Supplementary Advice on Conservation Objectives for Dogger Bank Special Area of Conservation

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Contents

Introduction

What the Conservation Advice package includes

The information provided in this document sets out JNCC's supplementary advice on the conservation objectives set for this site. This forms part of JNCC's formal conservation advice package for the site and must be read in conjunction with all parts of the package as listed below:

- Background Document explaining where to find the advice package, JNCC's role in the provision of conservation advice, how the advice has been prepared, when to refer to it and how to apply it;
- Conservation Objectives setting out the broad ecological aims for the site;
- Statements on:
    - the site's qualifying feature condition;
    - conservation benefits that the site can provide; and
    - conservation measures needed to support achievement of the conservation objectives set for the site.
- Supplementary Advice on Conservation Objectives (SACO) providing more detailed and site-specific information on the conservation objectives (this document);
- Advice on Operations providing information on those human activities that, if taking place within or near the site, can impact it and present a risk to the achievement of the conservation objectives.

The most up-to-date conservation advice for this site can be downloaded from the conservation advice tab in the Site Information Centre (SIC) on JNCC's website.

The advice presented here describes the ecological characteristics or 'attributes' of the site's qualifying feature: Annex I Sandbanks which are slightly covered by seawater all the time, specified in the site's conservation objectives. These attributes include extent and distribution, structure and function and supporting processes.

Figure 1 below illustrates the concept of how a feature's attributes are interlinked: with impacts on one potentially having knock-on effects on another e.g. the impairment of any of the supporting processes on which a feature relies can result in changes to its extent and distribution and structure and function.

Collectively, the attributes set out in Table 1 below, along with the objectives set for each of them, describe the desired ecological condition (favourable) for the site's feature. The condition of the feature contributes to its favourable conservation status more widely, as well as the site's integrity. All attributes listed in Table 1 must be taken into consideration when assessing impacts from an activity.

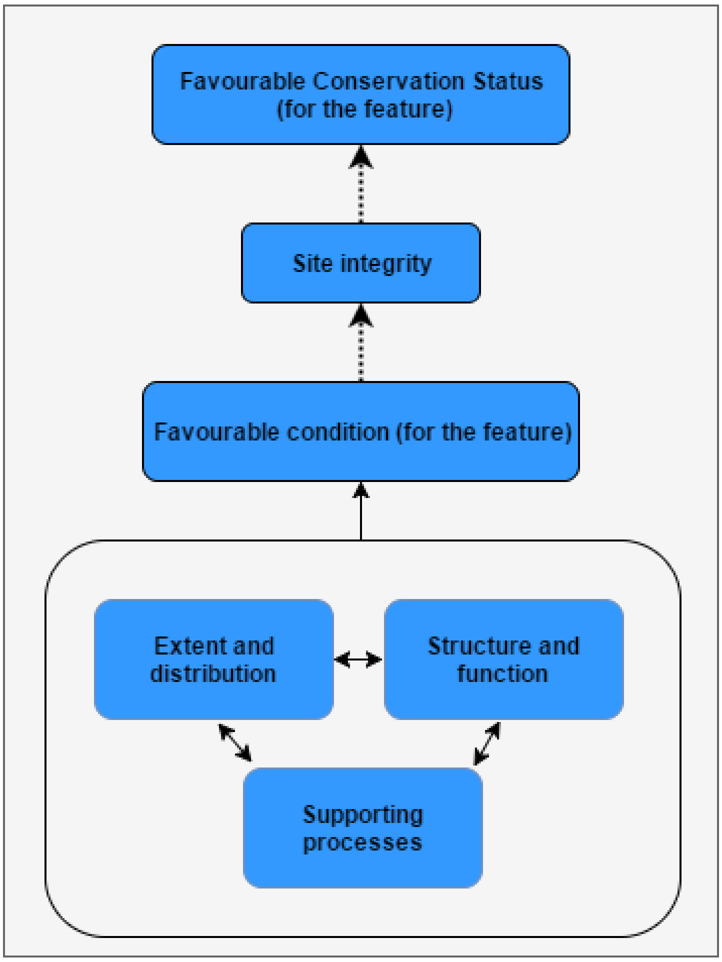

Figure 1. Conceptual diagram showing how feature attributes are interlinked, describe favourable condition and contribute to site integrity and wider favourable conservation status.

In Table 1 below, the attributes for Annex I Sandbanks which are slightly covered by seawater all the time are listed and a description provided in explanatory notes. An objective of restore or maintain is set for each feature attribute. The objective reflects our current understanding of a feature's condition e.g. where evidence indicates some of a feature's extent is lost and needs to be restored or that extent is not lost and needs to be maintained in order to ensure the feature is in overall favourable condition. The rationale for setting an objective is also provided in the explanatory notes, along with reference to supporting evidence from the site. Note that where it is not practical through human intervention to restore a feature's attribute, a maintain objective is set, accompanied by a statement to reflect the impracticality of restoration.

Note also that when a maintain objective is set, this does not preclude the need for management, now or in the future. Please see the conservation measures for further detail regarding managing activities.

Table 1. Supplementary advice on conservation objectives (SACO): Annex I Sandbanks slightly covered by seawater all the time.

Attribute: Extent and distribution

Objective: *JNCC understands that the site has been subjected to activities that have resulted in a change to the extent and distribution of the feature within the site. Installation and/or removal of infrastructure may have a continuing effect on extent and distribution. As such,* ***JNCC advise a restore objective*** *which is based on expert judgment; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities i.e. cabling and oil and gas industry activities. Our confidence in this objective would be improved with longer term monitoring and access to better information on the activities taking place within the site. Activities must look to minimise, as far as is practicable, changes in substratum within the site to minimise further impact on feature extent and distribution.*

Explanatory notes

Extent refers to the total area in the site occupied by the qualifying feature and must include consideration of its distribution, i.e. how it is spread out within the site. A reduction in extent has the potential to alter the biological and physical functioning of sedimentary habitat types (Elliott *et al.*,1998). The distribution of a habitat influences the component communities present, and can contribute to the health and resilience of the feature (JNCC, 2004). The extent within the site must be conserved to the full known distribution.

Annex I sandbanks are defined and delineated (Duncan, 2016) by:

- ***large-scale topography*** which is elevated, elongated, rounded or irregular, permanently submerged and predominantly surrounded by deeper water (EC, 2013);
- ***sediment composition*** that is mainly sandy sediments (sand is defined as sediment particles between 2 and 0.0625 mm in diameter and sandy sediment must be composed of less than 30% gravel and have more sand than mud). Other sediment types including boulders, cobbles or mud may also be present on a sandbank; and
- ***biological assemblages***. See JNCC's Marine Habitat Correlation Table for more detail about the range of biological communities (biotopes) that occur on Annex 1 sandbanks.

Loss of large scale topography would constitute loss of the sandbank feature extent. Loss of characterising sandbank biological assemblages or sandbank sediments from an area of the feature would constitute loss of sandbank habitat and a reduction in overall feature extent.

In the UK offshore area, there are two different types of sandbank:

1. Sandy mound sandbanks: created by glacial processes which have long since stopped acting on the feature. While surface sediments may be mobilised, the extent and distribution of the sandbanks as a whole remain broadly unaffected by ongoing hydrodynamic processes. It is important to note that we would not expect large scale topography or the underlying immobile substrates to recover, should they be physically impacted. The sandbank communities, however, are capable of recovering from impacts but this will be dependent on prevailing environmental conditions, the influence of human activities i.e. the scale of any current impacts, species life history traits, environmental connectivity between populations and habitat suitability (Mazik *et al.,* 2015);
2. Open shelf ridge sandbanks: can be relatively mobile with their extent and distribution being actively influenced by ongoing hydrodynamic processes and subsequently changing naturally over time. Recovery from physical impacts for these types of sandbanks is possible but again dependent on the range of factors mentioned in 1 above.

Extent and distribution within the site
The site map for Dogger Bank cSAC/SCI is available on JNCC’s Interactive MPA Mapper. Dogger Bank is a sandy mound type sandbank, formed by glacial processes and shaped by the Dogger Bank Formation, a geological formation deposited during the last glacial period (Cameron *et al.,* 1992). Dogger Bank contains the largest single continuous expanse of shallow sandbank in UK waters (JNCC, 2011).

The site boundary delineates the sandbank feature, calculated to be 12,331km^2. The crest of the Dogger Bank lies in water less than 20m deep and the bank gradually extends into deeper water with the greatest slope change around the 45-50m depth contour (Diesing *et al*., 2009; JNCC, 2011).
Some of the sandbank’s extent is currently considered to be lost due to the presence of large-scale and widespread infrastructure associated with offshore oil and gas and cabling activities, which have resulted in changes to the substratum of the site. Please see the attribute physical structure: sediment composition and distribution within the site for more information on the substrate types that compose the sandbank feature within the site. These industries have placed infrastructure i.e. gas platforms and pipelines and concrete mattressing commonly composed of concrete or steel in or on the seabed throughout the site. These result in changes to substratum from for example, sedimentary to hard substrate in places and consequently changes to sandbank communities such that these areas no longer represent sandbank feature as defined. Introduced substrates, such as rock dump, normally consisting of gravel or pebbles and cuttings piles are also deposited onto the seabed although it is not clear what this material consists of or how much of it there is within the site, so it is not clear if it impacts extent and distribution of the sandbank feature and is not considered further under this attribute.

Aggregates dredging is occurring within the site but we understand that this activity operates in such a way as to ensure that the distribution of surface sediments is not changed and so the feature’s extent would remain unimpacted. Further information on the impacts associated with human activities on the sandbank feature can be found in the Advice on Operations workbook for the site.

JNCC advise a restore objective which is based on expert judgment; specifically, our understanding of the feature’s sensitivity to pressures which can be exerted by ongoing activities i.e. cabling and oil and gas industry activities on the extent and distribution of sandbank feature’s sediment composition and consequently that of associated biological communities. Our confidence in this objective would be improved with longer term monitoring and access to better information on the activities taking place within the site. Activities must look to minimise, as far as is practicable, changes in substratum within the site to minimise further impact on feature extent and distribution.

Attribute: Structure and function

Objective: *JNCC understands that the site has been subjected to activities that have resulted in a change to the finer topography, sediment composition and distribution, and characteristic communities of the feature within the site. Installation and/or removal of infrastructure may have a continuing effect on structure and function, specifically the characteristic communities and sediment composition and distribution. Demersal fishing may also have an ongoing effect on the characteristic communities. As such,* ***JNCC advise a restore objective*** *which is based on expert judgment; specifically, our understanding of the feature’s sensitivity to pressures which can be exerted by ongoing activities i.e. demersal fishing, aggregate dredging, cabling and oil and gas industry activities. Our confidence in this objective would be improved with longer term monitoring and access to better information on the activities taking place within the site. Activities must look to minimise, as far as is practicable, disturbance and changes to the finer scale topography, sediment composition and biological communities within the site.*

Explanatory notes

Structure

Structure encompasses both the physical structure of a habitat type together with the biological structure. **Physical structure** refers to **finer scale topography** and **sediment composition and distribution** Physical structure can have a strong influence on the hydrodynamic regime at varying spatial scales in the marine environment as well as the presence and distribution of biological communities (Elliot *et al.*, 1998). This is particularly true of features like sandbanks which are large-scale topographic features. The biological structure refers to the **key and influential species** and **characteristic communities** present. Biological communities are important in not only characterising the sandbank feature but supporting the health of the feature i.e. its conservation status and the provision of ecosystem services by performing functional roles.

Physical structure: finer scale topography

Sandbank topography can be characterised by finer scale bedforms such as sand waves, mega-ripples and mounds which are driven by hydrodynamic processes. These bedforms can support different sediment types and associated communities (Elliott *et al.,* 1998; Barros *et al.,* 2004; Limpenny *et al.,* 2011). Where finer bedforms are known to be naturally present on a sandbank feature they should be conserved.

Physical structure: finer scale topography of the feature within the site

Bed forms around Dogger Bank are limited (EMU, 2010). However, sand waves (wavelengths greater than 25m) and megaripples (wavelengths between 0.5 and 25m) sculpted into both gravel and sand substrates are present in patches across the southern-western and the east-central area of the site GEMS (2011). Sand waves are symmetrical with wavelengths of 50-150m (average approximately 100m) and amplitudes up to 2m (average approximately 0.5m). Their crests are orientated in an east-northeast to west-southwest direction, but their symmetrical nature suggests that they are not actively migrating in any one direction (Forewind, 2013c).

Overall, JNCC consider finer-scale topography of the feature may be impacted by the activities occurring within the site and therefore **need to be restored**. This objective is based on expert judgment; specifically, our understanding of the feature’s sensitivity to pressures which can be exerted by ongoing activities i.e. aggregate dredging, cabling and oil and gas industry activities can modify bed forms in the site. Aggregates dredging occurs on the site and JNCC expects the physical structure of sandwaves to be impacted by dredging. The recovery is likely to be slow given the relatively static nature of the sandwaves.
Our confidence in this objective would be improved with longer-term monitoring and access to better information on the activities taking place within the site. Activities must look to minimise, as far as is practicable, disturbance and changes to the finer scale topography within the site. Further information on the impacts associated with human activities on Annex I Sandbanks slightly covered by seawater all the time can be found in the Advice on Operations workbook for the site.

Physical structure: sediment composition and distribution

Sediment composition of sandbanks is highly dependent on the level of energy experienced by the environment. It can be varied but in the offshore tends to be limited to primarily circalittoral sand but also circalittoral coarse sediments and to a lesser extent, circalittoral mixed sediments where finer sediment fractions (mud, silt/clay) are present. Coarser sediments tend to be located in higher energy environments that are subject to strong prevailing currents. Conversely, finer sediment types are typically associated with lower energy environments. Storm conditions however can mobilise all sediment types including coarser fractions. Furthermore, it is important to note that the composition and spatial distribution of sediments can change naturally over time.

Many functional ecological groups have specific niche sedimentary requirements; some species occur on all types of sediment, but most are restricted to a type and therefore limited in their distribution. Particle composition (including grain size and type) is a key driver influencing biological community composition (Cooper *et al.,* 2011; Coates *et al.,* 2015; 2016; Coblentz *et al.,* 2015) and the distribution and extent of these communities. The natural range of sedimentary habitats known to be present within a sandbank along with their composition and distribution, should be conserved.

Physical structure: sediment composition and distribution of the feature within the site

Sediment composition and distribution of sediments within the site can be seen in the site map available on JNCC's Interactive MPA Mapper. A few sedimentary habitat types are present, however finer subtidal sands dominate. The underlying substrate is composed mainly of clay material. Sands of variable thickness overlie the geological Dogger Bank Formation, reaching 20m thickness in the southeast, while thinner layers (typically 0.1 – 0.2m) cover the west and north of the site (British Geological Survey and Rijks Geologische Dienst, 1988; British Geological Survey, 1990a,1990b).

The majority of sediments present across the Dogger Bank are consist of fine sands with mud content below 5% (JNCC, 2011) with sandy gravel in patches mainly concentrated on the western edge of Dogger Bank. There is evidence of small mixed sediment patches located centrally in the site. Coarse sediment patches are widespread, most of which are relatively small but a few larger patches are notable towards the western and southern edges of the site. There are also a few muddy sediments in the central north area (Eggleton *et al*., 2017)

The sediment types within the site are characterised by the following Particle Sediment Analysis (PSA): Subtidal sand within the site are on average 1.31 ± 1.33%, 94.94. ± 3.16%, and 3.75 ± 2.90% (gravel, sand and silt/clay respectively). PSA reported for Subtidal mixed sediment within the site are on average 24.46 ± 19.13%, 58.90 ± 23.17%, and 16.64 ± 6.75% (gravel, sand and silt/clay respectively) and for Subtidal coarse sediment are on average 18.47 ± 18.98%, 79.30 ± 18.78%, and 2.23 ± 1.16% (gravel, sand and silt/clay respectively). PSA reported for Subtidal mud within the site are on average 2.00 ± 1.46%, 56.88 ± 27.47%, and 41.14 ± 27.47% (gravel, sand and silt/clay respectively).

The relatively dynamic nature of the currents around the site may mobilise finer surface sediments within the site and it is expected that the spatial distribution of the surface sediments could change naturally over time. Nevertheless, evidence indicates that the hydrodynamic regime on Dogger Bank operates in such a way as to generally retain mobile sediments on the bank and tidal current velocities are considered insufficient for initiating sediment transport (Wieking and Kröncke, 2005).

As mentioned previously under the extent and distribution attribute, infrastructure mainly from gas platforms and pipelines, and concrete mattressing is present on the seabed throughout the site. Where introduced, these result in changes to substratum from for example, sedimentary to hard substrate in places, such that these areas no longer represent sandbank feature as defined. Introduced substrates, such as rock dump, normally consisting of gravel or pebbles and cuttings piles are deposited onto the seabed although it is not clear what this material consists of or how much of it there is within the site and consequently it is unclear what impact this may have on sediment composition and distribution within the site. We expect finer sands to continue dominating the site, with mixed and coarse sediment remaining present within the site in patchy distributions along with muddy sediment to a lesser extent.

A restore objective is advised for sediment composition and distribution of the feature within the site based on expert judgment; specifically, our understanding of the feature’s sensitivity to pressures which can be exerted by ongoing activities i.e. cabling and oil and gas industry activities. Our confidence in this objective would be improved with longer term monitoring and access to better information on the activities taking place within the site. Activities must look to minimise, as far as is practicable, changes in substratum (grain size distribution) within the site. Further information on the impacts associated with human activities on Annex I Sandbanks slightly covered by seawater all the time can be found in the Advice on Operations workbook for the site.

Biological structure: key and influential species

Key species form a part of the habitat structure or help to define a biotope. Influential species are those that have a core role in the structure and function of the habitat. For example, species that are bioturbators which are benthic organisms that forage and burrow bottom tunnels, holes and pits in the seabed, help to cycle nutrients and oxygen between seawater and the seabed supporting organisms that live within and above the sediment. Grazers, surface borers, predators or other species with a significant functional role linked to the habitat can also be influential species. Changes to the spatial distribution of communities across the feature could indicate changes to the overall feature (JNCC, 2004). It is therefore important to conserve the key natural structural and influential species of the sandbank within the site to avoid diminishing biodiversity and ecosystem functioning within the habitat and to support its health (Hughes *et al.,* 2005).

Biological structure: key and influential species of the feature within the site
A variety of bioturbators, predators and grazers have been recorded from surveys within the Dogger Bank site, such as polychaete worms (*Spiophanes bombyx),* brittle stars *(Amphiura filiformis)*, as well as sea urchins, gastropods (Family Buccinidae), hermit crabs and other unidentified crustaceans. The bivalve *Arctica islandica*, commonly known as Ocean quahog and a notable species and listed OSPAR threatened or declining species is also present in the site (Eggleton *et al.,* 2017). A few individuals have been found associated mainly with subtidal sand although some were found in subtidal coarse sediment. *A. islandica's* abundance, population structure and distribution within the site is not well understood and is not considered further in our advice.

It is possible that the species listed above play a critical role in maintaining the structure and functioning of the protected subtidal sedimentary habitats. However, there is insufficient information available to support an understanding of the significance of the role which these species play in maintaining the structure and function of the qualifying feature. Therefore, it is not possible to set an objective for this sub-attribute and it is not considered further at this current time.

Biological structure: characteristic communities
The variety of communities present make up the habitat and reflect the habitat's overall character and conservation interest. Characteristic communities include, but are not limited to, representative communities, for example, those covering large areas, and notable communities, for example, those that are nationally or locally rare or scarce such as those listed as OSPAR threatened or declining, or known to be particularly sensitive.

The biological communities typical of sandbanks will vary greatly depending on location, sediment type and depth, as well as fine-scale physical, chemical and biological processes. Communities found on sandbank crests are predominantly those typical of mobile sediment environments and tend to have relatively low diversity. Fauna such as polychaetes (worms) and amphipods (shrimp-like crustaceans) thrive in this environment as they are able to rapidly bury themselves. Animals like hermit crabs, flatfish and starfish also live on the surface of the sandbanks. Deeper areas more sheltered from prevailing currents or wave action can have reduced sediment movement. Such areas tend to have a higher diversity of burrowing species and often can support an abundance of attached bryozoans, hydroids and sea anemones, particularly on stones and dead shells.

Changes to the spatial distribution of communities across the feature could indicate changes to the overall feature (JNCC, 2004). It is therefore important to conserve the natural spatial distribution, composition, diversity and abundance of the main characterising biological communities of the sandbank within the site to avoid diminishing biodiversity and ecosystem functioning within the habitat and to support its health (Hughes *et al.,* 2005).

Biological structure: characteristic communities of the feature within the site

Macrofaunal communities on the Dogger Bank show distinct spatial variability across the site and a high overall abundance of individuals, numbers of species and total biomass (Eggleton *et al.,* 2017). Despite this variability, evidence supports the existence of four main biological communities at this site (Wieking and Kröncke, 2003; Eggleton *et al*., 2017):

- the Bank community is the predominant one and straddles across the bank from north to southeast. It is mainly present in the shallowest part of the Dogger Bank and it is characterised by a *Bathyporeia-Tellina* community;
- the North-Eastern community bordering the northern North Sea, is inhabited by a community with lower densities but with the highest number of species. The tube-inhabiting Velvet anemone (*Cerianthus lloydii*) and the small echinoid *Echinocyamus pusillus* occur at high densities in the shallower part. The ophiuroid *Amphiura filiformis*, the bivalve *Abra prismatica* and the polychaete *Scoloplos armiger* are more common in the deeper part. The community has a high number of rare northern species and the diversity is highest of all four communities
- the South-West Patch community; a sub-group of the Bank community in the shallow western side (18-23 m depth) with the lowest species number and abundance. Here, *Bathyporeia elegans* is the most abundant species. The bivalve *Donax vittatus* and the polychaete *Nephtys cirrosa* show their highest abundances in this sub-area of the Bank community; and
- the Southern Amphiura community; is the deeper southern part of the Bank and harbours an *Amphiura* community. The polychaete *S. bombyx* is abundant, but here the ophiuroid *Amphiura filiformis* and its commensal bivalve *Kurtiella bidentata* dominate in numbers.

Large areas of heterogeneous sediments are characterised by species typical of sandy sediments, such as *Spiophanes bombyx*, *Tellina fibula*, *Magelona filiformis* and *Bathyporeia* spp. (Eggleton *et al.,* 2017). Epifauna samples include many endobenthic bivalves such as *Mactra stultorum*, *Donax vittatus*, *Arctica islandica* and *Ensis species*, and also the Masked crab (*Corystes cassivelaunus*) and Sea potato

(*Echinocardium cordatum*); species hardly encountered at the seabed surface (Van Moorsel, 2011). The most frequently observed taxonomic groups were Asteroidea (*Asterias rubens, Astropecten irregularis)*, the Cnidarian, *Alcyonium digitatum,* the bryozoan *Flustra* sp. and Paguridae (*Cancer pagurus*) although these varied widely with sediment composition (Eggleton *et al.,* 2017). Sandeels have been recorded on the western side of the bank (Forewind, 2013a).

While there are limited studies focussing specifically on the impacts of ongoing human activities on the Dogger Bank, there is an indication that over time (data spanning from 1920, 1950, 1980 to 2000) that longer-lived species e.g. bivalves such *Spisula subtruncata* and *Mactra stultorum* (rayed trough-shells) have now been substituted by short-living and opportunistic bivalve feeders e.g. *Spiophanes bombyx* (bristleworm, polychaeta)*, Amphiura filiformis* (brittle star belonging to the family amphiuridae) and *Phoronids* (horseshoe worms, a separate phylum) (Kröncke, 2011). Fish species such as the Thornback ray (*Raja clavata*) once found in greater numbers are now considered scarce on Dogger Bank and this has been attributed by some to historical use of bottom-towed gear (Jak *et al*., 2009).

Bottom trawling activity within the site can alter the biological communities of the sandbank feature. In addition, and as mentioned under the extent and distribution attribute, the change in substratum brought about by some activities associated with cabling and the oil and gas industry may result in a loss of sandbank habitat from areas of the site and consequently loss of the sandbank communities they support.

A restore objective is advised for characteristic communities of the feature within the site based on expert judgment; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities i.e. demersal fishing, cabling and oil and gas industry activities. Our confidence in this objective would be improved with longer term monitoring and access to better information on the activities taking place within the site. Activities must look to minimise, as far as is practicable, changes in the biological communities within the site. Further information on the impacts associated with human activities on Annex I Sandbanks slightly covered by seawater all the time can be found in the Advice on Operations workbook for the site.

Function

Functions are ecological processes that include sediment processing, secondary production, habitat modification, supply of recruits, bioengineering and biodeposition. These functions rely on the supporting natural processes and the growth and reproduction of those biological communities which characterise the habitat and provide a variety of functional roles within it (Norling *et al.,* 2007) i.e. **key and influential species** and **characteristic communities**

These functions can occur at a number of temporal and spatial scales and help to maintain the provision of ecosystem services locally and to the wider marine environment (ETC, 2011). Ecosystem services typically provided by Annex 1 sandbanks include:

- Nutrition: due to the level of primary and secondary productivity on or around sandbanks, a range of fish species use these areas as feeding and nursery grounds. Some will migrate to certain parts of the habitat for feeding and breeding e.g. cod, plaice, dab, sole (Ellis, 2012), whilst others are more resident e.g. sandeels (Scottish Natural Heritage, 2012) making the conservation of sandbanks important to the fishing industry;
- Bird and whale watching: foraging seals, cetaceans and seabirds may also be found in greater numbers in the vicinity of sandbanks due to their shallower nature that enhances the availability of their typical prey items (e.g. Daunt *et al.,* 2008; Scott *et al.,* 2010; Camphuysen *et al.,* 2011; McConnell *et al.,* 1999, Jones *et al.,* 2013);
- Climate regulation: by providing a long-term sink for carbon within sedimentary habitats.

The prevailing hydrodynamic energy levels and sedimentary composition have a strong influencing effect on the recovery potential of the functional components of subtidal sedimentary habitats – with higher-energy, coarser sedimentary habitats showing greater recovery potential following impact than lower-energy, finer sedimentary habitats (Dernie *et al.,* 2003). Recovery of populations of individual species or communities also depends on life history traits of species (e.g. their growth rate, longevity), and interactions with other species including predators. Furthermore, the environmental connectivity between populations or species patches, the suitability of the habitat (e.g. substrate type), depth, water and sediment quality (Mazik *et al.,* 2015) will also influence the recovery potential of features.

The natural range of sandbank communities within the site should be conserved to ensure the functions they provide support the health of the feature and the provision of ecosystem services to the wider marine environment.

Function of the feature within the site

The ecosystem services that may be provided by sandbanks within the site include:

- **Nutrition –** the site provides a feeding ground where prey is made available for a variety of species of commercial importance. The site hosts spawning areas for plaice (*Pleuronectes platessa*) and spawning and nursery grounds for young commercial fish species, such as sandeels (*Ammodytes* spp.), the common dab (*Limanda limanda*), sole (*Solea solea),* lemon sole *(Microstomus kitt)* and sprat (*Sprattus sprattus)* (JNCC, 2011; Coull *et al*.,1998; Ellis *et al*., 2012);

- **Bird and whale watching** – the site provides some supporting function for wider marine bird and mammal populations. Evidence shows, for example, that in the breeding season, Back-legged kittiwakes from colonies on the York coast forage (on sandeels mainly) as far as the Dogger Bank (Thaxter *et al*., 2012). Furthermore, data acquired over 2010-2015 by the RSPB from GPS tracking of kittiwakes from colonies at Filey Brigg and Flamborough Head, corroborate the previous findings (unpublished data, RSPB). Other marine bird species have maximum foraging ranges which overlap the site limits, and therefore might use the site as well (Thaxter *et al.,* 2012). The site falls within the Southern North Sea candidate Special Area of Conservation/Site of Community Importance, which suggests that this site may contribute to wider support of Harbour porpoise (*Phocoena phocoena*) (JNCC, 2017). Marine mammals such as Harbour seals have been recorded travelling out to the site from haul out sites on the east coast of England (Jones *et al.,* 2013), which support local wildlife tourism;
- **Climate regulation –** the range of sedimentary habitats and associated communities in the site perform known ecological processes common to sandbanks such as deposition and burial of carbon in seabed sediments through bioturbation, living biomass and calcification of benthic organisms (Hattam *et al*., 2015).

As previously set out under extent and distribution and characterising communities, there is evidence to indicate that the biological communities within the site may have been impacted by activities associated with the oil and gas industry, cabling and bottom trawling. The implications of this in terms of the significance of any impact on the health of the sandbank feature and its provision of ecosystem services to the wider marine environment are unclear. Some evidence (e.g. Wieking & Kröncke, 2005) supports the view that ecological function of the Dogger Bank is being impacted by wider environmental drivers i.e. enrichment of southern water masses due to riverine inputs and climatic variability. However, it is not feasible to manage these drivers a site level.

On a precautionary basis, a **restore objective is advised** for function within the site based on impacts to the characterising communities from ongoing activities i.e. demersal fishing, cabling and oil and gas industry activities. Our confidence in this objective would be improved by longer term monitoring, access to better information about the activities occurring within the site and a clearer understanding of the role which biological communities play in the health of the feature and its provision of ecosystem services. Activities must look to minimise, as far as is practicable, disturbance and changes to the biological communities within the site to conserve the functions that it provides to the wider marine environment.

Further information on the impacts associated with human activities on Annex I Sandbanks slightly covered by seawater all the time can be found in the Advice on Operations workbook for the site.

Attribute: Supporting processes

Objective: *A **maintain objective** is advised for supporting processes based on expert judgment; specifically, our understanding of the impacts of ongoing activities on the feature attributes. Our confidence in this objective would be improved with long-term monitoring, specifically of contaminant levels within the site and a better understanding of the hydrodynamic regime within the site. Activities must look to avoid, as far as is practicable, impairing the hydrodynamic regime within the site and exceeding Environmental Quality Standards set out in the relevant section below.*

Explanatory notes

The sandbank feature relies on a range of supporting natural processes to support the functions (ecological processes) and help any recovery from adverse impacts. For the site to fully deliver the conservation benefits set out in the statement on conservation benefits, the following natural supporting processes must remain largely unimpeded:

Hydrodynamic regime

Water and sediment quality

Hydrodynamic regime

Hydrodynamic regime refers to the speed and direction of currents, seabed shear stress and wave exposure. These mechanisms circulate food resource and propagules, influence water properties by distributing dissolved oxygen, and facilitating gas exchange from the surface to the seabed (Chamberlain *et al.,* 2001; Biles *et al.,* 2003; Hiscock *et al.,* 2004; Dutertre *et al.,* 2012). Hydrodynamic regime also effects the movement, size structure and sorting of sediment particles. Shape and surface complexity within sandbank features can be influenced by coarse as well as finer-scale oceanographic processes, supporting the formation of topographic bedforms. The hydrodynamic regime plays a critical role in the natural formation and movement of mobile sandbanks.

Hydrodynamic regime within the site

The predominant wave direction is from the north and the majority of waves are less than 2m in height but have been recorded to reach 6m (Posford Duvivier, 2001). The annual mean significant wave height ranges between 1.75-2.0m across the Dogger Bank (BERR, 2008).

While evidence indicates that the hydrodynamic regime on Dogger Bank operates in such a way as to generally retain mobile sediments on the bank, there is also evidence to suggest that parts of the site experience very strong tidal currents. Tidal current velocities across the Dogger Bank are generally considered insufficient for initiating sediment transport (Wieking and Kröncke, 2005). BERR (2008) modelled mid-depth peak flows for mean spring tides which show to be about 0.4m/s for the offshore. However, there are estimates of extreme tidal current velocities at eight locations across Dogger Bank (Mathiesen and Nygaard, 2010) with maximum extreme velocities for return periods of one, ten and 100 years of 0.88m/s, 0.98m/s and 1.11m/s, respectively (Forewind, 2013c).

Large parts of the Dogger Bank are however situated above the storm-wave base (Connor *et al.,* 2006) and it is estimated that during a storm event, sediment up to the particle size of medium sand can be mobilised as deep as 60m at the northern slope of the Dogger Bank (Klein *et al.,* 1999). Models of natural disturbance have estimated that the seabed in Dogger Bank is disturbed to 4 cm depth at least once every year by tides and waves (Diesing *et al.,* 2013). While it is likely that the presence of hard substrate supporting infrastructure on the site is impacting the hydrodynamic regime locally, it is unclear what impact this is having on the movement of sediment over the wider sandbank feature and the consequences for sandbank sediment composition and biological communities. There is no other evidence to suggest the hydrodynamic regime within the site is impacted by ongoing activities taking place at or near the site such that the conservation status of the feature may be impacted.

A maintain objective is advised for the hydrodynamic regime within the site based on expert judgment; specifically, our understanding of the impacts of ongoing activities on the hydrodynamic regime within the site. Our confidence in this objective would be improved with longer term monitoring, access to better information on the activities taking place within the site and a better understanding of how the hydrodynamic regime influences the sediment composition, biological communities and distribution within the site. Further information on the impacts associated with human activities on Annex I Sandbanks slightly covered by seawater all the time can be found in the Advice on Operations workbook for the site.

Water and sediment quality

Contaminants may also impact the ecology of a sandbank feature through a range of effects on different species within the habitat, depending on the nature of the contaminant (JNCC, 2004; UKTAG, 2008; EA, 2014). It is important therefore to avoid changing the natural water quality and sediment quality properties of a site and as a minimum ensure compliance with existing Environmental Quality Standards (EQS) as set out below.

Environmental Quality Standards (EQS)
The targets listed below for water and sediment contaminants in the marine environment are based on existing targets within OSPAR or the Water Framework Directive (WFD) and require concentrations and effects to be kept within levels agreed in the existing legislation and international commitments. These targets are set out in The UK Marine Strategy Part 1: The UK Initial Assessment, 2012).

Aqueous contaminants must comply with water column annual average (AA) Environmental Quality Standards (EQS) according to the amended Environmental Quality Standards Directive (EQSD) (2013/39/EU), or levels equating to (High/Good) Status (according to Annex V of the Water Framework Directive (WFD) (2000/60/EC), avoiding deterioration from existing levels.

Surface sediment contaminants (<1cm from the surface) must fall below the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) threshold. For example, mean cadmium levels must be maintained below the ERL of 1.2 mg per kg. For further information, see Chapter 5 of the OSPAR Quality Status Report (OSPAR 2010) and associated QSR Assessments.

The following sources provide information regarding historic or existing contaminant levels in the marine environment:

- Marine Environmental and Assessment National Database (MERMAN);
- The UK Benthos database available to download from the Oil and Gas UK website;
- Cefas Green Book;
- Strategic Environmental Assessment Contaminant Technical reports available to download from the British Geological Survey website;
- Charting Progress 1: The State of the UK Seas (2005) and Charting Progress 2: The State of the UK Seas (2014).

Water quality
The water quality properties that influence habitats include salinity, pH, temperature, suspended particulate concentration, nutrient concentrations and dissolved oxygen. They can act alone or in combination to affect habitats and their communities in different ways, depending on species-specific tolerances. In fully offshore habitats these parameters tend to be relatively more stable, particularly so for deeper waters, although there may be some natural seasonal variation. Water quality properties can influence the abundance, distribution and composition of communities at relatively local scales. Changes in any of the water quality properties can impact habitats and the communities they support (Elliot *et al.*,1998; Little, 2000; Gray and Elliot, 2009). Changes in suspended sediment in the water column may have a range of biological effects on different species within the habitat; affecting the ability to feed or breathe. A prolonged increase in suspended particulates for instance can have a number of implications, such as affecting fish health, clogging filtering organs of suspension

feeding animals and affecting seabed sedimentation rates (Elliot *et al.,*1998). Low dissolved oxygen can have sub-lethal and lethal impacts on fish and infaunal and epifaunal communities (Biles *et al.,* 2007). Concentrations of contaminants in the water column must not exceed the EQS listed above.

Water quality within the site

The Dogger Bank is a highly productive area due to its shallowness, topography, hydrography and sediment types (Wieking and Kröncke, 2001). The warmer waters from the Channel, located on the top of the bank and in more southerly regions, are enriched by riverine input and remain mixed throughout the year (Kröncke, 1992). The cool Atlantic waters to the north of the bank exhibit seasonal stratification during spring and summer (Wieking and Kröncke, 2005; Weston *et al.,* 2005). Available evidence indicates relatively low suspended sediment concentrations of the order of 2 mg/l with a maximum of 10 mg/l (Doerffer and Fisher, 1994; Eleveld *et al.,* 2004). Phytoplankton production on the bank occurs throughout the year with chlorophyll a (Chl a) levels up to 5.8 µg l^{-1} (Brockmann and Wegner, 1985; Brockmann *et al.,*1990), supporting a higher biomass of species at higher trophic levels year-round and creating a region that is biologically unique in the North Sea (Kröncke and Knust, 1995). As mentioned previously, riverine inputs and climatic variability are thought to be affecting ecological function at the Dogger Bank (Wieking and Kröncke, 2005) and these impacts are not feasible to manage at the site level. Atmospheric deposition in the North Sea has also been highlighted as a major source of contamination of trace metals (cadmium, lead, copper and zinc) (Injuk *et al.,* 1992) including in Dogger Bank (Norberg, 1990; Preston and Merrett, 1991).

While this information identifies possible sources of contamination, there is no information available at this time which indicates that water quality within the site is falling below Environmental Quality Standards (EQS). **JNCC therefore advise a maintain objective** for water quality within the site and that aqueous contaminants must be restricted to comply with water column annual average (AA_EQS) according to the amended Environmental Quality Standards Directive (EQSD) (2013/39/EU) or levels equating to (High / Good) Status (according to Annex V of the Water Framework Directive (WFD) (2000/60/EC), avoiding deterioration from existing levels.

Sediment quality

Various contaminants are known to affect the species that live in or on the surface of sediments. These include heavy metals like Mercury, Arsenic, Zinc, Nickel, Chrome and Cadmium, polyaromatic hydrocarbons (PAHs), poly-chlorinated biphenyls (PCBs), organotins (TBT) and pesticides such as hexachlorobenzene. These metals and compounds can impact species sensitive to particular contaminants, (e.g. heavy metals) and bioaccumulate within organisms thus entering the marine food chain (e.g. PCBs) (OSPAR 2009; 2010; 2012). This contamination can alter the structure of communities within a site e.g. lowering species diversity or abundance. It is important therefore to avoid changing the natural sediment quality of a site and as a minimum ensure compliance with existing EQS as set out above. Sediment contaminants must not exceed the EQS listed above.

Sediment quality within the site
The available evidence is inconclusive regarding sediment quality within the site. Some studies support a view that sediments within the site are contaminated with heavy metals (Kröncke and Knust, 1995, Scholten *et al.,* 1998, Langston *et al*.,1999), whilst others do not (Chapman, 1992; Chapman *et al.,* 1992 and Forewind, 2013b). It is unclear why studies differ in their conclusions however it is worth noting that there is a lack of consistency in the way the data were collected over the years as well as what has been measured which makes comparison difficult.

Charting Progress 2 reports that open seas are little affected by pollution and levels of monitored contaminants continue to fall, albeit slowly in many cases. Dogger Bank is, however, subject to a considerable number of oil and gas exploration developments where produced water and drill cuttings can act as potential sources of contaminants and so it is possible that sediment quality within the site in some places falls below EQS. Trends in the concentration and distribution of contaminants in sediments in the wider southern North Sea, including hydrocarbons (HCs), are similar as those described for surface water contamination i.e. higher concentrations in the immediate vicinity of installations with concentrations generally falling to background levels within a very short distance from discharge (Hartley Anderson Ltd., 2001). Gross contamination of sediments by metals extends no further than 500 m downstream from production platforms except for Barium, which shows evidence of elevated levels in the area within 500 to 1,000 m of platforms (Hartley Anderson Ltd., 2001). There are, however, some notable exceptions for Lead, Vanadium, Copper and Iron.

A maintain objective is advised. Whilst evidence indicates there may be elevated levels of contaminants in the site, exceeding EQS, a maintain objective is advised as restoration of contaminants in the offshore is not currently feasible. Our confidence in this objective would be improved with longer-term monitoring, specifically of contaminants within the site. Further information on the impacts associated with human activities on Annex I Sandbanks slightly covered by seawater all the time can be found in the Advice on Operations workbook for the site.

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