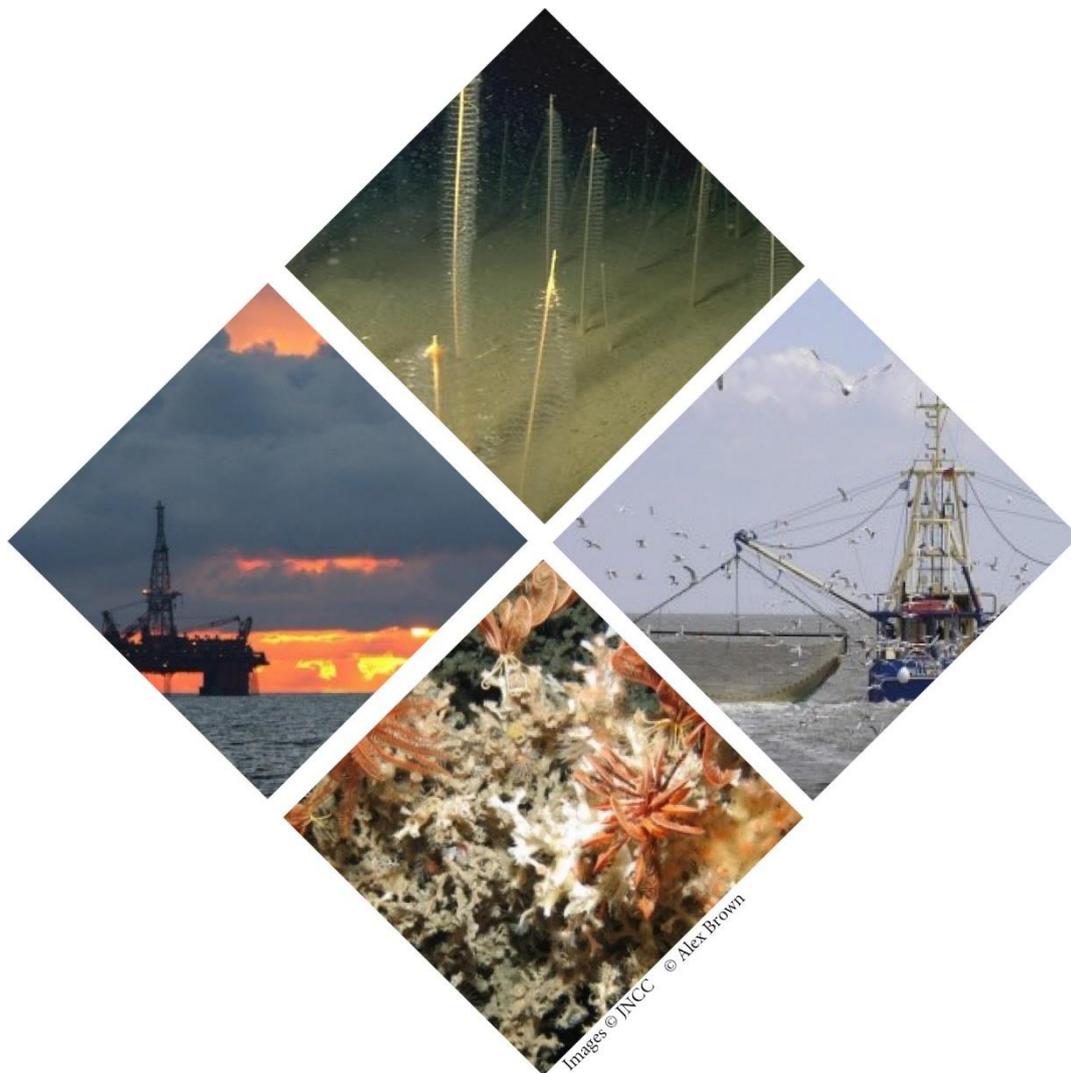


Supplementary Advice on Conservation Objectives for Rosemary Bank Seamount Nature Conservation Marine Protected Area

March 2018



Contents

Introduction	2
Table 1: Supplementary advice on the conservation objectives for Deep-sea sponge aggregations in Rosemary Bank Seamount NCMPA	5
Attribute: Extent and distribution	5
Attribute: Structure and function	7
Sponge composition	7
Sponge abundance.....	10
Spicule mats	11
Characteristic communities	11
Function.....	12
Attribute: Supporting processes.....	13
Hydrodynamic regime	14
Supporting habitat.....	14
Water and sediment quality.....	14
Environmental Quality Standard (EQS).....	14
Water quality.....	15
Sediment quality	16
Table 2: Supplementary advice on the conservation objectives for Seamount communities in Rosemary Bank Seamount NCMPA	17
Attribute: Extent and distribution	17
Attribute: Structure and function	19
Coral composition	19
Physical structure of the reef.....	20
Key and influential species.....	20
Characteristic communities	21
Function.....	22
Attribute: Supporting processes.....	23
Hydrodynamic regime	23
Physical topography.....	24
Supporting habitat.....	25
Water and sediment quality.....	25
Environmental Quality Standard (EQS).....	25
Water quality.....	26
Sediment quality	27
References	28

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 Seamount communities 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 large-scale feature (Seamount) and geological / geomorphological features (including iceberg ploughmark fields, slide scars, sediment drifts, sediment wave fields and the seamount scour moat) 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.

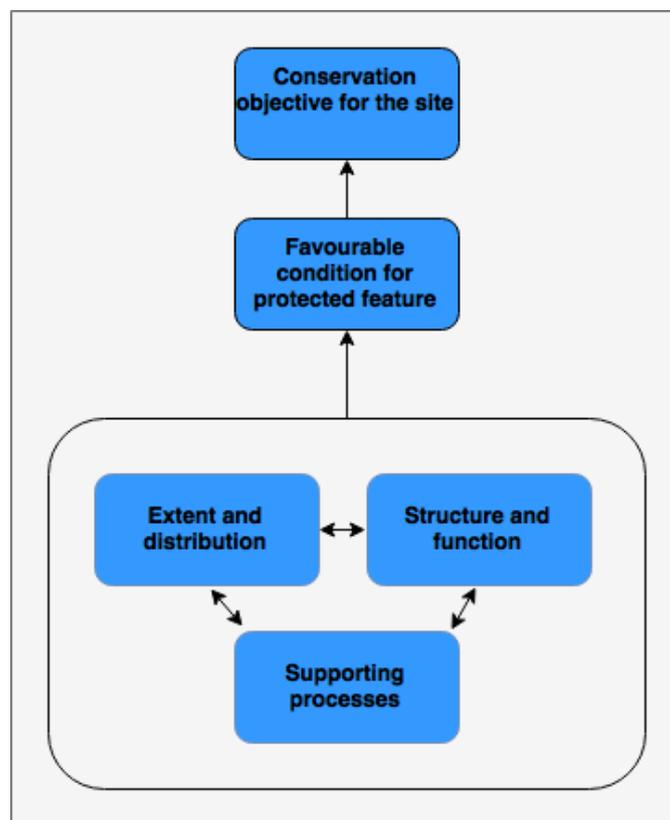


Figure 1. Conceptual diagram showing how a feature's attributes are interlinked and collectively describe favourable condition and contribute to the conservation objectives stated for the site.

In Table 1 and Table 2 below, the attributes for the Deep-sea sponge aggregations and Seamount communities are listed, respectively, 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 Rosemary Bank Seamount NCMPA

<p>Attribute: Extent and distribution</p>
<p>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.</p>
<p><u>Explanatory notes</u></p> <p>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.</p> <p>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):</p> <ul style="list-style-type: none">• More than 0.5 individuals per m²;• Registering as at least 'frequent' on the SACFOR scale; or• If bycatches of sponges exceed 400 kg, based on the ICES recommendation (ICES, 2013) for the identification of Vulnerable Marine Ecosystems¹. <p>In UK waters, four different subtypes of Deep-sea sponge aggregations have been identified (Henry and Roberts, 2014):</p> <ol style="list-style-type: none">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).

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. 1; Schönberg and Fromont, 2014). Other benthic organisms live on the surface of sponges or within the canals in the sponge's tissue. Sponge morphotype influences the abundance, diversity and composition of organisms living on or in the sponge (Neves and Omena, 2003; Montenegro-González and Acosta, 2010). A significant relationship has been observed between the structural complexity of biogenic structures, such as sponges and corals, and the number of taxa they support (Buhl-Mortensen and Mortensen, 2005; Buhl-Mortensen, 2010). Structural complexity of a sponge could be related to both its morphotype and size. Biodiversity may be increased by enhanced structural complexity because of an increase in the heterogeneity of habitats available for other benthic organisms e.g. providing elevated perches for other filter feeders (Bett and Rice, 1992; Bell, 2008) or 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.

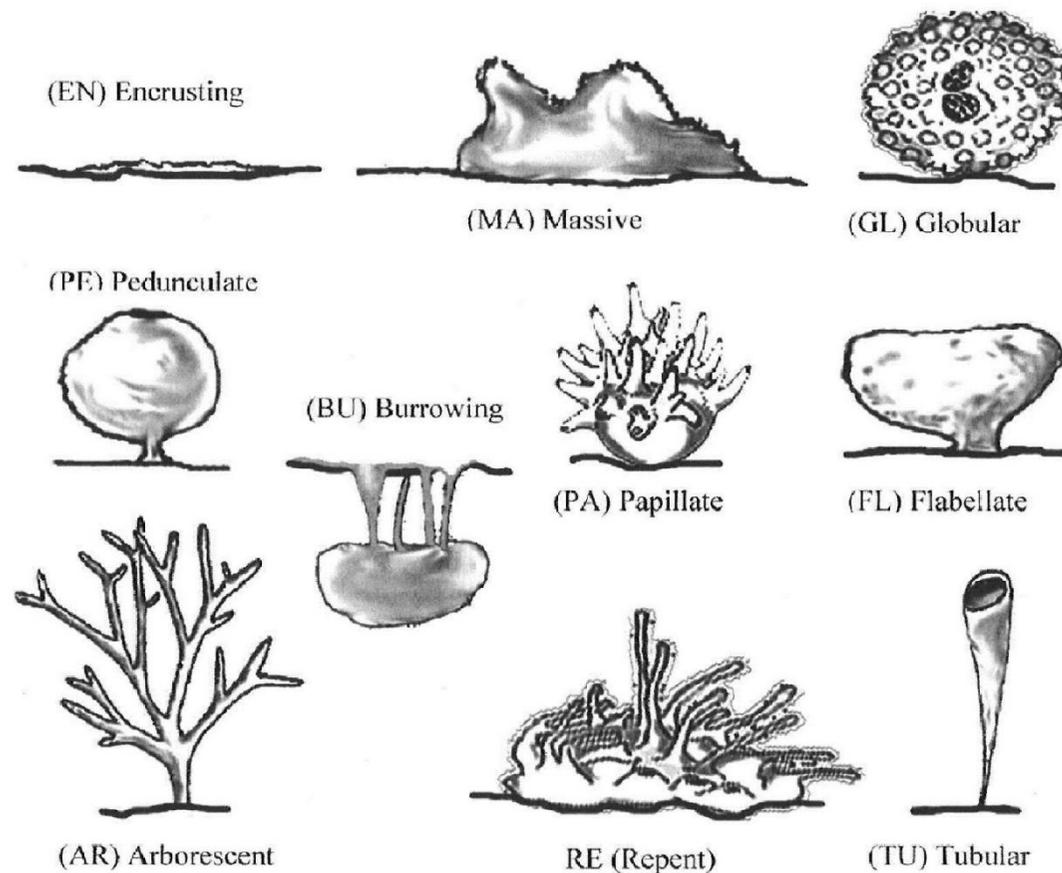


Figure 2. An example range of sponge morphotypes (from Berman et al., 2013).

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 *et al.*, 2016). These differences can be due to species, morphotype and/or life stage. These factors will all influence the ability of Deep-sea sponge aggregations to recover physical structure after damage and the sponge composition of the habitat if any recovery does occur. Growth to repair damaged tissue can be significantly faster than normal growth rates (Leys and Lauzon, 1998). However, although individual sponges can repair damage this does not indicate that recovery of the habitat structure from damage will be as rapid (ICES, 2009). Damaged *Geodia* can regrow to their original weight in a few weeks under laboratory conditions (Hoffmann *et al.*, 2003) but within a natural aggregation no evidence of repair is seen a year after damage (Freese, 2001). It is important to conserve the range of sponge species present in a Deep-sea sponge aggregation to increase the likelihood that some recovery may occur.

Sponge 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 a 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.

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).

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, 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).

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.*, 2008). 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.*, 2016). This may serve to increase the availability of prey species to predators

through enhancement to levels of biological diversity, potentially act as spawning grounds and provide refugia from predators for commercially important fish species.;

- Silicon regulation: by providing a long-term sink for silicon (Maldonado *et al.*, 2012, Tréguer and Rocha, 2013); and
- Provision of biochemical and biotechnological products: Sponges and their associated microbes produce a diverse array of chemicals, many of which have been shown to have applications in drug development (Laport *et al.*, 2009; Ebada *et al.*, 2010; Sawadogo *et al.*, 2015; Indraningrat *et al.*, 2016). Sponges may also have wider biotechnological applications (Hogg *et al.*, 2010) e.g. chitin networks from one species of sponge are effective at absorbing uranium contamination (Schleuter *et al.*, 2013). Sponge species typically found in Deep-sea sponge aggregations may also prove to have useful applications in the future.

The natural range of Deep-sea sponge aggregation 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.

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, 2004; 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 topography 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.

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.

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 Goeij *et al.*, 2008a; de Goeij *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.

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.*, 2008a; OSPAR, 2009a; 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.

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](#).

Table 2: Supplementary advice on the conservation objectives for Seamount communities in Rosemary Bank Seamount NCMPA

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 biogenic habitat 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 biogenic habitats. The distribution of a habitat influences the component communities present, and can contribute to the health and resilience of the feature (JNCC, 2004). It is important therefore to conserve the full known extent and distribution of the biogenic habitat within a site. The extent of coral habitats can vary naturally due to environmental conditions, and future increases in temperature and sea-water acidity could lead to a decline in coral extent (Jackson *et al.*, 2014). Thus, activities should not be permitted that are likely to reduce the distribution of the biogenic habitats.

Seamounts are submarine mountains that have peaks over 1000 m from the surrounding seafloor (OSPAR, 2010c). Seamount communities are the biogenic habitats that occur on seamounts. Seamount communities can be communities of non-reef forming corals (Hall-Spencer *et al.*, 2007), but may be also characterised by individual sponges, bivalves or bryozoans that combine to create a complex structural habitat on a seamount (Clark *et al.*, 2010). The communities can also be dominated by a single species of hard coral, forming dense cold-water coral reefs. If the densities of sponges or non-reef forming corals are high enough to meet the technical definitions for coral gardens (Henry and

Roberts, 2014) or deep-sea sponge aggregations (Henry and Roberts, 2014), then the habitat is classified as that habitat rather than a seamount community.

Growth rates of many corals are slow, but where they do persist, colonies can live for several thousands of years (Sun *et al.*, 2010; Carreiro-Silva *et al.*, 2013). Some reef-forming cold-water corals however have been recorded growing on average 1.4 cm per year (Sabatier *et al.*, 2012) and other deep-water corals can have growth rates exceeding 2 cm per year (Andrews *et al.*, 2002; Sherwood and Edinger, 2009). Coral habitats completely damaged by physical pressures such as those associated with benthic trawling do not show signs of recovery a decade after such pressure has been removed (Hall-Spencer *et al.*, 2002; Althaus *et al.*, 2009; Williams *et al.*, 2010; Howell *et al.*, 2013; Buhl-Mortensen *et al.* 2013; Buhl-Mortensen, 2017). However, recovery has been observed in areas where some living coral remains after impact (Buhl-Mortensen *et al.*, 2013; Buhl-Mortensen, 2017). If coral colonies are killed, any recovery of extent and distribution will be influenced by the method of reproduction, dispersal potential, the relative location of a potential source population of reproductive adults and the presence of suitable [supporting habitat](#) (Dahl *et al.*, 2012, Fox *et al.*, 2016). Evidence indicates that for some types of cold-water corals, successful recruitment events may occur once a decade (Stone *et al.*, 2015), which could limit recovery. Restoration could be encouraged by transplanting fast-growing corals from other locations.

Seamount communities form over hundreds or thousands of years (OSPAR 2010b). The sporadic reproduction of corals and slow growth rates of some species means that population recovery of the corals could take hundreds or thousands of years (Andrews *et al.*, 2002; Sherwood and Edinger, 2009; Silva *et al.*, 2013). In addition, if direct physical pressures are removed from a coral habitat, recovery of extent and distribution is uncertain due to predicted future decreases in ocean pH, which dissolves coral skeletons (Jackson *et al.*, 2014). Therefore, it is important to conserve the extent and distribution of the feature[s] as this cannot be easily be restored.

Extent and distribution of the Seamount communities within the site

The extent and distribution of the Seamount communities 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 with respect to coral habitats encompasses:

- [Coral composition](#) - namely the species, morphology and size of the coral colonies that characterise the community;
- [Physical structure of the reef](#) – including the topography of the reef and the available macrohabitats;
- [Key and influential species](#); and
- [Characteristic communities](#) present.

Coral composition

Coral colonies are made up of genetically identical polyps. Sessile and mobile benthic organisms may be associated with coral colonies, living on or within the coral tissue and around the colonies (Buhl-Mortensen and Mortensen, 2005; Bo *et al.*, 2009; Guilloux *et al.*, 2010; Ballion *et al.*, 2012; Mueller *et al.*, 2013; Ballion *et al.*, 2014; De Clippele *et al.*, 2015). The abundance, diversity and composition of associated organisms can vary between coral species, even within the same order (Ballion *et al.*, 2014; Carvalho *et al.*, 2014). A significant positive relationship has been found between both abundance and richness of associated organisms and coral colony size, number of branches and percentage of exposed skeleton (Buhl-Mortensen and Mortensen, 2005; Bo *et al.*, 2009; Buhl-Mortensen *et al.*, 2010; Ballion *et al.*, 2012; Carvalho *et al.*, 2014). These characteristics of the coral colony contribute towards its structural complexity, therefore structural complexity of an individual coral colony is likely to be influenced by age and species. 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 (De Clippele *et al.*, 2015) or refugia from predators (Buhl-Mortensen and Mortensen, 2005; Buhl-Mortensen *et al.*, 2010). The size and morphology of corals may also influence their susceptibility to damage from physical pressures such as abrasion, with larger individuals and species with less flexible skeletons more likely to be impacted, and the ability of corals to repair tissue after damage (Mortensen *et al.*, 2005; Henry and Hart, 2005; Stone *et al.*, 2015).

Species composition, and size and age structure of the coral community or communities forming the biogenic habitat, will influence the associated biological community and therefore it is important that these aspects of the habitat should be conserved.

Physical structure of the reef

Physical structure refers to finer scale topography and habitat composition. 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). Reef size and structure can create sheltered areas and increases sedimentation of particulate organic matter. This can result in higher abundances of associated organisms than surrounding habitats (Morigi *et al.*, 2012). Fish species associated with coral reefs have been shown to prefer different altitudes within a reef, and different slope aspects (Söffker *et al.*, 2011; Quattrini *et al.*, 2012). Variations in slope and surface roughness of a reef can increase diversity in benthic communities across the reef (Henry *et al.*, 2009) and so should be maintained.

Different habitats can occur across a cold-water coral reef (Buhl-Mortensen *et al.*, 2010; Lancaster *et al.*, 2014):

- **Living coral tissue** – dense areas of living cold water coral reef colonies. Within areas of live reef there are additional microhabitats, such as the tissue of living corals, surfaces of exposed coral skeletons, spaces within coral skeletons and the gaps between coral branches.
- **Dead coral framework communities** – dead coral reef framework can support communities of species that create biogenic habitats, such as sponges and non-reef forming corals, along with communities of other organisms such as hydroids, bryozoans and ascidians.
- **Coral rubble communities** – coral rubble creates a potentially mobile environment and therefore supports unique communities of meiofauna that are adapted to this.
- **Coral sediment communities** – infaunal and epifaunal communities associated with the coral sediment.

As conditions vary between these habitats, populations and diversity of associated benthic communities also differ between them (Mortensen and Fosså, 2006; Roberts *et al.*, 2008b; Henry *et al.*, 2009; Purser *et al.*, 2013; Buhl-Mortensen, 2017). As a result, the presence and extent of these macrohabitats generate biodiversity across cold-water coral reefs and therefore all need to be conserved.

Key and influential species

Key and influential species are those that have a core role to play in determining the structure and function of a biogenic habitat. For example, species that increase vertical complexity and provide a substrate for epibionts to colonise and use as an elevated perch (Braga-Henriques *et*

al., 2010). The main key and influential species within coral habitat features will be the coral community itself, however there may be other species such as sponges or bryozoans that also provide additional physical structure and habitat complexity. The tube dwelling polychaete *Eunice norvegica* lives in close association with cold-water corals, particularly *Lophelia pertusa*, stealing food particles from the coral host (Mueller *et al.*, 2013). The presence of the worm has been observed to almost quadruple calcification rates of corals (Mueller *et al.*, 2013) suggesting that its presence can influence reef development.

Changes to the spatial distribution of communities across coral habitats could indicate changes to a feature and as a result how it may function (JNCC, 2004). It is therefore important to conserve the key and influential species of biogenic habitats within a site to avoid diminishing biodiversity and ecosystem functioning and to support their conservation status (JNCC, 2004; Hughes *et al.*, 2005).

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, for example, those covering large areas, and notable communities, for example, those that are nationally or locally rare or scarce such as those listed as OSPAR threatened or declining, or known to be particularly sensitive to anthropogenic activities. Seamount communities are listed on the OSPAR threatened and/or declining habitats list, and this includes the characteristic communities associated with them (OSPAR, 2009b; OSPAR, 2010d; OSPAR, 2010c). Cold water coral reefs have also been recognised as Vulnerable Marine Ecosystems (VMEs) by the International Convention for the Exploration of the Sea (ICES).

Biological communities found within and on coral habitats can vary depending on the corals creating the habitat, location, and depth, as well as fine-scale physical, chemical and biological processes. A range of species have been found to have commensal or parasitic associations with deep-water coral species, some of which are obligate relationships (Buhl-Mortensen and Mortensen, 2004) such as strong associations of the brittlestar *Ophiomusium lymani* with bamboo corals (Henry and Roberts, 2014). Biological communities associated with coral habitats typically include filter feeders, such as ascidians, bryozoans, zoantherians, brittlestars and shrimp (Buhl-Mortensen and Mortensen, 2005; Bo *et al.*, 2009; Buhl-Mortensen *et al.*, 2010; De Clippele *et al.*, 2015; Carreiro-Silva *et al.*, 2017) which use the vertical structure created by corals as elevated perches to improve feeding (De Clippele *et al.*, 2015). As coral habitats develop in areas with relatively high currents, communities found in sediments within coral habitats are adapted to physical disturbance (Raes and Vanreusel, 2006). The characteristic communities associated with living coral colonies usually includes copepods that have evolved to be endoparasites in coral tissue (Buhl-Mortensen and

Mortensen, 2005; Baillon *et al.*, 2012; De Cippelle *et al.*, 2015). Coral rubble becomes covered with a biofilm, which supports communities of organisms that feed on this (Raes and Vanreusel, 2006).

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

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 corals, and associated biological communities (Armstrong *et al.*, 2014).

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 these habitats include:

- Nutrition: Coral habitats are potentially an important link in the flow of carbon between the pelagic and benthic environment (Cathalot *et al.*, 2015). Cold-water coral species secrete mucus which becomes a source of dissolved and particulate organic matter for the ecosystem. Sponge species can feed on this and it is incorporated into sponge detritus (Rix *et al.*, 2016), which is then consumed by higher trophic levels. This may serve to increase the availability of prey species to predators through enhancement of biological diversity, potentially providing refugia from predators (Stone *et al.*, 2015), locations to lay eggs (Henry *et al.*, 2016) or nurseries (Ballion *et al.*, 2012) for fish species. There is some evidence that the abundance of certain commercial fish species is higher within coral habitats compared to non-coral habitats (D'Onghia *et al.*, 2012; Pham *et al.*, 2015).
- Climate regulation: Dead coral skeletons are a long-term store of carbon (Armstrong *et al.*, 2014), although the coral calcification process emits carbon dioxide. Ocean acidification is expected to corrode the skeletons of dead deep-water scleractinian corals although cold-water coral reefs shallower than ~150 m, are not expected to be subject to corrosion as they will remain above the aragonite saturation horizon (Jackson *et al.*, 2014).
- Provision of recruits: The larvae of corals have a planktonic phase giving the potential for long distance dispersal. A coral habitat can create a supply of recruits to establish new or help maintain existing coral habitats elsewhere (Wright *et al.*, 2015; Fox *et al.*, 2016).

- Provision of biochemical and biotechnological products: Chemicals extracted from corals have been shown to have applications in the pharmaceutical industry (Sawadogo *et al.*, 2015; Ruiz-Torres *et al.*, 2017).

It is critical to ensure that the extent and distribution of coral habitats within a site, along with the composition of any key, influential 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 [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

Biogenic 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](#), the natural supporting processes of [hydrodynamic regime](#), [physical topography](#), [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 internal and surface wave exposure. These mechanisms circulate food resource and propagules, influence water properties by distributing dissolved oxygen, and facilitate gas exchange from the surface to the seabed (Hiscock *et al.*, 2004; Meinis *et al.*, 2007; Hosegood and van Haren, 2004; Wagner *et al.*, 2011).

Cold-water corals feed on zooplankton and other organic matter, therefore cold-water coral habitats require hydrographic conditions that result in a supply of sufficient organic matter to the seabed. Coral habitats occur where hydrodynamic conditions re-suspend particulate organic matter (POM) from the seabed into the water column, or where downwelling brings a fresh supply of POM from the sea surface (Meinis *et al.*, 2007; Davies *et al.*, 2009). The presence of various coral species is influenced by current velocities (Jones *et al.*, 2009; Tracey *et al.*, 2011). Moreover, the shape and orientation of coral reefs and carbonate mounds can be driven by the prevailing currents (Davies *et al.*, 2009; Buhl-Mortensen *et al.*, 2010; Järnegren and Kutti, 2016). Although corals require water movement to supply them with POM, feeding rates can reduce at high velocities (Purser *et al.*, 2010) suggesting that coral habitats may require a certain range of current velocities to develop. The hydrodynamic regime transports coral larvae as well as food. Changes to the hydrodynamic regime can alter the source and number of new recruits to coral habitats (Fox *et al.*, 2016). Morphology of sponges can be influenced by local hydrodynamics (De Clippele *et al.*, 2017). Hydrodynamic regime also effects the movement, size structure and sorting of sediment particles, and can therefore influence the [supporting habitat](#).

It is therefore important to conserve the prevailing hydrodynamic regime, in order to maintain the supply of food and larval recruits, and the supporting habitat of the coral habitats.

Physical topography

The [hydrodynamic conditions](#) required by corals are generated by the interaction of water currents and topographic features that strengthen internal tides (Davies *et al.*, 2009), generate internal waves (Meinis *et al.*, 2007) or increase mixing and primary productivity in shallower water (Roberts *et al.*, 2009). Coral habitats therefore tend to develop on continental slopes, along ridges and on topographic structures such as seamounts and carbonate mounds (Hall-Spencer *et al.*, 2007, Davies *et al.*, 2009, Tracey *et al.*, 2011; Tong *et al.*, 2012; Tong *et al.*, 2013). Hydrodynamic regime, specifically the direction of prevailing currents, influence the growth and morphology of carbonate mounds themselves, which can influence the type and distribution of biogenic communities occurring on the mounds (Wheeler *et al.* 2007). At a more local scale, coral colonies prefer elevated areas of seabed (Tong *et al.*, 2012; Tong *et al.*, 2013) to give them access to faster flowing water. This suggests that the surface topology of the seabed could influence density and distribution of non-reef forming corals within coral habitat features.

There are three types of reef forms; inherited reef forms have a morphology that reflects the underlying seabed; developed reef forms have a large scale morphology that has developed independent of the underlying seabed; and wall reef forms that occur on vertical slopes (Järnegren

and Kutti, 2016). For inherited and wall reefs, the physical structure of the reef and therefore the associated biodiversity is dependent on the underlying topography.

Supporting habitat

Most species of coral require hard substratum to attach to (e.g. Stone *et al.*, 2015), however some bamboo corals and sea-pens grow on sandy and muddy seabeds (Buhl-Mortensen *et al.*, 2010; Henry and Roberts, 2014). For reef forming corals, initial colonisation only requires a very small area of available hard substratum, such as a single pebble. After initial colonisation, the coral itself can provide hard substrata for subsequent colonies to develop (Buhl-Mortensen *et al.*, 2010). Species composition and density of colonies characterising other coral habitats will be influenced by the availability and type of underlying substratum.

Water and sediment quality

Contaminants may affect the quality of coral 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 important therefore to avoid changing the natural water quality and sediment quality properties of a site and as a minimum ensure compliance with existing Environmental Quality Standards (EQS) as set out below.

Environmental Quality Standard (EQS)

The targets listed below for water and sediment contaminants in the marine environment are based on existing targets within or the Water Framework Directive (WFD) and 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) 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 Quality Status Report ([OSPAR, 2010b](#)) and associated [QSR Assessments](#).

There are little data on the impact of aqueous and sediment contaminants on cold-water coral species, therefore no tolerance thresholds have been established for cold-water coral habitats. The general standards described above apply to these habitat features until more habitat specific information is available.

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 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 these 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 coral habitat features and associated communities at relatively local scales (Elliott *et al.*, 1998; Gray and Elliott, 2009).

Spawning in sea-pens has been shown to occur at specific water temperatures (Baillon *et al.*, 2013) and cold-water corals in laboratory experiments began to die at temperatures above 8.7°C (Leifman, 2016). This suggests that coral habitat features can only develop and survive within a specific range of water temperatures, and this is likely to be species specific.

Increased concentrations of sediment in the water column can have a negative impact on corals by reducing feeding activity, preventing access to oxygen and damaging corals by becoming embedded in their surface (Allers *et al.*, 2013; Leifman, 2016). *Lophelia pertusa* can tolerate short term increases in sedimentation, however burial of living coral tissue for more than a day resulted in death (Allers *et al.*, 2013). Responses to

increases in suspended particles are likely to vary between coral species, nature of suspended sediment and presence of other species in the community (Girard *et al.*, 2016; Leifman, 2016). As coral colonies feed on suspended particles, coral habitat features do require a supply of particulate organic matter to the seabed. Changes to water quality that reduces the supply of particulate organic matter and nutrients to corals may be detrimental.

Scleractinian cold-water corals create their skeleton from aragonite, which is a mineral of calcium carbonate. Atmospheric carbon dioxide emissions are lowering the amount of aragonite in seawater in a process called ocean acidification (Jackson *et al.*, 2014). This threatens deep-water scleractinian coral reefs and communities as seawater is becoming corrosive to their skeletons.

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 coral habitats have been identified.

Sediment quality

Various contaminants are known to have different effects on the species that live in or on coral habitats. These include heavy metals like mercury, arsenic, zinc, nickel, chromium and cadmium, poly-aromatic hydrocarbons (PAHs), poly-chlorinated biphenyls (PCBs), organotins (TBT) and pesticides such as hexachlorobenzene. These can impact species sensitive to particular contaminants (e.g. heavy metals), and bioaccumulate within organisms thus entering the marine food chain (e.g. polychlorinated biphenyls) (OSPAR, 2009a; OSPAR, 2010b; OSPAR, 2012). There is little research into the impact of sediment contaminants on corals, particularly from deep cold-water systems. If contamination occurs, this can lead to intolerant conditions and result in a change to typical species composition. It is therefore important to ensure sediment quality is maintained by avoiding activities that may cause resuspension of existing or the introduction of new contaminants. As a minimum, it is important to ensure compliance with existing EQS as set out above until thresholds specific to coral habitats have been developed.

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

- Allers, E., Abed, R.M.M., Wehrmann, L.M., Wang, T., Larsson, A.I., Purser, A. and de Beer, D. (2013). Resistance of *Lophelia pertusa* to coverage by sediment and petroleum drill cuttings. *Marine Pollution Bulletin*, 74: 132-140.
- Althaus, F., Williams, A., Schlacher, T.A., Kloser, R.J., Green, M.A., Barker, B.A., Bax, N.J., Brodie, P. and Schlacher-Hoenlinger, M.A. (2009). Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. *Marine Ecology Progress Series*, 397: 279-294.
- Andrews, A.H., Cordes, E.E., Mahoney, M.M., Munk, K., Coale, K., Cailliet, G. and Heifetz, J. (2002). Age, growth and radiometric age validation of a deep-sea, habitat-forming gorgonian (*Primnoa resedaeformis*) from the Gulf of Alaska. *Hydrobiologia*, 471: 101-110.
- Armstrong, C.W., Foley, N.S, Kahui, V. and Grehan, A. (2014). Cold water coral reef management from an ecosystem service perspective. *Marine Policy*, 50: 126-134.
- Baillon, S., Hamel, J-F., Wareham, V.E. and Mercier, A. (2012). Deep cold-water corals as nurseries for fish larvae. *Frontiers in Ecology and Environment*, 10: 351-356.
- Baillon, S., Hamel, J-F., Wareham, V.E. and Mercier, A. (2013). Seasonality in reproduction of the deep-water pennatulacean coral *Anthoptilum grandiflorum*. *Marine Biology*, 161: 10.1007/s00227-013-2311-8.
- Barrio Froján, C.R.S., Maclsaac, 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.
- 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 Science* 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.

- Bett, B.J. (2001). UK Atlantic Margin Environmental Survey: introduction and overview of bathyal benthic ecology. *Journal of Continental Shelf Research*, 21: 917-956.
- Braga-Henriques, A., Carreiro-Silva, M., Porteiro, F.M., de Matos, V., Sampaio, Í., Ocaña, O., and Ávila, S.P. (2010). The association between a deep-sea gastropod *Pedicularia sicula* (Caenogastropoda: Pediculariidae) and its coral host *Errina dabneyi* (Hydrozoa: Stylasteridae) in the Azores. *ICES Journal of Marine Science*, 68(2): 399-407.
- Bo, M., Bavestrello, G., Canese, S., Giusti, M., Salvati, E., Angiolillo, M. and Greco, S. (2009). Characteristics of a black coral meadow in the twilight zone of the central Mediterranean Sea. *Marine Ecology Progress Series*, 397: 53-61.
- Buhl-Mortensen, L. and Mortensen, P.B. (2004). Symbiosis in deep-water corals. *Symbiosis*, 37: 33-61.
- 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.
- 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., Aglen, A., Breen, M., Buhl-Mortensen, P., Ervik, A., Husa, V., Løkkeborg, S., Røttingen, I. and Stockhausen, H.H. (2013). Impacts of fisheries and aquaculture on sediments and benthic fauna: suggestions for new management approaches. *Fisken og Havet*, 2: 69 pages.
- Buhl-Mortensen, P. (2017). Coral reefs in the Southern Barents Sea: habitat description and the effects of bottom fishing. *Marine Biology Research*, 13(10): 1027-1040.
- Carreiro-Silva, M., Andrews, A.H., Braga-Henriques, A., de Matos, V., Porteiro, F.M. and Santos, R.S. (2013). Variability in growth rates of long-lived black coral *Leiopathes* sp. from the Azores (Northeast Atlantic). *Marine Ecology Progress Series*, 473: 189–199.
- Carreiro-Silva, M., Ocaña, O., Stanković, D., Sampaio, Í., Porteiro, F.M., Fabri, M-C. and Stefanni S. (2017). Zoantharians (Hexacorallia: Zoantharia) Associated with Cold-Water Corals in the Azores Region: New Species and Associations in the Deep Sea. *Frontiers in Marine Science*, 4: 10.3389/fmars. [online]. Available at: <https://doi.org/10.3389/fmars.2017.00088> [Accessed 24 January 2018].
- Carvalho, S., Cúrdia, J., Pereira, F., Guerra-García, J-M., Santos, M.N. and Cunha, M.R. (2014). Biodiversity patterns of epifaunal assemblages associated with the gorgonians *Eunicella gazella* and *Leptogorgia lusitanica* in response to host, space and time. *Journal of Sea Research*, 85: 37-47.
- 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.

Clark, M.R., Rowden, A.A., Schlacher, T., Williams, A., Consalvey, M., Stocks, K.I., Rogers, A.D., O'Hara, T.D., White, M., Shank, T.M. and Hall-Spencer, J.M. (2010). The ecology of seamounts: structure, function and human impacts. *Annual Review of Marine Science*, 2: 253-278.

Dahl, M.P., Pereyra, R.T., Lundälv, T. and André, C. (2012). Fine-scale spatial genetic structure and clonal distribution of the cold-water coral *Lophelia pertusa*. *Coral Reefs*, 31(4): 1135-1148.

Davies, A.J., Duineveld, G.C.A., Lavaleye, M.S.S., Bergman, M.J.N., van Haren, H. and Roberts, R.J. (2009). Downwelling and deep-water bottom currents as food supply mechanisms to the cold-water coral *Lophelia pertusa* (Scleractinia) at the Mingulay Reef complex. *Limnology and Oceanography*, 54: 620-629.

De Clippele, L.H., Buhl-Mortensen, P. and Buhl-Mortensen, L. (2015). Fauna associated with cold water gorgonians and sea pens. *Continental Shelf Research*, 105: 67-68.

De Clippele, L., Huvenne, V., Orejas, C., Lundälv, T., Fox, A. Hennige, S. and Roberts, J. (2017). The effect of local hydrodynamics on the spatial extent and morphology of cold-water coral habitats at Tisler Reef, Norway. *Coral Reefs*, doi:10.1007/s00338-017-1653-y [online]. Available at: <https://link.springer.com/article/10.1007/s00338-017-1653-y> [Accessed 24 January 2018].

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.

D'Onghia, G., Maiorano, P., Carlucci, R., Capezzuto, F., Carluccio, A., Tursi, A and Sion, L. (2012). Comparing Deep-Sea Fish Fauna between Coral and Non-Coral "Megahabitats" in the Santa Maria di Leuca Cold-Water Coral Province (Mediterranean Sea). *PLoS ONE*, 7: e44509. [online]. Available at: <https://doi.org/10.1371/journal.pone.0044509> [Accessed 24 January 2018].

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.

- Ebada, S.S., Lin, W.H. and Proksch, P. (2010). Bioactive Sesterterpenes and Triterpenes from marine sponges: Occurrence 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). Volume II Intertidal Sand and Mudflats and Subtidal Mobile Sandbanks. 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). WFD - Surface Water Classification Status and Objectives Environment Agency. [online]. Available at: <http://www.geostore.com/environmentagency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml> [Accessed March 2015].
- 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 July 2017].
- Fox, A.D., Henry, L-A., Corne, D.W. and Roberts, M. (2016). Sensitivity of marine protected area network connectivity to atmospheric variability. *Royal Society Open Science*, doi: 10.1098/rsos.160494. [online]. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/28018633> [Accessed 24 January 2018].
- 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.
- Girard, F., Fu, B. and Fisher, C.R. (2016). Mutualistic symbiosis with ophiuroids limited the impact of the Deepwater Horizon oil spill on deep-sea octocorals. *Marine Ecology Progress Series*, 549: 89-98.
- 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.
- 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].
- Guilloux, E.L.E., Hall-Spencer, J.M. Söffker, M.K. and Olu, K. (2010). Association between the squat lobster *Gastroptychus formosus* and cold-water corals in the North Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, 90: 1363-1369.

- 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: 3643-3650.
- Hall-Spencer, J.M., Allain, V. and Fossa, J.H. (2002). Trawling damage to Northeast Atlantic ancient coral reefs. *Proceedings of the Royal Society London, B*, 269: 507-511.
- Hall-Spencer, J.M., Rogers, A., Davies, J. and Foggo, A. (2007). Historical deep-sea coral distribution on seamount, oceanic island and continental shelf-slope habitats in the NE Atlantic. *Bulletin of Marine Science*, 81: 135-146.
- 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.
- Henry, L-A., Davies, A.J. and Roberts, J.M. (2009). Beta diversity of cold-water coral reef communities off western Scotland. *Coral Reefs*, 29: 427-436.
- Henry, L-A., Stehmann, M., De Clippele, L., Findlay, H., Golding, N. and Roberts, J. (2016). Seamount egg-laying grounds of the deep-water skate *Bathyraja richardsoni*. *Journal of Fish Biology*, doi: 10.1111/jfb.13041. [online]. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/27350418> [Accessed 24 January 2018].
- 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., Huvenne, V., Piechaud, N., Robert, K. and Ross, R.E. (2013). Analysis of biological data from the JC060 survey of areas of conservation interest in deep waters off north and west Scotland. JNCC Report No. 528. Peterborough.
- 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.
- 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].
- Irving, R. (2009). The identification of the main characteristics of stony reef habitats under the Habitats Directive. JNCC Report No. 432. Peterborough.
- Jackson, E.L., Davies, A.J., Howell, K.L., Kershaw, P.J. and Hall-Spencer, J.M. (2014). Future-proofing marine protected area networks for cold water coral reefs. *ICES Journal of Marine Science*, 71(9): 2621-2629.
- Järnegren, J. and Kutti, T. (2016). *Lophelia pertusa* in Norwegian waters. What have we learned since 2008? *NINA Report 1028*. Norwegian Institute for Nature Research.
- Joint Nature Conservation Committee (2004). Common Standards Monitoring Guidance for Littoral Rock and Inshore Sublittoral Rock Habitats. Version August 2004. Peterborough. [online]. Available at: http://jncc.defra.gov.uk/PDF/CSM_marine_rock.pdf [Accessed July 2017].
- Jones, K., Devillers, R. and Edinger, E. (2009). Relationships between Cold-water Corals off Newfoundland and Labrador and their Environment. Available at: https://www.researchgate.net/publication/242178763_Relationships_between_Cold-water_Corals_off_Newfoundland_and_Labrador_and_their_Environment [Accessed 16 December 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.
- Knudby, A., Kenchington, E., and Murillo, F.J. (2013). Modeling the Distribution of Geodia Sponges and Sponge Grounds in the Northwest Atlantic. *PLoS ONE*, 8: e82306. [online]. Available at: <https://doi.org/10.1371/journal.pone.0082306>. [Accessed July 2017].

- Kutti, T., Bannister, R.J., Fosså, J.H., Krogness, C.M., Tjensvoll, I. and Søvik, G. (2015). Metabolic responses of the deep-water sponge *Geodia barretti* to suspended bottom sediment, simulated mine tailings and drill cuttings. *Journal of Experimental Marine Biology and Ecology*, 473: 64–72.
- Lancaster, J., McCullum, S., Lowe, A.C., Taylor, E., Chapman, A. and Pomfret, J. (2014). Development of Detailed Ecological Guidance to support the application of the Scottish MPA Selection Guidelines in Scotland's seas. *Scottish Natural Heritage Commissioned Report No. 491*.
- 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.
- Leifmann, S. (2016). *Eco-physiological responses of cold-water corals to anthropogenic sedimentation and particle shape*. MSc thesis, NTNU. Trondheim, Norway.
- 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.
- 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, 113-182. ISBN: 978-0-12-394283-8.
- Maldonado, M., Aguilar, R., Bannister, R.J., Bell, J.J., Conway, K.W., Dayton, P.K., Díaz, C., Gutt, J., Kelly, M., 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. S. Rossi (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. *Oceologia*, 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.
- 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.
- Morigi, C., Sabbatini, A., Vitale, G., Pancotti, I., Gooday, A.J., Duineveld, G.C.A., DeStigter, H.C., Danovaro, R. and Negri, A. (2012). Foraminiferal biodiversity associated with cold-

water coral carbonate mounds and open slope of SE Rockall Bank (Irish continental margin-NE Atlantic). *Deep-Sea Research I*, 59: 54-71.

Mortensen, P.B., Buhl-Mortensen, L., Gordon D.C. Jr, Fader, G.B.J., McKeown, D.L., and Fenton, D.G. (2005). Effects of fisheries on deep-water gorgonian corals in the Northeast Channel, Nova Scotia (Canada). *American Fisheries Society Symposium*, 41: 369–382.

Mueller, C.E., Lundälv, T., Middelburg, J.J. and van Oevelen, D. (2013). The Symbiosis between *Lophelia pertusa* and *Eunice norvegica* Stimulates Coral Calcification and Worm Assimilation. *PLoS ONE*, 8(3): e58660.

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.

OSPAR Commission. (2009a). Agreement on Coordinated Environmental Monitoring Programme (CEMP) assessment criteria for the QSR 2010. *Monitoring and Assessment Series*. OSPAR Agreement 2009-2002.

OSPAR Commission. (2009b). Background document for *Lophelia pertusa* reefs. OSPAR Commission. <https://www.ospar.org/documents?d=7182> [Accessed 15 December 2017].

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

OSPAR (2010b). OSPAR Quality Status Report 2010. London: OSPAR Commission.

OSPAR Commission. (2010c). Background Document for Seamounts, OSPAR Commission. <https://www.ospar.org/documents?d=7222> [Access 16 December 2017].

OSPAR. Commission. (2010d). Background document for Coral Gardens. OSPAR Commission. <https://www.ospar.org/documents?d=7217> [Accessed 15 December 2017].

OSPAR (2012). Co-ordinated Environmental Monitoring Programme (CEMP) 2011 Assessment Report: OSPAR Commission.

Pascual, G.C. (2015). *The role of gorgonians as engineering species, in the structure and diversity of benthic communities*. MSc Thesis. University of Southampton.

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].

Pham, C.K., Vandeperre, F., Menezes, G., Porteiro, F., Isidro, F. and Morato, T. (2015). The importance of deep-sea vulnerable marine ecosystems for demersal fish in the Azores. *Deep-Sea Research I*, 96: 80–88.

- Purser, A., Larsson, A.I., Thomsen, L. and Oevelen, D. (2010). The influence of flow velocity and food concentration on *Lophelia pertusa* (Scleractinia) zooplankton capture rates. *Journal of Experimental Marine Biology and Ecology*, 395: 55-62.
- Purser, A., Ontrup, J., Schoening, T., Thomsen, L., Tong, R., Unnithan, V. and Nattkemper, T.W. (2013). Microhabitat and shrimp abundance within a Norwegian cold-water coral ecosystem. *Biogeosciences*, 10: 5579-5791.
- Quattrini, A.M., Ross, S.W., Carlson, M.C.T. and Nizinski, M.S. (2012). Megafaunal-habitat associations at a deep-sea coral mound off North Carolina, USA. *Marine Biology*, 159: 1079–1094.
- Raes, M. and Vanreusel, A. (2006). Microhabitat type determines the composition of nematode communities associated with sediment-clogged cold-water coral framework in the Porcupine Seabight (NE Atlantic). *Deep-Sea Research I*, 53: 1880-1894.
- 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. (2008a). Contamination of marine biogenic habitats and effects upon associated epifauna. *Marine Pollution Bulletin*, 56: 1057-1065.
- Roberts, J.M, Henry, L-A., Long, D. and Hartley, J.P. (2008b). Cold-water coral reef frameworks, megafaunal communities and evidence for coral carbonate mounds on the Hatton Bank, north east Atlantic. *Facies*, 54: 297-316.
- Roberts, J.M., Davies, A.J., Henry, L-A., Dodds, L.A., Duineveld, G.C.A, Lavaleye, M.S.S., Maier, C., van Soest, R.W.M., Bergman, M.J.N., Hühnerbach, V., Huvenne, V.A.I., Sinclair, D.J., Watmough, T., Long, D., Green, S.L. and van Haren, H. (2009). Mingulay reef complex: An interdisciplinary study of cold-water coral habitat, hydrography and biodiversity, *Marine Ecology Progress Series*, 397: 139-151.
- Ruiz-Torres, V., Encinar, J.H., Lopez, M-H., Pérez-Sánchez, A and Galiano, V, and Barraji n-Catal n, E. and Micol, V. (2017). An Updated Review on Marine Anticancer Compounds: The Use of Virtual Screening for the Discovery of Small-Molecule Cancer Drugs. *Molecules*, 22(7): 1037.10.3390/molecules22071037.
- Sabatier, P., Reyss, J-L., Hall-Spencer, J.M., Colin, C., Frank, N., Tisn rat-Laborde, N., Bordier, L., and Douville, E. (2012). ²¹⁰Pb-²²⁶Ra chronology reveals rapid growth rate of *Madrepora oculata* and *Lophelia pertusa* on world's largest cold-water coral reef. *Biogeosciences*, 9: 1253-1265.
- 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 18th 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.
- Sherwood, O. and Edinger, E. (2009). Ages and growth rates of some deep-sea gorgonian and antipatharian corals of Newfoundland and Labrador. *Canadian Journal of Fisheries and Aquatic Sciences*, 66: 142-152.
- 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.
- Söffker, M., Sloman, K.A. and Hall-Spencer, J.M. (2011). In situ observations of fish associated with coral reefs off Ireland. *Deep-Sea Research I*, 58: 818-825.
- 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: 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.
- Stone, R.P., Masuda, M.M. and Karinen, J.F. (2015). Assessing the ecological importance of red tree coral thickets in the eastern Gulf of Alaska. *ICES Journal of Marine Science*, 72: 900-915.
- Sun, Z., Hamel, J.F. and Mercier, A. (2010). Planulation periodicity, settlement preferences and growth of two deep-sea octocorals from the northwest Atlantic. *Marine Ecology Progress Series*, 410: 71-87.
- Tjensvoll, I., Kutti, T., Fosså, J.H. and Bannister, R.J. (2013). Rapid respiratory responses of the deep-water sponge *Geodia barretti* exposed to suspended sediments. *Aquatic Biology*, 19: 65-73.
- Tong, R., Purser, A., Unnithan, V. and Guinan J. (2012). Multivariate Statistical Analysis of Distribution of Deep-Water Gorgonian Corals in Relation to Seabed Topography on the Norwegian Margin. *PLoS ONE*, 7(8): e43534. doi:10.1371/journal.pone.0043534. [online]. Available at: <https://doi.org/10.1371/journal.pone.0043534> [Accessed 24 January 2018].
- Tong, R., Purser, A., Guinan, J. and Unnithan, V. (2013). Modelling the habitat suitability for deep-water gorgonian corals based on terrain variables. *Ecological Informatics*. 13: 123-132.
- Tracey, D.M., Rowden, A., Mackay, K. and Compton, T. (2011). Habitat-forming cold-water corals show affinity for seamounts in the New Zealand region. *Marine Ecology Progress Series*, 430: 1-22.

- 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.
- 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
- Wheeler, A.J., Beyer, A., Freiwald, A., de Haas, H., Huvenne, V.A.I., Kozachenko, M., Olu-Le Roy, K. and Opderbecke, J. (2007). Morphology and environment of cold-water coral carbonate mounds on the NW European margin. *International Journal of Earth Sciences*, 96: 37-56.
- Williams, A., Schlacher, T.A., Rowden, A.A., Althaus, F., Clark, M.R., Bowden, D.A., Stewart, R., Bax, N.J., Conalvey, M. and Kloser, R.J. (2010). Seamount megabenthic assemblages fail to recover from trawling impacts. *Marine Ecology*, 31(Suppl.1): 183-199.
- Wright, E.P., Kemp, K., Rogers, A. and Yesson, C. (2015). Genetic structure of the tall sea pen *Funiculina quadrangularis* in NW Scottish sea lochs. *Marine Ecology*, 36: 659-667.
- Wulff, J. (2001). Assessing and monitoring coral reef sponges: why and how? *Bulletin of Marine Science*, 69: 831–846.