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

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 and Offshore deep-sea muds specified in the site's conservation objective. These attributes are: extent and distribution, structure and function and supporting processes.

Supplementary advice on the conservation objectives for the geomorphological features: Sediment drifts and Polygonal fault systems representative of the Hatton Bank (and adjacent seafloor) Key Geodiversity Area are not currently provided in this document. Further information regarding these features can be found on the Site information Centre.

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 the following tables must be taken into consideration when assessing impacts from an activity.

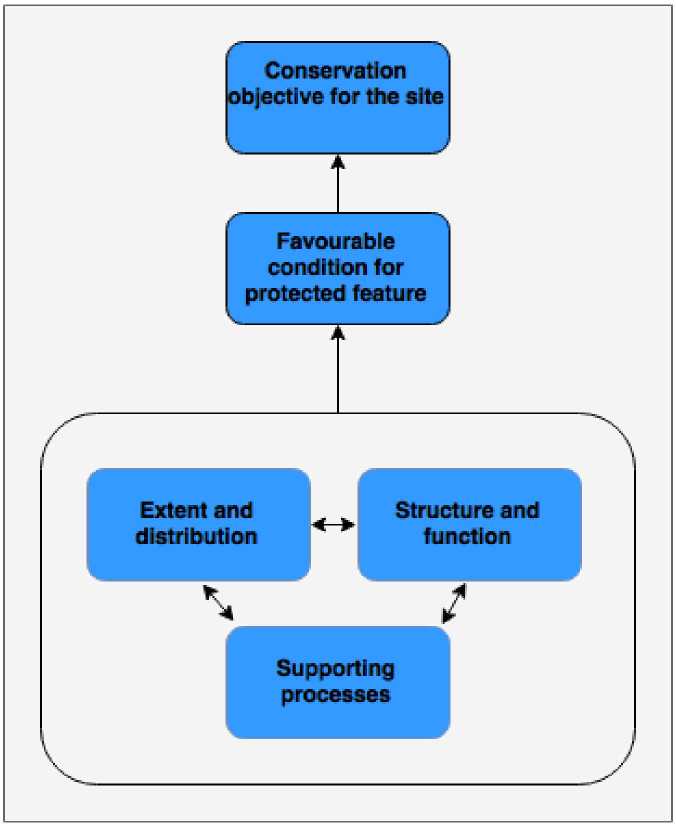


**Figure 1. Conceptual diagram showing how a feature's attributes are interlinked and collectively describe favourable condition and contribute to the conservation objectives stated for the site.**

In Table 1 and Table 2 below, the attributes for the Deep-sea sponge aggregations and Offshore deep-sea muds, respectively, 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 conserved 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 Deep-sea sponge aggregations in Hatton-Rockall Basin NCMPA

| Attribute: Extent and distribution |
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| **Objective:**<br>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**<br>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, 2004). It is important therefore to conserve the full known distribution of Deep-sea sponge aggregations within a site.<br><br>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):<br>• More than 0.5 individuals per $m^{-2}$;<br>• Registering as at least 'frequent' on the SACFOR scale; or<br>• If bycatches of sponges exceed 400 kg, based on the ICES recommendation (ICES, 2013) for the identification of Vulnerable Marine Ecosystems[1].<br><br>In UK waters, four different subtypes of Deep-sea sponge aggregations have been identified (Henry and Roberts, 2014):<br>1. **Boreal ostur sponge aggregations –** which are characterised by large structural geodiid sponges. Other erect and encrusting sponges may also be present. |

[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.

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 aggregation habitat 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; Mariani *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).

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**Extent and distribution of the Deep-sea sponge aggregations within the site**
The extent and distribution of the Deep-sea sponge aggregations 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 FeAST.

## 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**

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. 2; 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 refuges 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.

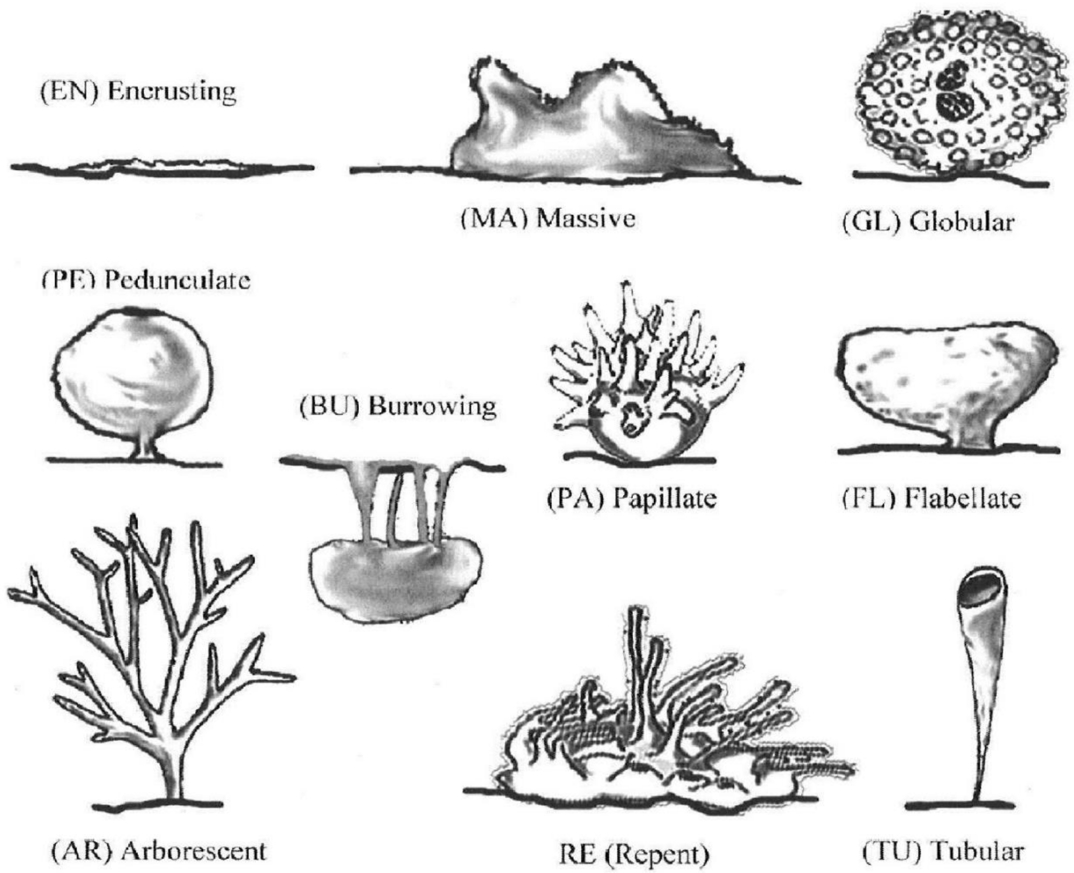


**Figure 2. An example range of sponge morphotypes (from Berman et al., 2013).**

Glass sponge fields are generally formed by a single species of structural sponge (Maldonado *et al.*, 2016). Bird's nest sponge (*Pheronema carpenteri*) fields are the most extensive type of glass sponge field in the North Atlantic (Howell *et al.*, 2016; Maldonado *et al.*, 2016).

Encrusting sponge dominated aggregations are characterised by low lying, encrusting and massive sponges (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; Mariani *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., 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.

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**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.

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**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 to 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. Spicule mats can cover around a third of the sea bed within bird's nest sponge fields (Bett and Rice, 1992).

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**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).

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**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 De La 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 communities 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.

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**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 FeAST.

## 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**
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.

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**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.

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**Water and sediment quality**
Contaminants may also 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, 2004; 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, 2010b) 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) and 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 Geoij *et al.*, 2008a; de Geoij *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.

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**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.

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**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.

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| For information on activities capable of affecting the protected features of the site, please see FeAST. |

**Table 2: Supplementary advice on the conservation objectives for Offshore deep-sea muds in Hatton-Rockall Basin NCMPA**

| **Attribute: Extent and distribution** |
|---|
| **Objective:**<br>**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**<br>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, 2004). The extent of the Subtidal sedimentary habitats within the site must be conserved to their full known distribution.<br><br>Subtidal sedimentary habitats are defined by:<br>• ***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<br>• ***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.<br><br>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:

- *Offshore deep-sea muds* - 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).

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**Extent and distribution of the Offshore deep-sea muds within the site**
The extent and distribution of the Offshore deep-sea muds 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 FeAST.

## 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.

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**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).

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**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, 2004). 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, 2004; 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).

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**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, 2004). 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, 2004; 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).

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**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 breeding and feeding 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);
- 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.

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**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 FeAST.

## 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).

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**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, 2004; 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) 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.

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**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; 2010b; 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.

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**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 FeAST.

# References

Barrio Froján, C.R.S., MacIsaac, K.G., McMillan, A.K., Sacau Cuadrado, M.M., Large, P.A., Kenny, A.J., Kenchington, E., and de Cárdenas González, E. (2012). An evaluation of benthic community structure in and around the Sackville Spur closed area (northwest Atlantic) in relation to the protection of vulnerable marine ecosystems. *ICES Journal of Marine Science*, 69: 213-222.

Barros, F., Underwood, A.J. and Archambault, P. (2004). The Influence of troughs and crests of ripple marks on the structure of subtidal benthic assemblages around rocky reefs. *Estuarine, Coastal and Shelf Science*, 60: 781-790.

Beaulieu, S.E. (2001). Life on glass houses: sponge stalk communities in the deep sea. *Marine Biology,* 138: 803-817.

Beazley, L.I., Kenchington, E.L., Murillo, F.J. and Sacau, M. (2013). Deep-sea sponge grounds enhance diversity and abundance of epibenthic megafauna in the Northwest Atlantic. *ICES Journal of Marine Scienc,e* 70: 1471-1490.

Beazley, L., Kenchington, E., Yashayaev, I. and Murillo, F.J. (2015). Drivers of epibenthic megafaunal composition in the sponge grounds of the Sackville Spur, northwest Atlantic. *Deep-Sea Research I,* 98: 102–114.

Bell, J.J. (2008). The functional roles of marine sponges. *Estuarine, Coastal and Shelf Science* 79: 341–353.

Bell, J.J., McGrath, E., Biggerstaff, A., Bates, T., Bennett, H., Marlow, J. and Shaffer, M. (2015). Sediment impacts on marine sponges. *Marine Pollution Bulletin,* 94: 5-13

Bell, J.J., Biggerstaff, A., Bates, T., Bennett, H., Marlow, J., McGrath, E. and Shaffer, M. (2017). Sponge monitoring: Moving beyond diversity and abundance measures. *Ecological Indicators,* 78: 470-488.

Berman, J., Burton, M., Gibbs, R., Lock, K., Newman, P., Jones, J. and Bell, J. (2013). Testing the suitability of a morphological monitoring approach for identifying temporal variability in a temperate sponge assemblage. *Journal for Nature Conservation,* 21: 173-182.

Best, M.A., Wither, A.W. and Coates, S. (2007). Dissolved oxygen as a physico-chemical supporting element in the Water Framework Directive. *Marine Pollution Bulletin*, 55: 53-64 [online]. Available at: http://www.sciencedirect.com/science/article/pii/S0025326X06003171 [Accessed 20 September 2017].

Bett, B.J. and Rice, A.L. (1992). The influence of hexactinellid sponge (*Pheronema carpenteri*) spicules on the patchy distribution of macrobenthos in the Porcupine Seabight (bathyal NE Atlantic). *Ophelia,* 36: 217–226.

Bett, B.J. (2012). Seafloor biotope analysis of the deep waters of the SEA4 region of Scotland's seas. JNCC Report No. 472 [online]. Available at: http://jncc.defra.gov.uk/pdf/472_web.pdf [Accessed 10 October 2015].

Biles, C.L., Solan, M., Isaksson, I., Paterson, D.M., Emes, C. and Raffaelli, G. (2003). Flow modifies the effect of biodiversity on ecosystem functioning: an in-situ study of estuarine sediments. *Journal of Experimental Marine Biology and Ecology*, 285: 165-177.

Buhl-Mortensen, L., Vanreusel, A., Gooday, A.J., Levin, L.A., Priede, I.G., Buhl-Mortensen, P., Gheerardyn, H., King, N.J. and Raes, M. (2010). Biological structures as a source of habitat heterogeneity and biodiversity on the deep ocean margins. *Marine Ecology* 31: 21-50.

Buhl-Mortensen L. and Mortensen P.B. (2005). Distribution and diversity of species associated with deep-sea gorgonian corals off Atlantic Canada. In: Freiwald A., Roberts J.M. (eds) Cold-Water Corals and Ecosystems. Erlangen Earth Conference Series. Springer, Berlin, Heidelberg.

Camphuysen, K., Scott, B. and Wanless, S. (2011). Distribution and foraging interactions of seabirds and marine mammals in the North Sea: A metapopulation analysis [online]. Available at: http://www.abdn.ac.uk/staffpages/uploads/nhi635/ZSLpaper-kees.pdf [Accessed 20 September 2017].

Cathalot, C., Van Oevelen, D., Cox, T.J.S., Kutti, T., Lavaleye, M., Duineveld, G. and Meysman, F.J.R. (2015). Cold-water coral reefs and adjacent sponge grounds: hotspots of benthic respiration and organic carbon cycling in the deep sea. *Frontiers in Marine Science*, 2: 37. [online] Available at: https://doi.org/10.3389/fmars.2015.00037 [Accessed December 2017].

Cebrian, E., Martí, R., Uriz, J.M. and Turon, X. (2003). Sublethal effects of contamination on the Mediterranean sponge *Crambe crambe*: metal accumulation and biological responses. *Marine Pollution Bulletin*, 46: 1273-1284.

Cebrian, E., Agell, G., Marti, R. and Uriz, M.J. (2006). Response of the Mediterranean sponge *Chondrosia reniformis* Nardo to copper pollution. *Environmental Pollution,* 141: 452-458.

Cebrian, E. and Uriz, M.J. (2007). Contrasting effects of heavy metals and hydrocarbons on larval settlement and juvenile survival in sponges. *Aquatic Toxicology,* 81: 137-143.

Chamberlain, J., Fernandes, T.F., Read, P., Nickell, D. and Davies, I.M. (2001). Impacts of biodeposits from suspended mussel (*Mytilus edulis* L.) culture on the surrounding surficial sediments. *ICES Journal of Marine Science*, 58: 411-416.

Coates, D.A., Alexander, D., Stafford, R. and Herbert, R.J.H. (2015). Conceptual ecological modelling of shallow sublittoral mud habitats to inform indicator selection. JNCC Report No. 557 [online]. Available at: http://jncc.defra.gov.uk/PDF/Report%20557_web.pdf [Accessed 20 September 2017].

Coates, D.A., Alexander, D., Herbert, R.J.H. and Crowley, S.J. (2016). Conceptual ecological modelling of shallow sublittoral sand habitats to inform indicator selection. JNCC Report No. 585 [online]. Available at: http://jncc.defra.gov.uk/pdf/Report_585_web.pdf [Accessed 20 September 2017].

Coblentz, K.E., Henkel, J. R., Sigel, B.J. and Taylor, C.M. (2015). Influence of sediment characteristics on the composition of soft-sediment intertidal communities in the northern Gulf of Mexico. PeerJ 3: e1014. [online]. Available at: https://dx.doi.org/10.7717/peerj.1014 [Accessed 20 September 2017].

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. and Reker, J.B. (2004). The Marine Habitat Classification for Britain and Ireland, Version 04.05

Cooper, K.M., Curtis, M., Wan Hussin, W.M.R., Barrio F.C.R.S., Defew, E.C., Nye, V. and Paterson, D.M. (2011). Implications of dredging induced changes in sediment particle size composition for the structure and function of marine benthic macrofaunal communities. *Marine Pollution Bulletin*, 62: 2087-2094.

Custódio, M.R., Hajdu, E., Lôbo-Hajdu, G., and Muricy, G. (eds) Porifera Research: Biodiversity, Innovation and Sustainability. Proceedings of the 7th International sponge symposium Rio de Janeiro, Brazil: Museu. Nacional: 613-620.

Daunt, F., Wanless, S., Greenstreet, S.P.R., Jensen, H., Hamer, K.C. and Harris, M.P. (2008). The impact of the sandeel fishery on seabird food consumption, distribution and productivity in the north-western North Sea. *Canadian Journal of Fisheries and Aquatic Science*, 65: 362-381.

de Goeij, J.M., Moodley, L., Houtekamer, M., Carballeira, N.M. and van Duyl, F.C. (2008a). Tracing 13C-enriched dissolved and particulate organic carbon in the bacteria-containing coral reef sponge *Halisarca caerulea*: Evidence for DOM-feeding. *Limnology and Oceanography*, 53(4), 1376-1386.

de Goeij, J.M., Berg, H., van Oostveen, M.M., Epping, E.H.G. and Duyl, F. (2008b). Major bulk dissolved organic carbon (DOC) removal by encrusting coral reef cavity sponges. *Marine Ecology-progress Series*, 357: 139-151.

Dernie, K.M., Kaiser, M.J. and Warwick, R.M. (2003). Recovery rates of benthic communities following physical disturbance. *Journal of Animal Ecology*, 72: 1043-1056.

Duckworth, A.R. (2003). Effect of wound size on the growth and regeneration of two temperate subtidal sponges. *Journal of Experimental Biology and Ecology* 287: 139-153.

Duckworth, A., West, L., Vansach, T., Stubler, A. and Hardt, M. (2012). Effects of water temperature and pH on growth and metabolite biosynthesis of coral reef sponges. *Marine Ecology Progress Series*, 462: 67-77.

Dutertre, M., Hamon, D., Chevalier, C. and Ehrhold, A. (2012). The use of the relationships between environmental factors and benthic macrofaunal distribution in the establishment of a baseline for coastal management. *ICES Journal of Marine Science*, 70: 294-308.

Ebada, S.S., Lin, W.H. and Proksch, P. (2010). Bioactive Sesterterpenes and Triterpenes from marine sponges: Occurance and pharmacological significance. *Marine Drugs,* 8: 313-346.

Elliott, M., Nedwell, S., Jones, N.V., Read, S.J., Cutts, N.D. and Hemingway, K.L. (1998). Intertidal sand and mudflats and subtidal mobile sandbanks volume II. An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. UK Marine SACs Project. Oban, Scotland, English Nature.

Environment Agency (EA) (2014). Water Framework Directive: Surface water classification status and objectives [online]. Available at: http://www.geostore.com/environmentagency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml [Accessed 20 March 2017].

European Topic Centre (ETC) (2011). Assessment and reporting under Article 17 of the Habitats Directive. Explanatory notes and guidelines for the period 2007-2012 [online]. Available at: https://circabc.europa.eu/sd/a/2c12cea2-f827-4bdb-bb56-3731c9fd8b40/Art17%20-%20Guidelines-final.pdf [Accessed 20 September 2017].

Fisheries Research Services (FRS) (2017). Sandeels in the North Sea. Scottish Government [online]. Available at: http://www.gov.scot/Uploads/Documents/ME01ASandeels.pdf Accessed 10 October 2017].

Freese, J.L. and Wing, B.L. (2003). Juvenile red rockfish, Sebastes sp., associations with sponges in the Gulf of Alaska. *Marine Fisheries Review,* 65: 38–42.

Freese, J.L. (2001). Trawl-induced damage to sponges observed from a research submersible. *Marine Fisheries Review*, 63 (3): 7-13.

Frost, T. (1981). Analysis of Ingested Particles within a Fresh-Water Sponge. *Transactions of the American Microscopical Society,* 100: 271-277.

Gage, J.D. (2001). Deep-sea benthic community and environmental impact assessment at the Atlantic Frontier. *Continental Shelf Research*, 1: 957-986.

Gentric, C., Rehel. K., Dufour, A. and Sauleau, P. (2016). Bioaccumulation of metallic trace elements and organic pollutants in marine sponges from the South Brittany Coast, France. *Journal of Environmental Science and Health, Part A,* 51: 213-219.

Gray, J. and Elliott, M. (2009). Ecology of Marine Sediments: From Science to Management, Second Edition, Oxford Biology.

Green, M.O., Vincent, C.E., McCave, I.N., Dickson, R.R., Rees, J.M. and Pearsons, N.D. (1995). Storm sediment transport: observations from the British North Sea shelf. *Continental Shelf Research,* 15: 889-912.

Greenwood, N., Parker, E.R., Fernand, L., Sivyer, D.B., Weston, K., Painting, S.J., Kröger, S., Forster, R.M., Lees, H.E., Mills, D.K. and Laane, R.W.P.M. (2010). Detection of low bottom water oxygen concentrations in the North Sea; implications for monitoring and assessment of ecosystem health. *Biogeoscience*, 7: 1357-1373.

Gubbay, S. (2002). The Offshore Directory *Review of a selection of habitats, communities and species of the north-east Atlantic.* [online]. Available at:

http://www.savethehighseas.org/resources/publications/offshore-directory-review-selection-habitats-communities-species-north-east-atlantic/ [Accessed January 2018].

Hadas, E., Shpigel, M. and Ilan, M. (2009). Particulate organic matter as a food source for a coral reef sponge. *The Journal of Experimental Biology*. 212: 3643-50.

Henry, L-A. and Hart, M. (2005). Regeneration from injury and resource allocation in sponges and corals–A review. *International Review of Hydrobiology,* 90: 125-158.

Henry, L-A. and Roberts, J.M. (2014). Applying the OSPAR habitat definition of deep-sea sponge aggregations to verify suspected records of the habitat in UK waters. JNCC Report No. 508. Peterborough.

Hiscock, K., Southward, A., Tittley, I. and Hawkins, S. (2004). Effects of changing temperature on benthic marine life in Britain and Ireland. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 14: 333-362.

Hogg, M.M., Tendal, O.S., Conway, K.W., Pomponi, S.A., Van-Soest, R.W.M., Krautter, M. and Roberts, J.M. (2010). Deep-sea sponge grounds: reservoirs of biodiversity. *UNEP-WCMC Biodiversity Series No. 32*, UNEP-WCMC, Cambridge.

Hosegood, P. and van Haren, H. (2004). Near-bed solibores over the continental slope in the Faeroe-Shetland Channel. *Deep-Sea Research Part II*, 51: 2943-2971.

Hoffmann, F., Rapp, H., Zöller, T. and Reitner, J. (2003). Growth and regeneration in cultivated fragments of the boreal deep water sponge *Geodia barretti* Bowerbank, 1858 (Geodiidae, Tetractinellida, Demospongiae). *Journal of Biotechnology*, 100: 109-18.

Howell, K.L., Piechaud, N., Downie, A.L. and Kenny A. (2016). The distribution of deep-sea sponge aggregations in the North Atlantic and implications for their effective spatial management. *Deep-sea Research 1,* 115: 309-320.

Hughes, T.P., Bellwood, D.R., Folke, C., Steneck, R.S. and Wilson, J. (2005). New paradigms for supporting the resilience of marine ecosystems. *Trends Ecological Evolution*, 20: 380-386.

Hughes, D.J. (2014). Benthic habitat and megafaunal zonation across the Hebridean Slope, western Scotland, analysed from archived seabed photographs. *Journal of the Marine Biological Association of the UK*, 94: 643-658.

ICES. (2009). Report of the ICES-NAFO Working Group on Deep-Water Ecology (WGDEC), 9–13 March 2009. ICES Advisory Committee [online]. Available at: http://vme.ices.dk/download/WGDEC_2009.pdf [Accessed July 2017].

ICES. (2013). Report of the ICES-NAFO Joint working Group on Deep-Water Ecology (WGDEC), 11–15 March 2013. ICES Advisory Committee, Floedevigen, Norway. [online]. Available at: http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2013/WGDEC/wgdec_2013.pdf [Accessed July 2017].

Indraningrat, A.A.G., Smidt, H. and Sipkema, D. (2016). Bioprospecting sponge-associated microbes for antimicrobial compounds. *Marine Drugs,* 14: doi:10.3390/md14050087. [online]Available at: http://www.mdpi.com/1660-3397/14/5/87. [Accessed 17 January 2018].

Joint Nature Conservation Committee (JNCC) (2004). Common standards monitoring guidance for inshore sublittoral sediment habitats [online]. Available at: http://jncc.defra.gov.uk/PDF/CSM_marine_sublittoral_sediment.pdf [Accessed 20 September 2017].

Jones, E., McConnell, B., Sparling, C. and Matthiopoulos, J. (2013). Grey and harbour seal density maps. Sea Mammal Research Unit to Marine Scotland Report [online]. Available at: http://www.scotland.gov.uk/Resource/0041/00416981.pdf [Accessed 20 September 2017].

Kahn, A.S., Yahel, G., Chu, J.W.F., Tunnicliffe, V. and Leys, S.P. (2015). Benthic grazing and carbon sequestration by deep-water glass sponge reefs. Limnology and Oceanography. 1-19. [online]. Available at: http://onlinelibrary.wiley.com/doi/10.1002/lno.10002/abstract. [Accessed July 2017].

Kenchington, E., Power D. and Koen-Alonso, M. (2013). Associations of demersal fish with sponge grounds on the continental slopes of the northwest Atlantic. *Marine Ecology Progress Series,* 477: 217–230.

Kersken, D., Göcke, C., Brandt, A., Lejzerowicz, F., Schwabe, E., Seefeldt, M.A., Veit-Köhler, G. and Janussen, D. (2014). The infauna of three widely distributed sponge species (Hexactinellida and Demospongiae) from the deep Ekström Shelf in the Weddell Sea, Antarctica. *Deep Sea Research Part II: Topical Studies in Oceanography,* 108: 101-112.

Klitgaard, A.B. and Tendal, O.S. (2004). Distribution and species composition of mass occurrences of large-sized sponges in the northeast Atlantic. *Progress in Oceanography*, 61: 57-98.

Laport, M.S., Santos, O.C.S. and Muricy, G. (2009). Marine Sponges: Potential sources of new antimicrobial drugs. *Current Pharmaceutical Biotechnology,* 10: 86-105.

Leys, S.P. and Lauzon, N.R.J. (1998) Hexactinellid sponge ecology: growth rates and seasonality in deep water sponges. *Journal of Experimental Marine Biology and Ecology*, 230: 111-129.

Limpenny, S.E., Barrio Frojan, C., Cotterill, C., Foster-Smith, R.L., Pearce, B., Tizzard, L., Limpenny, D.L., Long, D., Walmsley, S., Kirby, S., Baker, K., Meadows, W.J., Rees, J., Hill, K., Wilson, C., Leivers, M., Churchley, S., Russell, J., Birchenough, A. C., Green, S.L. and Law, R.J. (2011). The East Coast Regional Environmental Characterisation. MALSF. Cefas Report No. 08/04.

Little, C. (2000). The biology of soft shores and estuaries, Oxford University Press.

Maldonado, M., Ribes, M. and van Duyl, F.C. (2012). Nutrient Fluxes Through Sponges: Biology, Budgets, and Ecological Implications. In Mikel A. Becerro, Maria J. Uriz, Manuel Maldonado and Xavier Turon, editors: *Advances in Marine Biology,* Vol. 62, The Netherlands: Amsterdam, Academic Press, 2012, 113-182. ISBN: 978-0-12-394283-8 © Copyright 2012 Elsevier Ltd.

Maldonado, M., Aguilar, R., Bannister, R.J., Bell, J.J., Conway, K.W., Dayton, P.K., Díaz, C., Gutt, J., Kelly, M.R., Kenchington, E.L.R., Leys, S.P., Pomponi, S.A., Rapp, H.T., Rützler, K., Tendal, O.S., Vacelet, J. and Young, C.M. (2016). Sponge Grounds as Key Marine Habitats: A Synthetic Review of Types, Structure, Functional Roles, and Conservation Concerns. *Rossi, S. (ed.), Marine Animal Forests*, Springer International Publishing Switzerland.

Mariani, S., Uriz, M.J., Turon, X. and Alcoverro, T. (2006). Dispersal strategies in sponge larvae: integrating the life history of larvae and the hydrologic component. *Oecologia,* 149: 174-184.

Mayer, K.S., Young, C.M., Sweetman, A.K., Taylor, J., Soltwedel, T. and Bergmann, M. (2016). Rocky islands in a sea of mud: biotic and abiotic factors structuring deep-sea dropstone communities. *Marine Ecology Progress Series,* 556: 45-57.

Mazik, K., Strong, J., Little, S., Bhatia, N., Mander, L., Barnard, S. and Elliott, M. (2015). A review of the recovery potential and influencing factors of relevance to the management of habitats and species within Marine Protected Areas around Scotland. Scottish Natural Heritage Report No. 771 [online]. Available at: http://www.snh.org.uk/pdfs/publications/commissioned_reports/771.pdf [Accessed 20 September 2017].

McBreen, F. and Askew, N. (2011). UKSeaMap 2010 Technical Report 3. Substrate Data. Joint Nature Conservation Committee, Peterborough.

McConnell, B.J., Fedak, M.A., Lovell, P. and Hammond, P.S. (1999). Movements and foraging areas of grey seals in the North Sea. *Journal of Applied Ecology,* 36: 573–90.

McMurray, S., Blum, J. and Pawlik, J. (2008). Redwood of the reef: Growth and age of the giant barrel sponge Xestospongia muta in the Florida Keys. *Marine Biology*, 155: 159-171.

Mienis, F., de Stigter, H.C., White, M., Duineveld, G., de Haas, H. and van Weeringa, T.C.E. (2007). Hydrodynamic controls on cold-water coral growth and carbonate-mound development at the SW and SE Rockall Trough Margin, NE Atlantic Ocean. *Deep-Sea Research I,* 54: 1655-1674.

Montenegro-González, J. and Acosta, A. (2010). Habitat preference of Zoantharia genera depends on host sponge morphology. *Universitas Scientarium,* 15: 110-121.

Murillo, F.J., Kenchington, E., Lawson, J.M., Li, G. and Piper, D.J.W. (2016). Ancient deep-sea sponge grounds on the Flemish Bank and Grand Bank, northwest Atlantic. *Marine Biology* 163: [online]. Available at: https://doi.org/10.1007/s00227-016-2839-5. [Accessed July 2017].

Neves, G. and Omena, E. (2003). Influence of sponge morphology on the composition of the polychaete associated fauna from Rocas Atoll, northeast Brazil. *Coral Reefs,* 22: 123-129.

Norling, K., Rosenburg, R., Hulth, S., Gremare, A. and Bonsdorff, E. (2007). Importance of functional biodiversity and specific-specific traits of benthic fauna for ecosystem functions in marine sediment. *Marine Ecology Progress Series*, 332: 11-23.

OSPAR Commission (2009). Agreement on coordinated environmental monitoring programme assessment criteria for the QSR 2010. Monitoring and Assessment Series. OSPAR Agreement 2009-2002.

OSPAR (2010a). Background document for Deep-sea sponge aggregations. OSPAR Commission.

OSPAR Commission (2010b). Quality status report 2010. London.

OSPAR Commission (2012). Coordinated environmental monitoring programme 2011 assessment report.

Perea-Blázquez, A., Davy, S.K. and Bell, J.J. (2012). Estimates of Particulate Organic Carbon Flowing from the Pelagic Environment to the Benthos through Sponge Assemblages. *PLoS ONE,* 7(1): e29569. [online]. Available at: https://doi.org/10.1371/journal.pone.0029569. [Accessed December 2017].

Rix, L., de Goeij, J.M., Mueller, C.E., Struck, U., Middelburg, J.J., van Duyl F.C., Al-Horani, F.A., Wild, C., Naumann, M.S. and van Oevelen, D. (2016). Coral mucus fuels the sponge loop in warm- and cold-water coral reef ecosystems. *Scientific Reports* 6: [online]. Available at: https://www.nature.com/articles/srep18715 [Accessed December 2017].

Rix, L., de Goeij, J. M., van Oevelen, D., Struck, U., Al-Horani, F. A., Wild, C. and Naumann, M. S. (2017). Differential recycling of coral and algal dissolved organic matter via the sponge loop. *Functional Ecology*, 31: 778–789.

Roberts, D.A., Johnston, E.L. and Poore, A.G.B. (2008). Contamination of marine biogenic habitats and effects upon associated epifauna. *Marine Pollution Bulletin,* 56: 1057-1065.

Sayago-Gil, M., Long, D., Hitchen, K., Díaz-del-Río, V., Fernández-Salas, L.M. and Durán-Muñoz, P. (2010). Evidence for current-controlled morphology along the western slope of Hatton Bank (Rockall Plateau, NE Atlantic Ocean). *Geo-Marine Letters*, 30: 99-111.

Sawadogo, W.R., Boly, R., Cerella, C., Teiten, M.H., Dicato, M. and Diederich, M. (2015). A survey of marine natural compounds and their derivatives with anti-cancer activity reported in 2012. *Molecules,* 20: 7097-7142.

Schleuter, D., Günther, A., Paasch, S., Ehrlich, H., Kljajić, Z., Hanke, T., Bernhard, G. and Brunner, E. (2013). Chitin-based renewable materials from marine sponges for uranium absorption. *Carbohydrate Polymers,* 92: 712-718.

Schönberg, C.H.L. and Fromont, J. (2014). Sponge functional growth forms as a means for classifying sponges without taxonomy. Australian Institute Marine Science. [online] Available at: http://ningaloo-atlas.org.au/content/sponge-functional-growth-forms-means-classifying-spo [Accessed 18 December 2017].

Schönberg, C.H.L. (2016). Effects of dredging on filter feeder communities, with a focus on sponges. WAMSI Dredging Science Node. Report, Theme 6, Project 6.1 Western Australian Marine Science Institution.

Sciberras, M., Parker, R., Powell, C., Robertson, C., Kroger, S., Bolam, S. and Hiddink, J. (2016). Impacts of Bottom Fishing on Sediment Biogeochemical and Biological Parameters in Cohesive and Non-Cohesive Sediments. *Limnology and Oceanography*, 61: 2076-2089.

Scott, B.E., Sharples, J., Ross, O.N., Wang, J., Pierce, G.J. and Camphuysen, C.J. (2010). Sub-surface hotspots in shallow seas: fine-scale limited locations of top predator foraging habitat indicated by tidal mixing and sub-surface chlorophyll. *Marine Ecology Progress Series*, 408: 207-26.

Skilleter, G.A, Russel, B.D., Degnan, B.M. and Garson, M.J. (2005). Living in a potentially toxic environment: comparisons of endofauna in two congeneric sponges from the Great Barrier Reef. *Marine Ecology Progress Series* 304: 67-75.

Spetland, F., Rapp, H.T., Hoffmann, F. and Tendal, O.S. (2007). Sexual reproduction of *Geodia barretti* Bowerbank, 1858 (Porifera, Astrophorida) in two Scandinavian Fjords. In:

Talley, L.D. (2002). Salinity Patterns in the Ocean. The Earth System: Physical and Chemical Dimensions of Global Environmental Change, 1: 629-640 in Encyclopedia of Global Environmental Change.

Tillin, H.M., Hull, S.C. and Tyler-Walters, H. (2010). Development of a Sensitivity Matrix (pressures-MCZ/MPA features). Report to the Department of Environment, Food and Rural Affairs from ABPMer, Southampton and the Marine Life Information Network. Plymouth: Marine Biological Association of the UK. Defra Contract No. MB0102 Task 3A, Report No. 22 [online]. Available at: http://www.marlin.ac.uk/assets/pdf/MB0102_Task3-PublishedReport.pdf [Accessed 10 October 2017].

Tillin, H.M. and Tyler-Walters, H. (2014). Assessing the sensitivity of subtidal sedimentary habitats to pressures associated with marine activities: Phase 2 Report – Literature review and sensitivity assessments for ecological groups for circalittoral and offshore Level 5 biotopes. JNCC Report No. 512B [online]. Available at: http://jncc.defra.gov.uk/PDF/Report%20512-A_phase1_web.pdf [Accessed 10 October 2017].

Tréguer, P.J. and De La Rocha, C.L. (2013). The world ocean silica cycle. *Annual Review of Marine Science*, 5: 477-501.

Turon, X., Tarjuela, I. and Uriz, M.J. (1998) Growth dynamics and mortality of the encrusting sponge *Crambe crambe* (Poecilosclerida) in contrasting habitats: correlation with population structure and investment in defence. *Functional Ecology,* 12: 631-639.

Tyler-Walters, H., James, B., Carruthers, M. (eds.), Wilding, C., Durkin, O., Lacey, C., Philpott, E., Adams, L., Chaniotis, P.D., Wilkes, P.T.V., Seeley, R., Neilly, M., Dargie, J. and Crawford-Avis, O.T. (2016). Descriptions of Scottish Priority Marine Features (PMFs). Scottish Natural Heritage Commissioned Report No. 406 [online]. Available at: http://www.marlin.ac.uk/assets/pdf/406.pdf [Accessed 10 October 2017].

UK Technical Advisory Group on The Water Framework Directive (UKTAG) (2008). Proposals for Environmental Quality Standards for Annex VIII Substances. UK Technical Advisory Group on the Water Framework Directive.

Uriz, M.J., Maldonado, M., Turon, X. and Martí, R. (1998). How do reproductive output, larval behaviour, and recruitment contribute to adult spatial patterns in Mediterranean encrusting sponges? *Marine Ecology Progress Series,* 167: 137-148.

van Duyl, F., Hegeman, J., Hoogstraten, A. and Maier, C. (2008). Dissolved carbon fixation by sponge–microbe consortia of deep water coral mounds in the northeastern Atlantic Ocean. *Marine Ecology Progress Series,* 358: 137-150.

Wagner, H., Purser, A., Thomsen, L., Jesus, C.C. and Lundälv, T. (2011). Particulate organic matter fluxes and hydrodynamics at the Tisler cold-water coral reef. *Journal of Marine Systems,* 85: 19-29.

Wild, C., Mayr, C., Wehrmann, L., Schöttner, S., Naumann, M., Hoffmann, F. and Rapp, H. (2008). Organic matter release by cold water corals and its implication for fauna–microbe interaction. *Marine Ecology Progress Series*. 372. 67-75.

Witte, U., Brattegard, T., Graf, G. and Springer, B. (1997). Particle capture and deposition by deep-sea sponges from the Norwegian-Greenland Sea. *Marine Ecology Progress Series,* 154: 241-252.

Wulff, J. (2001). Assessing and monitoring coral reef sponges: why and how? *Bulletin of Marine Science,* 69: 831–846.