Supplementary Advice on Conservation Objectives for Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area

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JNCC

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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 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 protected feature condition and General Management Approach;
  - conservation benefits that the site can provide; and
  - conservation measures needed to further the conservation objectives stated for the site.
- Supplementary Advice on Conservation Objectives (SACO) providing more detailed and site-specific information on the conservation objectives (this document); and
- Advice on Operations providing information on those human activities that, if taking place within or near the site, could impact it and hinder the achievement of the conservation objectives stated for the site.

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 protected features: Deep-sea sponge aggregations, Offshore subtidal sands and gravels, Ocean quahog (*Arctica islandica*) aggregations, an area of the Faroe-Shetland Channel continental slope and Geodiversity features representative of the West Shetland Margin Paleo-Depositional System and West Shetland Margin Contourite Deposits Key Geodiversity Areas. These attributes are: 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 Tables 1-5 below, along with the objectives set for each of them, describe the desired ecological condition (favourable) for the site's features. Each feature within the site must be in favourable condition as set out in the site's conservation objective. All attributes listed in Tables 1-5 must be taken into consideration when assessing impacts from an activity.

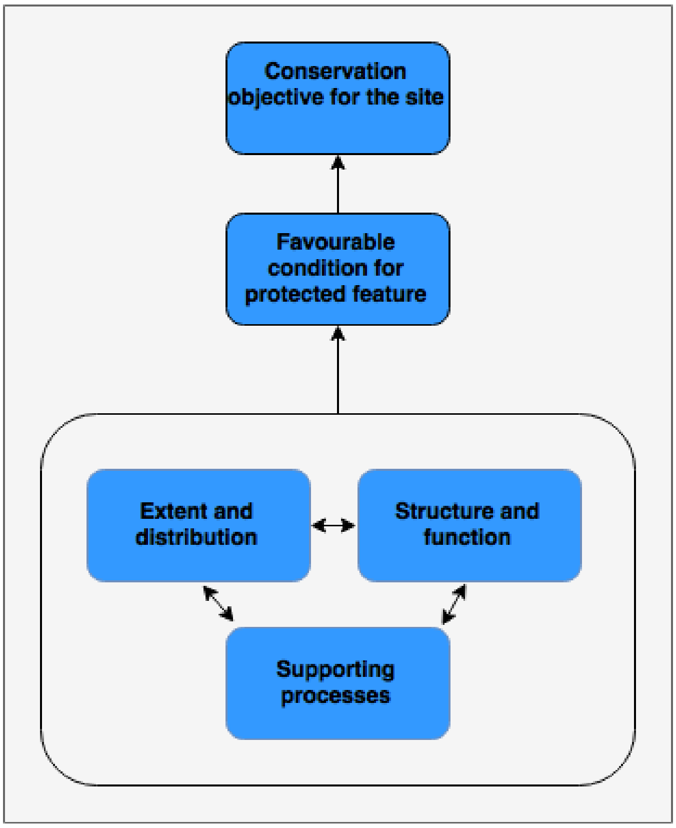

Figure 1. Conceptual diagram showing how a feature's attributes are interlinked and collectively describe favourable condition and contribute to the conservation objectives stated for the site.

The objectives listed in Tables 1-5 below reflect our current understanding of each protected feature's condition e.g. where evidence indicates some of a feature's extent is lost and needs to be recovered or that extent is not lost and needs to be conserved in order to ensure the feature is in overall favourable condition. The rationale for setting each 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 recover a feature's attribute, a conserve objective is set, accompanied by a statement to reflect the impracticality of restoration. Note also that when a conserve objective is set, this does not preclude the need for management, now or in the future. Please see the conservation measures relating to those activities JNCC consider may require additional management.

Table 1. Supplementary advice on the conservation objectives for Deep-sea sponge aggregations in Faroe-Shetland Sponge Belt NCMPA

Attribute: Extent and distribution
Objective: Recover *A **recover objective is advised** based on expert judgment; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities. Our confidence in this objective would be improved with longer-term monitoring. It is important to note however that recovery is expected to occur over a long timeframe in the order of decades or centuries depending on the degree of impact and the suitability of prevailing environmental conditions to support recovery. Activities should look to minimise, as far as is practicable, removal or dislodgement of sponges within the potential extent of Deep-sea sponge aggregations within the site.*
Explanatory notes Deep-sea sponge aggregations are known to have a naturally patchy distribution, influenced by suitable habitat type and wider environmental conditions. Evidence underpinning Deep-sea sponge aggregations are typically point records. It is therefore not possible to map or calculate an area of feature extent within a site. For Deep-sea sponge aggregations, extent will be a description of where in the site the conditions are suitable for the feature to occur. The focus for Deep-sea sponge aggregations is on its distribution, i.e. how it is spread out within the site and the factors underpinning its distribution. A reduction in distribution has the potential to alter the biological and physical functioning of the habitat. The distribution of a biogenic habitat such as Deep-sea sponge aggregations can be important in relation to the health and resilience of the feature (JNCC, 2004a). It is important therefore to conserve the full known distribution of Deep-sea sponge aggregations within a site. A Deep-sea sponge aggregation is a biogenic habitat characterised by the presence of structural sponges that occur above a specified density threshold (OSPAR, 2010a; Henry and Roberts, 2014): • More than 0.5 individuals per m^{-2}; • Registering as at least 'frequent' on the SACFOR scale; or • If bycatches of sponges exceed 400 kg, based on the ICES recommendation (ICES, 2013) for the identification of Vulnerable Marine Ecosystems[1]. In UK waters, four different subtypes of Deep-sea sponge aggregations have been identified (Henry and Roberts, 2014):

[1] While there are occurrences of Deep-sea sponge aggregations in UK waters that have been identified through bycatch records, JNCC does not recommend that trawl surveys are used to search for new instances of Deep-sea sponge aggregations or monitor known Deep-sea sponge aggregations.

1. **Boreal ostur sponge aggregations –** which are characterised by large structural geodiid sponges. Other erect and encrusting sponges may also be present
2. **Glass sponge fields –** dominated by a single type of glass sponge (Hexactinellidae). Usually these are bird's nest (*Pheronema carpenteri*) sponge fields, but could be formed by aggregations of other species of glass sponges.
3. **Encrusting sponge dominated aggregations** - characterised by low lying massive and encrusting sponges
4. **Stalked sponge grounds –** characterised by enhanced densities of stalked sponge species, typically on muddy sediments.

Evidence suggests that the sponges comprising Deep-sea sponge aggregations have limited potential to recover from removal, dislodgement, crushing or repeated exposure to significant sediment loading (ICES, 2009). Any recovery of extent will be influenced by the method of reproduction, dispersal potential, the relative location of a potential source population of reproductive adult sponges and the presence of suitable supporting habitat.

Generally, there is little information on the reproduction, recruitment, growth rates and longevity of deep-water sponges (Hogg *et al.*, 2010; Maldonado *et al.*, 2016). *Geodia barretti,* which can characterise boreal ostur aggregations, release gametes once or twice a year but less than 30% of the population is involved in reproduction each year (Spetland *et al*., 2007). Number of larvae produced and their dispersal ability varies between shallow water sponge species (Uriz *et al*., 1998; Marinani *et al*., 2006).

There is no information on the dispersal and larvae survival of deep-sea sponges, however small sponges within Boreal ostur aggregations are relatively rare suggesting successful reproduction is infrequent (Klitgaard and Tendal, 2004). Sexual reproduction has not been observed in Bird's nest sponges and aggregations are likely to be formed by asexual budding (Maldonado *et al.,* 2016). Sponge growth rates differ between species, season and environmental conditions (Leys and Lauzon, 1998; Turon *et al.,* 1998; Cebrian *et al.*, 2003; McMurray *et al.*, 2008; Duckworth *et al.*, 2012), and larger sponges tend to grow slower than smaller ones (Leys and Lauzon, 1998; McMurray *et al.*, 2008).

Based on annual growth rates, it is predicted that individual structural sponges can take decades to reach average sizes within the population (Leys and Lauzon, 1998; Klitgaard and Tendal, 2004). The life history traits of individual sponges indicate that recovery in extent of Deep-sea sponge aggregations after mortality or removal of adult sponges may take decades or centuries (ICES, 2009; Hogg *et al.*, 2010).

Extent and distribution within the site

The site protects examples of boreal ostur Deep-sea sponge aggregations. The locations of Deep-sea sponge aggregations known by JNCC are shown in the site map, which is available on JNCC's Interactive MPA Mapper. Confidence in the records of Deep-sea sponge aggregations from surveys carried out between 1996 and 2006 ranged from low to high, with higher confidence in records nearer the centre of the site (Henry and Roberts, 2014; Morris *et al.,* 2014). Within the site, records occur between the 400 and 600m depth contours, generally within the known extent of iceberg plough mark fields (a protected geodiversity of the site – see Table 5). The concentration of records is higher towards the middle of the site.

Oil and gas extraction and bottom contacting fishing gear (demersal trawling and demersal static fishing) occur in parts of the site where Deep-sea sponge aggregations occur. Such activities can result in sponges being dislodged and displaced, crushed or brought up to the surface, all of which can kill the sponges (ICES, 2009). These activities can therefore have a direct impact upon the extent and distribution of Deep-sea sponge aggregations within the site.

Evidence indicates that activities are occurring which are capable of affecting the extent and distribution of the feature. **JNCC therefore advise a recover objective**. Our confidence in this objective would be improved with longer-term monitoring and a better understanding of how activities impact the feature. The life history traits of sponges mean that Deep-sea sponge aggregations develop over decades or centuries (ICES, 2009; Hogg *et al.,* 2010) and therefore extent may not easily be restored through management intervention. Activities should look to minimise, as far as is practicable, removal or dislodgement of sponges within the potential extent of Deep-sea sponge aggregations within the site (between 400 and 600m).

For further information on activities capable of affecting Deep-sea sponge aggregations within the site, please see the Advice on Operations workbook.

Attribute: Structure and function

Objective: Recover

JNCC consider that there are activities occurring within the site that can impact the structure and function of Deep-sea sponge aggregations. As such, a recover objective is set for the sub-attributes; sponge composition, sponge abundance, characteristic communities and function. Overall, ***a recover objective is advised*** *for this attribute as a whole and is based on expert judgment; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities. Our confidence in this objective would be improved with longer-*

term monitoring. It is important to note however that recovery is expected to occur over a long timeframe in the order of decades or centuries depending on the degree of impact and the suitability of prevailing environmental conditions to support recovery. Activities should look to minimise, as far as is practicable, further removal, dislodgement or injury of sponges within the potential extent of Deep-sea sponge aggregations within the site.

Explanatory notes

Structure

Structure with respect to Deep-sea sponge aggregations encompasses:

- Sponge composition: namely the species, shape and size of the individual sponges that form the aggregation;
- Sponge abundance within the Deep-sea sponge aggregation;
- the presence of spicule mats, which have a strong influence on other species; and
- Characteristic communities present.

Sponge composition

Sponges are a highly diverse group of organisms and have a range of different morphotypes depending on species and/or environmental conditions (e.g. Fig. 1; Schönberg and Fromont, 2014). Other benthic organisms live on the surface of sponges or within the canals in the sponge's tissue. Sponge morphotype influences the abundance, diversity and composition of organisms living on or in the sponge (Neves and Omena, 2003; Montenegro-González and Acosta, 2010). A significant relationship has been observed between the structural complexity of biogenic structures, such as sponges and corals, and the number of taxa they support (Buhl-Mortensen and Mortensen, 2005; Buhl-Mortensen, 2010). Structural complexity of a sponge could be related to both its morphotype and size. Biodiversity may be increased by enhanced structural complexity because of an increase in the heterogeneity of habitats available for other benthic organisms e.g. providing elevated perches for other filter feeders (Bett and Rice, 1992; Bell, 2008) or refugia from predators (Freese and Wing, 2003). The communities of organisms living on or within individual sponges can also vary between different species of sponge with similar morphologies, possibly due to differences in the structure of the sponge tissue and/or the secondary metabolites the sponges produce (Skilleter *et al.*, 2005; Kersken *et al.*, 2014).

Key species form a part of the habitat structure or help to define a biotope. For Deep-sea sponge aggregations, the habitat structure is formed by the sponge species themselves, and therefore sponges are the key species in this habitat type. The ICES Working Group on Deep-Water Ecology has released a list of structural sponge species frequently found in Deep-sea sponge aggregations in the North Atlantic (see ICES, 2009).

A study of organisms living on stalked sponges found interspecific differences in the height above the seabed that species occupied (Beaulieu, 2001). This indicates that the size of sponges in a Deep-sea sponge aggregation can also influence the associated community, independently of sponge species and morphotype, and that a reduction in the height of sponges within an aggregation could lead to the loss of species from the community.

The diversity of sponge species, morphotypes and sizes within a Deep-sea sponge aggregation will influence the associated community and therefore it is important that these aspects of the structure of the Deep-sea sponge aggregation are conserved.

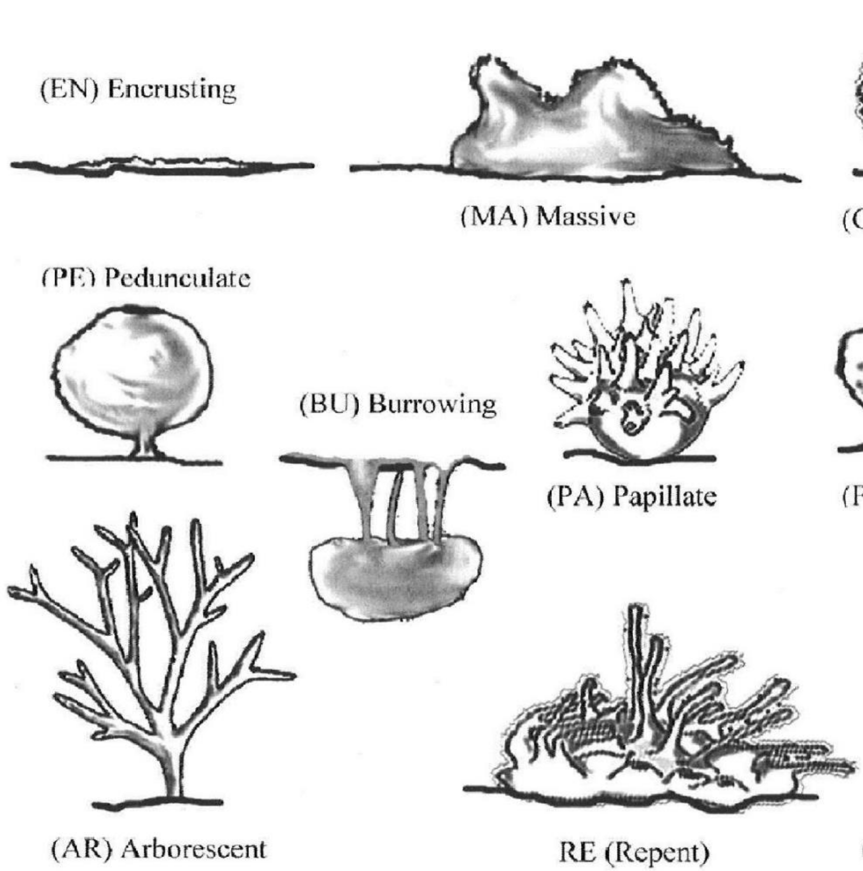

Figure 2. An example range of sponge morphotypes (from Berman et al., 2013).

Within the North Atlantic, boreal ostur sponge aggregations are typically composed of large structural sponges, including *Geodia atlantica, G. barretti, G. macandrewii, G. phlegraei, Phakellia sp* and *Stelletta normani* (Maldonado *et al.*, 2016; OSPAR, 2010a). Other erect and encrusting sponges can also occur within boreal ostur aggregations (Henry and Roberts, 2014).

If a sponge species can reproduce asexually, fragmentation of larger sponges could potentially increase the population of sponges in a Deep-sea sponge aggregation but will also reduce the size of the individuals (Hogg *et al.*, 2010). Consequently, although the extent of a Deep-sea sponge aggregation will not be reduced, the structure of the habitat may be altered. Sponges differ in their dispersal ability (Uriz *et al*., 1998; Marinani *et al*., 2006), growth rates (Duckworth *et al.,* 2012), ability to regenerate damaged tissue (Duckworth, 2003; Henry and Hart, 2005) and sensitivity to increased suspended sediment (Schönberg *et al.*, 2016). These differences can be due to species, morphotype and/or life stage. These factors will all influence the ability of Deep-sea sponge aggregations to recover physical structure after damage and the sponge composition of the habitat if any recovery does occur.

Growth to repair damaged tissue can be significantly faster than normal growth rates (Leys and Lauzon, 1998). However, although individual sponges can repair damage this does not indicate that recovery of the habitat structure from damage will be as rapid (ICES, 2009). Damaged *Geodia* can regrow to their original weight in a few weeks under laboratory conditions (Hoffmann *et al.,* 2003), but within a natural aggregation no evidence of repair is seen a year after damage (Freese, 2001). It is important to conserve the range of sponge species present in a Deep-sea sponge aggregation to increase the likelihood that some recovery may occur.

Sponge composition within the site

Within the site, the boreal ostur aggregation is formed by massive sponges including, *Geodia barretti, G. macandrewi, G. atlantica* and *G. phlegraei* (Henry and Roberts, 2014). The flabellate chalice sponge (*Phakellia ventilabrum)* was also observed during the survey of the site in 2012. Other erect sponges, and yellow and white encrusting sponges, are also present in the aggregation (Howell *et al.,* 2010). There is no specific information available on the size distribution of sponges present in the Deep-sea sponge aggregation within the site.

Oil and gas extraction and bottom contacting fishing gear (demersal trawling and demersal static fishing) occur in parts of the site where Deep-sea sponge aggregations occur. The species composition, size and morphology of the sponges can be affected by pressures exerted by these activities. Overall, **a recover objective has been advised**. Our confidence in this objective would be improved with better understanding of how activities impact the feature. Due to differences between sponge species in sensitivity to pressures and ability to recover, the species composition of the recovered habitat may be different to undisturbed Deep-sea sponge aggregations within the site. Activities should look to minimise, as far as is practicable, further physical damage to individual sponges within the potential extent of Deep-sea sponge aggregations within the site (400-600m).

For further information on activities capable of affecting Deep-sea sponge aggregations within the site, please see the Advice on Operations workbook.

Sponge abundance

The abundance of sponges within a Deep-sea sponge aggregation can influence the characteristic biological communities that are present. Beazley *et al.* (2015) found a positive relationship between the density of structural sponges and the biological diversity of other invertebrate taxa. The biomass and abundance of some fish species, such as shortnose snipe eel (*Serrivomer beanii*), deep-sea cat shark (*Apristurus profundorum*) and eelpout (*Lycodes* spp.) have also been shown to be higher in areas of a high sponge biomass (Kenchington *et al.*, 2013). Changes in the abundance of sponges may therefore have an impact on the characteristic biological communities and the biodiversity that a site can support. Sponge morphotype and available survey methods may influence how this attribute is described. If individual sponges can be identified on videos or stills, then abundance could be density of individual sponges. As the functions of sponges are directly linked to their biomass, the volume or biomass of sponges is valuable way of quantifying the abundance of larger sponges (Wulff, 2001). However, non-destructive survey methods, such as 3D camera technology, would be required. For some morphotypes e.g. encrusting sponges, distinguishing individuals is difficult and abundance should be described as area occupied or number of patches (Bell *et al.*, 2017).

Deep-sea sponge aggregations can vary in how the individual sponges are distributed within an aggregation, e.g. sponges can be randomly distributed or clustered (Uriz *et al.*, 1998). Sponges or clumps of sponges have communities of other organisms associated with them. Within a Deep-sea sponge aggregation, communities associated with one patch of sponges are likely to be more similar to communities on other nearby patches of sponges compared to patches that are located further away (Mayer *et al.*, 2016). Therefore, the spatial distribution of sponges or patches of sponges within the Deep-sea sponge aggregation could impact the overall diversity of associated organisms in the site.

It is important therefore to conserve the density and spatial distribution of sponges within a Deep-sea sponge aggregation to maintain the richness and diversity of the characteristic biological communities that may be present. Moreover, the spatial distribution of sponges may also effect how well the Deep-sea sponge aggregation can recover from a loss of individuals, as recovery could depend on the relative location of reproductive adults.

Sponge abundance within the site

In the boreal ostur aggregation present in the site, the density of sponges ranges from 0.001 to 0.818 individuals m^{-2} (Henry and Roberts, 2014). A site survey in 2012 observed *Phakellia ventilabrum* abundances between common and superabundant on the SACFOR scale on videos collected towards the middle of the site. The 2012 survey collected ten video tows containing Deep-sea sponge aggregations, with five of these recording sponge densities exceeding 0.5 individuals m^2; the other five video tows reported lower densities and classified as sparse or potential Deep-sea sponge aggregations (Morris *et al.,* 2014). There is no obvious trend in the location of the higher density records, compared to the sparse or potential records within the site (Morris *et al.,* 2014). This mixed distribution of densities is possibly because the Deep-sea sponge aggregations in the site tend to be associated with iceberg plough mark fields (a protected geodiversity feature of the site – see Table 5). This leads to a naturally patchy distribution of sponges within their potential extent within the site.

Oil and gas extraction and bottom contacting fishing gear (demersal trawling and demersal static fishing) occur in parts of the site where Deep-sea sponge aggregations occur. Sponge abundance can be affected by pressures exerted by these activities. Research undertaken from within the site indicates that sponge abundance is reduced in areas around wells where there are patches of drill cuttings visible on the sea-bed, possibly as a result of smothering (Jones *et al.,* 2006). This impact is generally observed within 100 m of the well, but the actual area of impact will depend on the hydrodynamics and type of drilling (Jones *et al.,* 2006; Jones *et al.,* 2007). Immediately after a drilling event, most surviving sponges within the area of disturbance occur on larger boulders that protrude above the level of smothering (Jones *et al*., 2006), however three years later the same boulders no longer supported sponges, indicating a more long-term effect on sponge abundances (Jones *et al.*, 2012). Therefore, the sponge abundance in Deep-sea sponge aggregations within a hundred metres of active or recently drilled wells may have been reduced by the activity.

In addition, bottom-contact fishing practices can reduce the abundance of sponges within a Deep-sea sponge aggregation through mortality, due to dislodgement and displacement, crushing and bringing sponges up to the surface as by-catch (ICES, 2009).

Evidence indicates that activities are occurring which are capable of affecting the abundance of sponges with the Deep-sea sponge aggregations feature of the site. **JNCC therefore advise a recover objective**. Our confidence in this objective would be improved with better understanding of how activities impact the feature. Due to differences between sponge species in sensitivity to pressures and ability to recover, the species composition and abundance of the recovered habitat may be different to undisturbed deep-sea sponge aggregations within the site.

The life history traits of sponges mean that Deep-sea sponge aggregations develop over decades or centuries (ICES, 2009; Hogg *et al.,* 2010) and therefore abundance may not easily be restored through management intervention. Activities should look to minimise, as far as is practicable, removal or dislodgement of sponges within the potential extent of Deep-sea sponge aggregations within the site (between 400 and 600m).

For further information on activities capable of affecting Deep-sea sponge aggregations within the site, please see the Advice on Operations workbook.

Spicule mats

Many species of sponges support their tissues with skeletal structures known as spicules (Hogg *et al.*, 2010). The spicules that form the skeleton of sponges can accumulate on the sea-bed in Deep-sea sponge aggregations, forming spicule mats. The presence of spicule mats alters the benthic community (Bett and Rice, 1992; Barrio Froján *et al*., 2012), possibly because they provide a hard substrate for attachment, act as refugia or enhance food availability to filter feeders; brittlestars and ascidians use the spicule mats as perches to access food particles in the higher flow rates above the sediment boundary layer (Bett and Rice, 1992). The numbers of polychaetes and brittlestars are positively correlated with the volume of spicules in the spicule mat (Bett and Rice, 1992), and these organisms are likely to be prey for fish and other benthic organisms. Spicule mats result in a hard surface on the seabed which inhibits colonisation by infaunal organisms (Gubbay, 2002). It is therefore important to conserve the presence and extent of spicule mats within Deep-sea sponge aggregations as they influence the characteristics of the habitat type. Where spicule mats are present, it is important that their extent and distribution is conserved.

Dense spicule mats are generally associated with glass sponges, however significant accumulations of spicules do occur in sponge aggregations dominated by *Geodia* sp such as boreal ostur aggregations and are associated with distinctive benthic communities (Klitgaard and Tendal, 2004; Barrio Froján *et al*., 2012, Murillo *et al*., 2016).

Spicule mats within the site

There is no information available on the presence or extent of spicule mats of the boreal ostur aggregation representing the Deep-sea sponge aggregations within the site.

A conserve objective is advised, however further information is needed. While evidence indicates that activities are occurring which are capable of affecting the extent and distribution of spicule mats within the site, there is insufficient information available to support a view as to the nature or scale of any impacts. Our confidence in this objective would be improved with better understanding of how the activities impact spicule mats.

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, those that are nationally or locally rare or scarce e.g. listed as OSPAR threatened or declining, or particularly sensitive. Deep-sea sponge aggregations are listed on the OSPAR threatened and declining habitats list, and this includes the characteristic communities associated with them (OSPAR, 2010a). Deep-sea sponge aggregations have also been recognised as Vulnerable Marine Ecosystems (VMEs) by the International Convention for the Exploration of the Sea (ICES) (ICES, 2013), who make recommendations for the protection of instances of the feature from fishing activity where they occur.

The biological communities characteristic of a Deep-sea sponge aggregation can vary depending on the structure of the Deep-sea sponge aggregation and other large-scale variables such as depth and current speed (Beazley *et al.*, 2015), as well as fine-scale physical, chemical and biological processes. The characteristic communities of Deep-sea sponge aggregations are generally epibenthic fauna typical of hard substrates (Gubbay, 2002) and tend to have relatively high biodiversity (Bett and Rice, 1992; Beazley *et al.*, 2013; Beazley *et al.*, 2015). Brittlestars are often associated with Deep-sea sponge aggregations (Henry and Roberts, 2014), which use the sponges and spicule mats as elevated perches to improve feeding (Bett and Rice, 1992).

It is important to conserve the natural spatial distribution, composition, diversity and abundance of the main characterising biological communities of the Deep-sea sponge aggregation within the site to avoid diminishing biodiversity and ecosystem functioning within the habitat and to support its health (Hughes *et al*, 2005).

Characteristics communities within the site

Only one community, Boreal ostur, has been associated with the Deep-sea sponge aggregations observed in the site (Howell *et al.*, 2010; Henry and Roberts, 2014). Along with the key sponge species mentioned above, this community is also characterised by brittlestars (e.g. *Ophiactis balli*), brachiopods, squat lobster (*Munida sp.*) and tube-building polychaetes (*Sepulidae*) (Howell *et al.,* 2010).

Oil and gas extraction and bottom contacting fishing gear (demersal trawling and demersal static fishing) occur in parts of the site where Deep-sea sponge aggregations occur. Characteristic communities associated with Deep-sea sponge aggregations can be affected by pressures exerted by these activities. Research undertaken from within the site indicates that sponge abundance is reduced in areas around wells where there are patches of drill cuttings visible on the sea-bed, possibly as a result of smothering (Jones *et al.,* 2006). This impact is generally observed within 100 m of the well, but the actual area of impact will depend on the hydrodynamics and type of drilling (Jones *et al.,* 2006; Jones *et al.,* 2007). Immediately after a drilling event, most surviving sponges within the area of disturbance occur on larger boulders that protrude above the level of smothering (Jones *et al*., 2006), however three years later the same boulders no longer supported sponges, indicating a more long-term effect on sponge abundances (Jones *et al.*, 2012). Therefore, the key species characterising the community is modified within a hundred metres of active or recently drilled wells.

In addition, bottom-contact fishing practices are capable of affecting the characteristic communities through removing benthic species and damaging or killing them by abrasion.

Evidence indicates that activities are occurring which are capable of affecting the characteristic communities of the Deep-sea sponge aggregations feature of the site. **JNCC therefore advise a recover objective**. Our confidence in this objective would be improved with better understanding of how activities impact the feature. Due to differences between sponge species in sensitivity to pressures and ability to recover, the species composition and abundance of the recovered habitat may be different to undisturbed deep-sea sponge aggregations within the site.

The life history traits of sponges mean that Deep-sea sponge aggregations develop over decades or centuries (ICES, 2009; Hogg *et al.,* 2010) and therefore abundance may not easily be restored through management intervention. Activities should look to minimise, as far as is practicable, removal or dislodgement of sponges within the potential extent of Deep-sea sponge aggregations within the site (between 400m and 600m).

For further information on activities capable of affecting Deep-sea sponge aggregations within the site, please see the Advice on Operations workbook.

Function

Functions are ecological processes that include sediment processing, secondary production, habitat modification, supply of recruits, bioengineering and biodeposition. These functions rely on natural supporting processes and the growth and reproduction of sponges, and associated biological communities, and provide a variety of functional roles within it (Bell, 2008).

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 that might typically be provided by Deep-sea sponge aggregations include:

- Nutrition: Sponges filter feed organic matter out of the water column, therefore Deep-sea sponge aggregations are a potentially important link in the flow of nutrients between the pelagic and benthic environment (Maldonado *et al*., 2012; Cathalot *et al.*, 2015). For example, cold-water corals can secrete mucus which becomes a source of dissolved and particulate organic matter (Wild *et al., 20*08). Sponges feed on the organic matter produced by cold-water corals and it is incorporated into sponge tissue, which is then shed and can be consumed by higher trophic levels (Rix *et al., 20*16). This may serve to increase the availability of prey species to predators through enhancement to levels of biological diversity, potentially act as spawning grounds and provide refugia from predators for commercially important fish species;
- Silicon regulation: by providing a long-term sink for silicon (Maldonado *et al.*, 2012, Tréguer and Rocha, 2013); and
- Provision of biochemical and biotechnological products: Sponges and their associated microbes produce a diverse array of chemicals, many of which have been shown to have applications in drug development (Laport *et al.,* 2009; Ebada *et al.*, 2010; Sawadogo *et al.*, 2015; Indraningrat *et al.*, 2016). Sponges may also have wider biotechnological applications (Hogg *et al.*, 2010) e.g. chitin networks from one species of sponge are effective at absorbing uranium contamination (Schleuter *et al.*, 2013). Sponge species typically found in Deep-sea sponge aggregations may also prove to have useful applications in the future.

The natural range of Deep-sea sponge aggregation within the site should be conserved to ensure that the functions they provide support the health of the feature and the provision of ecosystem services to the wider marine environment.

Function within the site

The ecosystem services provided by Deep-sea sponge aggregations in the site could include:

- Nutrition – the Faroe-Shetland Channel supports demersal fish species which are of commercial interest, e.g. Greenland halibut (*Reinhardtius hippoglossoides,* Bullough *et al.,* 1998; Gordon, 2001). The Deep-sea sponge aggregations and associated characteristic communities could help to support these species.

There is no specific data on the contribution that sponges in the site make to the global silicon cycle and the aggregation is not currently exploited for biochemical or biotechnological products.

Given that a recover objective is advised for all but one of the other sub-attributes under structure and function, and that these sub-attributes will be closely coupled with the functional significance of Deep-sea sponge aggregations within the site, JNCC also **advise a recover objective** for this sub-attribute.

For further information on activities capable of affecting Deep-sea sponge aggregations within the site, please see the Advice on Operations workbook.

Attribute: Supporting processes

Objective: Conserve

There is limited evidence to suggest that supporting processes of importance to the conservation of Deep-sea sponge aggregations are being impeded. The exception is the provision of supporting habitat, but this cannot be recovered through human intervention. Therefore, ***JNCC advise a conserve objective.*** *Our confidence in the setting of this objective would be improved with long term monitoring and with better understanding of the tolerance of Deep-sea sponge aggregations to different contaminants. Activities must look to avoid, as far as is practicable, exceeding Environmental Quality Standards and the disruption, obstruction or removal of iceberg plough mark fields within the site (as supporting habitat for Deep-sea sponge aggregations).*

Explanatory notes

Deep-sea sponge aggregations rely on a range of natural supporting processes to support ecological processes (functions) and recovery from any impacts. For the site to fully deliver the conservation benefits set out in the statement on conservation benefits, the following supporting processes must remain largely unimpeded: hydrodynamic regime; supporting habitat; water quality; and sediment quality.

Hydrodynamic regime

Hydrodynamic regime refers to the speed and direction of currents, seabed shear stress and internal and surface wave exposure. These mechanisms circulate larvae and organic material, and influence water properties by distributing dissolved oxygen and transferring it from the surface to the seabed (Hiscock *et al.*, 2004; Mienis *et al.*, 2007; Hosegood and van Haren, 2009; Wagner *et al.*, 2011).

Deep sea sponge aggregations require hydrographic conditions that result in a continuous supply of particulate and dissolved organic matter to the seabed that the sponges can feed on. Deep-sea sponge aggregations are thought to occur near areas where topology leads to the creation of internal waves (Howell *et al*., 2016), which would result in resuspension of food particles. Gamete release in the sponge *Geodia barretti* appears to coincide with phytoplankton blooms (Spetland *et al*., 2007), which suggests that hydrodynamic regime may also influence reproduction of sponges in Deep-sea sponge aggregations.

Hydrodynamic regime within the site

Five different water masses flow and converge within the Faroe-Shetland Channel where this site is located. The North Atlantic Water, Modified North Atlantic Water and Arctic Intermediate/North Icelandic Water masses flow in a north-easterly direction through the channel, while the Norwegian Sea Arctic Intermediate Water and Faroe-Shetland Channel Bottom Water masses flow in a south-westerly direction (Bett, 2012). The Modified North Atlantic Water, Arctic Intermediate/North Icelandic Water and Norwegian Sea Arctic Intermediate Water all occur between 500 and 600 m depth within the site, while the North Atlantic Water is shallower than 500 m and the Faroe-Shetland Channel Bottom Water occurs deeper than 600 m (Bett, 2012). The layering of these water masses which have contrasting characteristics interacts with the continental slope to create internal mixing of the water masses close to the seabed within the site (Bett, 2012; Mckenna *et al.,* 2016).

Current speeds of between 0.05 and 0.3 m s^{-1} have been recorded near the seabed within the site (Jones *et al.*, 2006; BP, 2010). Internal waves, known as solibores, travel up the continental slope near the seabed in the site (Hosegood and van Haren, 2004). The velocities of these waves are over 0.1 m s^{-1} (Hosegood and van Haren, 2004). The internal waves occur intermittently but have a significant impact on sediment transport, resuspending sediment from the seabed and transporting it up the continental slope (Hosegood and van Haren, 2004). The internal mixing of the water masses and internal waves result in ensuring a continual supply of particulate and dissolved organic matter for the Deep-sea sponge aggregations within the site to feed upon. These hydrodynamic conditions may also result in the supply of sponge larvae to parts of the site higher up the slope where sediment type provides appropriate supporting habitat for settlement.

Infrastructure associated with oil and gas extraction is present within the site, and can have an extremely localised effect on hydrodynamic regime. However, there is no evidence to suggest such potential impacts are having an effect on the Deep-sea sponge aggregations within the site. **JNCC therefore advise a conserve objective**. Our confidence in this objective would be improved with better understanding of the hydrodynamic regime within the site and how it has been affected by the installation of infrastructure over time, and its influence on the feature's conservation status.

For further information on activities capable of affecting Deep-sea sponge aggregations within the site, please see the Advice on Operations workbook.

Supporting habitat
The preferred seabed type of Deep-sea sponge aggregations varies between the different subtypes. It is therefore important to conserve the seabed sediment types and sediment distributions within a site, to ensure that there are favourable conditions for new sponge recruits to settle and maintain the spatial distribution of sponges in Deep-sea sponge aggregations.

Supporting habitat within the site
Species of *Geodia* settle on rocky substrates (Cárdenas and Rapp, 2015). Therefore, boreal ostur aggregations tend to develop where coarse sediment and cobbles and boulders are present. Within the site, the action of icebergs moving along the seabed during the last ice age has left ridges of boulders and cobbles, with areas of finer gravel in between (Bett, 2001; Irving, 2009). The resulting seabed feature is referred to as an iceberg plough mark field (also a protected geodiversity feature of the site – see Table 5).

Known records of boreal ostur Deep-sea sponge aggregations in the site are largely associated with these iceberg plough mark fields. Although these are relict features (i.e. the processes that led to the creation of them are no longer actively occurring), Iceberg plough mark fields are sensitive to pressures, such as surface abrasion and subsurface abrasion that are exerted by activities that occur within the site. **JNCC advise a conserve objective**, noting it is not possible to recover the extent and distribution of iceberg plough mark fields as supporting habitat for Deep-sea sponge aggregations. However, activities must look to minimise, as far as is practicable, further disruption, obstruction or removal of iceberg plough mark fields within the site.

For further information on activities capable of affecting Deep-sea sponge aggregations within the site, please see the Advice on Operations workbook.

Water and sediment quality

Contaminants may impact the ecology of a Deep-sea sponge aggregation by having a range of effects on different species within the habitat, depending on the nature of the contaminant (JNCC, 2004a; UKTAG, 2008; EA, 2014). It is important therefore to avoid changing the natural water 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 Standard (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 (EQSs) 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 (<1 cm 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.

There are little data on the impact of aqueous and sediment contaminants on Deep-sea sponge species, therefore no tolerance thresholds have been established for Deep-sea sponge aggregations. The general standards described above apply to this feature until more habitat specific information is available.
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; and
- Charting Progress 1: The State of the UK Seas (2005) & Charting Progress 2: The State of the UK Seas (2014).

Water quality
The water quality properties that influence Deep-sea sponge aggregations include salinity, pH, temperature, suspended particulate concentration, dissolved organic matter, silicate 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. They can influence the abundance, distribution and composition of Deep-sea sponge aggregations and associated communities at relatively local scales. Changes in any of the water quality properties, because of human activities, may impact habitats and the communities they support (Elliot *et al.*, 1998; Little, 2000; Gray and Elliot, 2009). Increased concentrations of fine sediment in the water column can have a negative impact on Deep-sea sponges by blocking feeding structures, reducing other physiological processes and damaging the surface of the sponges by abrasion of larger particles (Bell *et al.*, 2015).

Sponges consume organic matter that they filter out of passing seawater. The diet of sponges includes bacteria and other small planktonic organisms (Yahel *et al*., 2007; Hadas *et al*., 2009; Perea-Blázquez *et al*., 2012; Kahn *et al*., 2015). Sponges may have a preference for particles smaller than 10 µm (Witte *et al*., 1997) but they can feed on larger particles (Frost, 1981; Yahel *et al*., 1998; Ribes *et al*., 1999). Dissolved organic matter is also an important food source for sponges (de Geoji *et al.,* 2008a; de Geoji *et al*., 2008b; van Duyl *et al*., 2008; Rix *et al*., 2017). As a result, deep sea sponge aggregations require a continuous supply of particulate and dissolved organic matter to the seabed. Changes to water quality that reduces the supply of suspended particulate or dissolved organic matter to the sponges may also be detrimental.

It is important therefore to avoid changing the natural water quality of a site as a minimum to ensure compliance with existing EQS as set out above until thresholds specific to Deep-sea sponge aggregations have been identified.

Water quality within the site

Sponges require dissolved silicon to create their skeletons. The presence of *Geodia barretti, G. atlantica* and *G. phlegraei*, which are key species in boreal ostur aggregations, is determined by silicate concentrations near the seabed (Howell *et al*., 2016). There also appears to be a minimum bottom salinity of 34.3 – 34.6‰ below which important boreal ostur species cannot grow (Knuby *et al.*, 2013). G barretti, has an upper temperature tolerance of ~10°C and/or is unable to survive rapid temperature changes (Guihen *et al*., 2012; Howell *et al*., 2016).

The five different water masses that converge within the Faroe-Shetland Channel where this site is located have contrasting characteristics (Bett, 2012; Mckenna *et al.*, 2016). All five water masses have salinity values above the minimum threshold suggested by Knuby *et al.* (2013). The temperature range of the water masses are also all generally below 10°C (Mckenna *et al.*, 2016). The silicate concentration within the North Atlantic Water, Modified North Atlantic Water and the Arctic Intermediate/North Icelandic Water masses is between 2.5 and 7.5 µM l^{-1}, however the colder Norwegian Sea Arctic Intermediate Water and the Faroe-Shetland Bottom Water have higher silicate concentrations, 9.6-12.3 µM l^{-1} (Mckenna *et al.*, 2016).

The concentration of suspended particles and dissolved organic matter in the water column are properties of water quality. There are no site-specific data on the type and quantity of particulate and dissolved organic matter that sponges in the site consume. *G. barretti* exhibits a rapid 86% decline in respiration rate when exposed to a short burst of suspended sediment at a concentration of 100 mg L^{-1} (Tjensvoll *et al.*, 2013). Extended exposure of increased levels of suspended sediments that naturally occur on the seabed had no effect on the respiration rate of *G. barretti,* whereas continued cyclical exposure to crushed rock particles can lead to a permanent decrease in respiration rates within a month (Kutti *et al.*, 2015). Exposure to suspended sediments containing barite, which is found in drilling muds released during oil and gas extraction, have been shown to damage the cells of *G. barretti* (Edge *et al.*, 2016). Recovery from the short-term exposure to increased concentrations of suspended sediments that naturally occur on the seabed can be rapid; *G. barretti* returned to normal respiration rates within four hours (Tjensvoll *et al.*, 2013). However, repeated and long-term exposure may reduce the ability of sponges to grow and reproduce, particularly if the sediment is contaminated or not naturally found within the habitat (Kutti *et al.*, 2015).

Offshore oil and gas extraction occurs within the site, which can result in the release of chemicals, including heavy metals and polyaromatic hydrocarbons, and suspended sediments into the water column (BP, 2010). While this information identifies possible sources of contamination, there is currently no information available to indicate that water quality in the site is falling below EQSs. Indeed, the Charting Progress 2 reports that the open seas are little affected by pollution and levels of monitored contaminants continue to fall, albeit slowly in many cases.

Therefore, **JNCC advise a conserve objective** and that aqueous contaminants must be restricted to comply with water column annual average limits according to the amended environmental quality standards Directive (2013/39/EU) or levels equating to high/good status (Annex V of the Water Framework Directive 2000/60/EC), avoiding deterioration from existing levels. Our confidence in this objective would be improved with longer-term monitoring, a better understanding of contaminant levels in the site and how contaminants can impact the Deep-sea sponge aggregations present.

For further information on activities capable of affecting Deep-sea sponge aggregations within the site, please see the Advice on Operations workbook.

Sediment quality

Studies on shallow water sponges have shown that exposure to contaminants such as Copper or polyaromatic hydrocarbons (PAHs) can have a negative impact on sponges' feeding rates, settlement or survival, however the response varies between different sponge species (Cebrian *et al*., 2006; Cebrian and Uriz, 2007). The impact of a particular contaminant on sponges can be enhanced if other contaminants are also present (Cebrian and Uriz, 2007). Sponges filter large volumes of food particles, therefore even if contaminants do not impact the sponge, chemicals such as Aluminium, Iron, Nickel, Lead, PAHs and poly-chlorinated biphenyls (PCBs) can bioaccumulate within the sponge tissue (Gentric *et al*., 2006). Although impacts of contamination and bioaccumulation have not been studied in deep-water sponges, various contaminants are also likely to affect the species that live in or on Deep-sea sponge aggregations. Bioaccumulation in biogenic habitats can impact colonisation and settlement by mobile and sessile epifauna species sensitive to particular contaminants, (e.g. heavy metals), and lead to accumulation in species at higher trophic levels (Roberts *et al*., 2008; OSPAR, 2009; OSPAR, 2010b; OSPAR, 2012). This 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 until thresholds specific to Deep-sea sponge aggregations have been identified.

Sediment quality within the site

Measurements of total hydrocarbon in the sediment in areas of oil and gas extraction in the west of the site recorded values between 0.5 to 50.7 mg kg^{-1}, although a survey in 2007 recorded values less than 3 mg kg^{-1} (BP, 2010). The upper limit of total hydrocarbons for the wider Atlantic frontier region and Northern North Sea is around 11 mg kg^{-1} (UKOOA, 2001; BP, 2010). The total 2-4 ring polyaromatic hydrocarbons concentration observed within the site are within the range observed in wider regional surveys (BP, 2010). Concentrations of cadmium, chromium, copper, lead and zinc from the west of the site are all below ERL thresholds and the nickel concentration is below the background assessment concentrations (OSPAR, 2009; BP, 2010). However, drill cuttings accumulate around wells within the site (Jones *et al.,* 2006; 2007; 2012) and as these cuttings contain higher concentrations of various chemicals, higher concentrations of contaminants may be found in sediments in these localised areas.

As the current data suggest that contaminant concentrations are below ERL or generally reflect wider regional concentrations, **JNCC advise a conserve objective** and that activities must look to avoid, as far as is practicable, exceeding Environmental Quality Standards set out above. Our confidence in this objective would be improved with long term monitoring and a better understanding of contaminant levels in the site.

For further information on activities capable of affecting Deep-sea sponge aggregations within the site, please see the Advice on Operations workbook.

Table 2. Supplementary advice on the conservation objectives for Offshore subtidal sands and gravels in Faroe-Shetland Sponge Belt NCMPA

Attribute: Extent and distribution
Objective: Conserve ***JNCC advise a conserve objective****, however further information is needed. While evidence indicates that activities are occurring which are capable of affecting the extent and distribution of Offshore subtidal sands and gravels, there is insufficient information available to support a view as to the nature or scale of any impacts. Activities must look to minimise, as far as is practicable, reductions to the extent and distribution of the Offshore subtidal sands and gravels within the site.*
Explanatory notes Extent refers to the total area in the site occupied by Subtidal sedimentary habitats such as Offshore subtidal sands and gravels and must include consideration of their distribution i.e. how spread out they are within a site. A reduction in extent has the potential to alter the biological and physical functioning of Subtidal sedimentary habitat types such as Offshore subtidal sands and gravels (Elliott *et al.,* 1998; Tillin and Tyler-Walters, 2014). The distribution of a habitat influences the component communities present, and can contribute to the health and resilience of the feature (JNCC, 2004b). The extent of the Subtidal sedimentary habitats such as Offshore subtidal sands and gravels within the site must be conserved to their full known distribution. Subtidal sedimentary habitats such as Offshore subtidal sands and gravels are defined by: • ***Sediment composition*** (grain size and type) (e.g. Cooper *et al.,* 2011; Coates *et al.,* 2015; Coates *et al.,* 2016; Coblentz *et al.,* 2015). Some species can inhabit all types of sediment, whereas others are restricted to specific types; and • ***Biological assemblages*** - See JNCC's Marine Habitats Correlation Table for more detail about the range of biological communities (biotopes) that characterise Subtidal sedimentary habitats in the UK marine environment. In offshore environments, note that Subtidal sedimentary habitats are not typically dominated by algal communities. A significant change in sediment composition and/or biological assemblages could indicate a change in the distribution and extent of Subtidal sedimentary habitats such as Offshore subtidal sands and gravels within a site (see UK Marine Monitoring Strategy for more information on significant change). Reduction in extent has the potential to affect the functional roles of the biological communities associated with Subtidal sedimentary habitats such as Offshore subtidal sands and gravels (Elliott *et al.,* 1998; Tillin and Tyler-Walters, 2014) e.g. a change from coarser to finer sediment would alter habitat characteristics, possibly favouring deposit feeders over suspension feeders (Tillin and Tyler-Walters,

2014). Maintaining extent is therefore critical to maintaining or improving conservation status of Subtidal sedimentary habitats such as Offshore subtidal sands and gravels.

Offshore subtidal sands and gravels are more stable than their shallower equivalents, with diverse infaunal communities dominated by polychaetes, hatchet shells and small bivalves. Offshore fine to muddy sands support a variety of tube-building polychaetes, burrowing brittlestars and bivalves, while medium sands support the pea urchin (*Echinocyamus pusillus*) and fine sands host amphipods. Mobile predators present in this habitat include flatfish, starfish, crabs and hermit crabs. On the continental shelf, Offshore subtidal sands and gravels are equivalent to the EUNIS habitats A5.1: Subtidal coarse sediments, A5.2: Subtidal sand, and A5.4: Subtidal mixed sediments, but the Priority Marine Feature also covers deep-water examples of the habitat which occur on or beyond the continental slope in Scotland (Tyler-Walters *et al.,* 2016).

Extent and distribution within the site

The extent and distribution of Offshore subtidal sands and gravels are available to view on JNCC's Interactive MPA Mapper. The site area is calculated to be 5278 km^2. UKSeaMap 2016 predicts that Offshore subtidal sands and gravels occur throughout most of the site (more than 99%), with the exception of patches of deep-sea mud along the south-east boundary and small patches of rock in the north-west corner (JNCC, 2016). There are a large number of records of Offshore subtidal sands and gravels from a range of different surveys using both grabs and videos (e.g. Howell *et al.,* 2007; Bett, 2012; Morris *et al.,* 2014; BGS, 2015). These are relatively evenly distributed across the entire site (see distribution map linked above).

There is evidence from within the site that the deposition of drill cuttings around wells has increased the proportion of finer sediments in a localised area around the wells after drilling, with some change in sediment composition persistent up to ten years after the drilling event has taken place (Jones *et al.,* 2006; Jones *et al.,* 2007; Jones *et al.,* 2012). There is however no data available to determine if the increase in the fine sediment fraction is sufficient to change the habitat type from Offshore subtidal sands and gravels to muds, thereby modifying the extent and distribution of the feature.

JNCC therefore advise a conserve objective however further information is needed. While evidence indicates that activities are occurring which are capable of affecting the extent and distribution of Offshore subtidal sands and gravels, there is insufficient information available to support a view as to the nature or scale of any impacts. Activities must look to minimise, as far as is practicable, reductions to the extent and distribution of the Offshore subtidal sands and gravels within the site.

For further information on activities capable of affecting Offshore subtidal sands and gravels within the site, please see the Advice on Operations workbook.

Attribute: Structure and function

Objective: Recover

JNCC understands that the Offshore subtidal sands and gravels within the site have been subjected to activities that may have resulted in a change to the structure and function of the protected feature, specifically the characteristic communities and consequently function. As such, ***JNCC advise a recover objective*** *which is based on expert judgement; specifically, our understanding of the feature's sensitivity to pressures exerted by the activities present. Our confidence in this objective would be improved with longer-term monitoring of the condition of the characteristic biological communities of Offshore subtidal sands and gravels within the site. Activities must look to minimise, as far as is practicable, further changes in substrata and biological communities within the site.*

Explanatory notes

Structure refers to the physical structure of a Subtidal sedimentary habitat such as Offshore subtidal sands and gravels and its biological structure. Physical structure refers to finer scale topography and sediment composition. Biological structure refers to the key and influential species and characteristic communities present.

Physical structure: Finer scale topography

The topography of Subtidal sedimentary habitats such as Offshore subtidal sands and gravels may be characterised by features, such as mega-ripples, banks and mounds, which are either formed and maintained by ongoing hydrodynamic processes (active bedforms) or the result of long since passed geological processes (relict bedforms). As these bedforms support different sedimentary habitats and associated communities compared to the surrounding seabed, it is important that they are conserved (Elliott *et al.,* 1998; Barros *et al.,* 2004; Limpenny *et al.,* 2011). Recovery of active bedforms is likely, so long as the prevailing hydrodynamic regime remains largely unimpeded. However, the reverse is true with regards to relict bedforms.

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

The site includes several relict sedimentary topographical features: iceberg plough mark fields; prograding wedges; and slide deposits as well as active sedimentary topographic features: sediment wave fields and sand wave fields. These are also recognised as protected geodiversity features within the site (see Table 5).

While evidence indicates that activities are occurring which are capable of affecting some of the relict sedimentary topographical features such as iceberg plough marks, it is not feasible to recover reflect sedimentary topographical features once impacted through management intervention.

The active sedimentary topographical features are maintained by hydrodynamic processes and so may well change naturally over time. Pressures such as a physical change to another seabed type or artificial changes to topography may cause localised disruption to flow (and associated patterns of sediment transport) that could result in the loss of function of the feature in the immediate vicinity of the obstruction. There is increasing interest in the site for oil and gas exploration activities and such activity may have already affected the function of these features (although direct evidence of such impacts is not available). JNCC are uncertain as to whether any localised hydrodynamic changes may be taking place, for instance as a result of the installation of infrastructure associated with oil and gas extraction, which may have or be hampering the maintenance of the active sedimentary topographical features.

Overall, a **conserve objective is therefore advised**. Our confidence in the condition of the sedimentary topographical features would be improved by longer term monitoring. Activities should avoid the deposition of artificial substrata in areas where sediment and sand wave fields have been recorded or activities that lead to disruption, obstruction or removal of the relict geodiversity features.

For further information on activities capable of affecting Offshore subtidal sands and gravels within the site, please see the Advice on Operations workbook.

Physical structure: Sediment composition

On the continental shelf, sediment composition is highly dependent on the prevailing hydrodynamic regime. Coarser sediments tend to dominate in high energy environments that are subject to strong prevailing currents. Conversely, finer sedimentary habitats are typically associated with lower energy environments. However, storm conditions can mobilise all sediment types, including the coarser fractions, most notably in shallower waters (Green *et al.,* 1995).

In deeper waters, bottom currents may impact sediment composition through erosional and depositional processes (Sayago-Gil *et al.,* 2010). The continental shelf edge and upper continental slope (>200 m) have been shown to be impacted by currents, influencing sediment composition by depositing finer particles in deeper waters (Hughes, 2014). Indeed, mud content can increase exponentially with depth as hydrodynamic influence is reduced (Bett, 2012).

As sediment composition may be a key driver influencing biological community composition it is important that natural sediment composition is conserved (Cooper *et al.,* 2011; Coates *et al.,* 2015; Coates *et al.,* 2016; Coblentz *et al.,* 2015).

Physical structure: Sediment composition within the site

The Offshore subtidal sands and gravels within the site include areas of mixed sediment, coarse sediment and sand and muddy sand. The modelled habitat map, UKSeaMap 2016, predicts that just under 80% of the area of Offshore subtidal sands and gravels is mixed sediment. This sediment type occurs along the whole length of the site and at all depth ranges (JNCC, 2016). Sediment samples from areas predicted to be mixed sediment indicate average grain sizes of 20.6 ± 15.20%, 50.2 ± 20.88% and 29.3 ± 17.90%, for gravel, sand and silt/clay fractions respectively (BGS, 2015). Patches of coarse sediment are predicted to occur higher up the slope in the western parts of the site (UKSeaMap 2016; JNCC, 2016). The average composition of the coarse sediment is 25.5 ± 18.57% gravel, 71.0 ± 18.50% sand and 3.5 ± 2.43% silt/clay (BGS, 2015). UKSeaMap 2016 predicts areas of sand in the east of the site and strips of muddy sand in the deepest and shallowest parts of the site. Average grain sizes for the sand and muddy sand sections of Faroe-Shetland Sponge Belt NCMPA are 1.5 ± 1.67% for gravel, 87.3 ± 5.73% for sand and 11.1 ± 5.49% for silt/clay (BGS, 2015). Generally, the fine fraction in sediment samples tend to increase with depth down the continental slope in the site (Bett, 2012; Jones *et al.,* 2012).

The site includes iceberg ploughmark fields. In these fields, icebergs moving along the seabed during the last ice age have left ridges of boulders and cobbles on the seabed, with areas of finer gravel in-between (Bett, 2001; Irving, 2009). The processes that create the iceberg plough mark fields are no longer occurring, therefore if the fine scale distribution of sediments within the iceberg plough mark fields are disrupted it will not naturally recover.

There is direct evidence from within the site that the deposition of drill cuttings around wells has changed the seabed sediment from coarse to fine within ~250 m of a well immediately after drilling (Jones *et al.,* 2006; Jones *et al.,* 2007). Three years after drilling the area around the well where drill cuttings are visible on the seabed declined by ~85%; after ten years, there is further reduction but some change in sediment composition is still visible ten years after the drilling event (Jones *et al.,* 2012). Pipelines and other infrastructure associated with oil and gas extraction occur within the mapped extent of Offshore subtidal sands and gravels, primarily in the centre of the site and the south west corner. The installation of these infrastructure may have continuing effects on sediment composition.

JNCC advise a recover objective for Offshore subtidal sands and gravel sediment composition which is based on expert judgment; specifically, published scientific research from drilling events within the site and our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities. Activities must look to minimise, as far as is practicable, further disturbance and changes to sediment composition and distribution within the site. Our confidence in this objective would be improved with longer-term monitoring.

For further information on activities capable of affecting Offshore subtidal sands and gravels within the site, please see the Advice on Operations workbook.

Biological structure: Key and influential species

Key and influential species are those that have a core role in determining the structure and function of Subtidal sedimentary habitats such as Offshore subtidal sands and gravels. For example, bioturbating species (animals that forage and burrow tunnels, holes and pits in the seabed) help recycle nutrients and oxygen between the seawater and the seabed supporting the organisms that live within and on the sediment. Grazers, surface borers, predators or other species with a significant functional role linked to the Subtidal sedimentary habitats such as Offshore subtidal sands and gravels can also be classed as a key or influential species. Changes to the spatial distribution of communities could indicate changes to the overall feature and as a result how it functions (JNCC, 2004b). It is important to conserve the key and influential species of a site to avoid diminishing biodiversity and the ecosystem functioning provided by the protected Subtidal sedimentary habitats such as Offshore subtidal sands and gravels, and to support their conservation status (JNCC, 2004b; Hughes *et al.,* 2005).

Due to the prevailing influence of the hydrodynamic regime, higher energy, coarser sedimentary habitats show greater recovery potential following impact than lower energy, finer sedimentary habitats (Dernie *et al.,* 2003). Recovery of the feature is thought to be largely dependent on the scale of the disturbance and action of remaining key and influential species, such as burrowers. However, recovery of the communities associated with Subtidal sedimentary habitats such as Offshore subtidal sands and gravels also depends on the life-history traits of the species themselves (e.g. their growth rate, longevity) and their interactions with other species, including predators and prey. Furthermore, the environmental connectivity between populations or species patches, the suitability of the habitat (e.g. substrate type), depth, water and sediment quality will also influence the recovery potential of Subtidal sedimentary habitats such as Offshore subtidal sands and gravels (Mazik *et al.,* 2015).

Biological structure: Key and influential species of the feature within the site

Various species of grazers, bioturbators and predators have been recorded in the site. This includes sea urchins, (particularly *Cidaris cidaris*), brachiopods, sea cucumbers (*Parastichopus tremulus*), polychaete worms (e.g. tube building *Sepulidae, Paramphinome jeffreysii*), peanut worms (*Golfingia sp.*), squat lobster (*Munida* sp.) and starfish (*Asterias rubens*). Ocean quahog has also been recorded within the site (see Table 3). It is possible that these species play a critical role in maintaining the structure and functioning of Offshore subtidal sand and gravels habitats within the site. However, no further information is currently available to draw such conclusions with any degree of certainty.

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 habitat. Therefore, it is not possible to set an objective for this particular sub-attribute and it is not considered relevant at this current time.

Biological structure: Characteristic communities

The variety of biological 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, such as those covering large areas, and notable communities, such as those that are nationally or locally rare or scarce, listed as OSPAR threatened and/or declining, or known to be particularly sensitive to anthropogenic activities.

Biological communities within Subtidal sedimentary habitats such as Offshore subtidal sands and gravels vary greatly depending on location, sediment type and depth, as well as other physical, chemical and biological processes. Burrowing bivalves and infaunal polychaetes thrive in coarse sedimentary habitats where the sediment is well-oxygenated with animals, such as hermit crabs, flatfish and starfish, living on the seabed. In deeper and more sheltered areas, the effects of wave action and prevailing currents may be diminished, resulting in finer sedimentary habitats where burrowing species may have a key role to play in maintaining the biological diversity of the habitat.

Changes to the spatial distribution of biological communities across a Subtidal sedimentary habitat such as Offshore subtidal sands and gravels could indicate changes to the overall feature (JNCC, 2004b). It is therefore important to conserve the natural spatial distribution, composition, diversity and abundance of the main characterising biological communities of the Subtidal sedimentary habitats within a site to avoid diminishing biodiversity and ecosystem functioning within the habitat and to support its health (JNCC, 2004b; Hughes *et al.,* 2005).

Similar to the biological structure of key and influential species, the recovery of characterising species' function is dependent on the influence of prevailing environmental conditions, life-history traits and interactions between species, with environmental connectivity between populations or species patches, the suitability of the habitat (e.g. substrate type), depth, water and sediment quality further influencing the recovery potential of Subtidal sedimentary habitats such as Offshore subtidal sands and gravels (Mazik *et al.,* 2015).

Biological structure: Characteristic communities of the feature within the site
Two broad characteristic communities have been recorded in the site (Bett, 2012). These are broadly defined by the families of polychaete worms present:

- Spionidae – Capitellidae - Syllidae in Atlanto-Arctic sand and muddy sand (300-600 m) – Characterised by species of polychaetes from the families: Spionidae, Capitellidae, Terebellidae and Oweniidae, and distinguished from other biotopes in the region by the abundance of the Syllidae. The biotope was generally found in parts of the site shallower than 600 m where the sediment is coarser and the water temperature is highly variable.
- Cirratulidae – Maldanidae – Maldanidae in Arctic sand and muddy sand (600-1200 m) – Cirratulidae, Maldanidae, Amphinomidae, Terebellidae, and Spionidae polychaete families characterise this biotope. High abundances of Maldanidae distinguish the biotope from other biotopes identified in the region. This biotope occurs in deeper parts of the site where the water temperature is more stable and the sediment has a higher silt content.

The community composition within the site changes with depth down the continental slope (Howell *et al.,* 2007; Bett, 2012; Jones *et al.,* 2012). Reductions in abundance and diversity of benthic species have been observed around wells in the site following drilling events (Jones *et al.,* 2006; Jones *et al.,* 2007), partial recovery occurs between 3 and 10 years after the drilling but some species are still reduced or missing from the community (Jones *et al*, 2012). Impact of disturbance is lower for predators or detritovores which can feed on carcasses, than for filter feeders, recovery is also more rapid for mobile species than sessile ones (Jones *et al.,* 2006; Jones *et al.,* 2007; Jones *et al.,* 2012). In addition, demersal trawling occurs over the Offshore subtidal sands and gravels feature along the length of the site between around 500 and 600 m depth (Marine Scotland, 2017).

Bottom-contact fishing practices are capable of affecting the characteristic communities of Offshore subtidal sands and gravels within the site through removal or damage/mortality from abrasion pressures.

Overall, a **recover objective is advised** based on expert judgement; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities. Our confidence in this objective would be improved with longer-term monitoring of the condition of the characteristic biological communities of Offshore subtidal sands and gravels within the site.

For further information on activities capable of affecting Offshore subtidal sands and gravels within the site, please see the Advice on Operations workbook.

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. the key and influential species and characteristic communities present. 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 that may be provided by Subtidal sedimentary habitats such as Offshore subtidal sands and gravels include:

- Nutrition: Different sediment types offer habitat for various commercial species, which in turn are prey for larger marine species, including birds and mammals (FRS, 2017);
- Bird and whale watching: Foraging seals, cetaceans and seabirds may also be found in greater numbers near some Subtidal sedimentary habitats due to the common occurrence of prey for the birds and mammals (e.g. Daunt *et al.*, 2008; Scott *et al.*, 2010; Camphuysen *et al.*, 2011; McConnell *et al.*, 1999, Jones *et al.*, 2013); and

- Climate regulation: Providing a long-term sink for carbon within sedimentary habitats.

Similar to the biological structure of key and influential species and characterising species, function is dependent on the influence of prevailing environmental conditions, life-history traits and interactions between species: environmental connectivity between populations or species patches, the suitability of the habitat (e.g. substrate type), depth, water and sediment quality further influencing the recovery potential of Subtidal sedimentary habitats (Mazik *et al.*, 2015). It is critical to ensure that the extent and distribution of Subtidal sedimentary habitats within a site, along with the composition of any key and influential species and characteristic biological communities, are conserved to ensure the functions they provide are maintained.

Function within the site

The ecosystem services provided by Offshore subtidal sands and gravels in the site could include:

- Nutrition – the Faroe-Shetland Channel supports demersal fish species which are of commercial interest, e.g. Greenland halibut (*Reinhardtius hippoglossoides,* Bullough *et al.,* 1998; Gordon, 2001). The offshore subtidal sands and gravel communities could help to support these species.
- Bird and whale watching - There are enhanced feeding conditions for cetaceans within the wider Faroe-Shetland Channel and it is thought to be an important migratory pathway for certain cetacean species, e.g. fin and sei whales (Stone, 1988; Weir et al., 2001; Swift *et al*., 2002; Hastie *et al.,* 2003; Macleod, 2004; Macleod *et al*., 2006). The offshore subtidal sands and gravel communities could help to support their prey species.
- Climate regulation - sedimentary habitats provide a long-term carbon sink (Alonso et al., 2012), so are important for climate regulation.

Given that a recover objective is advised for the characteristic biological communities on which these functions are dependent, **JNCC also advise a recover objective** for this sub-attribute. Our confidence in this objective would be improved with longer-term monitoring of the condition of the characteristic biological communities of Offshore subtidal sands and gravels within the site and the role that such communities play in mediating the delivery of the ecosystem services identified.

For further information on activities capable of affecting the Offshore subtidal sands and gravels within the site, please see the Advice on Operations workbook.

Attribute: Supporting processes

Objective: Conserve

There is limited evidence to suggest that supporting processes are being impeded with respect to supporting the function of Offshore subtidal sands and gravels within the site. As such, ***JNCC advise a conserve objective*** *which is based on expert judgment, specifically our understanding of the feature's sensitivity to pressures associated with ongoing activities. 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, exceeding Environmental Quality Standards set out below.*

Explanatory notes

Subtidal sedimentary habitats such as Offshore subtidal sands and gravels and the communities they support rely on a range of natural processes to support function (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 (hyperlink is provided in the box at the top of this document), the following natural supporting processes must remain largely unimpeded - Hydrodynamic regime and 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 resources and propagules, as well as influence water properties by distributing dissolved oxygen, and facilitate 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 and sorting of sediment particles. Shape and surface complexity within Subtidal sedimentary habitat types can be influenced by hydrographic processes, supporting the formation of topographic bedforms (see finer scale topography). Typically, the influence of hydrodynamic regime on Subtidal sedimentary habitats such as Offshore subtidal sands and gravels is less pronounced in deeper waters, although contour-following currents (e.g. on the continental slope) and occasional episodes of dynamic flows can occur (Gage, 2001).

Hydrodynamic regime within the site

Five different water masses converge into the Faroe-Shetland Channel where this site is located. The North Atlantic Water, Modified North Atlantic Water and Arctic Intermediate/North Icelandic Water masses flow in a north-easterly direction through the channel, while the Norwegian Sea Arctic Intermediate Water and Faroe-Shetland Channel Bottom Water masses flow in a south-westerly direction (Bett, 2012). The layering of these water masses which have contrasting characteristics interacts with the continental slope to create internal mixing of the water masses close to the seabed within the Faroe-Shetland Sponge Belt NCMPA (Bett, 2012; Mckenna *et al.,* 2016).

Current speeds of between 0.05 to 0.3 m s^{-1} have been recorded near the seabed within the site (Jones *et al.*, 2006; BP, 2010). Internal waves, known as solibores, travel up the continental slope near the seabed in the Faroe-Shetland sponge Belt NCMPA (Hosegood and van Haren, 2004). The velocities of these waves are over 0.1 m s^{-1}. The internal waves occur intermittently but have a significant impact on sediment transport, resuspending sands and gravels on the seabed and transporting them up the continental slope (Hosegood and van Haren, 2004).

Infrastructure associated with oil and gas extraction are present within the mapped extent of the feature, and there is likely to be continuing interest in oil and gas extraction in the future. The presence of this infrastructure can have an extremely localised effect on the hydrodynamic regime within the site, it is not thought to have an adverse impact on the conservation status of the Offshore subtidal sand and gravels feature. As such, **JNCC advise a conserve objective** for this sub-attribute. This is based on expert judgment, specifically our understanding of the feature's sensitivity to pressures associated with ongoing activities. Our confidence in this objective would be improved with a better understanding of the hydrodynamic regime within the site and its influence on the feature's conservation status.

For further information on activities capable of affecting the Offshore subtidal sands and gravels within the site, please see the Advice on Operations workbook.

Water and sediment quality

Contaminants may affect the ecology of Subtidal sedimentary habitats through a range of effects on different species within the habitat, depending on the nature of the contaminant (JNCC, 2004b; UKTAG, 2008; EA, 2014). It is therefore important to avoid changing the natural water quality and sediment quality in a site and, as a minimum, ensure compliance with existing Environmental Quality Standards (EQSs).

The targets listed below for water and sedimentary contaminants in the marine environment and are based on existing targets within OSPAR or the Water Framework Directive (WFD) that require concentrations and effects to be kept within levels agreed in the existing legislation and international commitments as set out in The UK Marine Strategy Part 1: The UK Initial Assessment (2012). Aqueous contaminants must comply with water column annual average (AA) EQSs according to the amended EQS Directive (2013/39/EU) or levels equating to (High/Good) Status (according to Annex V of the WFD (2000/60/EC), avoiding deterioration from existing levels).

Surface sediment contaminants (<1 cm 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 Quality Status Report (OSPAR, 2010b) and associated QSR Assessments.

The following sources of information are available 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 from the British Geological Survey website; and
- Charting Progress 1: The State of the UK Seas (2005) & Charting Progress 2: The State of the UK Seas (2014).

Water quality

The water quality properties that influence the communities living in or on Subtidal sedimentary habitats such as Offshore subtidal sands and gravels 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. In deeper waters, dissolved oxygen levels are generally lower due to stratification of the water column and the isolation of bottom water masses (Greenwood *et al.,* 2010). Salinity also increases with depth, peaking about 50 m down, after which the salinity decreases with increasing depth to a minimum around 1000 m in North Atlantic waters (Talley, 2002).

Water quality can influence habitats and the communities they support by affecting the abundance, distribution and composition of communities at relatively local scales (Elliott *et al.,* 1998; Little, 2000; Gray and Elliott, 2009). For example, a prolonged increase in suspended particulates can also have several implications, such as affecting fish health, clogging filtering organs of suspension feeding animals and affecting seabed sedimentation rates (Elliott *et al.,* 1998). Low dissolved oxygen can also have sub-lethal and lethal impacts on fish, infauna and epifauna (Best *et al.,* 2007). Conditions in the deep-sea are typically more stable than in shallower habitats, therefore deep-sea organisms are expected to have a lower resilience to changes in abiotic conditions (Tillin *et al.,* 2010). Concentrations of contaminants in the water column must not exceed EQS.

Water quality within the site

The five different water masses that flow through the site have contrasting characteristics (adapted from Bett, 2012; Mckenna *et al.*, 2016):

	Temperature (°C)	Salinity (ppt)	Phosphate (µM L^{-1})	Nitrate (µM L^{-1})	Silicate (µM L^{-1})
North Atlantic Water	>8	35.35 - 35.45	0.6 - 1.1	9 - 16	2.5 - 7.5
Modified North Atlantic Water	6.5 - 8	35.1 - 35.3	0.6 - 1.1	9 - 16	2.5 - 7.5
Arctic Intermediate/North Icelandic Water	2 - 5.5	34.76 - 34.99	0.85 - 0.97	12.1 - 13.2	5.8 - 7.3
Norwegian Sea Arctic Intermediate Water	0.5 - -0.5	34.89 - 34.91	0.9 - 1.1	13.2 - 14.9	9.6 - 12.3
Faroe-Shetland Channel Bottom Water	< -0.5	34.91	0.8 - 1.1	9.6 - 14.8	11.77

The properties of the water masses influence the spatial distribution of the characterising communities within the site. In shallower parts of the site, where the North Atlantic Water, Modified North Atlantic Water and Arctic Intermediate/North Icelandic Water masses are present at the seabed, there is more mixing and the temperature of the water is highly variable. This leads to communities typical of Atlanto-Arctic Bathyl Sand (Bett, 2012). The Norwegian Sea Arctic Intermediate Water and Faroe-Shetland Channel Bottom Water are in contact with the sea-bed sediments in parts of the site below 600 m, here the water temperature is colder and much more stable. The two deeper water masses result in Arctic bathyl muddy sand communities (Bett, 2012)

Offshore oil and gas extraction occurs within the site, which can result in the release of chemicals, including heavy metals and polyaromatic hydrocarbons, and suspended sediments into the water column (BP, 2010). While this information identifies possible sources of contamination, there is currently no information available to indicate that water quality in the site is falling below EQSs. Indeed, the Charting Progress 2 reports that the open seas are little affected by pollution and levels of monitored contaminants continue to fall, albeit slowly in many cases. Therefore, **JNCC advise a conserve objective** and that aqueous contaminants must be restricted to comply with water column annual average limits according to the amended environmental quality standards Directive (2013/39/EU) or levels equating to high/good status (Annex V of the Water Framework Directive 2000/60/EC), avoiding deterioration from existing levels.

For further information on activities capable of affecting the Offshore subtidal sands and gravels within the site, please see the Advice on Operations workbook.

Sediment quality

Various contaminants are known to affect the species that live in or on the surface of Subtidal sedimentary habitats such as Offshore subtidal sands and gravels. These include heavy metals like mercury, arsenic, zinc, nickel, chromium and cadmium, polyaromatic hydrocarbons, polychlorinated biphenyls, organotins (such as TBT) and pesticides (such as hexachlorobenzene). These metals and compounds can impact species sensitive to contaminants, degrading the community structure (e.g. heavy metals) and bioaccumulate within organisms thus entering the marine food chain (e.g. polychlorinated biphenyls) (OSPAR, 2009; 2010; 2012). The biogeochemistry of mud habitats in particular is such that the effects of contaminants are greater (Sciberras *et al.,* 2016) leading in some cases to anoxic or intolerant conditions for several key and characterising species and resulting in a change to species composition. It is therefore important to ensure sediment quality is maintained by avoiding the introduction of contaminants and as a minimum ensure compliance with existing EQS as set out above, particularly in mud habitats.

Sediment quality within the site

Measurements of total hydrocarbon in the sediment in areas of oil and gas extraction in the site recorded values between 0.5 to 50.7 mg kg^{-1}, although a survey in 2007 only recorded values less than 3 mg kg^{-1} (BP, 2010). The upper limit of total hydrocarbons for the wider Atlantic frontier region and Northern North Sea is around 11 mg kg^{-1} (UKOOA, 2001; BP, 2010). The total 2-4 ring polyaromatic hydrocarbons concentration observed within the site are within the range observed in wider regional surveys (BP, 2010). Concentrations of cadmium, chromium, copper, lead and zinc from the west of the site are all below ERL thresholds and the nickel concentration is below the background assessment concentrations (OSPAR, 2009; BP, 2010). However, drill cuttings accumulate around wells within the site (Jones *et al.*, 2006; 2007; 2012), and as these cuttings contain higher concentrations of various chemicals, higher concentrations of contaminants may be found in sediments in these localised areas.

As the current data suggest that contaminant concentrations are below ERL or generally reflect wider regional concentrations, **JNCC advise a conserve objective** and that activities must look to avoid, as far as is practicable, exceeding Environmental Quality Standards set out above. Our confidence in this objective would be improved with long term monitoring and a better understanding of contaminant levels in the site.

For further information on activities capable of affecting the Offshore subtidal sands and gravels within the site, please see the Advice on Operations workbook.

Table 3. Supplementary advice on the conservation objectives for Ocean quahog (*Arctica islandica*) aggregations in Faroe-Shetland Sponge Belt NCMPA

Attribute: Extent and distribution
Objective: Conserve *The feature is exposed to activities associated with pressures to which Ocean quahog aggregations are considered to be sensitive. Despite this,* ***JNCC advises a conserve objective*** *acknowledging the substantial uncertainty around the ability of any site-based measures to support restoration of the feature within the site and in light of wider environmental impacts such as climate change and the feature's limited capacity to recruit or reproduce as described in the explanatory notes. Activities should look to minimise, as far as is practicable, disturbance to individuals that may result in a change to the extent and distribution of Ocean quahog aggregations within the site. Our confidence in the setting of this objective would be improved by a better understanding of the distribution of Ocean quahog aggregations throughout the site and monitoring of their condition.*
<u>Explanatory notes</u> Extent describes the occurrence of *Arctica islandica aggregations* (herein referred to as Ocean quahog aggregations), with distribution providing a more detailed overview of the species location(s) and pattern of occurrence within a site. It is important to consider the life histories and environmental preferences of the species as this will have a strong influence on extent and distribution. Ocean quahog is found around all British and Irish coasts, as well as offshore. The species has also been recorded from the Baltic, Iceland, the Faroe Islands, Onega Bay in the White Sea to the Bay of Biscay and from Labrador to North Carolina (Tyler-Walters and Sabatini, 2017). Benthic surveys have shown a reduction in North Sea distribution between 1902-1986 (Rumohr *et al.,* 1998). The same surveys also show a reduction in species abundance between 1972-1980 and 1990-1994. It is thought that UK waters are likely to be a sink of new recruits, with larval settlement events originating from Iceland separated by long periods without successful recruitment (Witbaard and Bergman, 2003). These recruits are thought to be carried down the east coast of the UK and into the mid and southern North Sea where the slower moving waters inside gyres allow settlement to occur. Temperature is also thought to play an important role in the successful recruitment of Ocean quahog, with increasing temperatures attributed as the cause of low recruitment success in North Sea populations (Witbaard and Bergman, 2003). As the seas around the UK warm, it is expected that southerly populations of Ocean quahog may experience increased recruitment failure resulting in a range contraction. Recovery of the feature within a site is therefore likely to be reliant on an infrequent and unpredictable supply of recruits from elsewhere and highly dependent on wider environmental pressures, such as climate change.

As a burrowing species, extent and distribution of supporting habitats will be important in governing the extent and distribution of the species. Ocean quahog has been found in a range of sediments, from coarse clean sand to muddy sand in a range of depths typically from 4 m to 482 m deep, but most commonly between 10 m to 280 m (Thorarinsdóttir and Einarsson, 1996; Sabatini *et al.,* 2008; OSPAR, 2009; Tyler-Walters and Sabatini, 2017). Ocean quahog is thought to have a high sensitivity to physical loss of habitat (Tyler-Walters and Sabatini, 2017). It is therefore important to conserve the extent and distribution of supporting habitats to provide the best chance of any potential settlement for new recruits and to retain existing individuals.

Extent and distribution within the site

Extent and distribution of Ocean quahog aggregations within the site are available to view on JNCC's Interactive MPA Mapper. To date, all records of Ocean quahog collected between 1998 and 2000 have been from the western corner of the site, where the water depth is less than 600m. Based on what is known about the habitat preferences of Ocean quahog (Witbaard and Bergman, 2003) the full extent of the site is considered suitable for Ocean quahog colonisation, however various surveys across the rest of the site have not located Ocean quahog. As a result, there is no information to suggest that the species does occur elsewhere within the site.

Offshore infrastructure such as oil platforms and pipelines which occur within the site could impact the extent and distribution of Ocean quahog aggregations. The Ocean quahog records within the site were found during environmental surveys associated with oil and gas extraction and records occur within 50m of associated infrastructure. Such installation practices often result in physical damage, smothering and mortality through the introduction of concrete mattresses, cuttings piles and rock dump. This type of activity has the potential to reduce or alter the extent and distribution of Ocean quahog aggregations within the site.

The feature is being exposed to activities associated with pressures to which Ocean quahog aggregations are considered to be sensitive and that this may be impacting the feature's extent and distribution. Despite this, **JNCC advises a conserve objective** acknowledging the substantial uncertainty around the ability of any site-based measures to support restoration of the feature within the site and in light of wider environmental impacts such as climate change and the feature's limited capacity to recruit/reproduce. Activities should look to minimise, as far as is practicable, a change in substrata that may result in a reduction to the natural extent of the Ocean quahog's supporting habitat within the site.

For further information on activities capable of affecting Ocean quahog aggregations, please see the Advice on Operations workbook.

Attribute: Structure and function

Objective: Conserve

The feature is exposed to activities associated with pressures to which Ocean quahog aggregations are considered to be sensitive. Despite this, ***JNCC advises a conserve objective*** *acknowledging the substantial uncertainty around the ability of any site-based measures to support restoration of the feature within the site and in light of wider environmental impacts such as climate change and the feature's limited capacity to recruit or reproduce as described in the explanatory notes. Activities should look to minimise, as far as is practicable, disturbance to individuals within the site. Our confidence in the setting of this objective would be improved by long-term monitoring information on the population of Ocean quahog aggregations throughout the site.*

Explanatory notes

Structure

Structure refers to the densities and age classes of individuals from a population found within a site. Ocean quahog are more prevalent in the northern North Sea than the southern North Sea. Recorded Ocean quahog densities typical in the North Sea are outlined in the table below.

Ocean quahog / m^2	Geographic location	Sampling method	Reference
Northern North Sea		Box coring	De Wilde *et al.* (1986)
12	Central Fladen grounds		
286	Northern Fladen	Triple D-dredge	Witbaard and Bergman (2003)
23	Southern Fladen		
Southern North Sea			
0.07	Oyster grounds		
0.14-0.17	North of Dogger Bank		
0.35	Central Oyster ground		

The structure of Ocean quahog populations tends to be highly skewed in the North Sea, with populations containing either adults or juveniles, as opposed to representatives of both age classes (AquaSense, 2001; Witbaard and Bergman, 2003; OSPAR, 2009). Sporadic recruitment and the detrimental effect of increasing temperature on juveniles is expected to have a significant effect on successful Ocean quahog recruitment. Recovery of a population within a site is likely to be reliant on an infrequent supply of recruits from elsewhere and the influence of wider environmental temperature changes brought about by climate change.

It is important to note that distinguishing between adult and juvenile Ocean quahog is difficult without in-depth analysis of shell growth, and that individuals of similar size may vary greatly in age. For example, individuals ranging from 50-179 years old showed little discernible difference in mean length (Ropes and Murawski, 1983). However, what is known is that growth rates are relatively fast during the juvenile stage between 3-7 years of age but slow down after 15 years (Thompson *et al.,* 1980; Cargnelli *et al.,* 1999; Tyler-Walters and Sabatini, 2017). Both sexes have highly variable shell lengths at sexual maturity, between 24 mm and 49 mm reported (Thompson *et al.,* 1980; Cargnelli *et al.,* 1999). Shell length is therefore not a reliable indicator of age for this species.

Recovery of Ocean quahog populations is hard to monitor and likely to be extremely slow (over centuries) due to the long-lived (up to 507 years recorded; Brix, 2013), slow-growing, low density, irregularly recruiting, high juvenile mortality and low fecundity of the species (Ridgeway and Richardson, 2010; Butler *et al*., 2012). For the UK, this is compounded by the fact that any recovery would likely be dependent on a supply of recruits from elsewhere. It is therefore important that the number and age class of individuals is conserved in the long-term to maintain the population within the site.

Structure within the site

There are 17 records of Ocean quahog within the site. There is no information available on the numbers and ages of the individuals found. As a result, it is not possible to determine density of the species or any changes in abundance over time. The age structure, growth rates and reproductive viability of the population located within the site are also currently unknown.

JNCC acknowledge the significant effect of prevailing sea temperatures on the likely survivorship and recruitment potential of Ocean quahog aggregations (Cargnelli *et al.*, 1999; Witbaard and Bergman, 2003; Tyler-Walters and Sabatini, 2017), and the reported widespread declines in the abundance of this species throughout the North Sea (Rumohr *et al*., 1998).

The feature is being exposed to activities associated with pressures to which Ocean quahog aggregations are considered to be sensitive and that this may be impacting the feature's structure and function. Despite this, **JNCC advises a conserve objective** acknowledging the substantial uncertainty around the ability of any site-based measures to support restoration of the feature within the site and in light of wider environmental impacts such as climate change and the feature's limited capacity to recruit/reproduce. Activities should look to minimise, as far as is practicable, disturbance to individuals within the site. Our confidence in the setting of this objective would be improved by long-term monitoring information on the population of Ocean quahog aggregations throughout the site.

For further information on activities capable of affecting Ocean quahog aggregations, please see the Advice on Operations workbook.

Function

Functions are ecological processes that include sediment processing, secondary production, habitat modification, supply of recruits, bioengineering and biodeposition. These functions rely on supporting natural processes and the growth and reproduction of Ocean quahog. These functions can occur at several temporal and spatial scales and help to maintain the provision of ecosystem services locally and to the wider marine environment (ETC, 2011).

Ecosystem services that may be provided by Ocean quahog include:

- Nutrition: Providing food for a broad range of fish and invertebrate species, including commercially important fish species, e.g. cod and haddock (Brey *et al.,* 1990; Rees and Dare, 1993; Cargnelli *et al.,* 1999);
- Regulatory processes: Providing a bentho-pelagic link by removing plankton and detritus from the water column;
- Scientific study: Ocean quahog longevity enables the construction of 'master chronologies' over hundreds of years to study climatic and environmental change (Butler *et al.*, 2012; Schöne, 2013). Ocean quahog also provide a key role in ageing research, and are an indicator of heavy metal pollution in sediments and historical environmental change (Weidman *et al.*, 1994; Zettler *et al.*, 2001; Liehr *et al.*, 2005; Schöne, 2005); and
- Carbon cycling and nutrient regulation: Maintaining healthy and productive ecosystems through the laying down of carbonate during shell growth and filter-feeding.

Function within the site

Whilst there is no direct evidence on the ecosystem services provided by the species with the site, Ocean quahog are filter feeders and remove plankton and detritus from the water column, playing a role in carbon cycling and nutrient regulation (Tyler-Walters and Sabatini, 2017). The longevity of Ocean quahog also enables scientists to construct 'master chronologies' over tens or hundreds of years to study changes in climate and environmental change using the biogenic carbonates stored in the growth rings of Ocean quahog (Schöne, 2013). This data can be used to: investigate the mechanisms driving ocean circulation and temperature variability in North Atlantic waters over the past millennia; understand the significance of external forcing (solar and volcanic), internal variability and climate oscillations (North Atlantic Oscillation and Atlantic Multidecadal Oscillation) in a coupled ocean-atmosphere model of the last 1000 years; and to research the mechanisms of longevity to better understand human ageing.

JNCC acknowledge the significant effect of prevailing sea temperatures on the likely survivorship and recruitment potential of Ocean quahog aggregations (Cargnelli *et al.,* 1999; Witbaard and Bergman, 2003; Tyler-Walters and Sabatini, 2017) and the reported widespread declines in the abundance of this species throughout the North Sea (Rumohr *et al*., 1998).

The Ocean quahog aggregations are being exposed to activities associated with pressures that the feature is considered sensitive to and that this may be impacting the feature's function. Despite this, **JNCC advises a conserve objective** acknowledging the substantial uncertainty around the ability of any site-based measures to support restoration of the feature within the site and in light of wider environmental impacts such as climate change and the feature's limited capacity to recruit or reproduce as described in the explanatory notes.

Activities should look to minimise, as far as is practicable, disturbance to individuals within the site. Our confidence in the setting of this objective would be improved by longer-term monitoring information on the population of Ocean quahog aggregations throughout the site.

For further information on activities capable of affecting Ocean quahog aggregations, please see the Advice on Operations workbook.

Attribute: Supporting processes

Objective: Conserve

JNCC consider there is limited evidence to suggest that supporting processes are being impeded with respect to supporting the Ocean quahog aggregations within the site. As such, ***JNCC advise a conserve objective*** *and that activities must look to avoid, as far as is practicable, exceeding Environmental Quality Standards set out below, as well as change in substrate extent and distribution. Our confidence in this objective would be improved with long-term monitoring, a better understanding of contaminant levels in the site and how contaminants can impact Ocean quahog aggregations.*

Explanatory notes

Ocean quahog rely on a range of supporting natural processes to support function (ecological processes) and help any recovery from adverse impacts. Supporting processes can be physical, biological and chemical in nature (Alexander *et al.*, 2014). In the case of Ocean quahog, these are the environmental conditions that can affect species persistence, growth and recruitment. For the site to fully deliver the conservation benefits set out in the statement on conservation benefits, hydrodynamic regime, supporting habitat and water and sediment quality must remain largely unimpeded.

Hydrodynamic regime

Hydrodynamic regime refers to the speed and direction of currents, seabed shear stress and wave exposure. These mechanisms circulate food resources and propagules, as well as influence water properties by distributing dissolved oxygen and transferring oxygen 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 and sorting of sediment particles, which as filter-feeders could affect the feeding behaviour, growth and survival of Ocean quahog. Alterations to the natural movement of water and sediment could affect the presence and distribution of Ocean quahog, particularly given the reliance on larvae from Icelandic waters to re-stock populations in the North Sea (Witbaard and Bergman, 2003). The natural movement of water and sediment should therefore not be hindered.

Hydrodynamic regime within the site

Five different water masses converge within the Faroe-Shetland Channel where the site is located. The North Atlantic Water, Modified North Atlantic Water and Arctic Intermediate/North Icelandic Water masses flow in a north-easterly direction through the channel, while the Norwegian Sea Arctic Intermediate Water and Faroe-Shetland Channel Bottom Water masses flow in a south-westerly direction (Bett, 2012). Current speeds of between 0.05 to 0.3 m s^{-1} have been recorded near the seabed within the site (Jones *et al.*, 2006; BP, 2010). Intermittent internal waves, known as solibores, travel up the continental slope at velocities of over 0.1 m s^{-1} (Hosegood and van Haren, 2004).

It is possible that the water masses flowing from the north-east transport Ocean quahog recruits down from Iceland, providing a source for the population to the site, as is the case with the North Sea populations (OSPAR, 2000; Witbaard and Bergman, 2003; Holmes *et al.,* 2003). Conserving the hydrodynamic regime could therefore be important to maintain the connectivity between sink and source populations of Ocean quahog, as well as providing oxygen and food to individuals within the site. While infrastructure known to be present may be having a localised effect on the hydrodynamic regime within the site, it is not thought that this is having an adverse impact on the conservation status of Ocean quahog. As such, **JNCC advise a conserve objective** for this sub-attribute.

For further information on activities capable of affecting Ocean quahog aggregations and their supporting habitat, please see the Advice on Operations workbook.

Supporting habitats

The extent and distribution of supporting habitat plays an important role in determining the extent and distribution of the species. As a burrowing species, Ocean quahog has been found in a range of sediments, from coarse clean sand to muddy sand in a range of depths typically from 4 m to 482 m deep, but most commonly between 10 m to 280 m (Thorarinsdóttir and Einarsson, 1996; Sabatini *et al.,* 2008; OSPAR, 2009). Ocean quahog are thought to have a high sensitivity to physical loss of habitat (Tyler-Walters and Sabatini, 2017). It is therefore important to conserve the extent and distribution of supporting habitats within the site to conserve Ocean quahog populations and provide the best chance of any potential settlement for new recruits.

Supporting habitats within the site

All Ocean quahog recorded within the site occurred between 400 and 600 m depth within deep-sea mixed substrata. This habitat accounts for approximately 80% of the site, however habitat considered suitable for Ocean quahog colonisation accounts for over 99% of the site.

The site includes locations where offshore infrastructure has been installed, such as oil platforms, subsea structures and pipelines. Such installation (and decommissioning) practices often result in a change of substrata on the seafloor through the introduction of concrete mattresses, cuttings piles and rock dump. Changes in sediment from coarse to fine around wells after drilling events has been observed in parts of the site where Ocean quahog have been recorded (Jones *et al.,* 2007), indicating this type of activity has the potential to reduce or alter the natural extent of supporting habitat for Ocean quahog. Whilst future decommissioning activities that do not require rock dump may result in habitat being introduced for Ocean quahog that is suitable for colonisation (once oil and gas operations within a site have ceased), colonisation is likely to be a very slow process due to the long-lived, slow reproducing and vulnerable nature of the species (Butler *et al.,* 2012; Brix, 2013; Ridgeway and Richardson, 2010; Tyler-Walters and Sabatini, 2017).

A conserve objective is advised, however further information is needed. While evidence indicates that activities are occurring which are capable of affecting the composition of the supporting habitat for Ocean quahog within the site, there is insufficient information available to support a view as to whether the nature or scale of any impacts occurring is sufficient to prevent it being suitable for Ocean quahog. Our confidence in this objective would be improved with better understanding of how the activities taking place are affecting the availability of supporting habitat. Activities must look to minimise, as far as is practicable, reductions to the extent and distribution of the supporting habitat for Ocean quahog within the site.

For further information on activities capable of affecting Ocean quahog and their supporting habitat, please see the Advice on Operations workbook.

Water and sediment quality

Ocean quahog is considered not sensitive to contaminants at Environmental Quality Standards (EQS) levels (Tyler-Walters and Sabatini, 2017). However, above this baseline, some contaminants may impact the conservation status of Ocean quahog depending on the nature of the contaminant (UKTAG, 2008; EA, 2014). Ocean quahog has a medium sensitivity to other water qualities, such as increases in temperature (Tyler-Walters and Sabatini, 2017). It is important therefore to avoid changing water and sediment quality properties of a site and as a minimum ensure compliance with existing EQSs.

The targets listed below for water and sedimentary contaminants in the marine environment and are based on existing targets within OSPAR or the Water Framework Directive (WFD) that require concentrations and effects to be kept within levels agreed in the existing legislation and international commitments as set out in The UK Marine Strategy Part 1: The UK Initial Assessment (2012). Aqueous contaminants must comply with water column annual average (AA) EQSs according to the amended EQS Directive (2013/39/EU) or levels equating to (High/Good) Status (according to Annex V of the WFD (2000/60/EC), avoiding deterioration from existing levels).

The following sources of information are available regarding historic or existing contaminant levels in the marine environment:

- Marine Environmental and Assessment National Database (MERMAN);
- An Analysis of UK Offshore Oil and Gas surveys 1975-1995;
- Cefas' Green Book; and
- Cefas' Containment Status of the North Sea Report (2001) & Contaminant Status of the Irish Sea' Report (2005).

The water quality properties that influence Ocean quahog include salinity, pH, temperature, suspended particulate concentration, nutrient concentrations and dissolved oxygen. These parameters can act alone or in combination to affect Ocean quahog according to 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. Changes in any of the water quality properties through human activities may impact habitats and the communities they support (Elliot *et al.,* 1998; Little, 2000; Gray and Elliot, 2009).

Salinity does not appear to be a limiting factor for the distribution of Ocean quahog, since the species is found in the Baltic Sea at 16 ppt (OSPAR, 2009), in the mid-Atlantic Bight at 32-34 ppt (Cargnelli *et al.,* 1999) and Oeschger and Storey, (1993) successfully kept adult quahog at 22 ppt in the laboratory for several weeks.

Experimental evidence has shown that lower pH (380-1120 µatm pCO_2), has no effect on shell growth or crystalline microstructure in Ocean quahog as Ocean quahog can actively pump protons to drive increased calcification (Stemmer *et al.*, 2013; Stemmer *et al.*, 2014). This suggests that although Ocean quahog can buffer against the effects of short-term acidification, longer-term acidification may have energetic consequences and ultimately restrict growth and/or reproductive output.

Adult Ocean quahog have a medium sensitivity to increases in water temperature. Evidence suggests that the optimal temperature for Ocean quahog survival, spawning and recruitment is 6-16°C (Loosanoff, 1953; Merrill *et al.,* 1969; Golikov and Scarlato, 1973; Jones, 1981; Mann, 1989; Cargnelli *et al.,* 1999; Harding *et al.,* 2008). Temperature change can be local (associated with localised effects, such as warm-water effluents, are highly unlikely to have a significant impact in offshore environments) or global (associated with climate change). The impacts on habitats and species from global temperature change can be direct, e.g. changes in breeding or growing seasons, predator-prey interactions, symbiotic relationships and species' physiologies, or indirect, e.g. changes in habitat conditions (Begum *et al.,* 2010). Many uncertainties exist in predicting our future climate and the impacts on habitats and species (EC, 2013).

Temperature has been attributed as the cause of low recruitment in North Sea populations, potentially increasing larval mortality and consequently restricting their southernmost extent (Witbaard and Bergman, 2003; Harding *et al.,* 2008). Temperature-induced changes in phytoplankton communities can also have knock-on effects on zooplankton communities, which can in turn impact filter-feeding organisms, such as Ocean quahog (Witbaard *et al.,* 2003). Witbaard *et al.* (2003) found that at high densities, copepods associated with warming seas intercept the downward flux of food particles to Ocean quahog, leading to slower shell growth. It is therefore important to conserve the natural temperature regime of the water column as far as is practicable against wider environmental pressures.

Ocean quahog are thought to have a low sensitivity to deoxygenation, nutrient enrichment, organic enrichment, changes in suspended sediments and smothering (Tyler-Walters and Sabatini, 2017). Although low levels of smothering via siltation events are unlikely to affect Ocean quahog, high levels of smothering could restrict the ability of Ocean quahog to feed or breathe (Elliot *et al.,* 1998; Morton, 2011). Adult Ocean quahog can switch from aerobic to anaerobic respiration and will be able to resurface post-smothering (Sabatini *et al.,* 2008). Powilleit *et al.,* (2009) documented a high burrowing potential in Ocean quahog after experimental burial, successfully burrowing to the sediment surface through a covering layer of 32-41 cm. Although Ocean quahog can survive low dissolved oxygen levels, it could have sub-lethal and lethal affects under long-term anoxia (Taylor 1976; Weigelt, 1991; Strahl *et al.* 2011).

Ocean quahog are not considered sensitive to organic and inorganic pollutants (Tyler-Walters and Sabatini, 2017). However, JNCC advise that aqueous contaminants should be restricted to comply with water column annual average limits according to the amended environmental quality standards Directive (2013/39/EU) or levels equating to high/good status (Annex V of the Water Framework Directive 2000/60/EC), avoiding deterioration from existing levels. It is important therefore to carefully consider any proposals or human activity that could change the natural water quality properties affecting a site and as a minimum ensure compliance with existing EQS.

Water and sediment quality within the site

The five different water masses that converge within the Faroe-Shetland Channel where this site is located have contrasting characteristics in terms of temperature, salinity and concentrations of phosphate, nitrate and silicate (Bett, 2012; Mckenna *et al.*, 2016). Offshore oil and gas extraction occurs within the site, which can result in the release of chemicals, including heavy metals and polyaromatic hydrocarbons, and suspended sediments into the water column (BP, 2010). The Charting Progress 2 reports that the open seas are little affected by pollution and levels of monitored contaminants continue to fall, albeit slowly in many cases.

The total 2-4 ring PAHs concentration, and concentrations of cadmium, chromium, copper, lead, nickel and zinc in sediment from within the Faroe-Shetland Sponge Belt NCMPA are below ERL thresholds and/or background concentrations for the wider region (UKOOA, 2001; OSPAR, 2009; BP, 2010). There is some indication that concentrations of total hydrocarbons within sediments in the site are higher than background levels in the Atlantic frontier region and Northern North Sea (UKOOA, 2001; BP, 2010), however there is no information available to determine whether this is impacting the populations of Ocean quahog within the site.

While this information identifies possible sources of contamination, there is currently no information available to indicate that water or sediment quality in the site is falling below EQSs. **JNCC advise a conserve objective**, due to lack of evidence to suggest that contamination of water or sediment is impacting Ocean quahog within the site. JNCC also advise that activities must look to avoid, as far as is practicable, exceeding EQSs set out above. Our confidence in this objective would be improved with long term monitoring, a better understanding of contaminant levels in the site and how contaminants can impact Ocean quahog.

For further information on activities capable of affecting Ocean quahog and their supporting habitat, please see the Advice on Operations workbook.

Table 4. Supplementary advice on the conservation objectives for the area of continental slope in the Faroe-Shetland Sponge Belt NCMPA

Attribute: Extent and distribution
Objective: Conserve *As a large-scale geological feature, it is not considered that any activities currently taking place, or that may take place in the future, are capable of affecting the extent and distribution of the area of the Faroe-Shetland Channel continental slope protected within this site.* ***A conserve objective*** *is advised based on expert judgment; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities.*
<u>Explanatory notes</u> In the context of a large-scale feature, extent and distribution refers to area the large-scale feature occupies within a site. **Site advice** The entire area of the site covers a section of the Faroe-Shetland Channel continental slope. As a large-scale geological feature, it is not considered that any activities currently taking place, or that may take place in the future, are capable of affecting the extent and distribution of the area of the Faroe-Shetland Channel continental slope protected within this site. As such, **JNCC advise a conserve objective**.
Attribute: Structure and function
Objective: Conserve *As a large-scale geological feature, it is not considered that any human activities are capable of affecting the physical nature of the area of the Faroe-Shetland Channel continental slope protected within this site. Moreover, there is no evidence to suggest that the functional role of the Faroe-Shetland Channel continental slope has been impaired.* ***A conserve objective is advised*** *based on expert judgment; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities.*
<u>Explanatory notes</u> In the context of a large-scale feature, structure refers to the physical nature of the feature and the functional role it plays in supporting the wider health and biodiversity of Scotland's seas. --

Physical nature within the site

The Faroe-Shetland channel continental slope is a gradient of bedrock overlain with sediment that divides the Scottish continental shelf from the deeper waters of the Faroe-Shetland Channel. As a large-scale geological feature, it is not considered that any human activities are capable of affecting the physical nature of the area of the Faroe-Shetland Channel continental slope protected within this site. As such, **JNCC advise a conserve objective**.

Function within the site

Functions provided by large-scale features 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 that may be the provided by the area of the Faroe-Shetland Channel continental slope protected within the site include:

- Whale and dolphin watching - The interaction between hydrographic processes and the continental slope may enhance feeding conditions through the aggregation of principle prey items (e.g. squid, herring, blue whiting and krill) for several species of cetacean, including sperm whale, minke whale, orca, fin whale, long-finned pilot whale and Atlantic white-sided dolphin (Stone, 1988; Weir *et al.,* 2001; Swift *et al*., 2002; Macleod, 2004; Macleod *et al.,* 2006). In addition, the topography of the Faroe-Shetland Channel continental slope and wider channel is thought to be of functional significance as a migratory pathway/corridor for several cetacean species. Of these, based on the data available, fin and sperm whales are the most regular users of the route. These cetacean species seem to use the channel as a passageway to move through into colder, temperate waters to the north to feed in the early summer months whilst some remain in the channel (e.g. Macleod *et al.,* 2006) before travelling.
- Nutrition - The same process outlined above is also true for fish assemblages; many of which are of commercial importance (Bullough *et al., 19*98; Gordon, 2001).
- Enhanced levels of biological productivity - The diversity and abundance of species present within the site has been linked to the presence of the mixing zone at the intermediate water masses which act against the continental slope. For example, benthic fauna indicates a diversity and abundance maximum at the intermediate water masses (Bett, 2000; Bett, 2001; Narayanaswamy *et al.*, 2005; Narayanaswamy *et al.*, 2010).

There is no evidence to suggest that the functional role of the Faroe-Shetland Channel continental slope has been impaired as a result of human activity. As such, **JNCC advise a conserve objective**.

Attribute: Supporting processes

Objective: Not Set

The Faroe-Shetland Channel continental slope is a relict geological feature. As such, consideration of supporting processes is not of relevance.

Explanatory notes

In the context of large-scale features, supporting processes refers to the role that the hydrodynamic regime plays in maintaining the functional significance of the feature within a site

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Supporting processes within the site

The Faroe-Shetland Channel continental slope is a relict geological feature. As such, consideration of supporting processes is not of relevance.

Table 5. Supplementary advice on the conservation objectives for the geodiversity features in Faroe-Shetland Sponge Belt NCMPA

Terminology

- *Geodiversity features* – a collective term for geological and geomorphological features.
- *Key Geodiversity Area* – a collective term for geodiversity features that in combination make up the key geodiversity interests of a site.
- *Relict* – a category of geodiversity features which have been formed by geological processes which are no longer taking place e.g. iceberg plough marks formed by glacial movement during the last ice age.
- *Active* – a category of geodiversity features which are formed and maintained by natural processes that are still taking place e.g. sand and sediment wave fields which are maintained by the prevailing hydrodynamic regime.

Overview of the protected geodiversity features of the site

The site protects geodiversity features comprising two Key Geodiversity Areas within Scotland's seas:

- **The West Shetland Margin Paleo-depositional system –** comprising the following relict geomorphological components: Continental slope channels, iceberg plough marks, prograding wedges and slide deposits; and
- **The West Shetland Margin contourite deposits -** comprising the following active geomorphological components: sand wave fields and sediment wave fields.

There is no direct information on the condition of the protected geodiversity features within the site. Consequently, the conservation objective attributes have been set based on JNCC's understanding of the sensitivity of the protected geodiversity features to pressures associated with human activities to which the features are considered to be sensitive (based on Brooks, 2013). It is important to note that only physical pressures (such as abrasion to the seabed surface and the physical removal or deposition of material) are considered to pose a threat to the integrity of relict protected geodiversity features of the site. For active protected geodiversity features, changes to the prevailing hydrodynamic regime may also pose a threat to the conservation status of these features.

Attribute: Extent and distribution

Objective: Conserve

While evidence indicates that activities are occurring which are capable of impacting the protected geodiversity features, it is not feasible to recover reflect geodiversity features once impacted through management intervention. In addition, JNCC are uncertain as to whether any *localised hydrodynamic changes may be taking place, for instance because of the installation of infrastructure associated with oil and gas extraction, which may have or be hampering the maintenance of the active geodiversity features.* ***A conserve objective is therefore advised****. Our confidence in the condition of the protected geodiversity features would be improved by longer term monitoring. Activities should avoid the deposition of artificial substrata in areas where sediment and sand wave fields have been recorded or activities that lead to disruption, obstruction or removal of the relict geodiversity features.*

Explanatory notes

In the context of the protected geodiversity features of the site, extent and distribution refers to area occupied within a site. Any significant loss of extent to relict geodiversity features may be more significant than for active geodiversity features because the processes that led to the formation of relict features are no longer taking place. The extent and distribution of the protected geodiversity features within the site is shown on the JNCC's Interactive MPA Mapper.

Extent and distribution within the site

West Shetland Margin Paleo-depositional system

Continental slope channels

There are ten continental slope channels within this site. The channels run south-east from the northern boundary of the site and are all located towards the western end of the site. The total mapped area of the channels is ~30 km^2 with a mean area of ~3 km^2. Brooks (2013) concludes that continental slope channels have no resilience to physical pressures that may result in a loss to the extent and distribution of the feature such as physical extraction of material from the seabed. This is because such activities have the potential to cause partial disruption to the feature's surface or stratigraphy and as relict features they are unable to recover. Whilst JNCC consider that there may be activities taking place that may result in the physical removal of parts of continental slope channels within the site, it is not possible to recover a relict feature. As such, **JNCC advise a conserve objective** for this protected geodiversity feature. Activities must look to minimise, as far as is practicable, reductions to the extent and distribution of the Continental slope channels within the site.

Iceberg plough marks

An iceberg plough mark field is present along the south-eastern side of the site. The total mapped area is 1,817 km^2; approximately a third of the total site area. Brooks (2013) concludes that iceberg plough marks have no resilience to pressures that may result in a loss to the extent and distribution of the feature such as physical extraction of material from the seabed. This is because iceberg plough marks are relict features formed by the process of glacial movement and the fact that the unconsolidated nature of the feature makes them vulnerable. However, Brooks

(2013) also note that the partial deposition/placement of material onto the feature is not likely to affect its integrity but may affect its function in terms of the support it provides to biodiversity interests (see Structure and Function). Whilst JNCC consider that there may be activities taking place that may result in the physical removal of areas of iceberg plough marks within the site, it is not possible to recover a relict feature. As such, **JNCC advise a conserve objective** for this protected geodiversity feature. Activities must look to minimise, as far as is practicable, reductions to the extent and distribution of the Iceberg plough mark fields within the site.

Prograding wedges and Slide deposits

There is a prograding wedge to the west of the site with an area of 565 km^2, which forms part of the Rona Wedge. 1,735 km^2 of the Foula wedge is also present in the centre of the site. In the east of the site there is an unnamed slide deposit that is ~330 km^2. There are also sections of an additional four slide deposits along the north-western boundary of the site, ranging in size from ~2 km^2 to ~20 km^2. This includes part of another unnamed slide deposit, the full extent of the Walker Slide, and small sections of the Afen Slide and the Paleo-Afen Slide.

Prograding wedges and slide deposits are relict features. As such, they have been defined as having no resilience to pressures associated with physical disturbance. However, owing to the very large scale of the features, any impacts arising from physical pressures associated with human activities are considered negligible (Brooks, 2013). As such, **JNCC advise a conserve objective** for these protected geodiversity features. Activities must look to minimise, as far as is practicable, reductions to the extent and distribution of the prograding wedges and slide deposits within the site.

West Shetland Margin contourite deposits

Sand and sediment wave fields

The sand and sediment wave fields occur in the north east of the site. There is a single sand wave field within the site, with an area of ~345 km^2. Further up the slope from the sand wave field are two sediment wave fields, one 125 km^2 and the other 195 km^2.

These protected geodiversity features are actively maintained by hydrodynamic processes and so extent of these features may well change naturally over time. Pressures such as a physical change to another seabed type or artificial changes to topography may cause localised disruption to flows (and associated patterns of sediment transport) that could result in the loss of distribution and extent of the feature in the immediate vicinity of the obstruction. There is increasing interest in the site for oil and gas exploration activities and such activity may have already affected the extent and distribution of these protected geodiversity features (although direct evidence of such impacts is not available).

JNCC are uncertain as to whether any localised hydrodynamic changes may be taking place, for instance as a result of the installation of infrastructure associated with oil and gas extraction, which may have or be hampering the maintenance of the active geodiversity features. A **conserve objective is therefore advised**. Our confidence in the condition of the protected geodiversity features would be improved by longer term monitoring. Activities should avoid the deposition of artificial substrata in areas where sediment and sand wave fields have been recorded.

Attribute: Structure and Function

Objective: Conserve

While evidence indicates that activities are occurring which are capable of impacting the protected geodiversity features, it is not feasible to recover relict geodiversity features once impacted through management intervention. In addition, JNCC are uncertain as to whether any localised hydrodynamic changes may be taking place, for instance because of the installation of infrastructure associated with oil and gas extraction, which may have or be hampering the maintenance of the active geodiversity features. ***A conserve objective is therefore advised****. Our confidence in the condition of the protected geodiversity features would be improved by longer term monitoring. Activities should avoid the deposition of artificial substrata in areas where sediment and sand wave fields have been recorded or activities that lead to disruption, obstruction or removal of the relict geodiversity features.*

Explanatory notes

In the context of the protected geodiversity features of the site, structure refers to the physical nature of protected geodiversity features and function as both the scientific importance of the features in their own right, as well as the role they play in supporting biological functioning.

Structure within the site

West Shetland Margin Paleo-depositional system

Continental slope channels

The Continental slope channels in the site are straight and parallel, and generally between 50-250 m wide, with a maximum depth of 40 m (Brooks *et al.*, 2013). Brooks (2013) concluded that continental slope channels have no resilience to physical pressures that may result in impacts to the physical structure of this feature. Whilst JNCC consider that there may be activities taking place that may result in impacts to the physical structure of continental slope channels within the site, it is not possible to recover a relict feature. As such, **JNCC advise a conserve objective** for this protected geodiversity feature. Activities must look to minimise, as far as is practicable, changes to the structure and function of the Continental slope channels within the site.

Iceberg plough marks
The iceberg plough marks along the upper slope and shelf of the Scottish continental shelf are considered to be 2 m deep and 20 m wide, with a maximum length of 5.5 km. Brooks (2013) concluded that iceberg plough marks have no resilience to physical pressures that may result in impacts to the physical structure of the feature. This is because iceberg plough marks are relict features formed by the process of glacial movement and the fact that the unconsolidated nature of the feature makes them vulnerable. Whilst JNCC consider that there may be activities taking place that may result in impacts to the physical structure of areas of iceberg plough marks within the site, it is not possible to recover a relict feature. As such, **JNCC advise a conserve objective** for this protected geodiversity feature. Activities must look to minimise, as far as is practicable, changes to the structure and function of the Iceberg plough mark field within the site.

Prograding wedges and Slide deposits
The prograding wedges are stacked accumulations or glacial deposited sediments that are typically, 200-400 m thick (Stoker, 1995; Brooks *et al.*, 2013). Many of the slide deposits in Scottish waters have been buried and therefore are not visible on the surface of seabed (Brooks *et al.*, 2013). The Afen Slide is younger and therefore is visible on acoustic surveys, which indicate an area of rough sea bed (Brooks *et al.*, 2013).

These are relict features and as such, they have been defined as having no resilience to pressures associated with physical disturbance. However, owing to the very large scale of the feature (in terms of both geographical extent and sediment thickness), any impacts arising from physical pressures associated with human activities are considered negligible (Brooks, 2013). As such, **JNCC advise a conserve objective** for this protected geodiversity feature. Activities must look to minimise, as far as is practicable, changes to the structure and function of the prograding wedges and slide deposits within the site.

West Shetland Margin contourite deposits
Sand and sediment wave fields
The sediment wave fields higher up the slope are predominantly isolated waves that are narrow and low in height (Brooks *et al.*, 2013). The sand wave field consists of around six individual sheets and additional waveforms which are up to 120 m wide (Wynn *et al*., 2002).

These protected geodiversity features are actively maintained by hydrodynamic processes and so the structure of these features may well change naturally over time. Pressures such as a physical change to another seabed type or artificial changes to topography may cause localised disruption to flows (and associated patterns of sediment transport) that could result in the loss of structure of the feature in the immediate vicinity of the obstruction. There is increasing interest in the site for oil and gas exploration activities and such activity may have already affected the structure of these protected geodiversity features (although direct evidence of such impacts is not available).

JNCC are uncertain as to whether any localised hydrodynamic changes may be taking place, for instance as a result of the installation of infrastructure associated with oil and gas extraction, which may have or be hampering the maintenance of the active geodiversity features. A **conserve objective is therefore advised**. Our confidence in the condition of the protected geodiversity features would be improved by longer term monitoring. Activities should avoid the deposition of artificial substrata in areas where sediment and sand wave fields have been recorded.

Function within the site

West Shetland Margin Paleo-depositional system

Functions provided by geodiversity features 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 that may be the provided by the protected geodiversity features of the West Shetland Margin paleo-depositional system Key Geodiversity Area include:

- Scientific importance: all the protected geodiversity features of the West Shetland Margin paleo-depositional system Key Geodiversity Area form part of a palaeo-depositional system that was active during the last glacial period and so represent a valuable record of the glacial history of the area (Brooks *et al.*, 2013).
- Habitat provision: The iceberg plough marks that form a component of this Key Geodiversity Area are also considered to be of functional importance as a settlement point for deep-sea sponge aggregations; a protected biodiversity feature of the site which themselves provide ecosystem services. See Function under Deep-sea sponge aggregations for further information.

Whilst JNCC consider that there may be activities taking place that are capable of affecting the conservation status of the protected geodiversity features that comprise this Key Geodiversity Area, it is not possible to recover them through human intervention. As such, **JNCC advise a conserve objective** and recommend that:

- activities that result in the physical removal of unconsolidated material associated with the continental slope channels and iceberg plough marks within the site are kept to a minimum; and

- activities that result in the infilling or obscuring of the protected geodiversity features comprising this Key Geodiversity Area (particularly iceberg plough marks given their role as a settlement point for Deep-sea sponge aggregations) are kept to a minimum.

West Shetland Margin contourite deposits

Functions provided by geodiversity features 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 that may be the provided by the protected geodiversity features of the West Shetland Margin contourite deposits Key Geodiversity Area include:

- Scientific importance: The protected geodiversity features of the West Shetland Margin Contourite Deposits Key Geodiversity Area represent part of a complex of sandy bedforms that are unique to UK waters and are considered to be of scientific importance for study (Brooks *et al.,* 2013).

These protected geodiversity features are actively maintained by hydrodynamic processes and so may well change naturally over time. Pressures such as a physical change to another seabed type or artificial changes to topography may cause localised disruption to flows (and associated patterns of sediment transport) that could result in the loss of function of the feature in the immediate vicinity of the obstruction. There is increasing interest in the site for oil and gas exploration activities and such activity may have already affected the function of these protected geodiversity features (although direct evidence of such impacts is not available).

JNCC are uncertain as to whether any localised hydrodynamic changes may be taking place, as a result for instance due to the installation of infrastructure associated with oil and gas extraction, which may have or be hampering the maintenance of the active geodiversity features. A **conserve objective is therefore advised**. Our confidence in the condition of the protected geodiversity features would be improved by longer term monitoring. Activities should avoid the deposition of artificial substrata in areas where sediment and sand wave fields have been recorded.

Attribute: Supporting processes

Objective: Conserve

Supporting processes are not considered to be of relevance to the protected geodiversity features that comprise the West Shetland Margin Paleo-depositional system as they are all relict features. However, the protected geodiversity features comprising the West Shetland Margin contourite deposits are actively maintained by the prevailing hydrodynamic regime. JNCC do not believe there is any evidence to suggest that the prevailing hydrodynamic regime has been affected by human activities. As such, ***JNCC advise a conserve objective****.*

Explanatory notes

In the context of the protected geodiversity features of the site, supporting processes refers to the role that the prevailing **hydrodynamic regime** plays in maintaining the integrity of active protected geodiversity features within the site.

Supporting processes within the site

West Shetland Margin Paleo-depositional system

All of the protected geodiversity features comprising this Key Geodiversity Area are relict features. As such, consideration of supporting processes is not of relevance to the conservation status of the protected geodiversity features.

West Shetland Margin contourite deposits

Five different water masses converge in the Faroe-Shetland Channel that includes this site. The North Atlantic Water, Modified North Atlantic Water and Arctic Intermediate/North Icelandic Water masses flow in a north-easterly direction through the channel, while the Norwegian Sea Arctic Intermediate Water and Faroe-Shetland Channel Bottom Water masses flow in a south-westerly direction (Bett, 2012). The layering of these water masses which have contrasting characteristics interacts with the continental slope to create internal mixing of the water masses close to the seabed within the Faroe-Shetland Sponge Belt NCMPA (Bett, 2012; Mckenna *et al.*, 2016).

Current speeds of between 0.05 to 0.3 m s^{-1} have been recorded near the seabed within the site (Jones *et al.*, 2006; BP, 2010). Internal waves, known as solibores, travel up the continental slope near the seabed in the site (Hosegood and van Haren, 2004). The velocities of these waves are over 0.1 m s^{-1} (Hosegood and van Haren, 2004). The internal waves occur intermittently but have a significant impact on sediment transport, resuspending sands and gravels on the seabed and transporting them up the continental slope (Hosegood and van Haren, 2004).

Infrastructure associated with oil and gas extraction are present within the mapped extent of the feature, and there is likely to be continuing interest in oil and gas extraction in the future. The presence of this infrastructure can have an extremely localised effect on the hydrodynamic regime within the site. These protected geodiversity features are actively maintained by the prevailing hydrodynamic regime, and are therefore potentially affected by such changes. JNCC do not believe there is any evidence to suggest that the prevailing hydrodynamic regime has been affected by human activities. As such, **JNCC advise a conserve objective**. Activities must look to minimise, as far as is practicable, changes to the hydrodynamics within the site.

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