheries with mobile bottom-contacting gear – and thus also the Danish sandeel fishery - would be still allowed. In BRG, mobile bottom-contacting gears and hence also the sandeel fishery would be allowed in a partial area (ca. 4 km^2 of the protected area).

On 4 February 2019, Germany finally submitted the agreed JR to the EU-COM. However, the EU-COM informed Germany and the Scheveningen Group that several improvements are necessary in order to fulfil the requirements of the Birds and Habitats Directive (letter of EU-COM to Germany and the Scheveningen Group, 24 May 2019). In this letter, EU-COM addressed the issue of the sandeel fishery only indirectly.

The JR regarding fisheries management measures in the Natura 2000-site Doggerbank to protect the habitat type 1110 "Sandbanks which are slightly covered by sea water all the time" (hereafter called habitat type „sandbanks") has been developed by Germany, the Netherlands and the United Kingdom in a separate trilateral process also in accordance with Article 11 and 18 of the CFP regulation. To protect the habitat type 1110 "sandbanks" in the German Natura 2000 site Doggerbank, a year-round exclusion of all mobile bottom-contacting gears, including demersal seines, in 50% of the protected area is proposed (see figure 1). Demersal seines would still be permitted in the Dutch and British fisheries management zones. The JR was finally accepted by all EU-MS and submitted to the EU-COM on 12 June 2019.

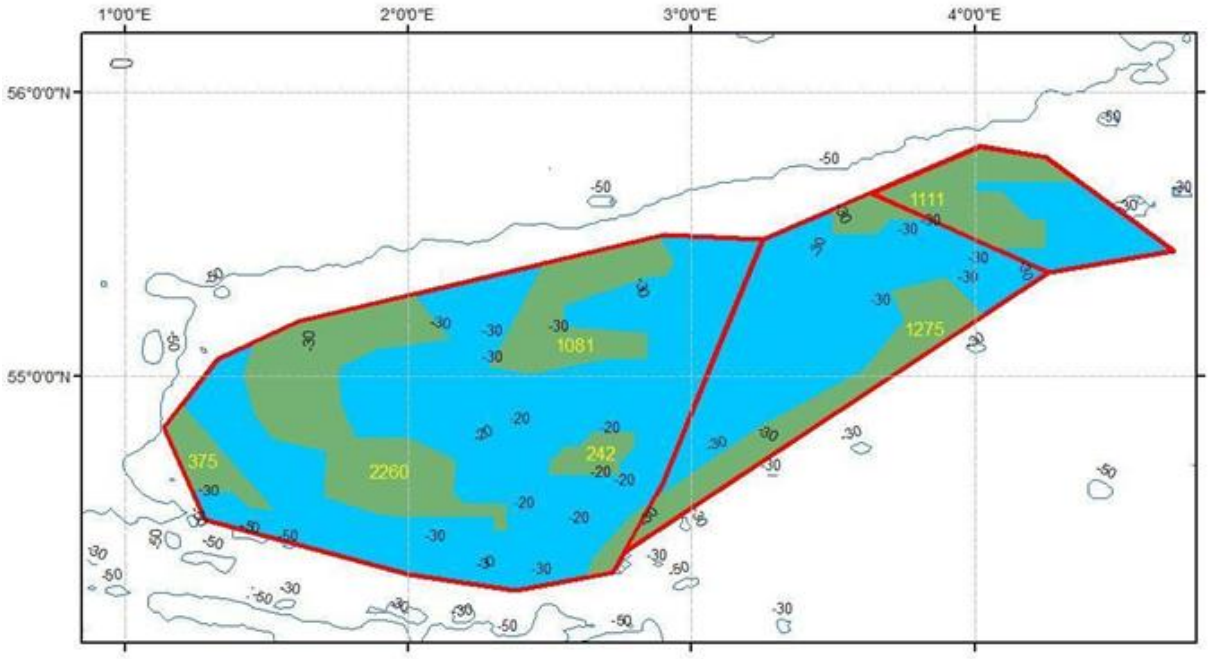


Figure 1: Proposal for year-round exclusion of all mobile bottom-contacting gears in the Natura 2000-site Doggerbank in the EEZ of UK, the Netherlands and Germany (from left to right) to protect the habitat type 1110 "sandbanks". Legend: Blue figures represent depths, yellow figures represent surface of the protected zone in km²; green areas represent future closed areas for bottom contacting fisheries, blue areas represent areas open for all fisheries.

.

2. Aim of the study

The overarching question of the present study is: How does sandeel fishery impact the marine ecosystem in the southern North Sea and the achievement of the conservation objectives of the marine protected areas in the German EEZ of the North Sea?

To answer this question following work was conducted:

- Characterization of the sandeel fishery and description of the status of sandeel stocks;
- Assessment of the impacts of the sandeel fishery on benthic communities;
- Assessment of the impacts of the sandeel fishery on seabirds and marine mammals and the achievement of the respective conservation objectives
  - On the basis of a current analysis of the food web of the southern North Sea and
  - On the basis of results of earlier studies analysing the trophical importance of sandeels for certain predators;
- Assessment of current ICES advices (2019) for sandeel Total Allowed Catches (TACs) in the sandeel areas SA1r und SA2r and implemented sandeel TACs of recent years (2016 – 2018).

3. The sandeel fishery

The sandeel family (*Ammodytidae*) includes several genera with a total of 18 species. For fisheries in the Northeast Atlantic including the North Sea, four species of two genera play a particularly important role:

- the lesser sandeel (*Ammodytes marinus*),
- the small sandeel (*A. tobianus*),
- the great sandeel (*Hyperoplus lanceolatus*) and
- the greater sandeel *(H. immaculatus*).

The sandeel fishery is a so-called „industrial fishery“, i.e. the target fish is not used for direct human consumption but processed into fish meal and fish oil, which is, inter alia, used for animal feeding especially in aquaculture. The sandeel fishery catches rather unselective all species mentioned above, but in the North Sea the small sandeel as the most common sandeel species comprises the largest proportion of sandeel catches.

In the following, sandeel fishery in the North Sea is described by looking at two aspects (1.) the fishing gear used and (2.) the status of sandeel stocks relevant for the German EEZ.

3.1. Fishing gear

In the sandeel fishery in the German EEZ of the North Sea mainly bottom otter trawls (FAO gear code OTB) with small mesh sizes (< 16 mm) are used, e.g. 99,9 % of Danish catches are taken with this fishing gear (Schulze 2018). Other gears used for catching sandeel are bottom pair trawls (PTB), midwater otter trawls (OTM) and pelagic pair trawls (PTM). In the German EEZ of the North Sea, PTMs are only used to a very small extent (e.g. < 0,1 % of Danish sandeel catches are taken with PTM). The sandeel fishery takes place seasonally, mainly from April until June. Denmark holds the highest catch quota in the sandeel areas in the German EEZ. Sweden, Germany and UK have lower quota shares.

3.2. Status of sandeel stocks in the southern North Sea

Since 2011, ICES (International Council for the Exploration of the Sea) has been giving separated advices for sandeel TACs in the seven different sandeel areas (SA, 1-7r, Fig. 2).

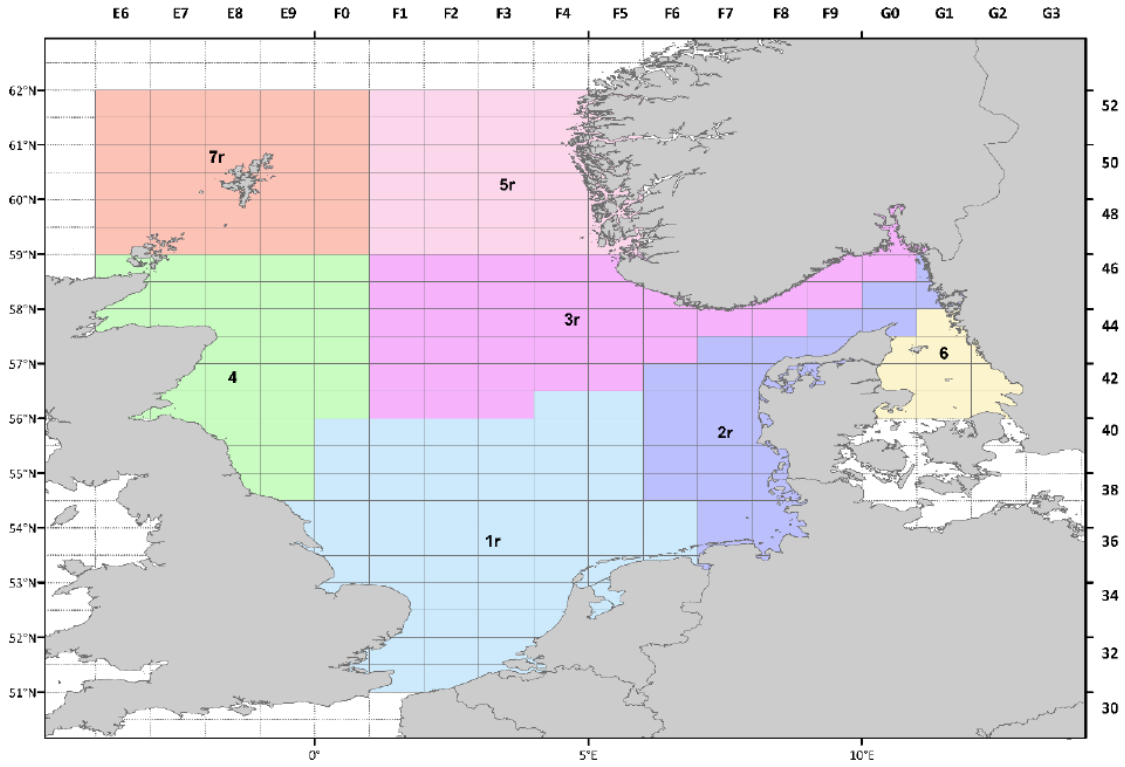


Figure 2: Location of the sandeel areas (1-7r) in the North Sea (ICES 2017). Only areas 1r and 2r are relevant for the German EEZ.

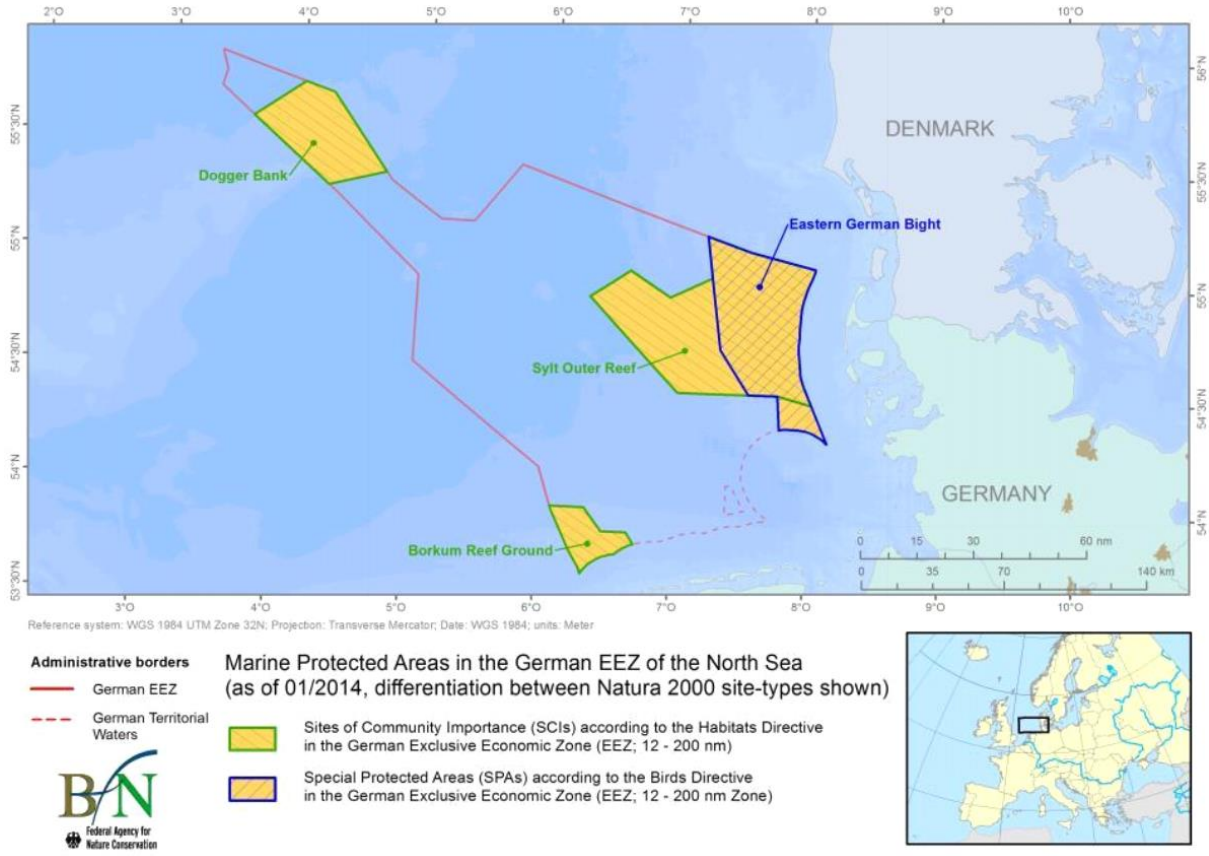


Figure 3: Marine protected areas in the German EEZ of the North Sea

The German marine protected areas SAR and BRG (Fig. 3) are located in the sandeel area „central and southern North Sea (SA2r)“ (Fig. 2). The Natura 2000 site “Doggerbank" (Fig. 3) is located within „central and southern North Sea, Doggerbank (SA1r)“ (Fig. 2). In both areas - as mentioned above - Denmark has the highest catch quota.

Sandeel in SA1r „central and southern North Sea including Doggerbank“

In sandeel area SA1r the biomass has been repeatedly below the reference value for sandeels according to the precautionary approach (Bpa, Biomass precautionary approach) since 2004 (see graph „SSB“- Spawning Stock Biomass - in Fig. 4, lower right panel). Main reason for the bad condition of the stock is the too high fishing pressure. After 2009, fishing mortality showed a downward trend, but then increased again in 2017 (see graph `Fishing pressure´ in Fig.4, lower left panel). In the year 2008 recruitment was on a similar level like in the 1980s, but decreased significantly thereafter. After the very low recruitment in the year 2015, recruitment in 2016 was again above the long-term average, but then 2017 the lowest in the whole time series (see graph `Recruitment´ in Fig.4, upper right panel). According to the recent ICES advice, catches of sandeel in area SA1r should not exceed 91.916 t (ICES 2019a).

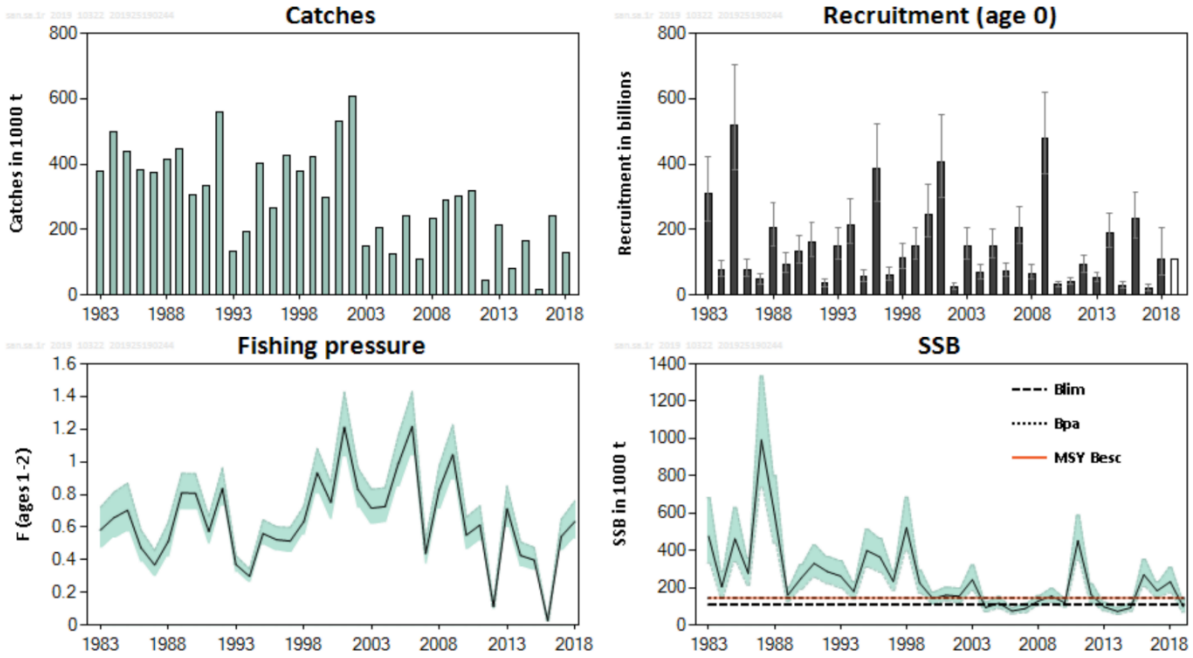


Figure 4: Sandeel stock in the sandeel area SA1r (central and southern North Sea, Doggerbank): Catches, Recruitment (age 0), Fishing pressure and Spawning-stock biomass, SSB, since 1983 (ICES 2019a).

Sandeel in SA2r „central and southern North Sea “

In sandeel area SA2r the biomass has been repeatedly below the reference value for sandeels according to the precautionary approach (Bpa, Biomass Precautionary approach) since the year 2000 (see graph `SSB´ in Fig. 5). As a result, average recruitment has been well below the previous average value (see graph `Recruitment´ in Fig.5), with the exception of the strong 2016 year class. Reason for this low SSB and the low recruitment is the too

high fishing pressure (see graph for `Fishing pressure´ in Fig.5). Because the stock is too small, the high fishing pressure has resulted in reduced catches (see graph `Catches´ in Fig. 5). The strong 2016 year class would have been able to rebuild the stock quickly and permanently, but catches were much too high in the following year, thus a recovery of the stock was not possible.

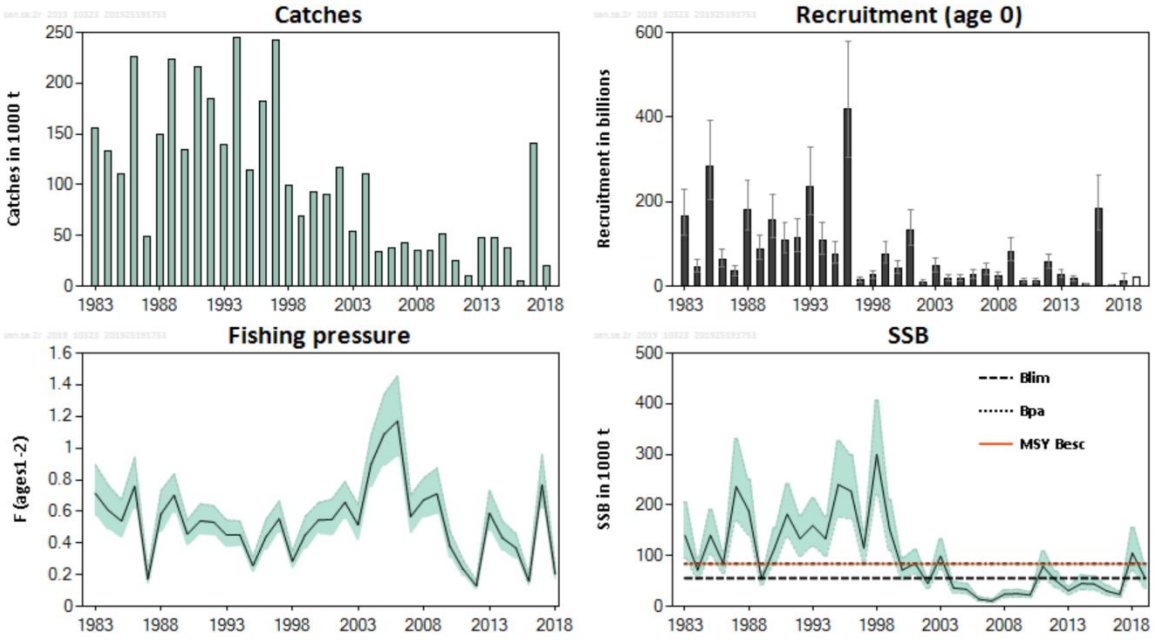


Figure 5: Sandeel stock in sandeel area SA2r (central and southern North Sea): Catches, Recruitment age 0, Fishing pressure und Spawning-Stock Biomass, SSB, since 1983 (ICES 2019b).

ICES recommends zero catch for the sandeel stock in SA2r for 2019 (ICES 2019b). For the assessment of the stock status in 2020 ICES advises a monitoring TAC of ≤5.000 t, i.e. fishery research vessels of EU member states with catch quota should not take more than 5000 t sandeel in 2019 to gain information concerning the stock assessment. This information is the basis for the ICES advice for the TAC in 2020.

In conclusion, above mentioned sandeel stocks also occurring in marine protected areas in the German EEZ of the North Sea (Fig. 2, 3), are in a bad condition particularly due to a too high fishing pressure over several years.

4. Impacts of sandeel fishery on benthic communities

The sandeel fishery with bottom trawls has negative effects on the sea bed, on benthic communities and their characteristic species. The damage is caused by the footrope as well as by the otter boards. Danish sandeel fishing activities in the period 2011-17 in the marine protected areas SAR and BRG showed a high spatial overlap with the occurrence of the biotope type “species-rich gravel, coarse sand and shell-gravel areas”. This biotope type is protected under the German Federal Nature Conservation Act (§30) and has been identified as “special habitat type” according to the MSFD, Annex III, table 1 (Fig. 6).

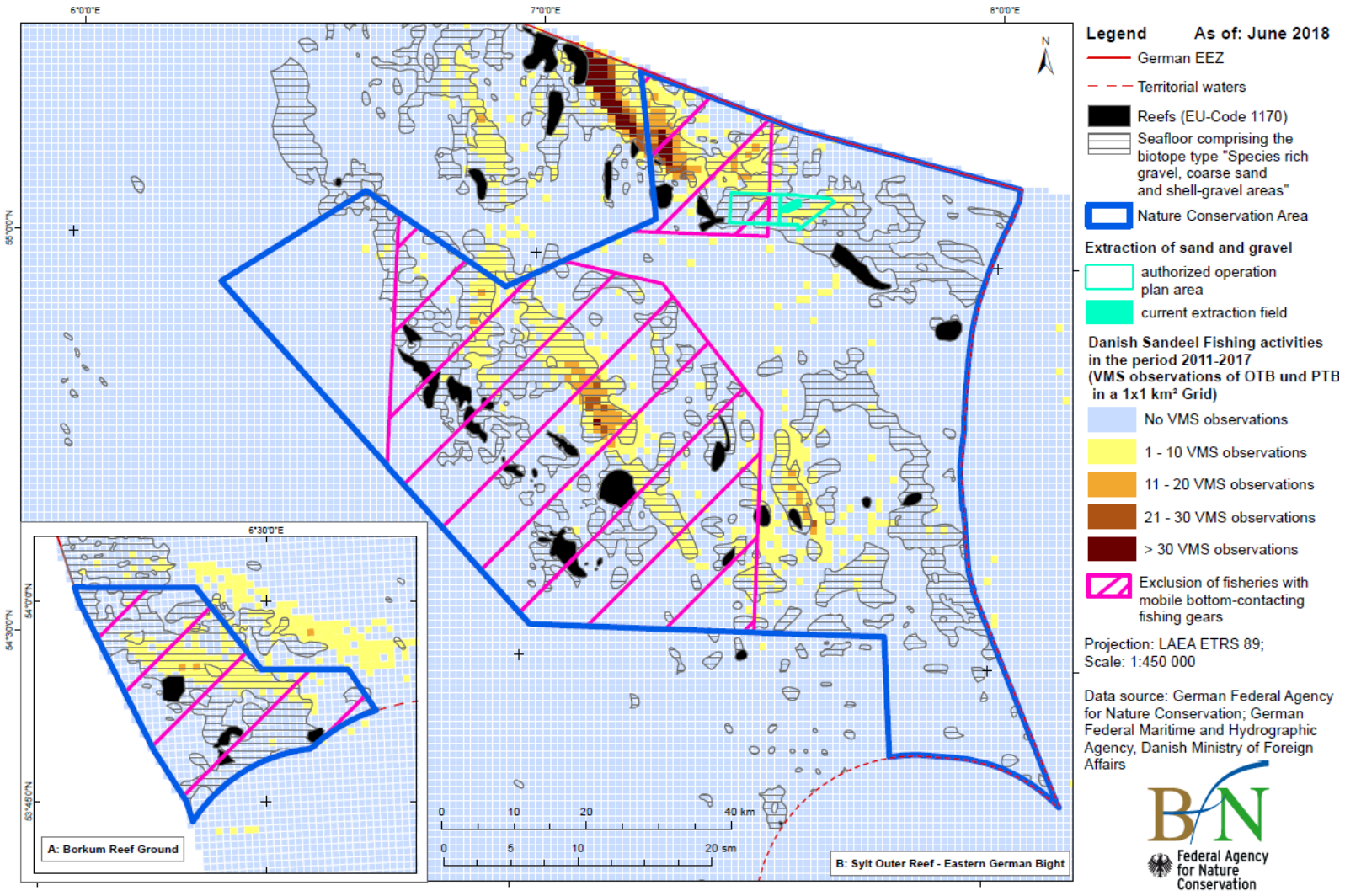


Figure 6: Danish sandeel fishing activities from 2011-2017 in the marine protected areas SAR and BRG and spatial overlap with the occurrence of the biotope type "species-rich gravel, coarse sand and shell-gravel areas" protected under the German Federal Nature Conservation Act (§30) and identified as "special habitat type" according to the MSFD, Annex III, table 1

The predominant substrate of the biotope type “species-rich gravel, coarse sand and shell-gravel areas” is coarse sandy and gravelly sediments. It enables the settlement of epibenthic communities, which cannot be found in such a species composition on pure sand or on hard substrate habitats (BioConsult 2018). The special habitat type (MSFD) “species-rich gravel, coarse sand and shell-gravel areas” is also a preferred sandeel habitat due to the specific sediment composition (BioConsult 2018) and the sandeel species are typical fish species of this protected biotope type and are therefore a conservation feature itself of the biocoenosis “species-rich gravel, coarse sand and shell-gravel areas”.

Regarding the impacts of sandeel fisheries on epi- and endobenthos, bottom otter trawls belong to the fishing gears with the most severe negative impact (Eigaard et al. 2016). The impacts of the sandeel fishery particularly on epi-and endofauna have not been investigated yet but numerous studies describe the general adverse effects of bottom otter trawls on epi- and endofauna (e.g. Rumohr & Krost 1991, Hiddink et al. 2006, Kaiser et al. 2006). BioConsult (2017) described that demersal seines[2] towed over the sea-floor for a certain time very likely have negative effects especially on sessile epibenthic species of the biotope type “species-rich gravel, coarse sand and shell-gravel areas” in the protected area SAR. Thus, it can be assumed that these species are also damaged by bottom otter trawls used in the sandeel fishery.

Additionally, also bycatch of non-target species by the sandeel fisheries constitutes a detrimental effect on the marine ecosystem. The sandeel fishery, often using nets with small mesh size (< 16 mm), is rather non-selective and catches also non-target fish species, e.g. potentially also protected species listed in Annex II of the Habitats Directive like the twait shad (*Alosa fallax*) (Thiel pers. Comm.).

5. Importance of sandeels in the food web of the southern North Sea

The importance of sandeels in the North Sea has been frequently analysed and described (Synopsis see Engelhard et al. 2014 in WKSAND 2016). Scientists from GEOMAR are currently investigating the trophic role of sandeels in the food web of the southern North Sea on behalf of the BfN (BfN/GEOMAR research project), particularly with regard to the ecological impacts of the sandeel fishery on predators in higher trophic levels (i.e. marine mammals, seabirds and piscivore fish species). In the framework of this study (Opitz et al. in prep) diet compositions of relevant taxonomic groups have been analysed and on this basis an ecosystem model is currently being developed using the software „Ecopath with Ecosim“ (EwE, www.ecopath.org) (Polovina 1984, Christensen & Pauly 1992, Christensen et al. 2000, Pauly et al. 2000).

[2] The basic principle of the demersal seines is encircling a large area with a net. Boat seines including demersal seines consist basically of a conical netting body, two relatively long wings and a bag. Long ropes serve to haul the net and to concentrate the fish on the sea-floor. Important component for the capture efficiency of boat seines is the long ropes extending from the wings, which are used to encircle a large area. Keeping the rope into close contact with the bottom as long as possible during the hauling is a major advantage and, for this reason, special heavy ropes are normally used. When fishing with Scottish seines, a marker buoy with flag, attached to the free end of the first rope is dropped over the side. From this buoy, ropes and net are exposed in an arc by the vessel. Thus, a large area is encircled until the vessel reaches the buoy again. Subsequently the net is gathering in with the help of the long ropes, which are then hauled over the sea-floor, while the vessel is slowly steaming forward (https://fischbestaende.thuenen.de/fanggeraete/aktive-geraete/wadennetze/bootswaden/; http://www.fao.org/fishery/fishtech/1008/en).

The current analyses of GEOMAR show that sandeels are a central dietary component for several predators in the southern North Sea (Fig. 7). As key species on the trophic level 3 (low trophic level species, LTL) in the southern North Sea, sandeels transfer energy from the trophic level 2 (particularly zooplankton and benthic macrofauna) to the higher trophic levels 4 and 5 (marine mammals, seabirds, piscivore fish species). A further indicator for the key role of sandeels is the high degree of interconnectedness of sandeels to other components of the southern North Sea ecosystem, which is even higher than that of herring or sprat. Therefore, an above-average number of piscivorous predators in higher trophic levels are dependent on sandeels in their diet (Fig.7).

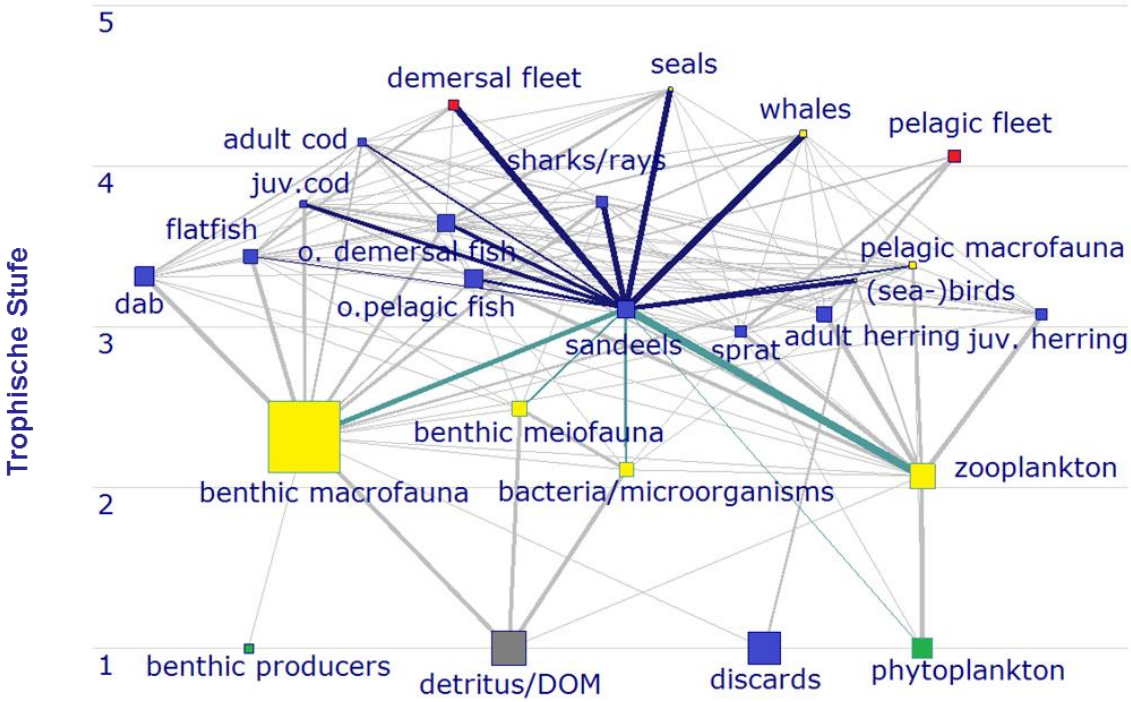


Figure 7: Position of sandeels in the food web of the southern North Sea (in dark blue: Flows from sandeel stock to fishery and to its predators; in green: Flows to sandeel stock from its food organisms). Area of squares is proportional to biomass of a group. The colour of the squares indicates affiliation to a specific group: Dark grey = Detritus, green = Primary producers, yellow = Marine organisms (except fish), blue = Fish, red = Fishing fleets. Trophic flows are shown by grey lines. The thickness of lines is proportional to the intensity of the matter fluxes (Opitz et al. in prep.).

For more detailed investigations regarding the role of sandeels in the foodweb of the southern North Sea, Opitz et al. (in prep.) have also compared grazing pressure on zooplankton by selected trophic groups. The results show that sandeels consume the highest amount of zooplankton per unit of area and time in comparison to other trophic groups including herring and sprat (Fig.8). Thus, sandeels exercise a top-down-control on the zooplankton community in the ecosystem of the southern North Sea. Model-based analyses of the diet composition and diet quantity furthermore indicate that sandeels are the most exposed to the pressure by natural predators in comparison to other prey (see Fig. 9).

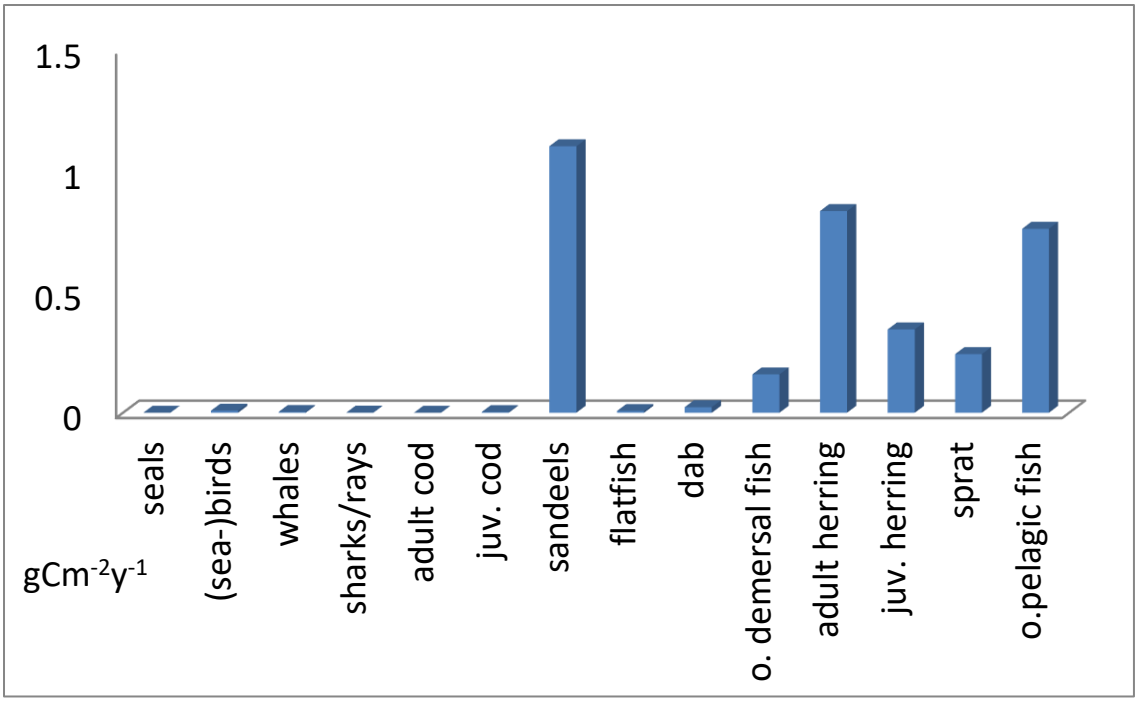


Figure 8: Grazing pressure on zooplankton by selected trophic species groups in g carbon per m² per year ($gCm^{-2}y^{-1}$) for the southern North Sea.
O. demersal fish/o.pelagic fish: Other demersal fish/other pelagic fish (Source: Opitz et al. in prep.)

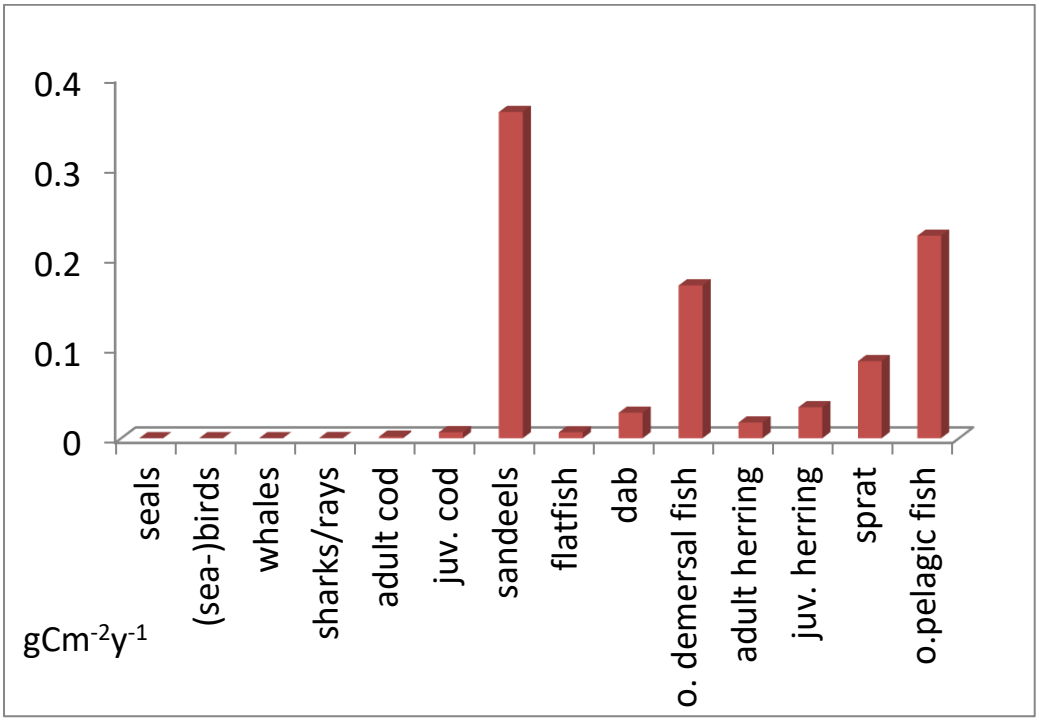


Figure 9: Pressure by natural predators on selected ecosystem components in g carbon per m² per year ($gCm^{-2}y^{-1}$) in the southern North Sea.
O. demersal fish/o.pelagic fish: Other demersal fish/other pelagic fish (Source: Opitz et al. in prep).

6. In summary, due to the central role of the sandeels in the marine ecosystem in the southern North Sea, all human activities impacting the status of the sandeel stocks have also serious effects on species of higher trophic levels (marine mammals, seabirds, predatory fish) as well as on lower trophic levels (mainly zooplankton). Especially the impacts of fishery on sandeels and other ecosystem components are analysed in more detail in the following chapter. **Impacts of sandeel fishery on the food web**

Sandeels are small short-lived schooling fish with a very high fat content making them a prefered target species for the industrial fishery. At the same time, sandeels are a very important food source for several predators of higher trophic levels like sea swallows, loons, harbour porpoise, grey seals but also for piscivore fish like gadoids, flatfishes as well as sharks and rays and play a key role in the food web of the North Sea as described in chapter 5. The intensive fisheries exploitation of sandeels can severely impact this food web and hence the basic diet for the above mentioned predators can be impaired. Studies by e.g. Hamer et al. (1993), Davis et al. (2005), Frederiksen et al. (2007) show that breeding success of the most sea bird species on the Shetland Islands like black-legged kittwake (*Rissa tridactyla*) and arctic Skua (*Stercorarius parasiticus*) is closely linked to the abundance of sandeels. In the 1990s, a low breeding success of the black-legged kittwake population on Isle of May (Scotland) has been observed, which was linked to the substantial reduction of the local sandeel biomass off Eastern Scotland caused by an intensive industrial sandeel fishery (Rindorf et al. 2000, Daunt et al. 2008). When the sandeel fishery in this area was closed, local sandeel biomass as well as breeding success of the local black-legged kittwake population increased subsequently (Rindorf et al. 2000, Daunt et al. 2008). According to Daunt et al. (2008) closure of sandeel fishery is a potential management option to protect the marine top predators, which are particularly sensitive to fluctuations in abundance of this target species.

Sandeels are also an important prey for marine mammals. Herr et al. (2009) showed the high temporal and spatial association between sandeel fishery and the occurrence of harbour porpoise in the German EEZ of the North Sea. According to the authors, this association is a proof for the strong preference of harbour porpoises for the areas, where sandeel fishery takes place. The impacts of sandeel fishery on harbour porpoises in the marine protected area SAR are particularly critical (Herr et al. 2009), since harbour porpoises aggregate in this area for mating and calving in spring and summer (Scheidat et al. 2006). The energetic costs of reproduction are particularly high for harbour porpoises, since they are often gestating and lactating at the same time (Lockyer 2007). Due to the limited energy storage capacity, harbour porpoises must feed frequently without longer fasting periods (Koopman et al. 1996). Not only sandeel stocks but also other prey species of harbour porpoise in the North Sea like cod, herring and sprat are heavily exploited. Even short periods of low prey availability can lead to a loss of weight as well as to changes in their distribution (Santos et al. 2004). Hence, it is important to protect the food resource of harbor porpoises particularly in areas like SAR by effective management measures.
In Schleswig-Holstein, health status of dead harbour porpoises (strandings) has been investigated by the Institute for Terrestrial and Aquatic Wild Animal Research (ITAW) since 1990. These harbour porpoises showed a substantial poorer health status, a shorter life expectancy and a consequently shorter reproduction time than individuals from waters with lower pressure exerted by human activities (e.g. fishery) (ITAW 2018 unpublished). In 2016 an increasing number of harbour porpoises suffocated on soles are registered at the North

Sea coast of Schleswig-Holstein. Since sole is a not preferred prey of harbour porpoises, these observations can indicate altered food availability as well as a switch to suboptimal prey (ITAW 2018 unpublished). At the same time, a 50%-decrease of harbour porpoises in the German EEZ of the North Sea has been observed in the scope of the BfN Monitoring (Status March 2019). Further studies are necessary in order to investigate, if there is a connection between sandeel abundance and the decrease of harbour porpoises.
Also populations of common guillemot and razorbills – which are particularly dependent on sandeels - in the German EEZ of the North Sea show declining trends in recent years (BfN Monitoring, status March 2019). The reasons for this decline have not yet been investigated, but it can be assumed that a reduced food availability caused by intensive sandeel fishery can play a role.

7. Assessment of current ICES advices (2019) for sandeel TACs in the sandeel areas SA1r und SA2r and implemented sandeel TACs of the recent years (2016 – 2018)

ICES has defined seven sandeel areas in the North Sea (see chapter 3.2). For the German EEZ of the North Sea sandeel areas SA1r (central and southern North Sea including Doggerbank) und SA2r (central and southern North Sea) are relevant. For the sandeel stock SA1r the ICES advice is not based on the biomass that can produce the maximum sustainable yield (B_{msy}) as required (according to article 2 of the CFP, Regulation (EU) 1380/2013), but on the lower biomass Besc = Bpa[3] (ICES 2019a). Thus, the catch of 91.916t for 2019 advised by ICES is higher than the maximum sustainable yield.
For 2016, ICES advised zero catch for sandeel stock SA1r, only a monitoring-TAC of ≤5000t should be taken (ICES 2019a). However, the EU council of Ministers did not adopt this advised TAC, but defined a TAC of 13.000t. Actual sandeel catch was even higher than the defined TAC (ICES 2019b). In 2017 and 2018 ICES advised higher catches - 255.956t and 134.461t respectively - which were adopted by the EU Council of Ministers as TACs and fished out by the fishery (ICES 2019a).

For sandeel stock SA2r ICES advised a zero catch for 2019, only catches of ≤5.000t for monitoring purposes should be allowed (ICES 2019b). This advice was also given for the years 2016 and 2018 and has been adopted by the EU Council of Ministers (ICES 2019b). Nevertheless, around 9.757t has been taken in the year 2016 and 20.000t in the year 2018 according to preliminary estimates (ICES 2019b). For 2017 ICES advised a higher catch (175.941t), adopted by EU Council of Ministers and fished out by the fishery (ICES 2019b). Thus, the strong sandeel year-class 2016 has been taken immediately by the high catches in 2017 and 2018, so that the stock was not able to recover (see chapter 3.2).

In conclusion, the management of sandeel stocks in the areas SA1r und SA2r cannot be assessed as sustainable. Too high TACs set by the EU Council of Ministers and the exceedance of TACs by the fishery respectively lead to a too high fishing pressure and thus to a bad condition of the sandeel stocks in the German EEZ of the North (see chapter 3.2). In addition to the direct effects on the sandeel stocks it can also be assumed that top predators like harbour porpoises as well as certain seabird species, particularly dependent on sandeel as prey with a high fat content, are severely affected. The current decrease of harbour

[3] Besc: Bescapement, modified for short-lived species, currently equal to Bpa

porpoises as well as several seabird species in the German EEZ of the North Sea could be therefore put into context with a reduced food availability caused by fisheries (see chapter 6). The core objective of the reformed CFP - implementation of a sustainable, ecosystem-friendly use of marine resources particularly in relation to the achievement of a good environmental status of the European oceans until 2020 according to the MSFD - cannot be achieved with this kind of fisheries management. Additionally, achievement of conservation objectives in the marine protected areas in the German EEZ of the North Sea is jeopardised by such impacts on food availability for the protected species.

8. Summary and conclusions

In general, the intensive sandeel fishery in the southern North Sea is a threat to a number of protected species and prevents the achievement of the good environmental status in the sense of the MSFD. The bad condition of the sandeel stocks in the central and southern North Sea shows that the main targets of the CFP (implementation of a sustainable, ecosystem-friendly use of the marine resources and exploitation according to the MSY-principle) and the MSFD (species and biotope types are in a good environmental status) have been missed so far.

From a marine nature conservation point of view, sandeel fishery operating with mobile bottom contacting fishing gear in the marine protected areas in the German EEZ of the North Sea threatens the achievement of MSFD objectives, in particular referring to descriptor 4 (Food webs) and descriptor 6 (Sea-floor integrity).

Being a preferred habitat of the sandeels, the biotope type “species-rich gravel, coarse sand and shell-gravel areas”, protected under the German Federal Nature Conservation Act (§30) and identified as “special habitat type” according to the MSFD, Annex III, table 1 and its characteristic species (e.g. *Spisula elliptica, Branchiostoma lanceolatum, Aonides paucibranchiata*) is particularly threatened by the sandeel fishery. This special habitat type according to the MSFD and habitat types of the Habitats Directive “reefs“ and “sandbanks“ are closely linked in the protected areas SAR and BRG. Together they form unique biotope complexes, which have to be protected as a whole. Thus, the conservation objectives for these habitat types according to the Habitats Directive and environmental targets in the framework of the MSFD can only be achieved when all mobile bottom-contacting gears are consequently excluded in the protected areas SAR and BRG without any fishery corridors where fisheries with mobile bottom-contacting gear – and thus also the Danish sandeel fishery - would be still allowed (see chapter 1).

Furthermore, a continued sandeel fishery in the marine protected areas seriously jeopardises the achievement of the conservation objectives for harbour porpoises and seabirds due to the impairment of food availability in these areas. Since sandeel is a key species in the food web of the southern North Sea, intensive fishery can lead to a significant food shortage for top predators in the North Sea (harbour porpoise, seals, seabirds, predatory fish), especially since further prey species like herring and sprat are also heavily exploited. In particular, top predators like harbour porpoises and certain seabird species would be threatened being especially dependent on sandeels as prey with a high fat content. Thus, these species are particularly sensitive to reduction of sandeel abundance through the intensive sandeel fishery. A continued overexploitation of the sandeel stocks in the German EEZ including the marine protected areas therefore jeopardises the achievement of conservation objectives

defined for these species in the German marine areas and at EU-level (not only in the marine protected areas).

Due to the significant negative ecological effects, sandeel fishery with mobile bottom-contacting gear should be banned in the marine protected areas to achieve the conservation objectives of the Birds and Habitats Directive as well as the implementation of the environmental targets of the MSFD. The currently proposed fishing corridors in the protected areas SAR and BRG (created due to a necessary compromise with Denmark, see chapter 1), in which all mobile bottom-contacting fishing gears (and thus also the Danish sandeel fishery) would be still allowed, should therefore be rejected.

Furthermore, additional scientific studies are required in order to investigate, whether and to what extent a link between sandeel fishery and the currently observed decreasing trends of the harbour porpoise populations as well as of certain seabird populations in the German North Sea exist.

Referenzen

BfN-Skripten 477 (2017): Download: https://www.bfn.de/fileadmin/BfN/service/Dokumente/skripten/Skript477.pdf

BioConsult (2017): Are “species-rich gravel, coarse sand and shell layers” within the Natura 2000-site “Sylt Outer Reef” sensitive to seine fishing? Download: http://www.bfn.de/fileadmin/BfN/meeresundkuestenschutz/Dokumente/Bioconsult-sensitivity-epifauna-KGS-Seines-2017-04-23.pdf

BioConsult (2018): Welche Bedeutung hat der Biotoptyp „artenreiche Kies-, Grobsand- und Schillgründe“ im NSG Sylter Außenriff für epibenthische Arten und Fische?

BMUB (Hrsg.) (2012): Anfangsbewertung der deutschen Nordsee nach Art. 8 Meeresstrategie-Rahmenrichtlinie. 3 Bund/Länder-Ausschuss Nord- und Ostsee, 13. Juli 2012.

Christensen, V., & Pauly, D. (1992): Ecopath II—a software for balancing steady-state ecosystem models and calculating network characteristics. Ecological Modelling, 61, 169-185. doi:10.1016/0304-3800(92)90016-8

Christensen, V., Walters, C., & Pauly, D. (2000): Ecopath and Ecosim: A user’s guide (October 2000 ed.). Vancouver, Canada: Fisheries Centre, University of British Columbia and Penang, Malaysia: ICLARM.

Cunningham, L., Sharples, R.J., and Hammond, P.S. (2004): Harbour seal diet in the UK. SCOS Briefing Paper 04/11, Sea Mammal Research Unit, University of St Andrews, pp. 88-90.

Daunt, F., Wanless, S., Greenstreet, S.P.R., Jensen, H., Hamer, K.C., Harris, M.P. (2008): The impact of the sandeel fishery closure in the northwestern North Sea on seabird food consumption, distribution and productivity. Canadian Journal of Fisheries and Aquatic Sciences, 65 (3). 362-381. https://doi.org/10.1139/F07-164

Davis, S.E., Nager, R.G., Furness, R.W. (2005): Food availability affects adult survival as well as breeding success of parasitic jaegers. Ecology 86:1047–1056

Eigaard, O.R., Bastardie, F., Breen, M., Dinesen, G.E., Hintzen, N.T., Laffargue, P., Mortensen, L.O., Nielsen, J.R., Nilsson, H.C., O Neill, F.G., Polet, H., Reid, D.G., Sala, A., Skold, M., Smith, C., Sorensen, T.K., Tully, O., Zengin, M., and Rijnsdorp, A.D. (2016): Estimating sea-floor pressure from demersal trawls, seines, and dredges

based on gear design and dimensions. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsv099.

Engelhard, G.H., Peck, M.A., Rindorf, A., Smout, S.C., van Deurs, M., Raab, K., Andersen, K.H., Garthe, S., Lauerburg, R.A.M., Scott, F., Brunel, T.,Aarts, G., van Kooten, T., and Dickey-Collas, M. (2014): Forage fish, their fisheries, and their predators: who drives whom? – ICES Journal of Marine Science, 71: 90–104.

Frederiksen, M., Furness, R.W., Wanless, S. (2007): Regional variation in the role of bottom- up and top- down processes in controlling sandeel abundance in the North Sea. Marine Ecology Progress Series, 337, 279–286.

Hamer, K.C., Monaghan, P., Uttley, J.D., Walton, P., Burns, M.D. (1993): The influence of food supply on the breeding ecology of black-legged kittwakes Rissa tridactyla in Shetland. Ibis 135: 255–263

Hammond, P.S. & Prime, J.H. (1990): The diet of British grey seals (*Halichoerus grypus*). Population Biology of Sealworm (*Pseudoterranova decipiens*) in Relation to its Intermediate and Seal Hosts (ed. W. D. Bowen), Canadian Bulletin of Fisheries and Aquatic Sciences 222, pp243-254.

Herr, H., Fock, H.O., Siebert, U. (2009): Spatio-temporal associations between Harbour porpoise (*Phocoena phocoena*) and specific fisheries in the German Bight. Biological Conservation 142: 2962–2972

Hiddink, J.G., Jennings, S., Kaiser, M.J., Queirós, A.M., Duplisea, D.E. & Piet, G.J. (2006): Cumulative impacts of sea-floor trawl disturbance on benthic biomass, production, and species richness in different habitats. Canadian Journal of Fisheries and Aquatic Science 63: 721-736.

ICES (2019a): Sandeel (Ammodytes spp.) in divisions 4.b and 4.c, Sandeel Area 1r (central and southern North Sea, Dogger Bank). In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, san.sa.1r, https://doi.org/10.17895/ices.advice.4720

ICES (2019b): Sandeel (Ammodytes spp.) in divisions 4.b–c and Subdivision 20, Sandeel Area 2r (central and southern North Sea). In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, san.sa.2r, https://doi.org/10.17895/ices.advice.4721

ICES (2017): Report of the Benchmark on Sandeel (WKSand 2016), 31 October - 4 November 2016, Bergen, Norway. ICES CM 2016/ACOM:33. 319 pp

Kaiser, M.J., Clarke, K.R., Hinz, H., Austen, M.C.V., Somerfield, P.J. & Karakassis, I. (2006): Global analysis of response and recovery of benthic biota to fishing. Marine Ecology Progress Series 311: 1-14.

Koopman, H.N., Iverson, S.J., Gaskin, D.E. (1996): Stratification and age-related differences in blubber fatty acids of the male harbour porpoise (Phocoena phocoena). Journal of Comparative Physiology B 165, 628–639.

Lockyer, C. (2007): All creatures great and smaller: a study in cetacean life history energetics. Journal of the Marine Biological Association of the United Kingdom 87, 1035–1045.

Mackinson, S. & Daskalov, G. (2007): An ecosystem model of the North Sea to support an ecosystem approach to fisheries management: description and parameterisation. Science Series Technical Report, Cefas Lowestoft, 142: 196 p.

Pauly, D., Christensen, V., & Walters, C. (2000): Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impact of fisheries. ICES Journal of Marine Science, 57, 697-706. doi:10.1006/jmsc.2000.0726

Polovina, J.J. (1984): Model of a coral reef ecosystem I. The ECOPATH model and its application to French Frigate Shoals. Coral Reefs, 3, 1-11.

Rindorf ,A., Wanless, S., Harris, M.P. (2000): Effects of sandeel availability on the reproductive output of seabirds. Marine Ecology Progress Series 202:241–252

Rumohr, H. & Krost, P. (1991): Experimental evidence of damage to benthos by bottom trawling with special reference to Arctica islandica. Meeresforsch. 33: 340-345.

Santos, N.B. et al. (2004): Variability in the diet of harbour porpoise (Phocoena phocoena) in Scottish waters 1992-2003. Marine Mammal Science 20: 1-27.

Scheidat, M., Gilles, A. & Siebert, U. (2006): Evaluating the distribution and density of harbour porpoises (*Phocoena phocoena*) in selected areas in German waters. In: Nordheim, v.H., Boedeker, D. & Krause, J. (Eds.) Progress in Marine Conservation in Europe. Springer, Berlin, Heidelberg: 189-208.

Schulze, T. (2018): International fishing activities in German waters in relation to the designated Natura 2000 areas and proposed management within. 174 pages. Thünen Institute of Sea Fisheries. Version 08.01.2018