OSPAR COMMISSION

Background document on *Sabellaria spinulosa* reefs

Biodiversity Series

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OSPAR Convention
The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l’Irlande, l’Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d’Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l’Espagne.

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Background Document for Sabellaria spinulosa reefs

Executive Summary

This Background Document for *Sabellaria spinulosa* reefs has been developed by OSPAR following the inclusion of this habitat on the OSPAR List of threatened and/or declining species and habitats (OSPAR Agreement 2008-6). The document provides a compilation of the reviews and assessments that have been prepared concerning this habitat since the agreement to include it in the OSPAR List in 2004. The original evaluation used to justify the inclusion of *Sabellaria spinulosa* reefs in the OSPAR List is followed by an assessment of the most recent information on its status (distribution, extent, condition) and key threats prepared during 2012. Chapter 7 provides recommendations for the actions and measures that could be taken to improve the conservation status of the habitat. In agreeing to the publication of this document, Contracting Parties have indicated the need to further review these proposals. Publication of this background document does not, therefore, imply any formal endorsement of these proposals by the OSPAR Commission. On the basis of the further review of these proposals, OSPAR will continue its work to ensure the protection of *Sabellaria spinulosa* reefs, where necessary in cooperation with other competent organisations. This background document may be updated to reflect further developments or further information on the status of the habitat which becomes available.

Récapitulatif

Le présent document de fond sur les récifs de *Sabellaria spinulosa* a été élaboré par OSPAR à la suite de l'inclusion de cet habitat dans la liste OSPAR des espèces et habitats menaces et/ou en déclin (Accord OSPAR 2008-6). Ce document comporte une compilation des revues et desévaluations concernant cet habitat qui ont été préparées depuis qu'il a été convenu de l'inclure dans la Liste OSPAR en 2004. L'évaluation d'origine permettant de justifier l'inclusion des récifs de *Sabellaria spinulosa* dans la Liste OSPAR est suivie d'une évaluation des informations les plus récentes sur son statut (distribution, étendue et condition) et des menaces clés, préparée en 2012. Le chapitre 7 fournit des propositions d'actions et de mesures qui pourraient être prises afin d'améliorer l'état de conservation de l'habitat. En se mettant d'accord sur la publication de ce document, les Parties contractantes ont indiqué la nécessité de réviser de nouveau ces propositions. La publication de ce document ne signifie pas, par conséquent que la Commission OSPAR entérine ces propositions de manière formelle. A partir de la nouvelle révision de ces propositions, OSPAR poursuivra ses travaux afin de s'assurer de la protection des récifs de *Sabellaria spinulosa* le cas échéant avec la coopération d'autres organisations compétentes. Ce document de fond pourra être actualisé pour tenir compte de nouvelles avancées ou de nouvelles informations qui deviendront disponibles sur l'état de l'habitat.

1. Background Information

Name of habitat

Sabellaria spinulosa reefs: Definition of habitat[1]

S. spinulosa is a small, tube-building polychaete worm found in the subtidal and lower intertidal/ sublittoral fringe. In most parts of its geographic range it does not form reefs but is solitary or found in small groups, encrusting pebbles, shell, kelp holdfasts and bedrock. When conditions are favourable, dense aggregations may be found, forming reefs up to about 60 cm high and extending over several hectares; these are often raised above the surrounding seabed. Reefs may persist in an area for many years although individual clumps may regularly form and disintegrate (Jackson & Hiscock, 2008; Jones *et al.,* 2000).

Correlation with habitat classification scheme

In the EUNIS classification *S. spinulosa* reefs fall into one of two categories: *S.spinulosa* encrusted circalittoral rock and *S.spinulosa* on stable circalittoral mixed sediment.

Habitat type[2]	**European EUNIS classification**	**Britain & Ireland classification**[3]
<u>*Sabellaria spinulosa* encrusted circalittoral rock</u> This biotope is typically found encrusting the upper faces of wave-exposed and moderately wave-exposed circalittoral bedrock, boulders and cobbles subject to strong/moderately strong tidal streams in areas with high turbidity. The crusts formed by the sandy tubes of the polychaete worm *Sabellaria spinulosa* may even completely cover the rock, binding the substratum together to form a crust. A diverse fauna may be found attached to, and sometimes obscuring the crust, often reflecting the character of surrounding biotopes. Bryozoans such as *Flustra foliacea, Pentapora foliacea* and *Alcyonidium diaphanum*, anemones such as *Urticina felina* and *Sagartia elegans*, the polychaete *Pomatoceros triqueter, Alcyonium digitatum*, the hydroid *Nemertesia antennina* and echinoderms such as *Asterias rubens* and *Crossaster papposus* may all be recorded within this biotope. There are two variants. The first (Sspi.ByB) contains significant cover of barnacles (*Balanus crenatus*) and bryozoans. The second (Sspi.As) has a dense turf of didemnid ascidians as well as scour-tolerant bryozoans such as *F. foliacea*, sponges such as *Tethya aurantium* and *Phorbas fictitius*, colonies of the serpulid worm *Salmacina dysteri* and patchy occurrences of the ascidians *Distomus variolosus, Polycarpa pomaria* and *Polycarpa scuba*.	A4.221	CR.MCR.CSab.Sspi
<u>*Sabellaria spinulosa* on stable circalittoral mixed sediment</u> The tube-building polychaete [*Sabellaria spinulosa*] at high abundances on mixed sediment. This species typically forms loose agglomerations of tubes forming a low lying matrix of sand, gravel, mud and tubes on the seabed. The infauna comprises typical sublittoral polychaete species such as *Protodorvillea kefersteini, Pholoe synophthalmica, Harmothoe spp, Scoloplos armiger, Mediomastus fragili], Lanice conchilega*]and cirratulids, together with the bivalve *Abra alba*, and tube building amphipods such as *Ampelisca* spp. The epifauna comprise a variety of bryozoans including *Flustra foliacea, Alcyonidium diaphanum* and *Cellepora pumicosa*, in addition to calcareous tubeworms, pycnogonids, hermit crabs and amphipods. The reefs formed by *Sabellaria* consolidate the sediment and allow the settlement of other species not found in adjacent habitats leading to a diverse community of epifaunal and infauna species. The development of such reefs is assisted by the settlement behaviour of larval *Sabellaria* which are known to selectively settle in areas of suitable sediment and particularly on existing *Sabellaria* tubes.	A5.611	SS.SBR.PoR.SspiMx

[1] See Section 7 for discussion on further elaboration of the definition of *S.spinulosa* reefs.
[2] http://eunis.eea.europa.eu/habitats/2113; http://eunis.eea.europa.eu/habitats/1693 [downloaded 29.10.12]
[3] Connor *et al* (2004)

Common characteristics of *Sabellaria spinulosa* reefs

S. spinulosa worms build tubes independently of each other and their tubes coalesce to form a rigid structure which can grow upwards away from the seafloor at high worm densities to form areas of biogenic reef. The reef effectively smothers the underlying substrate and the sediment consolidation gives the colony a stability that allows many other associated species, including epibenthic and crevice fauna, to become established. The reef infauna, much of which is between and within empty tubes, typically comprises polychaete species such as *Protodorvillea kefersteini*, *Scoloplos armiger*, *Harmothoe* spp., *Mediomastus fragilis*, *Lanice conchilega* and cirratulids together with the bivalves *Abra alba* and *Nucula* spp. and tube-building amphipods such as *Ampelisca* spp. Epifauna comprise calcareous tubeworms, pycnogonids, hermit crabs, amphipods, hydroids, bryozoans, sponges and ascidians (Connor *et al*., 2004).

The characteristics of the reefs are linked to the density of aggregations and these are known to vary widely, *e.g*. 120 / m^2 recorded in Belfast Lough, Northern Ireland and more than 4500 / m^2 in the Wash on the east coast of England (in Hendrick & Foster-Smith, 2006). Whilst some aggregations may be short-lived, with the reef disintegrating and disappearing soon after the death of the reef-builders, in other cases the reefs may repeatedly develop and decline in a regular succession through resettlement after each successive generation has died. Patchiness can be a feature of *S. spinulosa* reefs, such that the colonies may be interspersed with patches of underlying sediment (Hendrick & Foster-Smith, 2006; Limpenny *et al.,* 2010).

2. Original Evaluation against the Texel-Faial selection criteria

List of OSPAR Regions and Dinter biogeographic zones where the habitat occurs

The OSPAR List indicates *S. spinulosa* reefs occur in all OSPAR regions, but there is very limited evidence of their occurrence in Regions I and V.

Dinter (2001) biogeographic zones where *S.spinulosa* reefs occur:

Lusitanean- boreal – warm sub-province

Boreal-Lusitanean

Boreal

List of OSPAR Regions where the habitat is under threat and/or in decline

The OSPAR List recognises that *S.spinulosa* reefs are under threat and/or decline in Regions II and III.

Original evaluation against the Texel-Faial criteria for which the habitat was included on the OSPAR List

The nomination of *S.spinulosa* reefs to be placed on the OSPAR List was on the basis of an evaluation of their status according to the Texel-Faial Criteria (OSPAR, 2003). This cited sensitivity, rarity, ecological significance and decline, with information also provided on threat (Table 1). The original proposal was for all OSPAR regions, but this was modified in light of ICES advice to OSPAR Regions II & III, as these were areas where most information was available. Section 3 which updates this distribution information, indicates that *S.spinulosa* reefs are currently believed to occur in OSPAR regions II, III and the northern part of region IV.

Table 1: Original Texel-Faial evaluation

Texel-Faial evaluation	Description
Decline	Subtidal *S.spinulosa* reefs are reported to have been lost in at least five areas of the North East Atlantic (Jones *et al.,* 2000). Large subtidal *S.spinulosa* reefs were common along the slopes of the northern tidal inlets of the German Wadden Sea in the 1920s (Hagmeier & Kändler, 1927) but have been largely lost since that time. Riesen & Reise (1982) reported that extensive subtidal *S.spinulosa* reefs were lost from the Lister Ley, island of Sylt, between 1924 and 1982 and Reise & Schubert (1987) reported similar losses from the Norderau area. Only three living reefs were found during surveys in the early 1990s compared to 24 during the 19th century (Figure A). In the late 1990s, samples taken from the subtidal reefs in the German Wadden Sea consisted largely of compact lumps of empty tubes. In 2000, one of these reefs had diminished drastically in extent with the remainder in poor condition although dredge samples were occupied by many tiny tubes with living worms inside. The third reef which had covered about 18ha could no longer be detected when repeat surveys were carried out in 2002.In the UK there are reports of reefs being lost in Morecambe Bay (Taylor & Parker, 1993), whilst a report comparing records from 1986 and 2000 in the western North Sea suggest an increase in distribution and densities in this area (ICES, 2007).
Rarity	True stable reefs, as opposed to crusts of *S.spinulosa*, are believed to be rare or have a very restricted distribution (Holt *et al.,* 1998).
Sensitivity	The findings from many studies on the sensitivity of *S.spinulosa* have been brought together in reviews by Holt *et al* (1998), Jones *et al* (2000) and Jackson & Hiscock (2008) and can be found on the MarLIN website (www.marlin.ac.uk). The highest sensitivity is to substratum loss and displacement as the worms are fixed to the substratum and cannot reattach once dislodged, or rebuild their tubes if removed from them. Recruitment rates are high however and recovery could be quite rapid as this species is often one of the first to settle on newly exposed surfaces. *S.spinulosa* does not appear to be particularly sensitive to changes in water quality (Holt *et al.,* 1998), but is both sensitive and vulnerable to physical damage. It is probably tolerant to smothering in the short term although this will affect feeding and growth and may interfere with reproduction depending on the timing. *S.spinulosa* appears to be very tolerant of water quality variation, but is potentially vulnerable to the short-term and localized effects of mineral extraction and the effects of oil dispersants on the larvae. Overall, however, it has been concluded that *S.spinulosa* seems unlikely to show any special sensitivity to chemical contaminants (Jackson & Hiscock, 2003). Well-developed, more stable reefs seem to be very scarce, and this apparent rarity suggests that an unusual set of environmental factors and/or circumstances is required for their formation. It might, therefore, be expected that they would display sensitivity to some factor or factors, but Jones *et al.,* (2000) report there is little information from which to gain any insight into this.
Ecological significance	*S.spinulosa* reefs can provide a biogenic habitat that allows many other associated species to become established and acts to stabilize cobble, pebble and gravel habitats.They contain a more diverse fauna, with sometimes more than twice as many species and almost three times as many individuals, than nearby areas where *S.spinulosa* is absent (NRA, 1994). The reefs are of particular nature conservation significance when they occur on sediment or mixed substrata areas as they enable a range of other species to occur that would not otherwise be found in such areas.
Threat[4]	The greatest impact on this biogenic habitat is considered to be physical disturbance. Dredging, trawling, net fishing and potting can all cause physical damage to erect reef communities (Riesen & Riese, 1982) although studies by Vorberg (2000) on a similar species (*S.alveolata*) indicated only minor damage to tubes from shrimp fisheries and rapid recovery. Vorberg (2000) has also suggested that shrimp vessels used around the mid-20th century would have had insufficient force to damage robust *S.spinulosa* reefs. Nevertheless, populations, especially if loose aggregations, may be displaced by mobile fishing gear and therefore a precautionary intolerance rating of 'intermediate' has been suggested for this species in the sensitivity assessments carried out for the Marine Biological Information Network (*MarLIN*). Other physical disturbance from the installation of infrastructure such as pipelines and wind turbines may also have a detrimental effect. Aggregate dredging often takes place in areas of mixed sediment where *S.spinulosa* reefs may occur and could therefore damage reefs. Apart from direct removal, the impact of this activity on their long-term survival is unknown, but suspension of fine material during adjacent dredging activity is not considered likely to have detrimental effect. Pollution has been listed as one of the major threats to *S.spinulosa* in the Wadden Sea and may have partly contributed to their replacement by *Mytilus edulis* beds. Coastal engineering works (mainly dike and dam building) may have also had a negative influence by changing the hydrological regime in parts of the Wadden Sea (Voberg, 2000).

[4] Updated information on threats and pressures is presented in Section 4.

ICES evaluation: The OSPAR Leiden Workshop concluded that evidence for both the decline of and threat to *Sabellaria spinulosa* reefs was strong across the whole OSPAR area. ICES agreed that evidence for both decline and threat to this habitat was sufficient, but only in OSPAR Regions II and III (ICES, 2002).

3. Current status of the habitat

Distribution in OSPAR maritime area

The species *S. spinulosa* is widely distributed within the OSPAR maritime area, although the density of worms is typically low. Densely aggregated reef structures in contrast are relatively rare, and are typically restricted to areas with high levels of suspended sediment within OSPAR Region II.

Mapping and detailed descriptions of the habitat distribution is challenging, being hampered by:

1) the difficulties and discrepancies in categorisation of *S. spinulosa* 'reef' (Hendrick & Foster-Smith, 2006);
2) the temporal instability of many aggregations;
3) the difficulty in detection of *S. spinulosa* reef and
4) incomplete data sets.

As a consequence, many of the maps purporting to show the distribution of *S. spinulosa* reef habitat can be misleading through under- or over- representation of the resource or through misrepresentation of locations of current reef.

In the UK, recorded occurrences of the species are concentrated around the coasts of England and Wales with a more scattered distribution around Scotland and Ireland. However, the pattern follows the observational bias of surveyed locations, and it is possible that the relative scarcity around Scotland, Ireland and with increasing distance from shore is merely a reflection of lower sampling effort. There are a limited number of 'hot-spots' where high densities of the worm are typically found, most notably in the vicinity of the Wash and along the South Coast (Hendrick, 2007; Hendrick *et al.*, 2011). Specific reports of dense UK aggregations include records from the Bristol Channel (George & Warwick, 1985), Dorset (Collins, 2003), the Thames Estuary (Attrill *et al.*, 1996), the Northumberland coast (Jones, 1972), the southern North Sea (BBL Company, 2006; BMT Cordah Ltd., 2003), and several aggregations which have been reported from the Wash and general vicinity (Foster-Smith *et al.*, 1997; Foster-Smith & White, 2001; Jessop & Stoutt, 2006; Kenny & Rees, 1996; Unicomarine Ltd., 1994). From Scotland, dense *S. spinulosa* aggregations have been reported at Hilbre Island at the mouth of the Dee (McIntosh, 1922), from East Rocks, St Andrews (McIntosh, 1922) and to the south of Rattray Head on the north east coast (Braithwaite *et al.*, 2006). Other aggregations have been reported from north and west Wales (Hiscock, 1984), and Dublin Bay in Ireland (Walker & Rees, 1980). Such reefs may not be currently extant.

Elsewhere in the OSPAR area, reports of dense aggregations of *S. spinulosa* are focused on the Wadden Sea (*e.g*. Berghahn & Vorberg, 1997; Lotze, 2005; Nehring, 1999; Vorberg, 2005), although these have since largely declined or disappeared (Nehring, 1999; Vorberg *et al.*, 2009; Wolff *et al.*, 2010). Current dense *S. spinulosa* aggregations within this area are possible, if not likely, but have not been identified (Dr.R.Vorberg, Marine Science Service, Dassendorf, *pers comm*). Expert opinion suggests *S. spinulosa* is not a common species in French waters, though can be found in the Channel and south of Brittany, but not in sufficiently large aggregations to be considered 'reef' (Dr.J.Fournier, Muséum National d'Histoire Naturelle, Dr.L.Godet, University of Nantes, *pers comm*.). Nevertheless *S. spinulosa* reefs are listed as present in French waters in two Natura 2000 protected areas in OSPAR region II and six Natura 2000 protected areas in OSPAR Region IV. Further evidence of

S. spinulosa reefs may come to light during surveys and monitoring of offshore installations and/or dredging activities for example.

A summary of the distribution data of *S. spinulosa* reef habitat provided by OSPAR Contracting Parties is given in Appendix 1 and mapped in Figure A. This indicates that OSPAR Regions II and III are, or have been, the main centres of distribution of this habitat type. *S. spinulosa* reef is not thought to occur in Regions I and V at the present time or historically. Occurance in the northern part of Region IV is a possibility but requires confirmation.

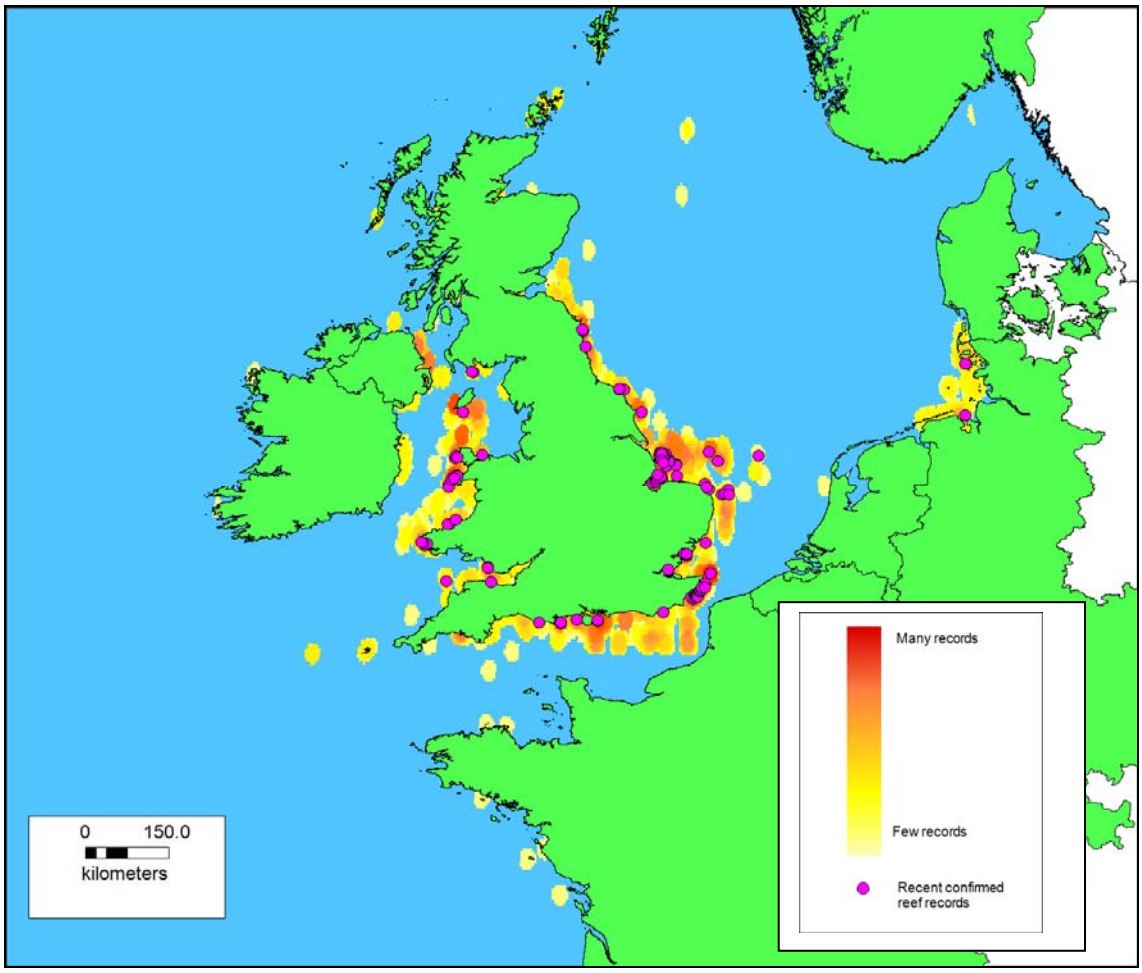

Figure A. The concentration of records of *Sabellaria spinulosa* in the OSPAR area shown as a colour gradation.

Note: *All records have been included. However, a minority of records might be considered historic and there is uncertainty about the current status of distribution of S. spinulosa in the Wadden Sea and the Atlantic coast of France. There is also uncertainty whether the records used to determine the distribution meet the criteria for "reef". Those that are more likely to be biogenic reef are shown as circles.*

Habitat extent

The total extent of *S. spinulosa* reef in the OSPAR area is unknown, and clear descriptions of *S. spinulosa* aggregations in the literature are limited, particularly in relation to their size. Some exceptions to this include an aggregation at the mouth of the Wash, described from underwater video as protruding up to 30 cm above the surrounding seabed and extending more or less continuously for hundreds of metres (Foster-Smith & White, 2001). Other descriptions come from seabed surveys for pipeline routes which have estimated various *S. spinulosa* aggregations to extend for approximately 0.5 km^2 (BMT Cordah Ltd., 2003; Fugro Denmark A/S, 2005), but with varying degrees of confidence in the assessment (Hendrick, 2006). A larger reef in the German Wadden Sea was reported to cover

an area of 1.4 km^2 (Vorberg, 2005), whilst less specific descriptions refer to huge colonies (Hartmann-Schröder, 1971), which occasionally cover several square kilometres (Schäfer, 1972).

Ambiguity regarding the extent of *S. spinulosa* reef is due in part to the difficulties in mapping the habitat and the apparently limited temporal stability of the structures. The boundaries of *S. spinulosa* reefs are rarely distinct and the aggregations are often patchy in nature, particularly towards the margins. The characteristics of the whole structure can thus vary throughout its extent. Added to this is the difficulty in detecting such a sub-tidal habitat in typically turbid conditions. Much work has been undertaken in recent years, however, there is still no standardised approach to the best techniques for detecting *S. spinulosa* reef and quantifying its extent (*e.g*. Foster-Smith, 2001; Foster-Smith *et al.*, 2010; Limpenny *et al.*, 2010).

Condition

The decline in *S. spinulosa* reef habitat from the Wadden Sea is well documented, and there is no evidence for a net recovery from this, or from the reported losses in Morecambe Bay, UK. Elsewhere, classification of the condition of *S. spinulosa* reef habitat is challenging, as is identification of a trend in condition.

In a similar way to *Modiolus modiolus* beds (OSPAR Commission, 2009), the condition of *S. spinulosa* reefs can be judged in different ways. For instance, the areal extent of the reef, its spatial patchiness, temporal stability, or via a number of biodiversity indices (Hendrick & Foster-Smith, 2006; Gubbay, 2007). Categorisation of condition may also consider a combination of these parameters, all of which present their own challenges for assessment. At present there is no consensus of approach or accepted yardstick against which to compare condition of individual reefs. Further to this, evidence suggests that *S. spinulosa* reefs may repeatedly develop and decline in a regular succession, through resettlement and demise of successive generations. An apparent deterioration in condition may therefore be natural and not necessarily reflective of an anthropogenic impact.

Determining change in condition is also problematic. Detailed, repeat assessments of *S. spinulosa* reef structures are rare. Where a particular reef has been repeatedly sampled, assessing temporal change is complicated by the patch dynamics of the reef system. Perceived changes may, for instance, simply result from differences in the position of samples between surveys, coupled with a naturally patchy distribution. Even where there is reasonable evidence of a change in reef condition (*e.g*. 'Saturn reef': BMT Cordah Ltd., 2003; Foster-Smith, 2005), the assessments focus on specific reef structures. The apparently ephemeral nature of *S. spinulosa* reefs is such that the condition of *S. spinulosa* reef habitat should be considered at a wider scale than individual reefs, though data is currently lacking in this regard. At present there is therefore too little evidence to determine the scale of or sensitivity to anthropogenic impacts, although they are known to be present in heavily used areas *e.g*. near aggregate extraction sites.

Limitations in knowledge

The difficulty in detecting and categorising *S. spinulosa* reef structures, their spatially patchy distribution and their temporal instability all add to uncertainty about the current distribution of this habitat. Nevertheless, understanding the environmental requirements, coupled with the knowledge of where high density aggregations have been found in the past can lead to confident predictions as to where *S. spinulosa* reef is unlikely to be and to identification of areas where it may be found.

Without detailed information on distribution, it is not possible to provide estimates of the extent of the habitat within the OSPAR area. Limited understanding of the natural dynamics of reef structures makes it difficult to assess condition and their spatial patchiness complicates detection of change. As a consequence of this, together with the limited number of reefs that have been assessed repeatedly, the sensitivity of reefs to various perturbations is not known and trends in condition cannot be

predicted with confidence. Limited understanding of the factors affecting recruitment success and of the source of larval supply preclude predictions on the potential for recovery and the rate at which it might occur.

4. Evaluation of threats and impacts

There are numerous reports in the literature of the disappearance of large *S. spinulosa* aggregations (*e.g*. Dörjes, 1992; Michaelis, 1978; Reise, 1982; Reise & Schubert, 1987; Riesen & Reise, 1982). In several cases, the declines have been attributed to anthropogenic disturbance, though in others there was no clear attributable cause. Table 2 summarises a range of human activities that have, or have the potential to have, an acute or chronic impact on *S. spinulosa* reefs, acting over a range of spatial scales.

Much of the work evaluating threats and impacts to *S. spinulosa* reef focuses on direct impacts to established reefs, with physical disturbance generally being considered the greatest threat in this regard:

Table 2 : Summary of main threats and impacts to *Sabellaria spinulosa* reefs.

Type of Pressure	***Cause***	***Comment***
Physical damage	Demersal fisheries; Offshore constructions (*e.g*. pipelines, renewable energy infrastructure); Aggregate extraction.	The greatest threat to *S. spinulosa* reefs is generally considered to be physical disturbance (OSPAR Commission, 2010; Rees & Dare, 1993; UK Biodiversity Group, 1999). The dwelling tubes constructed by *S. spinulosa* are relatively fragile and therefore susceptible to damage from direct physical impacts. If the individual worms themselves escape direct injury, they may still be left vulnerable to predation. Such impacts can also break reefs down into smaller fractions, thus making them more vulnerable to further damage and changing the habitat for the associated fauna.
Chemical contamination	Outfall pipes; Sludge dumping.	*S. spinulosa* is generally considered tolerant of chemical contamination (Holt *et al.*, 1997; Holt *et al.*, 1998; Jackson & Hiscock, 2008; Last *et al.*, 2011a) and has been found to thrive in polluted areas (Hoare & Hiscock, 1974; Jones, 1972; Walker & Rees, 1980). Despite this, pollution has been considered a major threat to *S. spinulosa* in the Wadden Sea where an increase in coastal eutrophication is thought to have favoured *Mytilus edulis* and *Bathyporei* spp. (UK Biodiversity Group, 1999; Vorberg, 2000).
Increased sedimentation and burial	Aggregate extraction; Offshore construction.	Sabellariid organisms live in dynamic sedimentary environments and some degree of sediment transport is essential for their tube-building. They are considered to have a low intolerance to burial from prolonged periods of increased levels of sedimentation (Holt*, et al.*, 1998; Jackson & Hiscock, 2008; Last *et al.*, 2011b).
Biological pressures	Larval predation – mariculture of filter feeders; Inter specific competition.	The extent to which biological pressures on *S. spinulosa* reefs are heightened by human activities are not clear. However, filtration of *S. alveolata* larvae by dense shellfish cultures is considered a threat to these reefs (Dubois *et al.*, 2007), and eutrophication may have given *Mytilus* a competitive advantage over *S. spinulosa* in the Wadden Sea (Vorberg*, et al.*, 2009).
Hydrological changes	Coastal engineering.	Changes in currents may affect larval distribution and/or the supply of tube-building material and nutrition.

Fishing: The shrimp fishery is most commonly implicated in the decline of *S. spinulosa* reefs. The loss of large reefs between the 1920s and 1980s from the subtidal shallows and channels of the northern Wadden Sea, for example, are thought to have been a consequence of the long-term effects of shrimp-fishing trawls (Reise, 1982; Reise & Schubert, 1987; Riesen & Reise, 1982). The fishing effort of the brown shrimp beam-trawl fishery increased considerably in the 1980s (Berghahn & Vorberg, 1997), simultaneous with the changes in benthos of the Wadden Sea. This further reinforced the view that the fisheries were responsible for the demise of *S. spinulosa* reefs, which have effectively been replaced by beds of the mussel, *Mytilus edulis,* and sand-dwelling amphipods, *Bathyporei* spp. (Reise & Schubert, 1987), though this may be partly attributed to an increase in coastal eutrophication favouring *M. edulis* (Vorberg, 2000). Fisheries of the pink shrimp, *Pandalus montagui* were similarly implicated in the loss of *S. spinulosa* reefs in the approach channels to Morecambe Bay, UK (Mistakidis, 1956; Taylor & Parker, 1993), and colonies in the Thames Estuary and the Wash have also been considered vulnerable to this fishery (Warren & Sheldon, 1967).

Despite the widespread view on the impacts of shrimp fisheries, there is little specific evidence of causation. Field work and empirical calculations undertaken by Vorberg (2000) suggest that the relatively light trawls used in *Crangon crangon* fisheries do not cause serious damage to sabellariid reefs, but his experimental findings relate exclusively to short-term effects following once-only disturbance by shrimping gear in the absence of a net. Trawling with heavier gear, such as those used by flatfish fisheries for example, is likely to have greater destructive potential. Obvious evidence of the destruction of *S. spinulosa* reef clumps by a beam trawler has been reported off the coast of Swanage, Dorset (Collins, 2003). Trawl scars in the vicinity of *S. spinulosa* aggregations have also been reported by several other surveys on the basis of side-scan sonar imagery (Marine Ecological Surveys Limited, 2005).

Aggregate extraction: By virtue of its habitat requirements, *S. spinulosa* is commonly found in areas of interest for aggregate extraction and dredging scars have been reported in close proximity to *S. spinulosa* aggregations (Foster-Smith, 2001; Pearce *et al.*, 2007). Apart from direct removal, the impact of this activity is unknown, although suspension of fine material during dredging operations is not considered likely to be detrimental (Last*, et al.*, 2011b; Pearce *et al.*, 2011).

Offshore construction: Pipe laying, cable trenching and the establishment of renewable energy infrastructure, for example, have all been perceived as threats to *S.spinulosa* reefs due to their potential for physical impact. However, as with aggregate extraction, all are likely to be relatively localised in their sphere of influence, permitting mitigation measures to lessen the degree of impact. The impact of coastal engineering works such as dyke or dam building has the potential to act over larger scales through alterations to the hydrological regime (Vorberg, 2000) and therefore have a potentially significant effect over much larger geographic areas.

Other potential threats: In contrast to discussion of perceived threats to established reef structures, there has been little specific focus on threats to the larval supply of *S. spinulosa* reefs in the literature, despite its importance for both the longevity of a reef and its potential for recovery following decline. This may reflect an assumption that larval supply is not limiting due to the widespread distribution of the species, and the seasonal prominence of *S. spinulosa* larvae in the nearshore plankton in many areas. The extent to which *S. spinulosa* aggregations are self-recruiting is unclear, however, and evidence suggests that recruitment success can be very variable (George & Warwick, 1985; Hendrick, 2007; Michaelis, 1978). Factors affecting larval supply may therefore pose a greater threat to *S. spinulosa* reefs than has hitherto been considered. It has been suggested, for instance, that larval retention within the Bay of Mont-Saint-Michel, France may explain the persistence of the reef of sister species *Sabellaria alveolata* over several hundreds of years (Dubois*, et al.*, 2007). However, recently these recruits are thought to be vulnerable to competition from epibionts such as oysters and green algae, which thrive in increasing nitrate levels, and could cause long-term damage to the reef itself.

(Dubois *et al.*, 2006). Elsewhere, filtration of *S. alveolata* larvae by high concentrations of cultured mussels and oysters have also been proposed as a threat to the parent reef (Dubois*, et al.*, 2007), a biological pressure that may arise from any dense aggregation of filter-feeders – native or non-native, natural or cultured. On a larger scale, it is predicted that acidification of the world's oceans could have serious consequences on some marine invertebrate populations due to effects of probable future acidification levels on larval stages (Dupont *et al.*, 2008). Although sensitivity of *S. spinulosa* reefs and their larvae to such chronic, generalised threats is unclear, their potential for widespread and long-term impact warrants further consideration

5. Existing Management measures

In addition to its listing by OSPAR, this reef habitat is the subject of several regional and national listings including the EC Habitats Directive (EEC/92/43); the Red List of threatened biotopes and biotope complexes of the Wadden Sea area (Ssymank & Dankers, 1996); a UK Biodiversity Action Plan priority habitat (Maddock, A. 2008 updated 2011); and a Habitat Feature of Conservation Importance under the Marine & Coastal Access Act, 2009 in England. Such listings serve to highlight the conservation needs of the habitat, but successful protection depends on specific actions that follow. For EU Member States more general measures, which should support the conservation of *S.spinulosa* reefs, are specified under the Water Framework Directive (EC/2000/60). These include requirements to ensure that any changes in water quantity and quality do not adversely affect sites of international importance, and to put in place measures to achieve or maintain 'Good Ecological Status'.

Annex I of the Habitats Directive lists 'reefs' as one of the habitat types which require protection through the designation of Special Areas of Conservation (SACs). As *Sabellaria spinulosa* reefs are covered by the definition of reefs (EU, 2007), they are named conservation features within a number of SACs *e.g*. the Wash & North Norfolk SAC and the Inner Dowsing, Race Bank and North Ridge candidate SAC in OSPAR Region II, and are listed as present in SACs in France in both OSPAR Region II (*e.g*. Tregor Goelo) and OSPAR Region IV (*e.g*. Ile de Groix and Bassin d'Arcachon et Cap Ferret).

Management measures specifically targeted at the reefs within these SACs are limited and at this stage their effectiveness has still to be evaluated. One example which is being used in the Wash, UK is closing 'core areas'[5] of reef to bottom trawled gear through voluntary agreement or alternatively by regulation or fishing licence condition (MMO, 2012). Another spatial measure is the use of a buffer zone (in the case of the Wash this relates to areas of mussel bed adjoining the reef), not available to the fishery, to protect the reef from physical damage (ESFJC, 2008).

Environmental surveys within and outside protected areas are carried out to inform Environmental Impact Assessments, undertaken for a variety of projects in offshore and coastal waters. In the UK these surveys are used to determine whether *S.spinulosa* reefs are present in areas targeted for construction projects so that management measures can be introduced to protect them if needed (*e.g*. MES, 2009; Henson, 2010). In the case of the proposed London array offshore windfarm in the outer Thames estuary, the project licence includes a requirement for micro-siting of individual turbines and cables if *S.spinulosa* reefs or reef-like structures are identified in the area (MMO, 2011). At the Thanet offshore windfarm off the Kent coast some turbines were repositioned to mitigate any potential ecological damage to known *S.spinulosa* reefs in the vicinity (Royal Haskoning, 2010).

[5] Defined in guidance from the Marine Management Organisation as "an area of ross worm reef that has occurred persistently or repeatedly when sampled" (MMO,2012). An index system provides further clarification based on number of times an area is surveyed and how often the habitat is found.

In addition, management measures are recommended to sectors whose activities may have an impact on *S.spinulosa* reefs. In the UK the Joint Nature Conservation Committee advice, which informs decisions on licences for aggregate extraction, is to exclude potential areas of biogenic reef from dredging activities, determine buffer zones from previous monitoring, and include monitoring in licence conditions (JNCC/EN, 2004).

A variety of bodies may be involved in providing advice, implementing, regulating and/or monitoring management measures for the conservation of marine habitats such as *S.spinulosa* reefs. These include Government offices, statutory undertakers, public bodies, and authorities who give consent to operations which may have some impact on the habitat. The current approach to management of this habitat is to use measures which focus on activities that may have a direct physical impact on the reefs. However, given that environmental conditions are a major influence (*e.g*. sediment loads, presence of sand waves and drop offs), a holistic approach to management will also be required. Future management measures may also need to take account of the dynamic nature of reefs which can colonise, evolve and degrade rapidly. This is well illustrated by studies showing their natural temporal and spatial variation. Risk assessments and management plans can be used to set out the procedures which will assist with the management of *S. spinulosa* reefs (Gubbay, 2007).

6. Conclusion on overall status

The limitations in knowledge described above, for example on the distribution and extent of reef, the dynamics of reef structure and the absence of repeat studies, make it difficult to be precise about the current overall status of *S.spinulosa* reefs in the OSPAR Maritime Area.

The original evaluation and supporting case report for *S.spinulosa* reefs provided information on sensitivity, rarity, ecological significance, decline, and threat. The greatest sensitivity is still believed to be physical damage, recognising that there can be a high recoverability rate where conditions are suitable. The ecological significance has been described in terms of the consolidation of sediment, providing a stability that allows many other associated species to become established. More recent studies show that the diversity of associated species appears to vary depending on the form of the *S.spinulosa* aggregations and may also differ between reefs.

Threat, rarity, and decline are all still relevant. Physical disturbance is the main consideration in relation to threat, and *S.spinulosa* reefs are still believed to be rare or have a very restricted distribution in OSPAR Regions II and III. The decline of reefs in specific areas compared to historic records is well documented. For example, almost all reefs which once occurred in the deep gullies in the Danish and German Wadden Sea are no longer present, although the specific causes are unknown. In UK waters, locations where it is found at high densities cover a relatively small geographic area.

Any change in the status of *S.spinulosa* reefs since its original nomination is difficult to determine because of continuing uncertainties about the current distribution, condition and extent of the habitat.

7. Action to be taken by OSPAR

Action/measures that OSPAR could take, subject to OSPAR agreement

Habitat definition

A more precise definition of *S.spinulosa* reef needs to be adopted to enable consistent identification, recording, mapping and assessment of condition. This could be done with reference to existing definitions in documents such as the EUNIS habitat classification scheme, and the Wadden Sea Red List; to work being undertaken by Contracting Parties and to the scientific literature (*e.g*. Hendrick, 2006, Gubbay, 2007). Useful elements to consider for inclusion in the definition would be physical,

ecological and temporal characteristics as well as practical aspects such as identification and measurement in the field using current survey techniques.

Habitat survey and mapping

Contracting Parties in regions where this habitat is known to occur should be encouraged to build their databases by looking at opportunities for habitat recording and mapping, particularly in association with surveys for proposed projects *e.g*. offshore infrastructure, cable laying or aggregate dredging, if data sharing is feasible. Targeted surveys and habitat mapping would be helpful in areas of known reefs, so that more can be learnt about reef condition and how they evolve and respond to natural change, as well as in response to human activities. This could be used to inform future management.

Assess management measures.

There are few examples of management measures targeted at the conservation of *S.spinulosa* reefs and, even where they exist, very limited assessment of their effectiveness. This issue needs further consideration and could usefully be done not only with reference to measures already being used for *S.spinulosa* reefs, but also for other epibenthic habitats which have been studied and been subject to management measures over a longer period of time. Useful information may also be found in studies of more ephemeral marine biotopes.

As set out in Article 4 of Annex V of the Convention, OSPAR has agreed that no programme or measure concerning a question relating to the management of fisheries shall be adopted under this Annex. However, where the Commission considers that action is desirable in relation to such a question, it shall draw that question to the attention of the authority or international body competent for that question. In the case of *S. spinulosa* reefs this may include assessment of how fisheries management measures might help safeguard *S. spinulosa* reefs, especially within protected areas, and how the fisheries sector might contribute data on the occurrence and condition of this habitat to OSPAR Contracting Parties.

The specific measures to be used will depend on the role of those responsible *e.g*. a regulatory body, an advisory body, or contractor undertaking work which may have an impact on *S. spinulosa* reefs. The different roles of these organisations will also shape their potential role in monitoring and review in order to determine the effectiveness of measures.

The scope to introduce management measures which are targeted at other threatened habitats and species on the OSPAR list, but through which *S.spinulosa* reefs might also benefit, should also be explored.

Research

Research to underpin management proposals and assess their effectiveness is key to improving the threatened and declining status of *S.spinulosa* reefs. OSPAR, in collaboration with Contracting Parties, could compile and promote a list of useful future research areas to relevant scientific funding bodies. Possible topics could include: characterisation of larval dynamics; factors determining colony morphology and its influence on local biodiversity; quantification of temporal stability of reef; degree of site fidelity and predictability of reef occurrence and; better quantification of the threat posed by anthropogenic impacts (both acute and chronic) on larval stages, adult worms and reef habitat.

Brief summary of the proposed monitoring system (see annex 2)

Target sites within areas known to be favourable for reef development should be identified using acoustic techniques (*e.g*., sidescan or multibeam) and then sampled visually using video. The use of limited grab sampling would provide quantitative information on populations of *S.spinulosa* and measurements of biodiversity. Monitoring should be set in the wider context of historic records and contemporary records from a variety of sources for the whole of the OSPAR area.

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Annex 1: Overview of data and information provided by Contracting Parties

Sabellaria spinulosa reefs were nominated for inclusion in the OSPAR List in 2001 by the UK.

Contracting Party	**Contribution made to the assessment (*e.g.* data/information provided)**	**Feature occurs in CP's Maritime Area**	**Comment**
Belgium	Yes	Yes	There are historical records of reefs up to around a century ago, without a clear location. There is no information pointing at the current presence of *Sabellaria spinulosa* reefs in Belgian waters.
Denmark		?*	
France	Yes	Yes	Insufficient information on current condition/trend. At present it seems that there are no areas in national waters where this habitat is of particular significance although they are recorded as present in two Natura 2000 sites in France in OSPAR Region II and in six sites in OSPAR region IV.
Germany	Yes	Yes	The species is currently present in German national waters, and historically there were reefs but these are no longer recorded to be present. Records previously provided by Germany date from 1900 through to 1999 and in references up to 2004. At present due to heavy bottom trawling and fishing pressure there is no documented occurrence of *Sabellaria spinulosa* reefs in German national waters Since the last data request from the OSPAR Commission for this particular habitat (2011) there have been no changes with regard to *Sabellaria spinulosa* reefs in German national waters.
Iceland	Yes	No	The species was identified in a single sample off the south coast of Iceland in 1846, but there are no records of its occurrence since, or of reefs.
Ireland		Yes#	
Netherlands		?+	
Norway	Yes	No	No registered occurrences of this habitat in Norwegian waters
Portugal		?	
Spain		?	
Sweden	Yes	No	No registered occurrences of this habitat in Swedish waters
UK	Yes	Yes	Records previously provided by UK date from 1978 through to 2010

* Waddensea report (Figure A) shows historic occurrence of reef in the Danish part of the Waddensea but Vorberg *et al* (2009) note no current records of reefs known in the Danish Waddensea
# No records in the OSPAR database but the National Parks & Wildlife Service for Ireland include *S.spinulosa* as one of the types of biogenic reef found around Ireland. There are also 4 records in the Irish National Biodiversity Data Centre map but no indication of whether they are of reefs or individual records.
+ Vorberg et al (2009) note no current records of reefs known in the Netherlands part of Waddensea

Annex 2: Description of the proposed monitoring and assessment strategy

I. Rationale

Sabellaria spinulosa reefs are currently loosely defined. The difficulty in detecting and categorising *S. spinulosa* reef structures, their spatially patchy distribution and their temporal instability all add to uncertainty about the current distribution of this habitat, and are relevant to the application of acoustic techniques for monitoring. Additionally, these biogenic reefs are widely reported to be ephemeral and subject to large natural fluctuations in local populations. The aim of monitoring should be to ensure that areas known to be favourable to reefs (defined, as a minimum, as dense populations of *S. spinulosa* forming crusts) continue to support reefs. In order to assess the status and trends of *S. spinulosa* reefs within an area it will be necessary to collate historical and contemporary records from a wide variety of sources, combined with a targeted monitoring programme of existing reefs to measure aspects of the habitat that are indicators of their health and biodiversity. These are some of the issues which need to be addressed in building a cost-effective and efficient monitoring programme for *S.spinulosa* reefs.

II. Need for a monitoring programme

The need for monitoring the status of *S. spinulosa* reef is acknowledged in the Water Framework Directive and national programmes (*e.g.*, the Trilateral Monitoring and Assessment Programme Monitoring Handbook). In addition, the conservation objectives and actions appropriate for *S. spinulosa* reefs in the UK are set out in the Biodiversity Action Plan and Local Biodiversity Action Plans (*e.g.*, Solandt, 2008), and for specific regions such as the English Channel (JNCC, 2004). However, detailed methodologies for monitoring have not yet been designed and survey effort has instead focused on testing techniques for detection of reefs and assessing anthropogenic impacts (*e.g.*, Limpenny *et al,* 2010; Pearce *et al*, 2007, Last *et al.*, 2011a&b).

Given that the reef provides a habitat of increased associated species diversity and refugia in areas that might otherwise be species-poor, it is important that a monitoring programme is designed that allows localised change in status to be assessed against the widespread distribution of the habitat within the OSPAR region. It is also important that a full assessment of status includes not only the extent and patchiness of the reef, but also indicators of population structure and associated biodiversity.

III. Methodology

Non-destructive survey

A combination of acoustic remote sensing techniques and sampling procedures will be required for monitoring and prospecting for *S. spinulosa* reefs in the open sea. Selected areas considered likely to support reefs can be surveyed at a broad scale (i.e. wide track spacing with less than 100% coverage) using acoustic techniques, such as sidescan and multibeam, to box in smaller areas that have the appropriate surface texture properties that might indicate the presence of reef. A more intensive acoustic survey can then provide information on the patchiness and extent of reef habitat. Care is needed to obtain the highest resolution from the acoustic systems (Limpenny *et al,* 2010).

These areas must be ground-truthed using visual observation in order to verify if the habitat contains reef. Drop-down or towed video are appropriate techniques and systems can be adapted for poor visibility (*e.g*. water lens systems or cameras deployed close to the seabed).

Biological aspects and population health

Reefs are vulnerable to destructive sampling techniques, such as dredges and beam trawls and these techniques are not recommended. However, it is important to sample the reef population of *S. spinulosa* and associated fauna in order to assess population density and biodiversity. More detailed examination of *S. spinulosa* for size structure and reproduction would be useful. Thus, it is recommended that some allowance is made for taking a limited number of grab samples for these purposes.

Environmental conditions

The conditions that are favourable or unfavourable to the development of reef are poorly known. Although the species is tolerant of high suspended sediment load, reef is likely to be destroyed by the direct action of dredging and some commercial fishing activities. Monitoring programmes should gather contextual information on these activities in the vicinity of areas selected for monitoring.

Geographic distribution and change

Monitoring designed specifically for reefs (as above) will be more valuable for assessment of the status of the habitat if set in the context of an evaluation of the current distribution of *S. spinulosa* reef in the whole of the OSPAR region. This will require the accumulation of evidence from a wide variety of sources and negative results will be as important as positive sightings in order to obtain information on sampling effort. Many commercial surveys on sand and gravel habitats are undertaken for the oil and gas, renewables, cable/pipeline and aggregate industries and the appropriate industry associations should be approached for records. Of special value would be visual records from ROV operations.

Large changes in the geographic distribution of *S. spinulosa* reefs within the OSPAR region are likely to have taken place over historic and recent times. It is important to build up a comprehensive database of these records in order to acertain the scale of change.

Monitoring the effect of direct pressures

The most likely causes of anthropogenic change to the status of *S.spinulosa* reefs are activities which impact the seabed such as dredging and some forms of fishing. Dredging takes place in licensed areas and any loss or damage and subsequent regeneration or recolonisation could usefully be picked up through the monitoring programmes which are usually already a requirement for such activities.

Damage or removal of biogenic reef by fishing gear will not be as spatially constrained. Indicators which may be useful in this regard would include changes in extent, abundance of typical species, percentage cover and/or density of species. However, agreeing on the spatial extent of any such monitoring will be challenging. If the target area is too small, the findings may be distorted by natural variation whereas practicalities would rule out too large an area. A fundamental issue in all cases would be determining whether changes are attributable to removal or due to the ephemeral nature of the habitat.

IV. Synergies

Many countries conduct benthic survey programmes, and high densities of *S. spinulosa* in grab samples may indicate areas of reef. In particular, beam trawl surveys for fisheries research and records of *S. spinulosa* reef structures in nets could be made available for evaluation.

Monitoring programmes required through the EC Habitats Directive for the Annex I habitat “Sandbanks which are slightly covered by sea water all the time” and for “stony reefs” under the Annex I “Reefs” habitat, could utilise methodologies that would also be suitable for monitoring

S. spinulosa reefs. It is also likely that monitoring of *Modiolus modiolus* beds and *Ostrea edulis* beds would employ similar methodologies and there is scope for combining programmes.

V. Assessment criteria

The assessment criteria will depend on the monitoring system used. However, if the techniques combining remote sensing with visual observation are followed (as above), then reefs can be assessed on the basis of the height of reef structure above the sea floor, patchiness within the reef and geographic extent of the reef. A qualitative or semi-quantitative assessment of associated epifauna/flora should also be possible with these non-destructive techniques.

However, grab-based survey data could also be accommodated. High population densities may provide reasonable evidence that the area might support reefs in the absence of visual confirmation.

VI. Timing and frequency

Many reefs appear to be ephemeral and may become established after a single heavy settlement of larvae. These reefs may also be subject to heavy predation and rapid decline. Thus, it is recommended that surveys specifically designed to monitor *S. spinulosa* reefs be undertaken in early summer. The frequency of survey will depend on the monitoring strategy adopted, especially if the survey is undertaken in synergy with other surveys. However, substantial changes in reef structure and location may be expected over periods of years and may represent the natural fluctuation of *S. spinulosa* populations. It will be difficult to accommodate these large, natural fluctuations within a monitoring strategy unless a broadscale approach is adopted (as outlined above).

VII. Reporting and quality assurance

Reef assessment will be made on the basis of multiple criteria. Confidence in the assessment can be gained by scoring the number of criteria measured (*e.g*. reef height, patchiness, extent, population density, biodiversity) and the techniques used to gather the data. Visual techniques supported by quality photographic records will provide more certain records than counts of individuals in a grab sample. High frequency sidescan towed close to the sea floor at low speed will provide more convincing images of reef than low frequency sidescan towed high above the sea floor at speed. Therefore, records should be supported by the appropriate metadata in order to be able to assess the quality of the data.

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