Supplementary Advice on Conservation Objectives for East of Haig Fras Marine Conservation Zone

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Contents

Introduction

What the conservation advice package includes

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

- Background Document explaining where to find the advice package, JNCC's role in the provision of conservation advice, how the advice has been prepared, when to refer to it and how to apply it;
- Conservation Objectives setting out the broad ecological aims for the site;
- Statements on:
    - the site's protected features condition and General Management Approach;
    - conservation benefits that the site can provide; and
    - conservation measures needed to support achievement of the conservation objectives set for the site.
- Supplementary Advice on Conservation Objectives (SACO) providing more detailed and site-specific information on the conservation objectives (this document); and
- Advice on Operations providing information on those human activities that, if taking place within or near the site, can impact it and present a risk to the achievement of the conservation objectives 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: High energy circalittoral rock, Moderate energy circalittoral rock, Subtidal coarse sediment / Subtidal mixed sediments mosaic, Subtidal sand, Subtidal mud, Fan mussel (*Atrina fragilis*) and Sea-pen and burrowing megafauna communities specified in the site's conservation objectives. 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 the following tables 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 Table 1, Table 2 and Table 3 must be taken into consideration when assessing impacts from an activity.

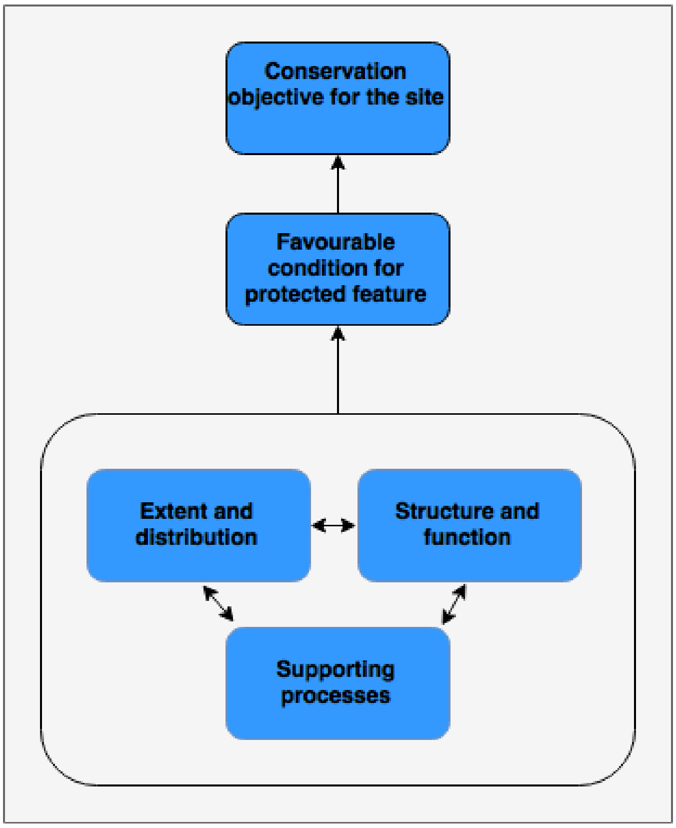

Figure 1. Conceptual diagram showing how a feature's attributes are interlinked and collectively describe favourable condition and contribute to the conservation objectives stated for the site.

In **Table 1** below, the attributes for High energy circalittoral rock and Moderate energy circalittoral rock are listed and a description provided in explanatory notes. In **Table 2** the attributes for the remaining broad-scale habitats (Subtidal coarse sediment / Subtidal mixed sediments mosaic, Subtidal sand and Subtidal mud) along with the feature of conservation importance Sea-pen and burrowing megafauna communities are listed with descriptions provided in the explanatory notes. In **Table 3** the attributes for Fan mussel (*Atrina fragilis*) are listed and a description provided in explanatory notes.

Please note our current understanding of whether the available evidence indicates that each attribute needs to be recovered or maintained is not provided. However, links to available evidence for the site are provided in the Tables below and should you require further site-specific information on the attributes listed for the site's features, please contact JNCC at OffshoreMPAs@jncc.gov.uk.

Table 1: Supplementary advice on the conservation objectives for High energy circalittoral rock and Moderate energy circalittoral rock in East of Haig Fras MCZ

Attribute: Extent and distribution
Objective: An objective has not been set for this attribute. Links to available evidence are provided below. Please contact JNCC at OffshoreMPAs@jncc.gov.uk for further site-specific information on this attribute.
Explanatory notes Extent refers to the total area in the site occupied by the qualifying feature and must include consideration of its distribution, i.e. how it is spread out within the site. A reduction in extent has the potential to alter the biological and physical functioning of habitat types (Elliott *et al.,*1998). The distribution of a habitat influences the component communities present, and can contribute to the health and resilience of the feature (JNCC, 2004a). The extent within the site must be conserved to the full known distribution. Rock habitats are defined by: • ***composition*** (particle size); • ***energy level;*** and • ***biological assemblages*** - see JNCC's Marine Habitats Correlation Table for more detail about the range of biological communities (biotopes) that characterise rock habitats in the UK marine environment. A significant change in either of these criteria within an MPA could indicate a change in the distribution and extent of rock habitats within a site. The extent of rock is unlikely to change over time, unless as a result of human activity, though habitat boundaries may become indistinct if rock is covered by a thin layer of sediment (JNCC, 2004a). Reduction in extent has the potential to affect the functional roles of the biological communities associated with the habitat (Elliott *et al.,* 1998; Tillin and Tyler-Walters, 2014). Maintaining or restoring extent is therefore critical to maintaining or restoring the conservation status of rock habitats. There is no recovery potential if the physical structure of the rock feature is diminished or removed. Hard compact substrata refers to rocks (including soft rock, e.g. chalk), boulders and cobbles. Such hard substrata that are covered by a thin and mobile veneer of sediment are classed as rock habitat if the associated biota is dependent on the hard substratum rather than the overlying

sediment. A variety of subtidal topographic features are included in this habitat such as: vertical rock walls, horizontal ledges, overhangs, pinnacles, gullies, ridges, sloping or flat bed rock, broken rock and boulder and cobble fields (EC Instruction Manual, 2013).

The biological community composition found on rock habitats vary enormously and are influenced by factors such as wave action, strength of the tidal stream, water clarity, the degree of scouring/erosion, and the shape of the rock formations themselves (Sebens 1991; Barry and Dayton 1991).

A general description of the different types of rock habitats found in the UK offshore marine environment of relevance to this MPA designation type is provided below:

- *A4.1 High energy circalittoral rock* - Occurs on extremely wave-exposed to exposed circalittoral bedrock and boulders subject to tidal streams ranging from strong to very strong (EUNIS Classification, 2007).

- *A4.2 Moderate energy circalittoral rock* - Mainly occurs on exposed to moderately wave-exposed circalittoral bedrock and boulders, subject to moderately strong and weak tidal streams (EUNIS Classification, 2007).

Extent and distribution of the High energy circalittoral rock and Moderate energy circalittoral rock within the site

The extent and distribution of this feature within the site is shown in the site map. For further site specific information please see the Site Information Centre.

For information on activities capable of affecting the protected features of the site, please see the Advice on Operations workbook (hyperlink is provided in the box at the top of this document).

Attribute: Structure and function

Objective:

An objective has not been set for this attribute. Links to available evidence are provided below. Please contact JNCC at OffshoreMPAs@jncc.gov.uk for further site-specific information on this attribute.

<u>Explanatory notes</u>

Structure

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

Physical structure: finer scale topography

Rock topography can be characterised by elevation from the surrounding seabed. Sessile species such as sponges, bryozoans and algae communities can thrive in shallower sites as the physical rock habitat arising from the seafloor provides a suitable substratum for attachment. Mobile species such as crustaceans, echinoderms and fish use the complexity of the physical structure of the rock habitat for shelter and hunting. Surface complexity can be highly variable, depending on factors such as rock type (i.e. hard or soft rock and the varying rugosity of substrate) and energy regime (i.e. erosion, stability of cobbles and boulders). Large immobile surfaces can develop very different communities to smaller rocks that maybe frequently overturned (i.e. during storms) (Sebens, 1991). Structural complexity can be provided by topographic features such as pavements, overhangs, cliffs, fissures, cracks, and crevices. Both provide heterogeneity, and the complexity of habitat is known to strongly influence megafaunal diversity and community composition (Lacharité and Metaxas, 2017; Loke *et al.,* 2015; Loke and Todd*,* 2016), allowing for niche specialisation (Sebens, 1991). Substratum space is an essential resource for sedentary organisms, and its availability is one of the most important population controlling factors amongst sedentary organisms (Barnes and Hughes, 1982) found on rock habitats.

Biological structure: key and influential species

Key species form a part of the habitat structure or help to define a biotope. Influential species are those that have a core role in the structure and function of the habitat. For example, species that help to cycle nutrients and oxygen between seawater and the seabed supporting organisms that live within benthic and pelagic communities. Other key and influential species may include those which provide additional and elevated hard substrates for other species, known as 'secondary substratum' these may affect water flow and thus the transport of resources and propagules within the community (Sebens, 1991). Grazers, surface borers, predators or other species with a significant functional role linked to the habitat can also be influential species. Changes to the spatial distribution of communities across the feature could indicate changes to the overall feature (JNCC, 2004a). It is therefore important to conserve the key natural structural and influential species of the rock feature within the site to avoid diminishing biodiversity and ecosystem functioning within the habitat and to support its health (JNCC, 2004a; Hughes *et al.,* 2005).

The key and influential species typical of rock features will vary greatly depending on location, energy regime and depth, as well as fine-scale physical, chemical and biological processes such as competition, grazing, predation (Barry and Dayton, 1991). Rock habitats can be highly variable in terms of the communities that they support and often support a zonation of benthic species and communities. Biological cover is expected to be dominated by epifaunal species. Habitat structural composition and the local energy regime are those most likely to have the biggest influence on the expected biological structure. For example, energy levels have been found to influence the morphology and size of species such as the cup coral *Caryophyllia smithii* (Bell, 2002). Areas more sheltered from prevailing currents or wave action can support an abundance of attached bryozoans, hydroids and sea anemones.

Recovery of the communities associated with rock habitats also depends on the life history traits of the species themselves (e.g. their growth rate, longevity) and interactions with other species including predators. The scale of the disturbance and action of remaining key and influential species will also influence recovery. Furthermore, the environmental connectivity between populations or species patches, the suitability of the habitat (e.g. substrate type), depth, and water quality (Mazik *et al.,* 2015) will also influence the habitat recovery potential.

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

The physical structure of substratum will influence the marine life that's likely to be present within a site. Structural and surface complexity, spaces between rocks, fissures and crevices are all examples of aspects that should be considered (Hiscock et al., 2006). The characteristic communities can be strongly influenced by the prevailing energy levels, with the strength of the tidal stream, turbidity of the waters and degree of scouring from sediments can all influence the communities present. Depending upon the energy regime present (high, moderate, low), a variety of encrusting species and those which attach to the rock can be expected, such as sponges, soft corals, crustose communities, polychaete, ascidians, hydroids and anemones. Other species present may include starfish, brittlestars, sea urchins, crabs, squat lobster, molluscs (such as Piddocks in cases of soft rock) and brachiopods.

Changes to the spatial distribution of communities across the feature could indicate changes to the overall feature (JNCC, 2004a). For example, non-native species may become invasive and displace native organisms by preying on them or out-competing them for resources such as food, space or both. In some cases, this has led to the elimination of indigenous species from certain areas (JNCC, 2004b). It is therefore important to conserve the natural spatial distribution, composition, diversity and abundance of the main characterising biological communities of the rock within the site to avoid diminishing biodiversity and ecosystem functioning within the habitat and to support its health (JNCC, 2004a; Hughes *et al.,* 2005).

Similar to the biological structure of key and influential species, the recovery of characterising species 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 and water quality further influencing the recovery potential of habitats (Mazik *et al.,* 2015).

Function

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

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

- Nutrition: due to the level of primary and secondary productivity on or around rock habitat, a range of fish species use these areas as feeding and nursery grounds (Ellis 2012), depending upon the biogeographic region.

There is no recovery potential if the physical structure of the rock feature is diminished or removed. The recovery of associated populations of individual species or communities depends on life history traits of species (e.g. their growth rate, longevity), and interactions with other species including predators. Furthermore, the environmental connectivity between populations or species patches, the suitability of the habitat (e.g. substrate type), depth, and water quality (Mazik *et al.,* 2015) will also influence the recovery potential of features.

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

Structure and function of the feature within the site

For further site-specific information on the structure and function of the feature within the site, please see the Site Information Centre.

For information on activities capable of affecting the protected features of the site, please see the Advice on Operations workbook (hyperlink is provided in the box at the top of this document).

Attribute: Supporting processes

Objective:

An objective has not been set for this attribute. Links to available evidence are provided below. Please contact JNCC at OffshoreMPAs@jncc.gov.uk for further site-specific information on this attribute.

Explanatory notes

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

Hydrodynamic regime

Water quality.

Hydrodynamic regime

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

The hydrodynamic regime can also influence the rate at which sediment is deposited, and this is known to influence the status of reef habitats and / or their associated communities. Sedimentation on reef habitats, though smothering, can influence community composition, alter species growth rates and potentially affect reproductive success, reducing larval recruitment.

Water quality

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

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

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

Water quality

The water quality properties that influence habitats include salinity, pH, temperature, suspended particulate concentration, nutrient concentrations and dissolved oxygen. They can act alone or in combination to affect habitats and their communities in different ways, depending on species-specific tolerances. In fully offshore habitats these parameters tend to be relatively more stable, particularly so for deeper waters, although there may be some natural seasonal variation. Water quality properties can influence the abundance, distribution and composition of communities at relatively local scales. Changes in any of the water quality properties can impact habitats and the communities they support (Elliot *et al.,*1998; Little, 2000; Gray and Elliot, 2009). Changes in suspended sediment in the water column may have a range of biological effects on different species within the habitat; affecting the ability to feed or breathe. A prolonged increase in suspended particulates for instance can have a number of implications, such as affecting fish health, clogging filtering organs of suspension feeding animals and affecting seabed sedimentation rates (Elliot *et al.,*1998). Low dissolved oxygen can have sub-lethal and lethal impacts on fish and infaunal and epifaunal communities (Best *et al.,* 2007). Concentrations of contaminants in the water column must not exceed the EQS listed above.

Supporting processes for the feature within the site

For further site-specific information on the natural processes which support the feature within the site, please see the Site Information Centre.

For information on activities capable of affecting the protected features of the site, please see the Advice on Operations workbook (hyperlink is provided in the box at the top of this document).

Table 2: Supplementary advice on the conservation objectives for protected sedimentary broad-scale habitats (Subtidal coarse sediment / Subtidal mixed sediments mosaic, Subtidal sand and Subtidal mud) and habitat Feature of Conservation Interest (Sea-pen and burrowing megafauna communities) in East of Haig Fras MCZ

Attribute: Extent and distribution

Objective:
An objective has not been set for this attribute. Links to available evidence are provided below. Please contact JNCC at OffshoreMPAs@jncc.gov.uk for further site-specific information on this attribute.

Explanatory notes

Extent refers to the total area in the site occupied by Subtidal sedimentary habitats 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 (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, 2004a). The extent of the Subtidal sedimentary habitats within the site must be conserved to their full known distribution.

Subtidal sedimentary habitats are defined by:

- ***Sediment composition*** (grain size and type) (e.g. Cooper *et al.,* 2011; Coates *et al.,* 2015; 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 within an MPA could indicate a change in the distribution and extent of Subtidal sedimentary habitats 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 (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.

A general description of the different types of Subtidal sedimentary habitats found in the UK offshore marine environment of relevance to this MPA is provided below:

- *A5.1 Subtidal coarse sediment* – Comprises of coarse sand, gravel, pebbles, shingle and cobbles. These sediments typically have low silt content and are characterised by robust fauna, including venerid bivalves (Connor *et al.,* 2004). The particle sizes of Subtidal coarse sediments are classed as more than 0.063 mm but predominantly contain grains sizes in excess of 2 mm (McBreen and Askew, 2011).
- *A5.2 Subtidal sand* – Comprises of clean medium to fine sands or non-cohesive slightly muddy sands. Such habitats are often subject to a degree of wave action or tidal currents which restrict the silt and clay content to less than 15%. This habitat is characterised by a range of taxa including polychaetes, bivalve molluscs and amphipods (Connor *et al.,* 2004). Subtidal sand is defined by the ratio of mud to sand being lower than 4:1, with particle sizes of less than 0.063 mm for mud and 0.063 mm to 2 mm for sand (McBreen and Askew, 2011).
- *A5.3 Subtidal mud* - Comprises of mud and cohesive sandy mud. This habitat is predominantly found in stable deeper/offshore areas where the reduced influence of wave action and/or tidal streams allow fine sediments to settle. These habitats are often dominated by polychaetes and echinoderms, such as *Amphiura* spp., sea-pens, such as the slender sea-pen (*Virgularia mirabilis*), and burrowing megafauna, such as the Norway lobster (*Nephrops norvegicus*) (Connor *et al.,* 2004), although polychaetes, sea spiders, molluscs, crustaceans and fish are also found. Bathymetry, current velocity, bottom water-mass distribution and particle size of the mud (clay, silty or sandy) have a significant influence on the distribution and composition of the seabed communities present. Subtidal mud is defined by a ratio of mud to sand being greater than 4:1, with particle sizes of less than 0.063 mm for mud and 0.063 mm to 2 mm for sand (McBreen and Askew, 2011). On the continental shelf, the Priority Marine Feature (PMF) Offshore deep-sea muds directly equates to the EUNIS habitat A5.3 Subtidal mud, but the PMF also covers deep-water examples that occur on or beyond the continental slope (Tyler-Walters *et al.,* 2016).
- *A5.4 Subtidal mixed sediments* – Comprises of mixed sediments found from extreme low water to deep, offshore circalittoral habitats. These habitats include a range of sediments, such as heterogeneous muddy gravelly sands and mosaics of cobbles and pebbles embedded in or lying upon sand, gravel or mud. Mixed sediments include mosaic habitats, such as superficial waves or ribbons of sand on a gravel bed or areas of lag deposits with cobbles/pebbles embedded in sand or mud and are less well defined, sometimes overlapping other habitat or biological subtypes. These habitats may support a wide range of infauna and epibionts, including polychaetes, bivalves, echinoderms, anemones, hydroids and bryozoans (Connor *et al.,* 2004). Subtidal mixed sediments are classed by a range sediment sizes, predominantly more than 0.063 mm, but mud may also be present (McBreen and Askew, 2011).
- *Sea-pen and burrowing megafauna communities* – Characterised by plains of fine mud, at water depths ranging from 15 to >200 m, that are heavily bioturbated by burrowing megafauna. Burrows and mounds may form a prominent feature of the sediment surface that may or may not include conspicuous populations of sea-pens, typically *Virgularia mirabilis* and *Pennatula phosphorea*. Burrowing

crustaceans present may include *Nephrops norvegicus, Calocaris macandreae* or *Callianassa subterranea*. In places, the tall sea-pen (*Funiculina quadrangularis*) may also be present. The burrowing activity of megafauna creates a complex habitat, providing deep oxygen penetration (OSPAR, 2011).

Extent and distribution of the sedimentary broad-scale habitats and habitat feature of conservation interest within the site
The designated features for this site are Subtidal coarse sediment / Subtidal mixed sediments mosaic, Subtidal sand, Subtidal mud and Sea-pen and burrowing megafauna communities. The extent and distribution of these features within the site are shown in the site map. For further site-specific information please see the Site Information Centre.

For information on activities capable of affecting the protected features of the site, please see the Advice on Operations workbook (hyperlink is provided in the box at the top of this document).

Attribute: Structure and function

Objective:

An objective has not been set for this attribute. Links to available evidence are provided below. Please contact JNCC at OffshoreMPAs@jncc.gov.uk for further site-specific information on this attribute.

Explanatory notes

Structure refers to the physical structure of a Subtidal sedimentary habitat 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 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: 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; 2016; Coblentz *et al.,* 2015).

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. 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 can also be classed as a key or influential species. Changes to the spatial distribution of communities across a Subtidal sedimentary habitat could indicate changes to the overall feature and as a result how it functions (JNCC, 2004a). 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, and to support their conservation status (JNCC, 2004a; 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 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 (Mazik *et al.,* 2015).

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 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 could indicate changes to the overall feature (JNCC, 2004a). 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, 2004a; 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 (Mazik *et al.,* 2015).

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 include:

- Nutrition: Different sediment types offer habitat for various commercial species, for instance mud habitats can be suitable for Norway lobster (Sabatini and Hill, 2008) and shallow sandy sediments can offer habitat for sand eels (Rowley, 2008), 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.

Structure and function of the feature within the site
For further site-specific information on the structure and function of the feature within the site, please see the Site Information Centre.

For information on activities capable of affecting the protected features of the site, please see the Advice on Operations workbook (hyperlink is provided in the box at the top of this document).

Attribute: Supporting processes

Objective:

An objective has not been set for this attribute. Links to available evidence are provided below. Please contact JNCC at OffshoreMPAs@jncc.gov.uk for further site-specific information on this attribute.

Explanatory notes

Subtidal sedimentary habitats 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 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).

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, 2004a; 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 2010) 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) and 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 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 the EQS.

Sediment quality

Various contaminants are known to affect the species that live in or on the surface of Subtidal sedimentary habitats. 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.

Supporting processes for the feature within the site

For further site-specific information on the natural processes which support the feature within the site, please see the Site Information Centre.

For information on activities capable of affecting the protected features of the site, please see the Advice on Operations workbook (hyperlink is provided in the box at the top of this document).

Table 3: Supplementary advice on the conservation objectives for Fan mussel (Atrina fragilis) in East of Haig Fras MCZ

Attribute: Extent and distribution

An objective has not been set for this attribute. Links to available evidence are provided below. Please contact JNCC at OffshoreMPAs@jncc.gov.uk for further site-specific information on this attribute.

Explanatory notes

Extent describes the occurrence of *Atrina fragilis* (herein referred to as Fan mussel), with distribution providing a more detailed overview of the species location(s) and pattern of occurrence within a site. The distribution of Fan mussels within a site is likely to consist of individuals found alone or in highly patchy small communities (Anon, 1999; ERCCIS, 2002; Hiscock *et al.,* 2005). It is important to conserve the full known extent and distribution of the Fan mussel population within a site, as well as the life history and environmental preferences of the species as this will have a strong influence on extent and distribution.

Fan mussel is found predominantly off southern and western British coasts, as well as northern Scotland and offshore (Seaward, 1982; Hiscock *et al*., 2005). Although Fan mussel has never been recorded as abundant in the UK, the species is categorised as "nationally rare" since 1970 and "scarce" and "threatened" in UK waters (Solandt, 2003; Hiscock and Jones, 2004; Hiscock *et al*., 2005).

Due to the severe decline of Fan mussel populations in the UK and the relatively slow growth rates associated with the species (3-4 cm a year with an average life expectancy of twelve years), it is thought that the Fan mussel's population extent and distribution within a site would be slow to recover from any loss (Anon, 1999; Solandt, 2003; Hiscock *et al*., 2005; Tyler-Walters *et al*., 2009). Scientific literature indicates that recovery of a population's extent and distribution within a site is likely to be reliant on several factors: the degree of anthropogenic disturbance, an unpredictable supply of recruits from elsewhere (i.e. the Bay of Biscay and the Iberian Peninsula; Hiscock *et al.,* 2005), and the presence of suitable supporting habitat within the site (this include a range of sediment types from mud, sand and gravel sediments to clay substrates). Recovery would also be highly dependent on wider environmental parameters such as temperature. Further advice on these factors is provided under the structure and supporting processes attributes.

Extent and distribution of fan mussel (*Atrina fragilis*) within the site
The extent and distribution of the feature within the site is shown in the site map. For further site-specific information please see the Site Information Centre.

For information on activities capable of affecting the protected features of the site, please see the Advice on Operations workbook (hyperlink is provided in the box at the top of this document).

Attribute: Structure and function

Objective: Maintain/Recover

An objective has not been set for this attribute. Links to available evidence are provided below. Please contact JNCC at OffshoreMPAs@jncc.gov.uk for further site-specific information on this attribute.

Explanatory notes

Structure

Structure refers to the densities and age classes of individuals from a population found within a site. The structure of Fan mussel populations is difficult to assess as although in the 19th century Fan mussel were a gregarious species in the UK often found in large populations (Jeffreys, 1863), more recent reports state that individuals are predominantly found alone or in highly patchy small communities (Anon, 1999; ERCCIS, 2002; Hiscock *et al.,* 2005). It is important that the number and age class of individuals within a site is conserved in the long-term to maintain the population.

The structure of Fan mussel populations tends to be highly skewed in UK waters, with populations containing mainly adults (Anon, 1999; ERCCIS, 2002; Hiscock *et al.,* 2005). This lack of juveniles has been attributed to the fact that UK waters act as a sink for Fan mussels, low fecundity, high larval mortality and the remoteness to other individuals (Marshall, 2002; Stirling *et al.*, 2016). Despite low reproductive output, as the seas around the UK warm, it is expected that UK populations of Fan mussel may experience increased recruitment from the Iberian Peninsula resulting in a range extension (Hiscock *et al.* 2004; Hiscock, 2012). Recovery of the feature within a site is therefore likely to be increasingly reliant on an unpredictable supply of recruits from elsewhere and influenced by warming seas associated with climate change.

Fan mussels can grow up to 40 cm long at a growth rate of around 3 - 4 cm a year (Anon, 1999). This suggests that larger individuals are at least 12 years old (Solandt, 2003). As with many animals, the growth rate is fastest in young individuals (up to 3 years old), slowing in later years at the onset of sexual maturity (Richardson *et al.,* 1999). After damage, Fan mussels are able to regrow shell material at a rate of 1 cm a year (Yong and Thompson, 1976). However, this may be highly dependent on location (Solandt, 2003) and therefore shell length is not a reliable indicator of age for this species.

Recovery of Fan mussel populations to damage is hard to monitor and slow due to the relatively long-lived, slow-growing, low density, irregularly recruiting, high juvenile mortality and low fecundity of the species (Anon, 1999; Solandt, 2003; Hiscock *et al*., 2005; Tyler-Walters *et al*., 2009). For the UK, this is compounded by the fact that any recovery would also be expected to be dependent on a supply of recruits from elsewhere.

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 Fan mussel. These processes 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 a Fan mussel population include:

- Scientific study: The study of *Atrina* shells provides information about changes in sea temperatures in the mid-Piacenzian (c.3.3–3.0 Ma) (Valentine *et al.,* 2011);
- Regulatory processes: Providing a bentho-pelagic link by removing plankton and detritus from the water column;
- Ecosystem engineering: Fan mussels can provide habitats for benthic communities acting as a substrate for their settlement, increasing their diversity and providing safe areas from predators (Cummings *et al*., 1998; Fryganiotis *et al*., 2013). They can also promote the growth of species relevant to the fisheries sector. For example, juvenile Pectinids attached to *Atrina* shells (Hall-Spencer *et al*., 1999); and
- Climate change regulation: Fan mussels take up carbon from the environment during the process of shell growth (NRC, 2010).

Structure and function of the feature within the site

For further site-specific information on the structure and function of the feature within the site, please see the Site Information Centre.

For information on activities capable of affecting the protected features of the site, please see the Advice on Operations workbook (hyperlink is provided in the box at the top of this document).

Attribute: Supporting processes

Objective: Maintain/Recover

An objective has not been set for this attribute. Links to available evidence are provided below. Please contact JNCC at OffshoreMPAs@jncc.gov.uk for further site-specific information on this attribute.

Explanatory notes

Fan mussel rely on a range of supporting natural processes to support function (ecological processes) and recovery from adverse impacts. Supporting processes can be physical, biological and chemical in nature (Alexander *et al.,* 2014). In the case of Fan mussel, it is unclear which of the supporting processes 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 larvae, 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). Consequently, the hydrodynamic regime is important for supporting Fan mussel feeding, growth and survival within a site.

Alterations to the natural movement of water and sediment within a site could affect the presence and distribution of Fan mussel, particularly given the reliance on larvae from the Bay of Biscay, France to re-stock populations in UK waters (Hiscock *et al.,* 2005). The natural movement of water and sediment within the site should therefore not be hindered.

Supporting habitat

The extent and distribution of supporting habitat plays an important role in determining the extent and distribution of the species. As a burrowing species, Fan mussel has been found in a range of sediments, from mud, sand and gravel sediments to clay substrates. The depth range occupied by the species is from mean low water spring to 400 m deep (Solandt, 2003), with higher densities found between 30 to 50 m (Fryganiotis *et al*., 2013). Fan mussel are thought to be highly sensitive to physical loss of habitat (Solandt, 2003; Hiscock and Jones, 2004; Hiscock et al., 2005; Tyler-Walters et al., 2009; Fryganiotis et al., 2013). It is therefore important to conserve the extent and distribution of supporting habitats within a site to provide the best chance of any potential settlement for new recruits and consequently conservation of its Fan mussel population.

Water and sediment quality

Fan mussel sensitivity to contaminants is poorly understood and consequently our confidence in sensitivity information is low. Fan mussel is not considered sensitive to contaminants at the Environmental Quality Standards (EQS) levels (Tyler-Walters and Wilding, 2017). However, above EQS levels, some contaminants may impact the conservation status of Fan mussel depending on the nature of the contaminant (UKTAG, 2008; EA, 2014).

The targets listed below for water and sedimentary contaminants in the marine environment 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 (Harries *et al*., 2001);
- Cefas' Green Book; and
- Cefas' Containment Status of the North Sea Report (2001) and Contaminant Status of the Irish Sea' Report (2005).

Fan mussel is sensitive to changes in several water quality parameters. 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 water quality properties that influence Fan mussel conservation status include salinity, pH, temperature, suspended particulate concentration, nutrient concentrations and dissolved oxygen (Anon,1999; Hiscock and Jones, 2004 and Tyler-Walters and Wilding, 2017). These parameters can act alone or in combination to affect Fan mussel 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 (Gray and Elliot, 2009).

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. Many uncertainties exist in predicting our future climate and the impacts on habitats and species (EC, 2013). It is therefore important to conserve the natural temperature regime of the water column as far as is practicable against wider environmental pressures.

Fan mussels are not considered sensitive to organic and inorganic pollutants (Tyler-Walters and Wilding, 2017). JNCC advise that aqueous contaminants should be restricted to comply with water column annual average limits according to the amended EQS 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.

Supporting processes for the feature within the site
For further site-specific information on the natural processes which support the feature within the site, please see the Site Information Centre.

For information on activities capable of affecting the protected features of the site, please see the Advice on Operations workbook (hyperlink is provided in the box at the top of this document).

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