NOTAT

Til FVM

Vedr. Forslag om lukning af UK farvand for tobisfiskeri

D. 12/5 2023

Fra DTU Aqua

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AR/GGLE/MVDMV

Resumé

The present document reviews the scientific analyses described in the document 'What are the ecosystem risks and benefits of full prohibition of industrial Sandeel fishing in the UK waters of the North Sea (ICES Area IV)?' (Defra request for advice). The document structure follows the 'Core advice', page i, of the report. Additional comments for parts of the report not cited in the 'Core advice' is given at the end of the document.

Anmodning

I notatet ønskes der en vurdering af det videnskabelige grundlag, som det britiske ministerium for miljø, fødevarer og landlige anliggender (Defra) har præsenteret som baggrund for den offentlige høring, samt hvordan det fremlagte videnskabelige grundlag harmonerer med ICES' rådgivning om tobisfiskeri i området.

Analyse

'If a full prohibition of sandeel fishing is implemented in UK waters of the North Sea, a viable alternative will be needed to monitor sandeels and the impacts of the area closure. This should capture the links between sandeels and food web dynamics and identify progress made towards Good Environmental Status (GES)'

This advice reflects the need to monitor effects of a closure. Sandeel abundance is not reflected accurately in traditionally used fisheries survey gear, and long-term information on the link between sandeel and dependent predators is only available from a few seabird colonies (e.g. Isle of May and Farne deep, Harris and Wanless 1997, Shetland, Bailey et al. 1991). The current estimates of sandeel abundance made by ICES are derived from fisheries data and surveys focused at providing indices for use in fisheries advice. The area closed off Firth of Forth is monitored by a small experimental quota for local fishing as well as a dredge survey of incoming recruits. The experimental quota has not impacted seabird breeding success and has provided information on stock size, age structure and the size of individual prey which has been used in sandeel assessments of population size (ICES HAWG 2023) as well as analyses of the effect of changes in sandeel availability on seabirds (Searle et al. 2023). In the event of a full closure of the fishery, such data will not be available. To document any oc-

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curring effects of an area closure, the report highlights that other means must be procured to attain indices of sandeel abundance and diet of dependent wildlife.

'Sandeel stocks experience high levels of natural fluctuation due to the influence of environmental variation on sandeel recruitment and production. A full prohibition of industrial sandeel fishing in the UK waters of the North Sea would offer some resilience at times of adverse natural conditions' (Benefit B1)

Biomass of short lived species tends to fluctuate more than is the case for long lived species as individual yearclasses constitute a larger proportion of the total biomass than for more long-lived species. For both short and long-lived species, low densities tend to lead to lower recruitment. Conversely, high densities may also lead to lower recruitment as well as possible effects on other species which are competing with sandeel for their planktonic food (p.13, 'Marine fish'). Sandeel differ from other forage fish in their strong site attachment and the way their distribution changes with abundance (Rindorf et al 2019). Low yearclasses seems to fail completely to appear in some areas whereas medium and large yearclasses appear in all areas. This unique attribute means that it is key to the role of sandeel in the ecosystem to maintain the stock size above the level leading to decreased recruitment.

In the 20 years since Arnott and others analysed the recruitment of sandeel in the North Sea as a whole (quoted on p.11 and 38), the analysis of the relationship between recruitment success and various environmental factors has been repeated several times using data from subpopulations without finding a consistent link between sandeel recruitment and SST or NAO. However, the recruitment of sandeel is highly influenced by ocean currents (Henriksen et al 2018) with unusually large yearclasses occurring in the Dogger area in 1994, 1996, 2001 and 2009. These unusually large yearclasses all fall within the time since the 1994 regime shift change in the North Sea small pelagic fish community linked to changes in copepod abundance and composition (Clausen et al. 2018). While there does not appear to be a trend in the occurrence of these events, the long term effect of climate change on ocean currents is unknown. There are indications that increased autumn temperatures may decrease survival of sandeel from age 0 to age 1 (Henriksen et al. 2021b).

As noted on page 11, Poloczanska et al. (2004) used age structured population models which indicated that even with low constant fishery exploitation pressure, the risk of population collapse still exists. The study of Poloczanska et al. used a fixed fishing pressure in all years without an adjustment in years of low biomass. This management strategy has long been recognized by ICES as unprecautionary. As a result, ICES advises to reduce fishing pressure when the stock is outside safe biological limits (below $MSYB_{trigger}$ for longlived stocks and below $B_{escapement}$ for shortlived stocks). For shortlived species, the ICES MSY strategy (also termed the escapement strategy) is designed to leave at least a specific amount of fish in the sea ($B_{escapement}$) for the next spawning rather than designed to fish with a constant fishing mortality. The level $B_{escapement}$ that is left after fishing is determined to be sufficient to provide a less than 5% risk of impairing recruitment in the coming year. The biomass is predicted accounting for consumption of fish, seabird and mammal predators, thereby ensuring that the mortality due to natural predators is given priority over fisheries mortality. If $B_{escapement}$ cannot be reached in the coming year, a closure of the fishery is recommended. As an extra safeguard in years where recruitment is indicated to be very high, a cap is placed on fishing mortality, reducing fishing pressure on large year classes. This management strategy reduces large biomasses but leaves small biomasses unfished. This minimises density dependent declines in recruitment of sandeel and potentially other species at high stock size and does not impact low biomass.

‘Sandeel availability has been linked to seabird breeding success and survival. Evidence from the literature and ecosystem modelling indicates that seabirds would be the biggest beneficiaries if sandeel fishing in the North Sea was prohibited. Ecosystem model simulations predict that a full prohibition of sandeel fishing in the UK waters of the North Sea would lead to an increase in seabird biomass of 7% in around 10 years, albeit under constant prevailing environmental conditions’

A number of seabird breeding populations are experiencing declines in the Northeast Atlantic. In the North Sea, species feeding on fish at the surface are not meeting the thresholds for breeding populations (OSPAR 2023), while non-breeding surface feeders and water column feeding breeding and non-breeding populations in the Greater North Sea are doing better with 75% meeting thresholds values (OSPAR 2023). It is suspected that the decline of some surface feeding species is linked to decreasing availability of small forage fish species at the surface. According to OSPAR (2017), the surface feeding species not meeting the breeding threshold are black-headed gull, northern fulmar, herring gull, common gull, lesser black-backed gull, blacklegged kittiwake, arctic skua, common tern, arctic tern, sandwich tern and little tern. Among these, outside of Shetland and Orkney, sandeels contributes 10% or less to the diet of black-headed gull, common gull and herring gull, (Furness and Tasker 2000) as well as lesser black-backed gull and northern fulmar (Engelhard et al 2014). Common tern and arctic tern consumption and breeding success is not related to sandeel biomass east of Scotland (Daunt et al 2008). The measures recommended by Furness et al 2013 to protect sandwich tern and common tern include excluding foxes and mink and improving nesting areas. For arctic skuas, supplementary feeding of breeding pairs is recommended. This leaves kittiwake as the species for which there is substantial concern for the effects of sandeel fishing.

Numerous studies of blacklegged kittiwakes demonstrate the dependence of breeding success in the Firth of Forth and around Shetland on local sandeel abundance as also cited in the report. Breeding kittiwakes east of Scotland depend on arrival of sandeel in their recruiting year (Daunt et al 2008). The sandeels do not appear in large numbers in the fishery until their subsequent year, at age 1 and older. Competition between kittiwakes and fishing must therefore act mainly through the potential effect of fishing on spawning biomass and from there to the number of recruiting fish in the subsequent year. As also stated in the report, the effects of sandeel abundance on blacklegged kittiwakes is strongly supported in the literature. There is an amplitude of studies from the Shetland (Bailey 1991) and Firth of Forth area (Searle et al 2023). However, the development of the eastern English kittiwake colonies are not consistently related to each other, indicating that they are not reacting to a common factor such as sandeel abundance in area 1r (Olin et al. 2022). Further, while Frederiksen et al. (2004) and Carroll et al. (2017) found that lower temperatures and lower fishing mortality were positively associated with sandeel biomass and kittiwake productivity, recent analyses have not confirmed the link between sandeel recruitment and growth and temperature (Henriksen et al. 2021b). However, low temperatures delay the emergence of sandeel from the sediment (Henriksen et al 2021a) and possibly also the settlement of juvenile sandeel on the sandeel habitats. Hence, the factors affecting the breeding success of kittiwakes may be related to the emergence behaviour of sandeel and/or to other temperature-related processes rather than simply the abundance of sandeel of age 1+. While improvement was seen in terms of breeding success of kittiwakes following the closure of an area off east Scotland to large scale fishing, this management measure did not fully restore breeding success of kit-

tiwakes to previous levels, indicating that other factors than food shortage are affecting this species in this area (Searle et al. 2023).
The Cury et al. (2011) paper states that as long as the biomass of prey fish exceeds a third of the maximum, no adverse effects are generally seen on seabird recruitment. Since the 1994 regime shift change in the North Sea small pelagic fish community linked to changes in copepod abundance and composition (Clausen et al. 2018), the maximum spawning biomass in areas 1r and 4 has been 527551 t and 235861 t (both in 1998 reflecting the exceptionally high 1996 yearclass). The biomass targeted in stock advice, $B_{escapement}$, is defined for the two stocks as 27% and 43% of this, respectively. Hence the targeted biomass is just below the recommendation of a third in area 1 and well above the recommendation in area 4. Note that the Cook et al. reference cited in the report misinterpreted the Cury et al. paper giving the definition 'The black line shows the maximum proportion of the sandeel population that can be fished for any given population size whilst sticking to the "Third for the Birds" rule of Cury et al. (2011), that a third of the long-term maximum biomass of sandeel must be left by fisheries to support sustainable seabird populations in the North Sea.'

The ecosystem models used in the report are mass balance models (described from page 22 onwards). They are designed based on the assumption that the production in a given ecosystem component together with production from alternative food sources determines the production of the linked predators. Should the production of all prey increase by 20%, that would mean that the biomass of all predators increased by 20% unless a carrying capacity is included in the model. The inherent assumption is that all predators are food limited. However, in the North Sea, there is little evidence to suggest that growth and recruitment of commercial fish is food dependent in the way that an increase in e.g. zooplankton biomass leads to an increase in fish recruitment and growth of the same magnitude. Instead, recruitment of sandeel appear to be greatly affected by ocean currents and growth and reproduction of demersal fish and marine mammals cannot generally be linked to the biomass of an individual prey species (Engelhard et al 2014). Further, seabird productivity is not linked to biomass of sandeel in the North Sea as a whole but rather to local densities in e.g. east of Scotland and around Shetland. The sandeel taken by different predators and the fishery are not the same. Seabirds such as kittiwakes in the breeding season feed on in-year recruits whereas the fishery targets sandeel in age 1 year and older. As stated in caveat 2, this difference is not included in the North Sea Ecopath with Ecosim model.
The two ecosystem models both employ the management strategy of constant fishing mortality, equivalent to the study of Poloczanska. This management strategy has long been recognized by ICES as unprecautionary and is not used. This difference is not mentioned in the caveats. The ecosystem model simulations do not account for the different dynamics and fisheries impact on the various sandeel stocks (Caveat 3). For example, the majority of dependent UK seabirds forage in area 4 and 5 during the breeding season whereas the fishery shifts between areas 1r, 2r, 3r and 4.
Caveat 4 speaks of the lack of inclusion of climate change in the simulations. As described above, climate change impacts on sandeel are not clear and may be either positive or negative.
The contribution of sandeel to the diet of porpoises relies heavily on sampling location and time. For example, southern porpoises only have about 10% sandeel in their diet (Mahfouz et al 2017) and the contribution of sandeel to the total diet varies greatly between years and in the decades sampled and reported by ICES (1980's, 1990's and 2000's). Only the 1990's had a proportion of sandeel exceeding

16% and the average was 21% (ICES 2017). It is unclear why the data used for toothed whales in the model exceeds this level.

'published research suggests increased sandeel biomass would have localised benefits for the condition of some commercial fish, however the impacts of prohibiting sandeel fishing on the overall stock biomasses of commercial fish would be limited and complex, with a mixture of positive and negative responses'
As stated in the report, there is little published evidence for impacts of increase sandeel biomass on recruitment and growth of predators. Indirect effects in both positive and negative directions are possible.

'the risk of primary displacement (displacing sandeel fisheries to alternate sandeel fishing grounds) is greatest for sandeel management area 1r (SA1r) as this management unit is shared across the UK-EU EEZ border. Secondary displacement (displacement onto other species) would increase the risk of exploitation of other forage fish, particularly non quota species and stocks'
Settled sandeels show movement that is sufficient to erase differences in length distribution up to 28 km within fishing grounds (Jensen et al. 2011). In contrast, larvae can easily travel 100 km, leading to substantial transport of larvae within the Dogger area and between this area and other parts of the North Sea (Christensen et al 2008). This means that displacement of fishing effort within a fishing ground is unlikely to change the mortality on that fishing ground when the distance is less than 28 km. Displacing fishing by more than this distance or between fishing grounds is likely to lead to differences in local fishing mortalities within and between fishing grounds within a stock assessment area. High local mortalities acting in areas of low abundance may lead to even lower abundances in this area. Due to the long transport distances of larvae, neither displacement scenario is likely to affect the amount of new recruits appearing the subsequent year in any of the fishing grounds in the area unless the total spawning stock is reduced below the level where recruitment is impacted.
The TAC given for area 4 covers all of area 4 as stated in the report and substantial exchange is expected within the Firth of Forth area (Jensen et al. 2011). The management strategy in area 4 targets a spawning biomass in the area after fishing, $B_{escapement}$, of 43% of the maximum observed since the 1994 regime shift to ensure that recruitment is not impaired. Since the assessment was first conducted for area 4 and a separate MSY advice was given in 2016, the stock has been fished with a low monitoring TAC to obtain samples for the assessment in 2019 and 2022 and a regular TAC in other years. In this period, the stock has not been below the level at which recruitment is impaired (B_{lim}) in any years. For comparison, in the period from 2005 to 2016 in the absence of a fishery beyond monitoring fishing, the stock was below B_{lim} i in 2007 to 2010 and again in 2015, reflecting the large variability in recruitment to this stock as also noted on page 39 of the report.
Hence, there is no evidence to suggest that the current management approach is unprecautionary or has led to local depletion.

Issues discussed in the report but not in 'Core advice'

Ecosystem approach in reference point setting

The use of F_{eco} allows $F_{MSYupper}$ fishing at high productivity and $F_{MSYlower}$ at low productivity for stocks managed using F_{MSY} ranges (p. 41). Short lived stocks already have highly variable advised fishing mortalities to reflect annual changes in productivity and safeguard recruitment in spite of these productivity changes. Similarly, the stocks referred to on page 42 are managed according to FMSY without a specific requirement for the coming year spawning stock biomass to exceed $B_{escapement}$. Hence, they are managed using a system allowing fishing mortality to exceed zero at a stock size below $B_{escapement}$ unlike short-lived stocks.

Benefits and risks listed in table 2 but not addressed in the core advice.

Impact type	Impact	Summary of ecosystem impact	Comment
Benefit B3	Increased occurrence of marine mammals within UK EEZ	Previous studies have linked the abundance of sandeels to the distributions of marine mammals in the North Sea, Therefore, if management actions led to an increase of sandeels in the UK EEZ, we might expect to observe an increased occurrence of marine mammals in UK waters.	The study of Ransjin et al. 2019 cited on p. 11 as the basis for this statement does not link the distribution of prey energy to the distribution of porpoises as stated in the report but merely suggests that this can now be attempted.
Benefit B3	Progress towards GES	Several substantiated links have been made between the abundance of sandeels and the survival and breeding success of birds, mammals, and commercial fish, linking to the targets and indicators of the UKMS and GES descriptors (D1, D3 and D4).	There are no references in the report to published studies linking a high biomass of sandeel to high recruitment in commercial fish, high survival or breeding success of mammals or high survival of seabirds.

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