Supplementary Advice on Conservation Objectives for Croker Carbonate Slabs candidate Special Area of Conservation and Site of Community Importance

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Contents

Introduction

What the conservation advice package includes

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

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

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

The advice presented here describes the ecological characteristics or 'attributes' of the site's qualifying feature: Submarine structures made by leaking gases specified in the site's conservation objectives. These attributes include extent and distribution, structure and function and supporting processes.

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

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

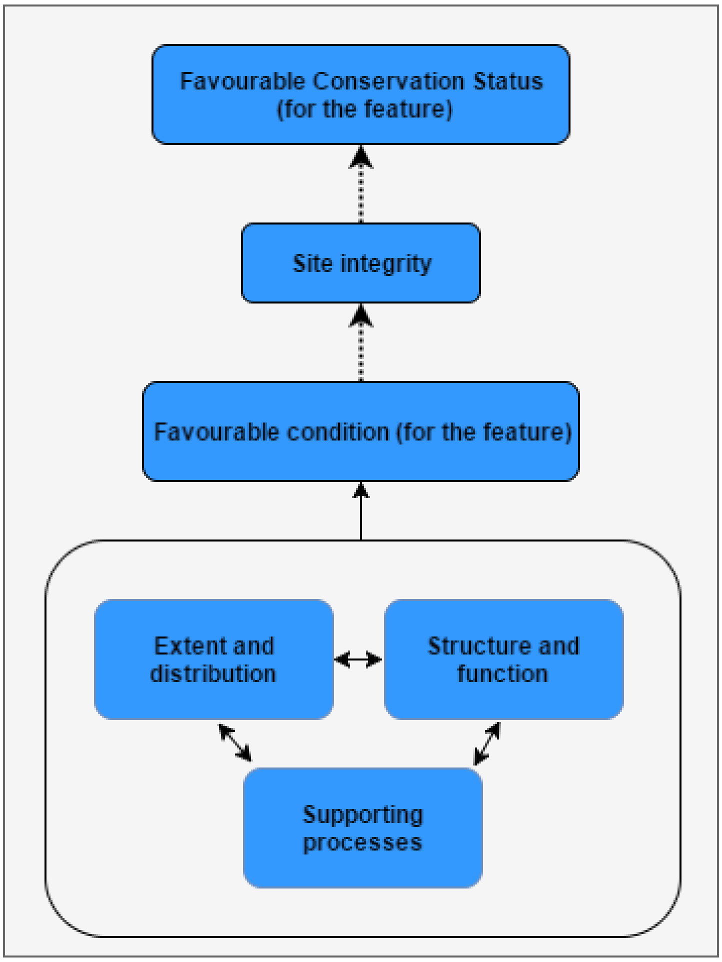

Figure 1. Conceptual diagram showing how feature attributes are interlinked, describe favourable condition and contribute to site integrity and wider favourable conservation status.

In Table 1 below, the attributes for the Annex I Submarine structures made by leaking gases are listed and a description provided in explanatory notes.

Please note our current understanding of whether the available evidence indicates that each attribute needs to be restored or maintained is not provided. Links to available evidence for the site are provided in the Table below. If you require further site-specific information on the attributes listed for the site's feature please contact JNCC at OffshoreMPAs@jncc.gov.uk.

Table 1: Supplementary advice on the conservation objectives for Annex I Submarine structures made by leaking gases in Croker Carbonate Slabs cSAC/SCI

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 Annex 1 Submarine structures made by leaking gases form over geological time scales. The slow formation of the carbonate structures that characterise the physical structure of this habitat is dependent upon the migration of gases (methane) to the seabed and is mediated by a unique community of microbial organisms. These communities undertake the anaerobic oxidation of methane (AOM) at the sulphate-methane interface (SMI), which is most commonly close beneath the seabed surface (Boetius *et al*., 2000). AOM leads to the precipitation of a carbonate cement that binds the seabed sediments to form Methane-Derived Authigenic Carbonate (MDAC) (Niemann *et al*., 2005). It is the MDAC feature itself that is directly equivalent to the qualifying feature Annex 1 Submarine structures made by leaking gases. There are two main types of Submarine structures made by leaking gases known to occur in UK waters: 1. **Bubbling reefs**: formed by carbonate cement resulting from the AOM (known as MDAC) (Interpretation Manual - EUR28, 2013). Bubbling reef structures are elevated from the surrounding seabed to form various topographic features. Extent is determined by the physical area occupied by the MDAC[1]. 2. **Submarine structures associated with pockmarks**: Pockmarks are depressions or craters in the seabed formed by the expulsion of fluids. To be considered a pockmark associated submarine structure, MDAC must be present within a pockmark. In the case of this type of the Annex I feature, it is the physical area occupied by the MDAC within a pockmark that represents the extent of the Annex I habitat of interest, as opposed to the area of the pockmark (Interpretation Manual - EUR28, 2013). A variation in feature extent has the potential to alter the biological functioning of the habitat. Feature extent may change naturally over time, for example by the temporary or permanent covering or infilling of the feature by mobile sediments. In the case of submarine structures

[1] '*Method for Creating a Map of Annex I Submarine Structures made by Leaking Gases in UK Waters'*, JNCC (2016). Available at: http://jncc.defra.gov.uk/pdf/20130621_AnnexI_SubmarineStructures_v3_Method.pdf

associated with pockmarks, the periodic expulsion of large volumes of methane (Hong *et al.*, 2016) may expel sediments from within pockmarks that in turn results in the uncovering of buried MDAC.

Due to the slow formation of MDAC, to restore feature extent once lost is difficult or impossible. Accretion of the feature may be on-going or may have ceased – dependent on whether or not gas is still migrating to the seabed from the underlying sediments/rocks, and the presence of the mediating microbial communities. However, it is important to note that the feature does not have to be actively accreting to be considered an example of the Annex 1 feature.

Extent and distribution of the Annex I Submarine structures made by leaking gases within the site
The Croker Carbonate Slabs cSAC/SCI protects an example of the "bubbling reefs" subtype of Annex I habitat Submarine structures made by leaking gases. The extent and distribution of this feature within the site is shown in the site map. For further site-specific information please see the Site Information Centre.

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

Attribute: Structure and function

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

Explanatory notes

Structure
Structure encompasses both the physical structure of a habitat type together with the biological structure. 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). The biological structure refers to the key and influential species and characteristic communities present. Biological communities are important in not only characterising the feature but supporting its health i.e. its conservation status and the provision of ecosystem services by performing functional roles.

Physical structure

Bubbling reef structures lie on, or stand above the surrounding seabed. Topographic features such as blocks, slabs, pavements, overhangs, vertical pillars and cliffs are formed and these can be characterised as either 'low relief' or 'high relief'. High relief MDAC is raised at least 20 cm above the surrounding sediment, whilst low relief MDAC protrudes less than 20 cm (Whomersley *et al.,* 2010). The MDAC provides a hard substrate that differs from the surrounding seabed and offers structural complexity through the presence of fissures, cracks and crevices that afford habitat to a range of marine life.

Key and influential species

MDAC is formed as a consequence of the anaerobic oxidation of methane (AOM) at the sulphate-methane interface (SMI) that most commonly occurs within a few tens of centimetres beneath the seafloor. AOMs; consortia of methanotrophic archaea and sulphate-reducing bacteria (Boetius et al., 2000; Niemann et al., 2005) are fundamental to the formation of Annex I Submarine structures formed by leaking gases (MDAC). In addition to the precipitation of MDAC, AOM activity leads to the release of hydrogen sulphide; consequently, mats of thiotrophic (sulphide-oxidising) bacteria (e.g. Beggiatoa spp.) often occur in the immediate vicinity (probably restricted to a few centimetres) of where there is active AOM, and can therefore be used as evidence of active gas seepage. Sulphide-rich sediments are toxic to 'normal' benthic organisms, but may host specialist organisms, for example those with chemosynthetic symbionts.

Species associated with Annex I Submarine structures formed by leaking gases can be either categorised as; i) those associated with AOM and the presence in the sediments of methane and hydrogen sulphide; or ii) those associated with the hard-substrate provided by MDAC. Either or both categories may be found in both types of the feature.

The biological communities that live within and around the active methane seepage and MDAC are important not only in characterising Submarine structures made by leaking gases but also in supporting the provision of ecosystem services by performing functional roles. Certain species may form a key component of the habitat's structure (e.g. encrusting and reef-forming species). Influential species are likely to have a key role affecting the structure and function of the habitat such as grazers, surface borers, predators or other species with a significant functional role linked to the habitat.

Crusts of *Sabellaria spinulosa* may be a common occurrence on the feature. Their presence can influence community composition; supporting a diverse range of epifauna as well as influencing the physical structure of the seabed. Boring species may be present and are important because of their ability to influence MDAC structure, adding further complexity to the surface of the feature, creating ecological niches for other organisms to colonise. Thiotrophic bacterial mats, where present, indicate active gas seepage, AOM and the potential presence of specialist organisms with chemosynthetic symbionts (Hovland *et al.,* 2012).

Characteristic communities

A variety of communities may be found living within and upon MDAC and reflect its overall character and conservation interest. The biological communities typical of the feature may vary greatly depending on the physical structure of the MDAC itself, depth and fine-scale physical, chemical and biological processes and also the general oceanographic context (water depth, current strength etc.). AOMs and specialist communities may be present within the immediate vicinity of active methane seepage pathways, in either bubbling reefs or pockmark associated structures.

Where AOMs are present, thiotrophic bacterial mats (e.g. *Beggiatoa spp.*) are likely to be present on the seabed in the immediate vicinity (probably restricted to a few centimetres) of active seep vents. In the presence of hydrogen sulphide the 'normal' benthic communities are likely to be depleted, but organisms hosting symbiotic chemosynthesisers such as the gutless nematode *Astomonema southwardorum,* bivalves *Thyasira sarsi* and *Lucinoma borealis* may be present (Hovland *et al.,* 2012; Hartley, 2005; Gafeira and Long, 2015).

Bubbling reef formations of MDAC support diverse benthic communities which tend to differ from those of the surrounding habitat (Judd, 2005). Communities tend to vary depending on the structure of the MDAC, whether it is high or low relief and on other environmental factors The MDAC can be extensively colonised by the soft coral *Alcyonium digitatum*, dense hydroid turf of *Eucratea loricata* and *Diphasia pinaster*, and the robust hydroid *Tubularia indivisa*, which can be indicative of strong currents. Tubeworms such as *Sabella pavonina* and *Sabellaria spinulosa* and boring bivalves such as *Hiatella arctica* and boring sponges such as *Cliona celata* may be other abundant taxa. Sponges such as the yellow boring sponge *Cliona celata* and *Lophonopsis nigri*cans can also be present covering high relief MDAC (Whomersley *et al.,* 2010). The surface complexity of the feature supports a large diversity of both sessile bryozoans (such as *Flustra foliacea* and *Vesicularia spinosa*) and mobile invertebrate species (such as *Cancer pagurus* and *Nephrops norvegicus*). Animals such as the long-clawed squat lobster (*Munida rugusa)* and European lobster (*Homarus gammarus*) seek shelter in the numerous overhangs and crevices, further enhancing the biological diversity of communities found within and on MDAC (Whomersley *et al.,* 2010, Interpretation Manual - EUR28, 2013).

It is important to conserve the natural spatial distribution, composition, diversity and abundance of the characterising biological communities and key and influential species of the feature within the site to avoid diminishing biodiversity and ecosystem functioning of the habitat (JNCC, 2004a; Hughes *et al.,* 2005).

Function

Functions are ecological processes e.g. sediment processing, secondary production, habitat modification, supply of recruits, bioengineering and biodeposition. Biological communities associated with habitats may contain species that perform key functional roles that help to maintain conservation status. Functions are reliant on natural supporting processes and the growth and reproduction of biological communities which characterise the habitat and as mentioned previously, providing a variety of functional roles within it (Norling *et al.,* 2007). These can occur at a number of temporal and spatial scales and help to maintain the provision of ecosystem services (ETC, 2011) locally and to the wider marine environment. Ecosystem services which Annex 1 Submarine structures made by leaking gas can provide include:

- Climate regulation: by providing a natural storage capacity for greenhouse gases e.g. methane; and
- Nutrition: by providing habitat a food source as well as refugia for a variety of fauna, including a range of commercially important fish species.

Both bubbling reefs and submarine structures associated with pockmarks provide a habitat that differs from the surrounding seabed. The physical structure of MDAC support a more diverse range of epifaunal marine species as the physical structure of MDAC provides a surface for attachment. Submarine structures may also provide a refugia for a variety of fish species, but it is presently unclear as to whether this is a result of the hard substrate of the MDAC or the pockmarks in the case of submarine structures associated with pockmarks. Active gas seeps and associated structures may have ecological significance because of the utilisation of methane and its by-product, hydrogen sulphide, by chemosynthesisers (Judd, 2001).

Structure and function of the feature within the site

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

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

Attribute: Supporting processes

Objective:

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

Explanatory notes

The feature relies on a range of natural processes to support ecological functioning. Supporting processes are the physical, biological and chemical controls that give rise to a habitat, shaping its characteristics and determining its faunal composition (Alexander *et al*., 2014). 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: natural gas seepage and MDAC accretion, hydrodynamic regime, water and sediment quality.

Natural gas seepage and MDAC accretion

Natural gas migration plays a fundamental role in the accretion of MDAC as a result of anaerobic oxidation of methane below the seabed surface (Niemann *et al*., 2005). Consequently, anaerobic oxidation of methane (AOM) within the site will be reliant on a supply of natural gas. It is important that this process remains unhindered, noting that gas seepage may be naturally intermittent (Judd, 2001).

Hydrodynamic regime

Hydrodynamic regime refers to the speed and direction of currents, seabed shear stress and wave exposure. These mechanisms circulate food resource and propagules and influence water properties by distributing dissolved oxygen, transferring it from the surface to the seabed (Dutertre *et al.,* 2012; Hiscock *et al.,* 2004; Biles *et al.,* 2003; Chamberlain *et al.,* 2001). Hydrodynamic regime also effects the movement, size and sorting of sediment particles.

MDAC is formed at the sulphate-methane interface (SMI), which is normally located beneath the seabed (except where gas flow is sufficient for sulphate utilisation during AOM to exceed supply, in which case it may rise to the seabed). Consequently, overlying sediments must have been removed (e.g. by erosion by strong currents, or fluid expulsion during pockmark activity) for MDAC to be present at or above the normal seabed. Moreover, the hydrodynamic regime interacts with the physical structure of pockmarks, serving to reduce bottom currents below a critical minimum. This allows for increased larval settlement from the water column into these areas (Snelgrove, 1994).

Water and sediment quality
Contaminants may also impact the conservation status of the biological communities associated with MDAC by having a range of biological effects on different species within the habitat, depending on the nature of the contaminant (JNCC, 2004b; UKTAG, 2008; EA, 2014). It is important therefore to avoid changing the 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 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 (<1cm from the surface) must fall below the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) threshold. For example, mean cadmium levels must be maintained below the ERL of 1.2 mg per kg. For further information, see Chapter 5 of the Quality Status Report (OSPAR 2010) and associated QSR Assessments.

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

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

Water quality
The water quality properties that influence habitats include salinity, pH, temperature, suspended particulate concentration, nutrient concentrations and dissolved oxygen. They can act alone or in combination to affect habitats and their communities in different ways, depending on species-specific tolerances. In fully offshore habitats these parameters tend to be relatively more stable, particularly so for deeper waters,

although there may be some natural seasonal variation. They can influence the abundance, distribution and composition of communities at relatively local scales. Changes in any of the water quality properties, as a result of human activities, may impact habitats and the communities they support (Elliot *et al.,* 1998; Little, 2000; Gray and Elliot, 2009). Changes in suspended sediment in the water column may have a range of biological effects on different species within the habitat; affecting the ability to feed or breathe. A prolonged increase in suspended particulates for instance can have a number of implications, such as affecting fish health, clogging filtering organs of suspension feeding animals and affecting seabed sedimentation rates (Elliot *et al.,* 1998). Low dissolved oxygen can have sub-lethal and lethal impacts on fish and infaunal and epifaunal communities (Best *et al.,* 2007).

Sediment quality
Contaminants are known to have different effects on the species that live in or on the surface of sediments and hard substrate. These include heavy metals like Mercury, Arsenic, Zinc, Nickel, Chrome and Cadmium, polyaromatic hydrocarbons (PAHs), poly-chlorinated biphenyls (PCBs), organotins (TBT) and pesticides such as hexachlorobenzene. These can impact species sensitive to particular contaminants, (e.g. heavy metals) and may bioaccumulate within organisms, entering the marine food chain (e.g. PCBs) (OSPAR Commission 2009, 2010, 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.

Supporting processes for 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 Advice on Operations workbook for the site (hyperlink is provided in the box at the top of this document).

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