Supplementary Advice on Conservation Objectives for Scanner Pockmark Special Area of Conservation

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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 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: Annex I 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 below, along with the objectives set for each of them, 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.

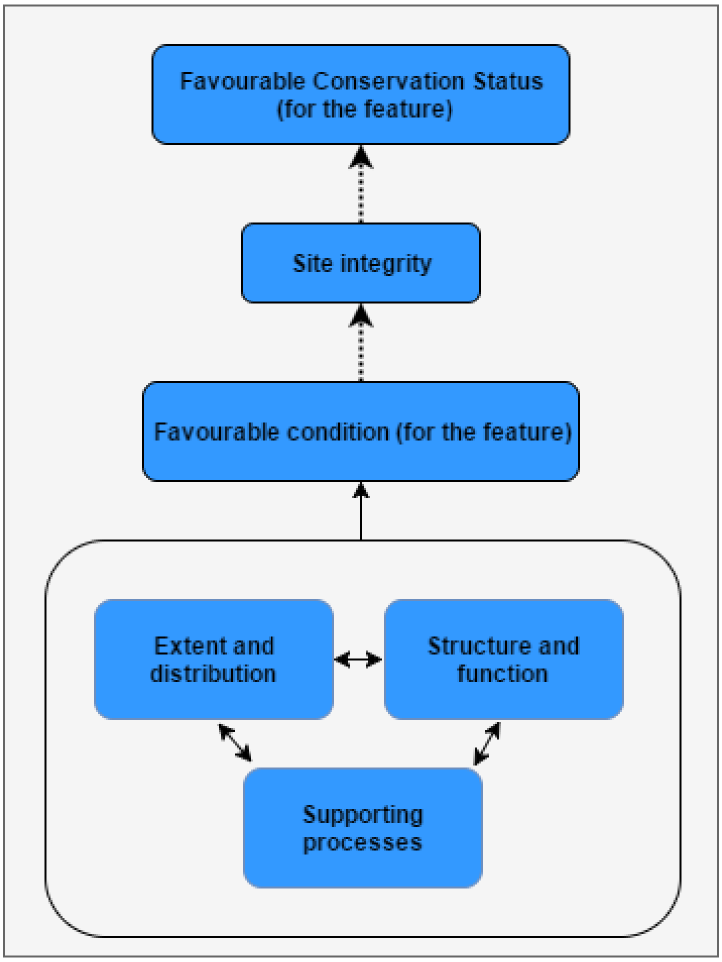

Figure 1. Conceptual diagram showing how feature attributes are interlinked, describe favourable condition and contribute to site integrity and wider favourable conservation status.

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. An objective of restore or maintain is set for each feature attribute. The objective reflects our current understanding of a feature's condition e.g. where evidence indicates some of a feature's extent is lost and needs to be restored or that extent is not lost and needs to be maintained in order to ensure the feature is in overall favourable condition. The rationale for setting an objective is also provided in the explanatory notes, along with reference to supporting evidence from the site. Note that where it is not practical through human intervention to restore a feature's attribute, a maintain objective is set, accompanied by a statement to reflect the impracticality of restoration.

Note also that when a maintain objective is set, this does not preclude the need for management, now or in the future. Please see the conservation measures for further detail regarding managing activities.

Table 1. Supplementary advice on the conservation objectives for Annex I habitat 1180 Submarine structures made by leaking gases in Scanner Pockmark SAC.

Attribute: Extent and distribution

Objective: Maintain

JNCC understands that sidewall slumping and subsequent infilling has happened in some of the pockmarks within the site and that this has resulted in burial of the feature i.e. a reduction in its extent and distribution. It is also unclear if the sidewall slumping is natural or the result of impacts from ongoing human activities. Regardless, a maintain objective is advised as it is not considered feasible through management intervention to restore Submarine structures made by leaking gases if they have been buried. Activities must look to minimise, as far as is practicable, impacts on feature extent and distribution.

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, 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

[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

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 associated with pockmarks, the periodic expulsion of large volumes of methane (Hong *et al.*, 2017) 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 within the site

The Scanner Pockmark SAC protects an example of pockmarks type of Annex I submarine structures made by leaking gases qualifying feature as described above. The site includes 77% of the total known resource of this type in UK waters considering all potential records of the feature. The site map for Scanner Pockmark SAC showing the extent and distribution of the qualifying feature is available to view on JNCC's Interactive MPA mapper, comprising both verified and potential records. During the most recent survey (reported in Rance *et al*., 2017), only potential records of the feature were identified based on the interpretation of acoustic data. However, verified examples of MDAC have been identified in earlier surveys of the site (Hovland and Judd, 1988).

Sixty-seven pockmarks covering 0.7 km^2 have been identified within the site (Gafeira and Long, 2015). Thirty-two of the pockmarks within the site covering 0.6 km^2 have potential examples of MDAC present interpreted from acoustic data. High acoustic backscatter may be indicative of hard carbonate structures so are considered as potential feature records associated with pockmarks (JNCC, 2016). Both verified and potential occurrences of the habitat are considered to represent the extent of the feature within the site (JNCC, 2016).

It is clear from the evidence presented in Gafeira and Long (2015) that pockmark sidewall slumping has occurred over time. The cause of pockmark sidewall slumping within the site is unknown and could be attributed to either anthropogenic activities, such as bottom trawling known to occur in the site, or due to natural processes (Gafeira and Long, 2015). Pockmark infilling through sidewall slumping can obscure the venting of natural gas from the seabed and result in burial of the feature located at its base, reducing the extent and distribution of the feature within the site. In Scanner Pockmark SAC, burial of structures appears to have occurred, obscuring previously recorded MDAC.

Regardless of the cause of sidewall slumping, it is not considered practicable to restore the extent and distribution of the feature once buried. There is a lack of evidence of active gas seepage based on the findings of the most recent site survey (Rance *et al*., 2017) and the slow accretion rate of MDAC means that the feature forms over geological time scales.

For these reasons, **JNCC advise a maintain objective** noting it is not possible for the feature to be recovered by management intervention. Activities must look to minimise, as far as is practicable, further impact on the feature's extent and distribution within the site. Further information on the impacts associated with human activities on Submarine structures made by leaking gases can be found in the Advice on Operations workbook.

Attribute: Structure and function

Objective: Restore

JNCC understands that pockmark sidewall slumping, and associated infilling, has happened in some of the pockmarks within the site. This has obscured verified records of MDAC previously recorded in 1985 and 1990. It is unknown whether the cause of pockmark sidewall slumping is natural or anthropogenic in nature. It is not considered feasible through management intervention to restore the physical structure of MDAC once buried and so this sub-attribute and the associated functions that MDAC provides are set as a maintain objective. However, based on our understanding of the sensitivity of the feature's characteristic biological communities to pressures associated with demersal trawling occurring within the site, specifically physical removal and abrasion, JNCC advises a restore objective for this particular sub-attribute. Our confidence in this advice would be improved with a better understanding of the degree to which burial of the feature and its biological communities has occurred within the site. Activities must look to minimise, as far as is practicable, impacts on the physical structure and biological assemblages within the site.

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

Similar to bubbling reefs, the Methane-Derived Authigenic Carbonate (MDAC) associated with pockmarks provides a hard substrate differing to the surrounding seabed. The physical structure of MDAC outcroppings from the seabed commonly takes the form of blocks, pavements and slabs. Created by the expulsion of fluids, pockmarks are large seabed depressions which may or may not contain MDAC created by the anaerobic oxidation of methane (AOM). The physical structure of pockmarks can change naturally over time e.g. through the slumping of sidewalls, or by continued fluid escape activity resulting in continuing AOM, formation of MDAC, and hydrogen sulphide release. Changes to the physical structure of the pockmark, such as sidewall slumping, may serve to bury existing MDAC and therefore will determine whether the structures are exposed and fully functional as a feature. Sidewall slumping may be attributed to either natural or anthropogenic influences but either cause can alter the structure of the Annex I feature structure by covering this with a layer of sediment. Although the feature of interest itself is the MDAC, it is also important to conserve the pockmark feature associated with the Annex I feature to avoid infilling from anthropogenic causes.

Physical structure within the site

Pockmarks within Scanner Pockmark SAC have a depth of up to 17m, but the majority of the pockmarks are between 1m and 2m deep. At the base of pockmarks within the site, large blocks of MDAC have been recorded in the past (Hovland and Judd, 1988), but have not been confirmed by more recent 2012 survey data (Rance *et al*., 2017). However, many of the mapped pockmarks in the area showed a high backscatter response which may be indicative of the presence of MDAC (Gafeira and Long, 2015) and require further investigation.

By comparing multibeam datasets from 2012 with those from 2001, there is evidence that the physical structure of the interest feature at the Scanner Pockmark SAC has changed (Gafeira and Long, 2015). Some of the pockmarks appear to have infilled due to sidewall slumping, interrupting gas migration and likely obscuring any MDAC at the base of pockmarks (Gafeira and Long, 2015).

There is a lack of evidence of active gas seepage based on the findings of the most recent site survey (Rance *et al*., 2017) and the slow accretion rate of MDAC means that the feature forms over geological time scales. **JNCC therefore advise a maintain objective** noting it is not possible for the feature to be recovered by management intervention. Activities must look to minimise, as far as is practicable, further impact on the feature's structure within the site. Further information on the impacts associated with human activities on Submarine structures made by leaking gases can be found in the [Advice on Operations workbook.]

Biological structure: key and influential species

MDAC is formed as a consequence of the anaerobic oxidation of methane (AOM) at the sulphate-methane interface 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.

Pockmarks may be characterised by species typically associated with sedimentary habitats. However, on or around MDAC may be colonised by species requiring a hard substrate (something rarely present in the types of sediment suitable for pockmark formation). Thiotrophic bacterial mats, where present, indicate active gas seepage, AOM and the potential presence of specialist organisms with chemosynthetic symbionts (Hovland *et al.,* 2012).

Biological structure: key and influential species in the site

There is limited information regarding the key and influential species that play a critical role in the formation of Annex I habitat Submarine structures made by leaking gases within the site. White bacterial mats were observed adjacent to MDAC during surveys of the site in 1985 and 1990, more recent surveys have found no instances of bacterial mats (Rance *et al*., 2017). JNCC are not aware of any other key or influential species that play a critical role in setting the foundations for colonisation of characterising communities associated with MDAC within the Scanner Pockmark SAC. Due to insufficient information available, it is not possible to set an objective for this sub-attribute and it is not considered further in our advice.

Biological structure: 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).

MDAC located in pockmarks provide hard substrate which differs from the surrounding, typically muddy, seafloor. This provides more ecological niches for the colonisation of a range of marine species (Judd, 2001). Invertebrate specialists of hard substrate occurring on MDAC within pockmarks can include Hydrozoa, Anthozoa, Ophiuroidea and Gastropoda (Interpretation Manual - EUR28, 2013). Examples of likely species could include the deeplet sea anemone (*Bolocera tuediae)*, Dahlia anemone (*Urticina felina)*, plumose anemone (*Metridium senile),* Common whelk *Buccinum undatum* and the brittlestar *Ophiura albida* on the carbonate structures. The carbonate structures can provide shelter for fish species such as wolf fish (*Anarhichas lupus)* (Dando, 2001).

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

Biological structure: characteristic communities within the site

The pockmark sidewalls are comprised of mixed/coarse sediment types and the pockmarks themselves sit within areas of subtidal mud or sandy mud within the site (Rance *et al*., 2017). Macrofaunal analyses have shown highest abundances but low species diversity within the pockmark features. However, assemblages were not found to be significantly different inside and outside the pockmarks (Rance *et al*., 2017). Although pockmark infilling appears to have obscured MDAC structures and bacterial mats, meiofaunal analyses from 2012 showed a very high abundance and dominance of the nematode species *Astomonema southwardarum,* known to host endosymbiotic, chemoautotrophic bacteria within their body cavity (Rance et al., 2017). This species was first described at the Scanner Pockmark area (Austen *et al*., 1993). Earlier surveys have recorded presence of other chemosynthetic species such as the bivalve *Thyasira sarsi*, which are also largely dependent on endosymbiotic sulphur-oxidising bacteria for nutrition and may indicate the presence of active methane seeps. It should however be noted that these shallow-water seep, symbiont containing species are not restricted to seep sites but can all be found in other reducing environments (Dando, 2010).

When the site contained exposed carbonate structures, these provided a hard substrate suitable for colonisation by organisms such as the sea anemones *Bolocera tuediae, Urticina felina* and *Metridium senile* (Dando *et al.,* 1991). The structures and pockmark depressions have also attracted a range of fish species. Fish noted in the pockmark were *Myxine glutinosa* (hagfish), *Rhinonemus cimbrius* (fourbeard rockling), *Melanogrammus aeglefinus* (haddock) and *Sebastes viviparus* (small redfish) on top of the MDAC and within the pockmarks and *Anarhichas lupus* (wolf-fish) lying in cavities under the rocks. These fish appear to use the pockmark depressions and the carbonate structures for shelter, since no large fish were seen outside the pockmark (Dando, 2001). The 2012 survey did not find evidence of the carbonate structures being present, however species may still use the pockmark depressions themselves. Other invertebrates that have been observed at the Scanner Pockmark SAC include *Pennatula phosphorea (*phosphorescent sea pen*), Virgularia mirabilis* (slender sea pen) and *Cerianthus lloydii* (tube anemone) in the sediments of the pockmark. Among other species, hermit crabs (*Pagurus* sp.), large echinoderms and squat lobsters were also found in the site (Dando *et al.,* 1991).

The cause of pockmark sidewall slumping within the site is unknown and could be attributed to either anthropogenic activities, such as demersal trawling known to occur in the site, or due to natural processes (Gafeira and Long, 2015). Vessel Monitoring System (VMS) data (2009-15) suggests that fishing activity within the site is predominantly demersal trawling and recent studies have found evidence of trawling scars on the seabed (Gafeira and Long, 2015). These could be a result of recent activity, but could also have occurred further in the past because trawling scars can persist in low energy environments. Two exploration oil wells completed in 1984 by ConocoPhillips UK near the centre of the site, also presented acoustic anomalies on sidescan sonar and backscatter, likely to be attributed to the rig anchorage and cutting deposits (Gafeira and Long, 2015). JNCC considers that these activities have the potential to impact the characterising communities associated with Submarine structures made by leaking gases within the site and may have already done so.

Notwithstanding the point that it is not practicable to unbury MDAC and its characteristic biological communities through management intervention where smothering/burial has occurred, other pressures associated with fishing e.g. indirect removal of characteristic biological communities may have taken place affecting the communities present. Therefore, **JNCC advise a restore objective,** noting that this refers specifically to the restoration of characteristic biological communities associated with MDAC that have been subject to removal or abrasion pressures associated with demersal trawling. It does not refer to the restoration of characteristic biological communities that have already been subjected to burial through pockmark sidewall slumping, as such restoration is impossible. Activities must look to minimise, as far as is practicable, further impact on the feature's characterising communities within the site. Further information on the impacts associated with human activities on Submarine structures made by leaking gases can be found in the Advice on Operations workbook.

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).

Function of the feature within the site

Based on survey evidence collected in 2012 and reported in Rance *et al.* (2017), there is limited empirical evidence for any ecosystem function being delivered by the Scanner Pockmark SAC. The infilling of pockmarks that has been identified within the site has obscured carbonate structures and bacterial mats previously recorded in 1985 and 1990. Consequently, the delivery of ecosystem services provided by Scanner Pockmarks SAC is likely to have been impaired. It is not clear whether this infilling from sidewall slumping is caused by natural variation or anthropogenic impacts. **JNCC advises a maintain objective** as it is not considered practicable to unbury the feature nor its associated biological communities. However, further information on the presence of unburied MDAC would affect our judgement on the objective of this sub-attribute and discovery of instances of unburied MDAC may change our judgement for the sub-attribute in the future. Activities must look to minimise, as far as is practicable, further impact on the feature's function within the site. Further information on the impacts associated with human activities on Submarine structures made by leaking gases can be found in the Advice on Operations workbook.

Attribute: Supporting processes

Objective: Maintain

A maintain objective is advised for supporting processes based on expert judgment; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities. Our confidence in this objective would be improved with long-term monitoring, a better understanding of the source of the natural gas seepages within the site and the influence it has on the formation and change in distribution of the feature, contaminant levels within the site and a better understanding of the hydrodynamic regime within the site. Activities must look to avoid, as far as is practicable, impairing the natural gas seepage, MDAC accretion and hydrodynamic regime within the site and exceeding Environmental Quality Standards set out in the relevant section below.

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 quality and sediment quality.

Natural gas seepage and MDAC accretion
Natural gas migration plays a fundamental role in the accretion of Methane-Derived Authigenic Carbonate (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).

Natural gas seepage and MDAC accretion within the site
Acoustic evidence of gas seeps in Scanner Pockmark SAC have been recorded by numerous surveys at the Scanner and Scotia pockmark complexes within the Scanner Pockmark SAC (e.g. Hovland and Sommerville, 1985; Judd, 2001; Judd and Hovland, 2007) most recently in 2005 where only relatively weak gas flares were detected (Gafeira and Long, 2015). Bacterial mats can also indicate active gas seepage over long periods of time. Earlier surveys in 1985 and 1990 identified several bacterial mats within the site, but more recently none have been observed (Gafeira and Long, 2015). Infilling of pockmarks (whether caused by natural or anthropogenic factors) is thought to have obscured these, as well as the MDAC that was previously recorded, potentially impeding gas seepage.

There is anecdotal evidence to suggest that the submarine structures are sustained by shallow biogenic gas seepage (Hartley, 2005); however, if deeper petrogenic gas supports the structures, there is potential for a reduction in seepage if the underlying reservoir is depleted through commercial activities (Oil & Gas UK 2008). Currently there are no active wells within the site.

The infilling of pockmarks from sidewall slumping that has been identified within the site is likely to have obscured carbonate structures, bacterial mats and interrupted gas migration. However, recovery of this process is not possible through human intervention. As such, **JNCC advise a maintain objective**. Whilst the exact cause of pockmark slope failure is unknown, activities must look to minimise, as far as is practicable, impacts on natural gas seepage and MDAC accretion within the site. Our confidence in this objective would be improved with long-term monitoring, better access to information on activities within the site, a better understanding of the source of the natural gas seepages within the site and the influence it has on the formation and change in distribution of the feature. Further information on the impacts associated with human activities on Submarine structures made by leaking gases can be found in the Advice on Operations workbook.

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, 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).

Hydrodynamic regime within the site

Sediment migration is thought to be relatively limited in this part of the North Sea. This has resulted in the persistence of impacts to seafloor sediments such as trawl and anchor scars, and the persistence of elevated levels of hydrocarbons from exploratory oil-well discharges which remained close (up to 200m) to the source point (UK Benthos Dataset in Gafeira and Long, 2015).

There is no evidence to suggest the hydrodynamic regime within the site is impacted by human activities. It is important to maintain the regional hydrodynamic regime around the Scanner Pockmark SAC to ensure that key processes such as the interaction of currents with the physical structure of pockmarks, resulting in increased larval settlement and deposition of organic material, remain unimpacted. As such, **JNCC advise a maintain objective**.

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 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 Standards (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).

Water quality within the site

There is limited site-specific information available regarding water quality at the time of writing (February 2018). Historically, there has been oil and gas activity occurring within or in the near vicinity of the site. Several water toxicity studies have concluded that the necessary dilution to achieve a 'No Effect Concentration' would be reached at <10 to 100m and usually less than 500m from the discharge point depending on currents and water stratification (Gafeira and Long, 2015). There are two exploratory oil wells in one location within the site so there may be possible risk of water toxicity, although these were abandoned in 1984.

The Charting Progress 2 reports that the open seas are little affected by pollution and levels of monitored contaminants continue to fall, albeit slowly in many cases. JNCC conclude that water contaminants within the site are unlikely to be exceeding EQS given the distance from sources of pollution. JNCC therefore advise that aqueous contaminants must be maintained below the annual average (AA_EQS) 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).

A maintain objective is advised for water quality based on expert judgment; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities. Our confidence in this objective would be improved with longer-term monitoring, specifically of contaminants within the site. Further information on the impacts associated with human activities on Submarine structures made by leaking gases can be found in the Advice on Operations workbook.

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.

Sediment quality within the site

Sediment migration is thought to be relatively limited in this part of the North Sea resulting in the persistence of elevated levels of hydrocarbons from exploratory oil-well discharges which have remained close (up to 200m) to the source point (UK Benthos Dataset in Gafeira and Long, 2015). This suggests that any contamination that occurs would persist for long periods of time, especially within pockmarks due to the reduced bottom velocity at the base of the pockmark. Historically, there has been oil and gas activity occurring within and in the vicinity of the site and therefore there may be risk of contamination from these sources. There are two exploratory oil wells in one location within the site, within 200m of potential feature records, although these were abandoned in 1984.

There is limited information available to ascertain the sediment contaminant levels within the site at the time of writing (February 2018). Clean Seas Environment Monitoring Program (CSEMP, 2014) assessment of data supplied by the British Oceanographic Data Centre reveals that levels for contaminants appear to be within expected background and EQS levels for this area. There is one data point located approximately 20 km from Scanner Pockmark SAC which supports this.

A **maintain objective is advised** for sediment quality based on expert judgment; specifically, our understanding of the feature's sensitivity to pressures which can be exerted by ongoing activities i.e. oil and gas sector activities. Our confidence in this objective would be improved with longer-term monitoring, specifically of contaminants within the site. Further information on the impacts associated with human activities on Submarine structures made by leaking gases can be found in the Advice on Operations workbook.

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