



# MarLIN

## Marine Information Network

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# *Sabellaria spinulosa*, didemnids and other small ascidians on tide-swept moderately wave-exposed circalittoral rock

MarLIN – Marine Life Information Network  
Marine Evidence-based Sensitivity Assessment (MarESA) Review

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**Please note.** This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [<https://www.marlin.ac.uk/habitats/detail/348>]. All terms and the MarESA methodology are outlined on the website (<https://www.marlin.ac.uk>)

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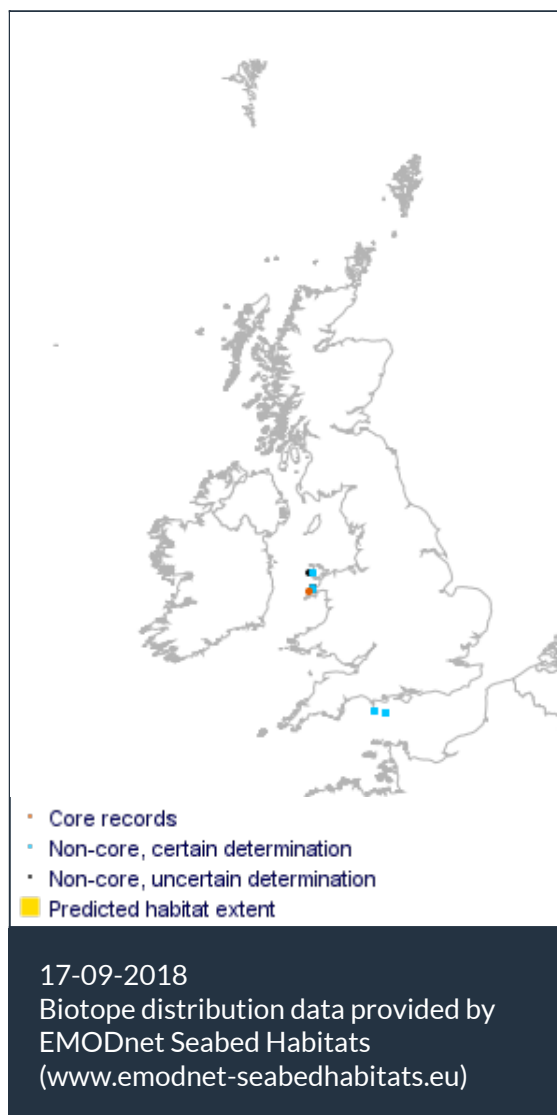


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*Sabellaria spinulosa* crusts on silty turbid circalittoral rock.  
 Photographer: Anon.  
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Referred by Dr Bryony Pearce

## Summary

### ☰ UK and Ireland classification

<b>EUNIS 2008</b>	A4.2212	<i>Sabellaria spinulosa</i> , didemnid and small ascidians on tide-swept moderately wave-exposed circalittoral rock
<b>JNCC 2015</b>	CR.MCR.CSab.Sspi.As	<i>Sabellaria spinulosa</i> , didemnids and other small ascidians on tide-swept moderately wave-exposed circalittoral rock
<b>JNCC 2004</b>	CR.MCR.CSab.Sspi.As	<i>Sabellaria spinulosa</i> , didemnids and other small ascidians on tide-swept moderately wave-exposed circalittoral rock
<b>1997 Biotope</b>	CR.MCR.As.MolPol.Sab	Dense ascidians, bryozoans and hydroids on a crust of <i>Sabellaria spinulosa</i> on tide-swept circalittoral rock

### 🔍 Description

This variant is typically found on tide-swept, moderately wave-exposed circalittoral bedrock, boulders and cobbles subject to slight sand-scour. It occurs predominantly in the lower circalittoral. This variant normally appears as a bedrock/boulder outcrop or reef with a dense crust

of the polychaete *Sabellaria spinulosa* and a dense turf of didemnid ascidians and scour-tolerant bryozoans such as *Flustra foliacea*, *Pentapora foliacea* and *Cellaria* species. There may be discreet clumps of *Alcyonium digitatum* and sparse sponges such as *Tethya aurantium* and *Phorbas fictitius*. Patchy occurrences of the small ascidians *Polycarpa scuba*, *Polycarpa pomaria* and *Distomus variolosus* may be present on the tops of rocks and boulders whilst in crevices between, the anemone *Urticina felina* may be found. Species such as *Asterias rubens*, *Crossaster papposus*, the serpulid worm *Salmacina dysteri* and the anemone *Sagartia elegans* are occasionally seen on the rock surface. This variant has been recorded from the Lleyn Peninsula, the Skerries and around Pembrokeshire in Wales. (Information from Connor *et al.*, 2004; JNCC, 2015).

### ↓ Depth range

10-20 m, 20-30 m

### Additional information

-

### ✓ Listed By

- none -

### Further information sources

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## Habitat review

### 🔄 Ecology

#### Ecological and functional relationships

*Sabellaria spinulosa* crusts on the substratum may be sufficiently dense to prevent the settlement or attachment of other species to the substratum (although the crust may itself act as a substratum). On the horizontal surface of the wreck of the MV Robert off Lundy, *Sabellaria spinulosa* was an initial colonizer dominating the surface and possibly blocking contaminants from anti-fouling paints. The crust of *Sabellaria spinulosa* was colonized by a rich community including especially erect bryozoans and hydroids and colonial tunicates (Hiscock, 1981, Hiscock & Rostron, unpublished). The community on the MV Robert is now (revised 2003 classification) recognised as included in MCR.Sspi, now CR.MCR.CSAB.Sspi: *Sabellaria spinulosa* encrusted circalittoral rock. *Ophiothrix fragilis*, selected as an important functional species in the biotope, may occur in dense aggregations (George & Warwick, 1985) but more typically in lower densities (Connor *et al.*, 1997(a)). Dense aggregations of brittle stars may also occupy space that could otherwise be taken up by other species. Both *Sabellaria spinulosa* and *Ophiothrix fragilis* are suspension feeders. In dense brittle star beds, food availability may be monopolised by *Ophiothrix fragilis* restricting the growth of other species (George & Warwick, 1985). *Urticina felina* is a passive carnivore, waiting to trap animals that stumble into its tentacles. Other characteristic species from the biotope are scavengers (*Pagurus bernhardus*) and detrital grazers (*Sterromphala cineraria*).

#### Seasonal and longer term change

Most of the characterizing species in the biotope have a longevity of several years (Davoult *et al.*, 1990; Gage, 1990; Wilson, 1971; Chia & Spaulding, 1972). High recruitment of *Sabellaria spinulosa* may result in 'reinforcement' of the crust of tubes on the substratum. Winter storms can break up these crusts, particularly if on more mobile substrata. Areas where *Sabellaria spinulosa* had been lost due to winter storms appeared to recolonize up to a maximum thickness of 2.4 cm during the following summer (R. Holt, pers. comm. in Jones 1998). Potential high recruitment of *Ophiothrix fragilis* following mild winters (Smaal, 1994) may cause increases in numbers of brittle stars present in aggregations on the ross worm crusts. *Ophiothrix fragilis* also appears, in some areas, to have a multi-annual (about 4 years) cycle (Davoult *et al.*, 1993). The community described from the wreck of the MV Robert that is recognised as MCR.Spi was described five years after the sinking of the vessel.

#### Habitat structure and complexity

Habitat complexity will vary depending on the species composition of the biotope. Dense crusts of *Sabellaria spinulosa* can provide greater structural complexity to bare bedrock habitats and may consolidate areas with more mobile substrata such as cobbles, or muddy gravels. The crusts can provide a textured substratum, and shelter between tubes etc. Species that burrow into soft substrata may also occur in thick crusts. For a list of associated species in a thoroughly sampled example of a *Sabellaria spinulosa* crust, see George & Warwick, 1985). However, crusts are often quite bare of other epibiota. The presence of dense aggregations of *Ophiothrix fragilis* also contributes to increases in structural complexity and considerable numbers of species may utilise these beds (Warner, 1971). Extensive *Mytilus edulis* has been noted from the biotope in south Wales and these will also increase structural diversity.

## Productivity

George and Warwick, (1985) note that in a hard-bottom reef community with *Sabellaria spinulosa*, production is overwhelmingly dominated by the suspension feeding *Ophiothrix fragilis*. Much of this production may be through regeneration of broken arms (Sköld, 1998) Since the biotope is circalittoral, few algae are present and consequently, primary production is low. *Sabellaria spinulosa* larvae may settle in swarms and result in very high recruitment (Wilson, 1929). Rapid growth in suitable conditions may result in high productivity.

## Recruitment processes

*Sabellaria spinulosa*, *Ophiothrix fragilis* and most of the other associated sessile species have planktonic larvae and the potential for dispersal over considerable distances (Wilson, 1929; Davoult *et al.*, 1990). Recruitment of *Sabellaria spinulosa* is probably enhanced by the presence of adults or even just sand grain tubes of the same species (Wilson, 1929). In areas with considerable water movement, populations of *Ophiothrix fragilis* probably do not autorecruit due to the long duration (26 days) of the larval stage (Davoult *et al.*, 1990). *Ophiothrix fragilis* larvae may settle on dense aggregations of adults (Warner, 1971). Some characteristic species may not recruit so readily, for instance the larva of *Urticina felina* inhabits the water column, but is not considered to be truly pelagic and probably has limited dispersal abilities (Solé-Cava *et al.*, 1994). Areas where *Sabellaria spinulosa* had been lost due to winter storms appeared to recolonize up to a maximum thickness of 2.4 cm during the following summer (R. Holt, pers. comm. in Jones 1998). *Sabellaria spinulosa* adults are permanently attached to the substratum so no immigration of adults is possible. Recruitment processes of other species will vary according to the species composition of the biotope which may reflect in some measure the species present in nearby rocky biotopes.

## Time for community to reach maturity

*Sabellaria spinulosa* recruits readily although environmental conditions can affect success. In ideal conditions, (extrapolated from the similar species *Sabellaria alveolata*), growth can be rapid and sexual maturity reached within the first year. Other species in the biotope may not be so quick in reaching maturity. For instance, *Urticina felina* is noted as being a slow growing, large anemone living for several years (Chia & Spaulding, 1972). The smallest recorded fertile anemone was at least 1.5 years old (Wedi & Dunn, 1983). There is considerable debate over the growth rate and longevity of *Ophiothrix fragilis*. Gage, (1990) worked on growth bands in the skeletal ossicles of the brittle star. Growth rates were estimated to be slow and lifespan to be at least 10 years, with sexual maturity probably achieved at about 10 mm disk diameter (several years old). Davoult *et al.*, (1990) estimate longevity to be as short as 9 months with development to maturity taking from 6-10 months depending on time of recruitment. The overall time for the community to reach maturity will also depend to some extent on other species in the biotope (sometimes occurring in high densities) e.g. *Mytilus edulis* (Hiscock, 1979). Other species in this biotope may reflect, in some measure, the species found in nearby rocky biotopes. The community described from the wreck of the MV Robert that is recognised as MCR.Spi was described five years after the sinking of the vessel.

## Additional information

*Sabellaria spinulosa* appears to occur in high densities and form crusts especially in turbid and polluted waters. It occurs extensively in the Severn Estuary and Bristol Channel (with *Sabellaria alveolata*) (George & Warwick, 1985) and on tide-swept mobile substrata such as the English

Channel (K. Hiscock pers. comm.). It was an initial colonizing species on a wreck off Lundy and was abundant in an area severely polluted by an acidified halogenated effluent (Hoare & Hiscock, 1974).

## Preferences & Distribution

### Habitat preferences

<b>Depth Range</b>	10-20 m, 20-30 m
<a href="#">Water clarity preferences</a>	
<b>Limiting Nutrients</b>	Data deficient
<b>Salinity preferences</b>	Full (30-40 psu)
<b>Physiographic preferences</b>	
<b>Biological zone preferences</b>	Lower circalittoral
<b>Substratum/habitat preferences</b>	Bedrock, Cobbles, Large to very large boulders, Small boulders
<b>Tidal strength preferences</b>	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.)
<b>Wave exposure preferences</b>	Moderately exposed
<b>Other preferences</b>	High levels of suspended sediment.

### Additional Information

- Density of *Sabellaria spinulosa* is high. At the Bristol Channel location studied by George & Warwick (1986), densities in excess of 4,000/m<sup>2</sup> for loosely aggregated *Sabellaria spinulosa* were recorded whilst the area sampled by Hiscock & Rostron (unpublished) on a level hard substratum had a single layer crust with 9,561 individual *Sabellaria spinulosa* in 1.4m<sup>2</sup>.
- High levels of suspended sediment are required in order for *Sabellaria spinulosa* to construct its tubes.

## Species composition

### Species found especially in this biotope

### Rare or scarce species associated with this biotope

-

### Additional information

Although there are two records of the MCR.Sspi biotope in the MNCR survey database, species richness information is available for only one with 42 species being noted. In the study undertaken by George & Warwick (1985) of aggregations most likely on cobbles and pebbles, 24 different species were recorded but only 'countable' species were included.

## Sensitivity review

### Sensitivity characteristics of the habitat and relevant characteristic species

As *Sabellaria spinulosa* is the species that creates the biogenic reef habitat, the sensitivity assessments are based on *Sabellaria spinulosa* alone and do not consider the sensitivity of associated species that may be free-living or attached to the reef. A wide range of species are associated with reef biotopes that provide habitat and food resources, this biotope is characterized by a dense turf of didemnid ascidians and scour-tolerant bryozoans such as *Flustra foliacea*, *Pentapora foliacea* and *Cellaria* species. The reef and individual *Sabellaria spinulosa* worms are not dependent on these associated species to create or modify habitat, provide food or other resources. OSPAR (2008) note that where reefs consist of empty tubes rather than tubes with living *Sabellaria spinulosa* they point to the presence of suitable habitat and should be reported as *Sabellaria spinulosa* reef. For the purposes of the sensitivity assessments, however, reference has been made to impacts on living worms and tubes rather than empty tubes alone.

### Resilience and recovery rates of habitat

Gibb *et al.* (2014) noted that empirical evidence to assess the likely recovery rate of *Sabellaria spinulosa* reefs from impacts is limited and significant information gaps regarding recovery rates, stability and persistence of *Sabellaria spinulosa* reefs were identified. Any extrapolations between different population densities e.g. between thin crusts and thick reefs and between *Sabellaria spinulosa* and the congener *Sabellaria alveolata* must, therefore, be treated cautiously as the evidence may not be applicable. It should also be noted that the recovery rates are only indicative of the recovery potential. Recovery of impacted populations will always be mediated by stochastic events and processes acting over different scales including, but not limited to, local habitat conditions, further impacts and processes such as larval-supply and recruitment between populations.

Studies carried out on reefs of the congener *Sabellaria alveolata* within the low inter-tidal suggest that areas of small, surficial damage within reefs may be rapidly repaired by the tube building activities of adult worms. Vorberg (2000) found that trawl impressions made by a light trawl in *Sabellaria alveolata* reefs disappeared four to five days later due to the rapid rebuilding of tubes by the worms. Similarly, studies of inter tidal reefs of *Sabellaria alveolata* by Cunningham *et al.* (1984) found that minor damage to the worm tubes as a result of trampling, (i.e. treading, walking or stamping on the reef structures) was repaired within 23 days. However, more severe, localised damage caused by kicking and jumping on the reef structure, resulted in large cracks between the tubes, and removal of sections (ca 15x15x10 cm) of the structure (Cunningham *et al.*, 1984). Subsequent wave action enlarged the holes or cracks. However, after 23 days, at one site, one side of the hole had begun to repair, and tubes had begun to extend into the eroded area. At another site, a smaller section (10x10x10 cm) was lost but after 23 days the space was already smaller due to rapid growth (Cunningham *et al.*, 1984). *Sabellaria spinulosa* reefs are more fragile than *Sabellaria alveolata* (Bryony Pearce, pers comm, 2014, cited in Gibb *et al.*, 2014) and recovery rates between reefs made by the two species may vary but this has not been established.

Where reefs are extensively damaged or removed, then recovery will rely on larval recolonization. Aspects of *Sabellaria spinulosa* reproduction have been studied (Wilson, 1970; Pearce *et al.*, 2007; Pearce *et al.*, 2011b). Individuals may rapidly reach sexual maturity, Linke (1951) reported that *Sabellaria spinulosa* inhabiting the intertidal spawned at 1 or 2 years old and growth rate studies by (Pearce *et al.*, 2007) also suggest sexual maturity for subtidal populations could be



reached within the first year. Pearce *et al.* (2007) constructed size-frequency histograms based on wet weight of complete *Sabellaria spinulosa* collected from the Hastings Shingle Bank. These suggest that *Sabellaria spinulosa* is capable of rapid growth, approaching maximal adult biomass within months (Pearce *et al.*, 2007).

The reproductive phase (see below) appears to be relatively long and *Sabellaria spinulosa* spend 6-8 weeks as planktonic larvae (Wilson, 1970). As a result, there is a good larval supply with high dispersal potential. Pearce *et al.* (2011a) found that separating the adult *Sabellaria spinulosa* from tubes in the laboratory induced gamete release, (Pearce *et al.*, 2011a) suggest this represents a 'significant evolutionary development whereby Sabellariid polychaetes spawn in response to disturbance as a means of potentially securing the future population'.

Aside from induced spawning by disturbance, a number of studies have indicated that the major spawning event is in the spring. Plankton trawls during a survey by Pearce *et al.* (2011a) revealed a high abundance of *Sabellaria spinulosa* larvae in February 2008 and smaller numbers in September and November 2009 while Garwood (1982) found planktonic larvae on the north east coast of England from August to November. These findings suggest that the main spawning event is at the beginning of the year but larvae are produced throughout the subsequent months. A February spawning event resulting in spring settlement is supported by the findings of George & Warwick (1985) and Wilson (1970a), who reported larval settlement in March in the Bristol Channel and Plymouth areas respectively. These findings suggest colonization of suitable habitats may be most likely in the Spring but could occur over extended periods.

The longevity of *Sabellaria spinulosa* reefs is not known and may vary between sites depending on local habitat conditions. In naturally disturbed areas reefs may undergo annual cycles of erosion and recolonization (Holt *et al.*, 1998). Surveys on the North Yorkshire and Northumberland coasts found that areas where *Sabellaria spinulosa* had been lost due to winter storms, appeared to be recolonized up to the maximum observed 2.4 cm thickness during the following summer (R. Holt pers comm., cited from Holt *et al.*, 1998). Recovery of thin encrusting reefs may, therefore, be relatively rapid.

In some areas, reefs may persist for long periods, although there is a significant lack of studies on the temporal stability of *Sabellaria spinulosa* reefs (Limpenny, 2010). It has been suggested that the tubes of the worm are able to persist for some time in the marine environment, therefore the age of the colony may exceed the age of the oldest individuals present (Earll & Erwin, 1983). Laboratory experiments have suggested that larvae settle preferentially on old tubes (Wilson, 1970). Therefore, providing environmental conditions are still favourable, recovery of senescent or significantly degraded reefs through the larval settlement of *Sabellaria spinulosa* is stimulated by the presence of existing tubes (Earll & Erwin, 1983).

Successful recruitment may be episodic. Wilson (1971) cites the work of Linke (1951) who recorded the appearance of *Sabellaria spinulosa* reefs on stone-work of intertidal protective groynes. In 1943 no colonies were present (time of year of this observation is unknown) but by September 1944 there were reefs 6-8 m wide and 40-60 cm high stretching for 60 m. Linke (1951) assumed that settlement took place in 1944. In the summer of 1945 many colonies were dead and those remaining ceased growth in the autumn. Thick reefs may, therefore, develop rapidly and may also decline quickly. It should be noted, that these results should be interpreted cautiously, due to the possibility that the observed species may have been *Sabellaria alveolata* (Bryony Pearce, *pers comm.*).

Other evidence, such as the studies undertaken within and adjacent to the Hastings Shingle Bank aggregate extraction area demonstrate a similarly rapid recolonization process (Cooper *et al.*, 2007; Pearce *et al.*, 2007). Recolonization within two previously dredged areas appeared to be rapid, substantial numbers of *Sabellaria spinulosa* were recorded in one area in the summer following cessation of dredging activities and another area was recolonized within 16-18 months (Pearce *et al.*, 2007). Recruitment was therefore annual rather than episodic in this area. Recovery to the high abundance and biomass of more mature reefs was considered to require 3-5 years in larval recruitment was successful every year (Pearce *et al.*, 2007).

In some cases, however, when reefs are removed they may not recover. The Wadden Sea has experienced a widespread decline of *Sabellaria spinulosa* over recent decades with little sign of recovery. This is thought to be partly due to ecosystem changes that have occurred (Reise, *et al.*, 1989; Buhs & Reise, 1997) exacerbated by fishing pressures that still continue (Riesen & Reise, 1982; Reise & Schubert, 1987). Likewise, no recovery of *Sabellaria spinulosa* has occurred in the approach channels to Morecambe Bay (Mistakidis 1956; cited from Holt *et al.*, 1998). There is no overriding explanation for this, but it is believed this is due to a lack of larval supply or larval settlement, since larvae may preferentially settle on existing adult reefs (although directly settlement on sediments also occurs), or alterations in habitat (Holt *et al.*, 1998).

**Resilience assessment.** The evidence for recovery rates of *Sabellaria spinulosa* reefs from different levels of impact is very limited and the rates at which reefs recover from different levels of impact, and whether these rates are similar or not between biotopes, have not been documented. Recovery rates are likely to be determined by a range of factors such as the degree of impact, the season of impact, larval supply and local environmental factors including hydrodynamics.

The evidence from *Sabellaria alveolata* reefs (Vorberg, 2000; Cunningham *et al.*, 1984) suggests that areas of limited damage on a reef, e.g. where resistance is 'Medium', could be repaired rapidly (within weeks) through the tube-building activities of adults). It is not known if *Sabellaria spinulosa* exhibits the same response but the assessment of resilience in this instance as 'High' indicating that recovery would be likely to occur within 2 years is relatively precautionary.

Predicting the rate of recovery following extensive removal is more problematic. Some thin crusts of *Sabellaria spinulosa* are relatively ephemeral and disappear following natural disturbance such as storms but recover the following year (Holt *et al.*, 1998), suggesting that recovery is 'High' (within 2 years), even where reefs are removed. In other instances, recolonization has been observed within 16-18 months but full recovery to a state similar to the pre-impact condition of high adult density and adult biomass is suggested to require three to five years where recruitment is annual (Pearce *et al.*, 2007). Recovery from significant impacts (where resistance is assessed as 'None' or 'Low') is therefore predicted to be 'Medium' (2-10 years).

The evidence varies between peer reviewed literature on life histories and grey literature on recovery from impacts. Therefore, the confidence in the quality of the evidence is assessed as 'Medium'. The applicability of the evidence is also 'Medium' based on limited studies of direct impact and inference from the life history of the species, while the concordance is assessed as 'Medium' based on agreement in direction but not magnitude, that is, the rate of recovery.

**Note:** The resilience and the ability to recover from human induced pressures is a combination of the environmental conditions of the site, the frequency (repeated disturbances versus a one-off event) and the intensity of the disturbance. Recovery of impacted populations will always be mediated by stochastic events and processes acting over different scales including, but not limited

to, local habitat conditions, further impacts and processes such as larval-supply and recruitment between populations. Full recovery is defined as the return to the state of the habitat that existed prior to impact. This does not necessarily mean that every component species has returned to its prior condition, abundance or extent but that the relevant functional components are present and the habitat is structurally and functionally recognisable as the initial habitat of interest. It should be noted that the recovery rates are only indicative of the recovery potential.

## Hydrological Pressures

	Resistance	Resilience	Sensitivity
<b>Temperature increase (local)</b>	<b>High</b> Q: Medium A: Low C: NR	<b>High</b> Q: High A: High C: High	<b>Not sensitive</b> Q: Medium A: Low C: Low

No empirical evidence was found for the temperature tolerance of *Sabellaria spinulosa*; nevertheless, its widespread distribution suggests that it is tolerant to temperature variations (Gibb *et al.*, 2014). *Sabellaria spinulosa* has the greatest geographical range of all the sabellariids, according to current records, encompassing Iceland, the Skagerrak and the Kattegat, the North Sea, the English Channel, the northeast Atlantic, the Mediterranean, the Wadden Sea and the Indian Ocean, (Achari, 1974; Riesen & Reise, 1982; Reise & Schubert, 1987; Hayward & Ryland, 1998; Foster-Smith, 2000; Collins, 2005).

	Resistance	Resilience	Sensitivity
<b>Temperature decrease (local)</b>	<b>High</b> Q: High A: Medium C: NR	<b>High</b> Q: High A: High C: High	<b>Not sensitive</b> Q: High A: Medium C: Low

*Sabellaria spinulosa* occurs north to the Arctic and is therefore considered tolerant of a decrease in temperature at the pressure benchmark. This conclusion is supported by observations made on oyster grounds in the River Crouch throughout the severe winter of 1962–1963 that *Sabellaria spinulosa* appeared unaffected by the cold. The mean daily temperature was recorded at a depth of 1 fathom (1.8 m) below low water (equinoctial spring tide) and the lowest temperature recorded was  $-1.8^{\circ}\text{C}$  (Crisp, 1964). At Penmon in Bangor, *Sabellaria spinulosa* also appeared not to suffer from the low temperatures and live individuals were readily found (Crisp, 1964).

**Sensitivity assessment.** Given the widespread distribution of *Sabellaria spinulosa* it is unlikely that this species is sensitive to temperature variations at the pressure benchmark. Resistance is therefore assessed as 'High' and resilience is assessed as 'High' (no impact to recover from), so that all the *Sabellaria* biotopes within this group are assessed as 'Not Sensitive'.

	Resistance	Resilience	Sensitivity
<b>Salinity increase (local)</b>	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence for the range of physiological tolerances to salinity changes were found for *Sabellaria spinulosa* by Gibb *et al.* (2014). As reefs are largely subtidal they are less exposed to hypersaline conditions resulting from coastal brine discharge and natural evaporation (lagoons). There is therefore no direct or indirect evidence for sensitivity to an increase in salinity and this element of the pressure is not assessed.

**Sensitivity assessment.** No evidence was found for tolerance of hypersaline conditions and sensitivity to this benchmark is not assessed based on lack of evidence.

### Salinity decrease (local)

**Low**

Q: Medium A: Low C: NR

**Medium**

Q: Medium A: Medium C: Medium

**Medium**

Q: Medium A: Low C: Low

No evidence for the range of physiological tolerances to decreases in salinity was found for *Sabellaria spinulosa* by Gibb *et al.* (2014). The sensitivity assessment made in that report was therefore based on recorded habitat preferences, as described below.

*Sabellaria spinulosa* does not seem to occur in very low salinity areas (Holt *et al.*, 1998) but has been recorded from estuaries including the Crouch, Mersey (Killeen & Light, 2000) and the Thames (Limpenny, 2010). Buhs & Reise (1997) surveyed 12 channel systems in the Wadden Sea and found that *Sabellaria spinulosa* reefs occurred in the northern tidal inlets which experienced salinity levels ranging from 28 to 30 psu. There is some speculation (Foster-Smith & Hendrick, 2003) that McIntosh (1922) misidentified samples of *Sabellaria spinulosa* as the congener *Sabellaria alveolata* from the Humber estuarine population (Holt *et al.*, 1998). These records indicate that reduced and variable salinities can be tolerated to some extent but the paucity of records suggests that areas of reduced salinity do not provide optimal habitat.

**Sensitivity assessment.** As the salinity tolerances of *Sabellaria spinulosa* are unclear the potential impact of salinity change, at the pressure benchmark, is uncertain. The reported distribution of *Sabellaria spinulosa* from fully marine to estuarine habitats does suggest some tolerance of changes in salinity although a decrease in salinity at the extreme of the pressure benchmark (reduction in 10 psu) may not be tolerated. Resistance is therefore assessed as 'Low' (loss of 25-75% of extent). Reef resilience (following habitat recovery) is considered to be 'Medium' (2-10 years). Sensitivity, based on combined resistance and resilience, is therefore assessed as 'Medium'.

### Water flow (tidal current) changes (local)

**High**

Q: High A: Low C: High

**High**

Q: High A: High C: High

**Not sensitive**

Q: High A: Low C: High

*Sabellaria spinulosa* tend to occur in areas of high water movement where larvae, tube building materials and food particles are suspended and transported (Jones *et al.*, 2000). The relative importance of tidal versus wave induced movements to support reefs is, however, unclear (Holt *et al.*, 1998). There is currently limited in-situ data on the specific water flow tolerances of *Sabellaria spinulosa*, although colonies have been found in areas with sedimentary bed forms that suggest current velocities in the range of 0.5 m/s to 1.0 m/s (Mistakidis, 1956; Jones *et al.*, 2000; Davies *et al.*, 2009). In the southern North Sea close to the coast of England, *Sabellaria spinulosa* reefs have been recorded in areas exposed to peak spring tidal flows of 1.0 m/s (Pearce *et al.*, 2014). Davies *et al.* (2009) also found through laboratory experiments with *Sabellaria spinulosa* in tanks that increasing the water flow to an average of 0.03 m/s is adequate to begin distribution of the sediment rain from the airlift throughout the tank and that doubling the water flow to almost 0.07 m/s further improved particle distribution throughout the tank. It is therefore likely that *Sabellaria spinulosa* will exist in habitats with a water flow anywhere above 0.07 m/s so that particles are suspended and distributed for the use of tube building and feeding.

Tillin (2010) used logistic regression to develop statistical models that indicate how the probability of occurrence of the congener *Sabellaria alveolata* changes over environmental gradients within the Severn Estuary. The model predicted response surfaces were derived for each biotope for each of

the selected habitat variables, using logistic regression. From these response surfaces the optimum habitat range for each biotope could be defined based on the range of each environmental variable where the probability of occurrence, divided by the maximum probability of occurrence, is 0.75 or higher. These results identify the range for each significant variable where the habitat is most likely to occur. The modelled ranges should be interpreted with caution and apply to the Severn Estuary alone (which experiences large tidal ranges, high currents and extremely high suspended sediment loads and is therefore distinct from many other estuarine systems). However, these ranges do provide some useful information on environmental tolerances. The models indicate that for subtidal *Sabellaria alveolata* the maximum optimal current speed (the range in which it is most likely to occur) ranges from 1.26-2.46 m/s and the optimal mean current speed ranges from 0.5-1.22 m/s. Although not directly applicable to *Sabellaria spinulosa* this data suggests that tube-building *Sabellariids* are able to occur within a broad range of current speeds.

In cases of reduced water flow, *Sabellaria spinulosa* is likely to suffer a reduction in the supply of suspended food and particles that are integral for growth and repair. A long-term decrease in water flow may reduce the viability of populations by limiting growth and tube building. No evidence was found for threshold levels relating to impact.

**Sensitivity assessment.** The range of flow tolerances recorded (0.5 m/s to 1 m/s cited by Jones *et al.*, 2000; Braithwaite *et al.*, 2006; Davies *et al.*, 2009) suggest that the worms have a broad tolerance of different flow levels. Tillin (2010) modelled optimal flow speeds of 0.5-1.22 m/s for the congener *Sabellaria alveolata*. The worms may retract into tubes to withstand periods of high flows at spring tides and some non-lethal reduction in feeding efficiency and growth rate may occur at the edge of the range. Similarly, a reduction in flow may reduce the supply of tube-building materials and food but again, given the range of reported tolerances a change at the pressure benchmark is not considered to result in mortality. Resistance is therefore assessed as 'High' and resilience as 'High' (no impact to recover from) and the biotope is, therefore, considered to be 'Not sensitive'.

#### Emergence regime changes

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Changes in emergence are 'not relevant' to this biotope which is restricted to subtidal habitats.

#### Wave exposure changes (local)

High

Q: Low A: NR C: NR

High

Q: High A: High C: High

Not sensitive

Q: Low A: Low C: Low

No empirical evidence was found to assess this pressure. This biotope occurs in habitats that are moderately exposed to wave action (JNCC, 2015). At depth, the motion from surface waves becomes oscillatory and produces back-and-forth water movement at the seabed (Dubois *et al.*, 2006). In sublittoral habitats water movements are likely to provide sand and food particles that are necessary for *Sabellaria spinulosa* to build tubes, feed and subsequently grow and develop.

**Sensitivity assessment.** *Sabellaria spinulosa* reefs are robust, stable structures that are present subtidally in naturally disturbed environments and areas with high water flow, changes (decrease or increase) in wave height at the pressure benchmark are not considered to affect reefs within this biotope. All biotopes within this group are therefore considered to have 'High' resistance to this pressure, resilience is assessed as 'High' (no impact to recover from) and all subtidal reef

biotopes are considered to be 'Not Sensitive'.

## Chemical Pressures

	Resistance	Resilience	Sensitivity
<b>Transition elements &amp; organo-metal contamination</b>	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available.

<b>Hydrocarbon &amp; PAH contamination</b>	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR
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This pressure is **Not assessed** but evidence is presented where available.

<b>Synthetic compound contamination</b>	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR
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This pressure is **Not assessed** but evidence is presented where available.

<b>Radionuclide contamination</b>	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR
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No evidence.

<b>Introduction of other substances</b>	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR
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This pressure is **Not assessed**.

<b>De-oxygenation</b>	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR
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Cole *et al.* (1999) suggest possible adverse effects on marine species below 4 mg/l and probable adverse effects below 2 mg/l. No information was found regarding *Sabellaria spinulosa* tolerance to changes in oxygenation and this pressure is not assessed due to lack of evidence.

<b>Nutrient enrichment</b>	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low
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No direct evidence was found to assess this pressure. As the reefs are circalittoral increased nutrient enrichment (eutrophication) would not stimulate the overgrowth of macroalgae on reefs as light penetration is too limited (especially in turbid areas) to allow growth. Enhanced phytoplankton production may increase food supply and increased siltation and deoxygenation from

algal blooms is likely to be mitigated by water movements in the areas most suitable for *Sabellaria spinulosa* reefs.

**Sensitivity assessment.** At the pressure benchmark, which refers to the maintenance of 'good' status according to the Water Framework Directive, *Sabellaria spinulosa* reefs are considered 'Not sensitive'.

## Organic enrichment

**High**

Q: Medium A: High C: NR

**High**

Q: High A: High C: High

**Not sensitive**

Q: Medium A: High C: Low

Limited direct evidence was found to assess the effects of this pressure. *Sabellaria spinulosa* was reported to show enhanced growth adjacent to a sludge dumping area in Dublin Bay (Walker & Rees 1980). Hence, *Sabellaria spinulosa* reef biotopes are probably resistant to a high level of organic enrichment. Information on the levels of organic matter in Dublin Bay were not provided and so it is unclear how the levels experienced relate to the pressure benchmark.

*Sabellaria spinulosa* reefs are found in areas of high water movement of up to 1 m/s (Pearce *et al.*, 2014, see change in water flow for further details) that would naturally disperse some organic matter preventing accumulation and siltation. In larger, dense colonies of *Sabellaria spinulosa*, sand, detritus, and finer faecal materials collect in between worm tubes. These detritus layers do not interrupt the normal growth of the individuals or of the colony as a whole (Schafer, 1972). Taking into consideration these points it seems likely that *Sabellaria spinulosa* are resistant to the deposition of a fine layer of organic materials.

Indirect effects arising from inputs of organic matter are possible where habitat quality and species interactions are altered. In the Wadden Sea large subtidal areas of *Sabellaria spinulosa* reefs have been completely lost since the 1920s. This decline has been partly attributed to an increase in coastal eutrophication that has favoured blue mussel beds (Dörjes, 1992; Hayward & Ryland, 1998; Benson *et al.*, 2013). However, a direct causal link has not been established and it is possible that the decline of *Sabellaria spinulosa* reefs was due to physical damage from fishing activities rather than competitive interactions (Jones *et al.*, 2000).

**Sensitivity assessment.** Little evidence was found to support this sensitivity assessment. Habitat preferences for areas of high water movement suggest that organic matter would not accumulate on reefs, limiting exposure to this pressure. *Sabellaria spinulosa* and the associated species assemblage (which typically includes attached filter feeders from a number of phyla) is likely to be able to consume extra organic matter. This conclusion is supported by the enhanced growth rates that have been recorded on the vicinity of sewage disposal areas (Walker & Rees, 1980). Resistance is therefore assessed as 'High' to this pressure and recovery is assessed as 'High' (no impact to recover from). All *Sabellaria spinulosa* reef biotopes within this group are considered to be 'Not Sensitive' at the pressure benchmark.

## ▲ Physical Pressures

**Resistance**

**None**

Q: High A: High C: High

**Resilience**

**Very Low**

Q: High A: High C: High

**Sensitivity**

**High**

Q: High A: High C: High

**Physical loss (to land or freshwater habitat)**

All marine habitats and benthic species are considered to have 'No Resistance' to this pressure and

to be unable to recover from a permanent loss of habitat. Sensitivity within the direct spatial footprint of this pressure is, therefore 'High'. Although no specific evidence is described confidence in the resistance assessment is 'High', due to the incontrovertible nature of this pressure. Adjacent habitats and species populations may be indirectly affected where meta-population dynamics and trophic networks are disrupted and where the flow of resources e.g. sediments, prey items, loss of nursery habitat etc. is altered. No recovery is predicted to occur.

#### Physical change (to another seabed type)

**None**

Q: Low A: NR C: NR

**Very Low**

Q: High A: High C: High

**High**

Q: Low A: Low C: Low

The introduction of artificial hard substratum is considered at the pressure benchmark level and it is noted that *Sabellaria spinulosa* can colonize artificial structures and have been found on a gas pipeline off the coast of Aberdeen (Mistakidis, 1956). An increase in the availability of artificial substratum may support reef development in areas where sedimentary habitats were previously unsuitable for colonisation.

Where rock substrata are overlain by sediments the impact on habitat suitability for *Sabellaria spinulosa* will depend on the sediment changes that result. *Sabellaria spinulosa* reefs can develop on stable or coarse mixed substrata but mud and sandy muds are considered unsuitable, based on the lack of records of reefs occurring on these sediment types which is likely due to the mobility of the sediment, the lack of sand for tube-building and possibly the re-suspension of fine sediments clogging feeding structures and gills, however this is assumed rather than based on direct evidence.

**Sensitivity assessment.** It should be noted that the basis of the sensitivity assessment for this pressure is the sensitivity of the biotope to changes in substratum type, rather than the sensitivity of *Sabellaria spinulosa* to the mechanism by which this occurs (e.g. complete smothering of the biotope, then any recovery, if possible). A permanent change in substratum type from the bedrock, boulder or cobble substrata and coarse mixed sediments to fine sediments, to the degree that sediments are re-classified as mud or sandy mud would severely reduce habitat suitability and would be considered likely to prevent subsequent recovery of the reef. The resistance of the biotope to this pressure is, therefore, assessed as **None** (loss of >75% of extent), resilience is **Very low** (the pressure is a permanent change) and sensitivity is assessed as **High**.

#### Physical change (to another sediment type)

**Not relevant (NR)**

Q: NR A: NR C: NR

**Not relevant (NR)**

Q: NR A: NR C: NR

**Not relevant (NR)**

Q: NR A: NR C: NR

Not relevant to biotopes occurring on bedrock. Some examples of this biotope occur on mixed sediments with some sand and gravel. A change in sediment type to fine muds or sandy muds is likely to lead to the loss of suitable habitat. The resistance of the biotope to this pressure is, therefore, assessed as **None** (loss of >75% of extent), resilience is **Very low** (the pressure is a permanent change) and sensitivity is assessed as **High**. See also the physical change to another sediment type pressure for further discussion.



**Habitat structure changes - removal of substratum (extraction)**

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

*Sabellaria spinulosa* reefs on rock would be sensitive to the removal of surface layers of the reef and the habitat. However, extraction of rock substratum is considered unlikely and this pressure is considered to be 'Not relevant' where this biotope occurs on bedrock. Where this biotope occurs on boulders or cobbles or mixed sediments, the removal of these would result in loss of the habitat. Biotope resistance, in this instance is assessed as 'None' and resilience as 'Medium' following restoration of the habitat. Sensitivity is, therefore, assessed as 'Medium'. Where the extraction removes all boulders and cobbles or sediment then the biotope will not be able to recover and sensitivity will be higher (see physical change to another seabed type pressure).

**Abrasion/disturbance of the surface of the substratum or seabed**

Low

Q: Low A: NR C: NR

Medium

Q: Medium A: Medium C: Medium

Medium

Q: Low A: Low C: Low

*Sabellaria spinulosa* reef biotopes are directly exposed to physical damage that affects the surface. The effects of abrasion coupled with penetration of sub-surface layers are described in a separate section below, this section describes abrasion of the surface only.

Gibb *et al.* (2014) found no direct evidence for impacts of the surface only for *Sabellaria spinulosa*. Studies of intertidal reefs of the congener *Sabellaria alveolata* (Cunningham *et al.*, 1984) have found that the reef recovered within 23 days from the effects of trampling, (i.e. treading, walking or stamping on the reef structures) by repairing minor damage to the worm tube porches. Severe damage caused by kicking and jumping on the reef structure, resulted in large cracks between the tubes, and removal of sections (ca 15 x15 x10 cm) of the structure (Cunningham *et al.*, 1984). Subsequent wave action enlarged the holes or cracks. However, after 23 days, at one site, one side of the hole had begun to repair, and tubes had begun to extend into the eroded area.

To address concerns regarding damage from fishing activities in the Wadden Sea, Vorberg (2000) used video cameras to study the effect of shrimp fisheries on *Sabellaria alveolata* reefs. The imagery showed that the 3 m beam trawl easily ran over a reef that rose to 30 to 40 cm, although the beam was occasionally caught and misshaped on the higher sections of the reef. At low tide, there were no signs of the reef being destroyed and, although the trawl had left impressions, all traces had disappeared four to five days later due to the rapid rebuilding of tubes by the worms. The daily growth rate of the worms during the restoration phase was significantly higher than undisturbed growth (undisturbed: 0.7 mm, after removal of 2 cm of surface: 4.4 mm) and indicates that as long as the reef is not completely destroyed recovery can occur rapidly.

*Sabellaria spinulosa* reefs are suggested to be more fragile than *Sabellaria alveolata* (B. Pearce, pers comm, cited from Gibb *et al.*, 2014) and therefore surface abrasion may lead to greater damage and lower recovery rates than observed for *Sabellaria alveolata*. *Sabellaria spinulosa* reefs are often only approximately 10cm thick, surface abrasion can, therefore, severely damage and/or remove a reef (see also evidence from penetration and disturbance of the substratum, below). No direct observations of reef recovery, through repair, from abrasion were found for *Sabellaria spinulosa*.

**Sensitivity assessment.** Based on the evidence discussed above, abrasion at the surface of *Sabellaria spinulosa* reefs is considered likely to damage the tubes and result in sub-lethal and

lethal damage to the worms. Resistance is therefore assessed as 'Low' (loss of 25-75% of tubes and worms within the impact footprint). Resilience is therefore assessed as 'Medium' (within 2 years) and sensitivity is therefore assessed as 'Medium'. This assessment is relatively precautionary and it should be noted the degree of resilience will be mediated by the character of the impact. The recovery of small areas of surficial damage in thick reefs is likely to occur through tube repair and may be relatively rapid.

**Penetration or disturbance of the substratum subsurface**

**None**

Q: Medium A: High C: High

**Medium**

Q: Medium A: Medium C: Medium

**Medium**

Q: Medium A: Medium C: Medium

*Sabellaria spinulosa* reef biotopes are directly exposed to physical damage that affects the surface layers (abrasion) and penetrates deeper beneath the surface of the reef. No quantitative studies were found and although Vorberg (2000) is widely cited (see above in the abrasion section) the study used a light shrimp trawl on *Sabellaria alveolata* reefs and the relevance to *Sabellaria spinulosa* and the use of heavy fishing trawls is questionable.

*Sabellaria spinulosa* reefs in the Wadden Sea suffered great losses in the 1950s which are thought to be due to heavy anchor chains being trawled over grounds in association with shrimp fishing (Reise & Schubert, 1987; JNCC, 2013). It is believed that local fishermen targeted areas of *Sabellaria spinulosa* reef due to their association with the brown shrimp *Crangon crangon*, and that deliberate attempts to remove the reefs were made so that fishing gear was not snagged and damaged (Defra, 2004; JNCC, 2013). Similar activity has been reported by fishermen at Ramsgate on *Sabellaria spinulosa* reefs in the Thames sea area but no direct evidence has been identified (Fariñas-Franco, 2014).

Other studies have found significant evidence of trawl scars from unspecified fisheries through *Sabellaria spinulosa* reefs (Collins, 2003; Pearce *et al.*, 2007) indicating that damage from fishing gear is a real possibility (Hendrick *et al.*, 2011). Obvious evidence of the destruction of *Sabellaria spinulosa* reef clumps by a beam trawler has been reported off the coast of Swanage, Dorset (Collins, 2003; cited from Benson *et al.*, 2013). The loss of reefs within a monitoring zone may have been due to bottom trawling based on the presence of trawl scars within the survey area, although the loss cannot be directly attributed to this activity based on the lack of direct observation (Pearce *et al.*, 2011a).

*Sabellaria spinulosa* reefs remain extensive despite clear damage from bottom trawling at Hastings Shingle Bank (Cooper *et al.*, 2007; Pearce *et al.*, 2007) and at the Thanet offshore wind farm site (Pearce *et al.*, in press). However, in other areas such as the Wadden Sea (Riesen & Reise, 1982) and Morecambe Bay (see references in Holt *et al.*, 1998), reefs which have been thought to have been trawled have disappeared and have not recovered. It is acknowledged that the limited evidence available does not allow these losses to be directly attributed to fishing.

At the Hastings site, a newly developed reef (six months old) demonstrated the same multivariate community structure of fauna inhabiting a nearby reef that had been observed over the past 5 years (Pearce *et al.*, 2007). This suggests that the epifauna community associated with *Sabellaria spinulosa* reefs could also recover from fishing activity quickly, but it should be noted that the older reef had experienced on-going fishing activity and so the associated assemblage may be at a relatively early successional stage (Pearce *et al.*, 2007). The quick recovery of the reef and associated biota was not seen in the Wadden Sea after shrimping activity in the 1950's. Instead, together with a loss of mussel beds and seagrass, community composition in the subtidal zone

changed and a significant decline in sessile species was observed (Reise *et al.*, 1989; Buhs & Reise, 1997; Reise & Buhs, 1999; Reise, 2005).

**Sensitivity assessment.** Structural damage to the seabed sub-surface is likely to damage and break-up tube aggregations leading to the loss of reef within the footprint of direct impact. *Sabellaria spinulosa* is assessed as having a resistance of 'None' to this pressure (removal of >75% of the reef in the pressure footprint). Based on evidence (Pearce *et al.*, 2007; Pearce *et al.*, 2011a) resilience was assessed as 'Medium'. Therefore, the sensitivity of *Sabellaria spinulosa* biotopes within this group is considered to be 'Medium'.

#### Changes in suspended solids (water clarity)

**High**

Q: High A: Low C: High

**High**

Q: High A: High C: High

**Not sensitive**

Q: High A: Low C: High

*Sabellaria spinulosa* do not rely on light penetration for photosynthesis, it is also believed that visual perception is limited and that this species does not rely on sight to locate food or other resources. In a recent review of the sensitivity of *Sabellaria spinulosa* reefs to anthropogenic disturbance, Fariñas-Franco *et al.* (2014) concluded that impacts on *Sabellaria spinulosa* due to a decrease in water clarity resulting from an increase in suspended solids (inorganic or organic) are unlikely although no thresholds regarding tolerance or intolerance were found. Decreases in suspended particles that reduce the supply of food or tube-building materials may, however, negatively impact this species (Davies *et al.*, 2009; Last *et al.*, 2011).

*Sabellaria spinulosa* relies on a supply of suspended solids and organic matter in order to filter feed and build protective tubes and so they are often found in areas with high levels of turbidity. Davies, *et al.* (2009) and Last, *et al.* (2011) developed Vortex Resuspension Tanks (VoRT) which are able to test the effects of a change in the composition of suspended sediment on benthic species. This laboratory experiment manipulated turbidity and current flow and demonstrated the susceptibility of *Sabellaria spinulosa* to a decrease in suspended particulate matter (SPM). A clear erosion of tubes was observed in the absence of SPM and subsequent starvation of tube building materials. At high and intermediate sediment regimes (high SPM ~71 mg / l) conditions were comparable to what might be expected within only a few hundred meters distance of a primary aggregate extraction site and *Sabellaria spinulosa* maintained a cumulative growth rate at these rates of SPM. This supports the view that availability of suspended particles is necessary for *Sabellaria spinulosa* development and that tolerance of elevated levels is likely (Davies *et al.*, 2009).

Indirect evidence for the tolerance of *Sabellaria spinulosa* for changes in turbidity is provided by the persistence of reefs on the outskirts of aggregate dredging areas (Pearce *et al.*, 2007, 2011a) which appear unaffected by extraction which is likely to have led to sediment plumes. Such plumes, however, are short-lived (Tillin *et al.*, 2011) and therefore the long-term effect depends on the duration of dredging activities.

Tillin (2010) used logistic regression to develop statistical models that indicate how the probability of occurrence of the congener *Sabellaria alveolata* changes over environmental gradients within the Severn Estuary. The model predicted response surfaces were derived for each biotope for each of the selected habitat variables, using logistic regression. From these response surfaces the optimum habitat range for each biotope could be defined based on the range of each environmental variable where the probability of occurrence, divided by the maximum probability of occurrence, is 0.75 or higher. These results identify the range for each significant variable where the habitat is most likely to occur. The modelled ranges should be interpreted with caution and apply to the Severn Estuary alone (which experiences large tidal ranges, high currents and

extremely high suspended sediment loads and is therefore distinct from many other estuarine systems). However, these ranges do provide some useful information on environmental tolerances. The models indicate that for subtidal *Sabellaria alveolata* the optimal mean neap sediment concentrations range from 515.7-906 mg/l and optimal mean spring sediment concentrations range from 855.3-1631 mg/l. Although not directly applicable to *S. spinulosa* this data suggests that tube-building sabellariids are tolerant to very high levels of suspended sediment. Fine sediments such as mud may clog the gills and feeding tentacles of some polychaetes and therefore the potential impact will be mediated by the character of the pressure.

**Sensitivity assessment.** The benchmark for this pressure refers to a change in turbidity of one rank. *Sabellaria spinulosa* do not photosynthesise and do not rely on sight to locate resources and therefore no effects are predicted for reef biotopes from an increase or decrease in clarity resulting from a change in one rank on the water framework directive scale. Experiments (Davies *et al.*, 2009) and predictive modelling (Tillin, 2010) indicate that tube building sabellariids can tolerate a broad range of suspended solids. Resistance to this pressure is therefore assessed as 'High' and resilience as 'High' (no impact to recover from).

### Smothering and siltation rate changes (light)

**High**

Q: High A: Medium C: NR

**High**

Q: High A: High C: High

**Not sensitive**

Q: High A: Medium C: Low

*Sabellaria spinulosa* are often found in areas of high water movement with some degree of sediment transport essential for tube-building and feeding. *Sabellaria spinulosa* reefs adjacent to aggregate dredging areas appear unimpacted by dredging operations (Pearce *et al.*, 2007; Pearce *et al.*, 2011a). Evidence suggests that given the dynamic sedimentary environments in which sabellariids live, their populations can certainly persevere in turbid conditions in spite of 'typical' natural levels of burial (Last *et al.*, 2011) and that recovery from burial events is high.

Direct evidence for the effects of siltation on *Sabellaria spinulosa* is limited to the experiments undertaken by Last *et al.* (2011). Last *et al.* (2011) buried *Sabellaria spinulosa* worms (isolated into artificial tubes), under three different depths of sediment – shallow (2 cm), medium (5 cm) and deep (7 cm). The results indicate that *Sabellaria spinulosa* can survive short-term (32 days), periodic sand burial of up to 7 cm. Last *et al.* (2011) suggested that the formation of 'emergence tubes' (newly created tubes extending to the surface) under sediment burial allowed *Sabellaria spinulosa* to tolerate gradual burial and that perhaps this mechanism allows for continued adult dispersal. This mechanism occurred most rapidly throughout the 8-day burial at ~1mm per day (Last *et al.*, 2011) but even though tube-growth still seems possible under burial, it is likely that a dumping of fine and coarse material will block feeding apparatus and therefore worm development will be curtailed.

The evidence above suggests that Ross worm reefs are sensitive to damage from siltation events (Hendrick *et al.*, 2011). However, at the pressure benchmark, the depth of burial is likely to be similar or less than that experienced during natural storm events that move sediments and, in areas of high water movement, deposits of fine sediments are likely to be remobilised and moved.

**Sensitivity assessment.** In areas of high water flow dispersion of fine sediments may be rapid and this will mitigate the magnitude of this pressure by reducing the time exposed. Based on the experiments by Last *et al.* (2011) which are considered relevant to the pressure benchmark, resistance and resilience are assessed as 'High' and this biotope is considered to be 'Not sensitive'.

**Smothering and siltation rate changes (heavy)****None**

Q: Low A: NR C: NR

**Medium**

Q: High A: Low C: High

**Medium**

Q: Low A: Low C: Low

*Sabellaria spinulosa* are often found in areas of high water movement with some degree of sediment transport essential for tube-building and feeding (Jackson & Hiscock, 2008). Given their preference for turbid waters their tolerance to the suspension and/or settlement of fine material during adjacent dredging activity may be high (Tyler-Walters, 2007; Jackson & Hiscock, 2008; Tyler-Walters, 2008). *Sabellaria spinulosa* reefs adjacent to aggregate dredging areas appear unimpacted by dredging operations (Pearce *et al.*, 2007; Pearce *et al.*, 2011a). Evidence suggests that given the dynamic sedimentary environments in which sabellariids live, their populations can certainly persevere in turbid conditions in spite of 'typical' natural levels of burial (Last *et al.*, 2011) and that recovery from burial events is high. The congener *S. alveolata* was reported to survive short-term burial for days and even weeks in the south west as a result of storms that altered sand levels up to two meters, they were, however, killed by longer-term burial (Earll & Erwin 1983).

Direct evidence for the effects of siltation on *Sabellaria spinulosa* is limited to the experiments undertaken by Last *et al.* (2011). The experimental conditions do not, however, relate to the pressure benchmark (30 cm of siltation in a single event). Last *et al.* (2011) buried *Sabellaria spinulosa* worms (isolated into artificial tubes), under three different depths of sediment – shallow (2 cm), medium (5 cm) and deep (7 cm). The results indicate that *Sabellaria spinulosa* can survive short-term (32 days), periodic sand burial of up to 7 cm. Last *et al.* (2011) suggested that the formation of 'emergence tubes' (newly created tubes extending to the surface) under sediment burial allowed *Sabellaria spinulosa* to tolerate gradual burial and that perhaps this mechanism allows for continued adult dispersal. This mechanism occurred most rapidly throughout the 8-day burial at ~1mm per day (Last *et al.*, 2011) but even though tube-growth still seems possible under burial, it is likely that a dumping of fine and coarse material will block feeding apparatus and therefore worm development will be curtailed.

A *Sabellaria spinulosa* reef off the coast of Dorset has shown periodic burial from large sand waves (Collins, 2003). The displacement of some colonies that had established themselves on a gas pipeline 1km off the coast of Aberdeen was also associated with burial (Mistakidis, 1956; cited by Holt *et al.*, 1998). Furthermore the loss of a 2 km<sup>2</sup> area of Ross worm reef in Jade Bay, North Sea was attributed to burial as a consequence of mud deposition, although fishing activity may have contributed to the decline (Dörjes, 1992, cited from Hendrick *et al.*, 2011).

The evidence above suggests that *Sabellaria spinulosa* reefs are sensitive to damage from siltation events (Hendrick *et al.*, 2011). However, recovery is likely to be rapid given that larval dispersal is not interrupted and new reefs are likely to be able to establish themselves over old buried ones as postulated by (Fariñas-Franco *et al.*, 2014).

**Sensitivity assessment.** No direct evidence was found for the length of time that *Sabellaria spinulosa* can survive beneath 30 cm of sediment. In areas of high water flow dispersion of fine sediments may be rapid and this will mitigate the magnitude of this pressure by reducing the time exposed. However, this mitigating effect was not taken into account as it depends on site-specific conditions. Resistance was assessed as 'None' due to the depth of overburden. Resilience was assessed as 'Medium' (2-10 years) and sensitivity was therefore categorised as 'Medium'.

**Litter****Not Assessed (NA)**

Q: NR A: NR C: NR

**Not assessed (NA)**

Q: NR A: NR C: NR

**Not assessed (NA)**

Q: NR A: NR C: NR

Not assessed.

<b>Electromagnetic changes</b>	No evidence (NEv)	No evidence (NEv)	No evidence (NEv)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

No evidence.

<b>Underwater noise changes</b>	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not relevant.

<b>Introduction of light or shading</b>	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not relevant.

<b>Barrier to species movement</b>	Medium	High	Low
	Q: Low A: NR C: NR	Q: Medium A: Low C: Medium	Q: Low A: Low C: Low

No direct evidence was found to assess this pressure. As the larvae of *Sabellaria spinulosa* are planktonic and are transported by water movements, barriers that reduce the degree of tidal excursion may alter the supply of *Sabellaria spinulosa* to suitable habitats from source populations. However, the presence of barriers may enhance local population supply by preventing the loss of larvae from enclosed habitats. This species is therefore potentially sensitive to barriers that restrict water movements, whether this will lead to beneficial or negative effects will depend on whether enclosed populations are sources of larvae or are 'sink' populations that depend on outside supply of larvae to sustain the local population.

**Sensitivity assessment.** As this habitat is potentially sensitive to changes in tidal excursion and exchange, resistance is assessed as 'Medium' and resilience as 'High', sensitivity is, therefore 'Low'. It should be noted that offshore circalittoral habitats are unlikely to be exposed to this pressure.

<b>Death or injury by collision</b>	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not relevant' to seabed habitats. NB. Collision by grounding vessels is addressed under 'surface abrasion'.

<b>Visual disturbance</b>	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not relevant.

## Biological Pressures

	Resistance	Resilience	Sensitivity
<b>Genetic modification &amp; translocation of indigenous species</b>	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

*Sabellaria spinulosa* and the associated species found within the habitat complex are not farmed or translocated and therefore this pressure is 'Not relevant'.

	High	High	Not sensitive
<b>Introduction or spread of invasive non-indigenous species</b>	Q: Low A: NR C: NR	Q: High A: High C: High	Q: Low A: Low C: Low

No direct evidence relating to the impacts of the introduction of non-indigenous species on *Sabellaria spinulosa* reefs was found to support this assessment by Gibb *et al.* (2014). For many of the non-indigenous species that are found in UK seabed habitats, there are no records to suggest that their distribution overlaps with *Sabellaria spinulosa* reefs.

The oyster drill, *Urosalpinx cinerea*, is not known to predate on polychaetes (Brown & Richardson, 1988), therefore, their introduction is not considered a threat to *Sabellaria spinulosa*. There is, however, some overlap between the environmental niche of *Sabellaria spinulosa* and the oysters that *Urosalpinx cinerara* selectively feed on (Brown & Richardson, 1988).

Japanese wireweed *Sargassum muticum* and green sea fingers *Codium fragile* have the potential to compete for space where *Sabellaria spinulosa* reefs occur intertidally, however, intertidal biotopes are not included in this assessment and these species are unlikely to impact deeper subtidal reefs such as this biotope, where the turbid conditions result in an unsuitable habitat for macroalgae.

No records of the carpet sea squirt *Didemnum vexillum*, the reef building serpulid *Ficopomatus enigmaticus*, the colonial sea squirt *Perophora japonica*, or Japanese kelp *Undaria pinnatifida*, suggest these species occur on or near *Sabellaria spinulosa* reefs. However, further spread may impact subtidal *Sabellaria spinulosa* reefs through smothering or competition, although this is entirely speculative. Replacement of the characterizing didemnid ascidians and bryozoans would alter the character of the biotope.

Two species that potentially pose a threat to *Sabellaria spinulosa* reefs are the Pacific oyster *Magallana gigas* and the slipper limpet *Crepidula fornicata*. Reefs of *Sabellaria alveolata* in the bay of Mont Saint Michel, France are becoming increasingly colonized by the pacific oyster *Magallana gigas* (Dubois *et al.* 2006). Given the high filtration rates of *Magallana gigas*, it is believed that they can out-compete *Sabellaria alveolata* for feeding resources (Dubois *et al.*, 2006). In the Wadden Sea *Magallana gigas* has replaced blue mussels (Foster-Smith, 2000) suggesting that *Magallana gigas* may impact filter feeding, reef forming organisms in general. The reasons underlying the species shift from *Mytilus edulis* to *Magallana gigas* have not been elucidated, however, and may be due to recent changes in climactic conditions (Thieltges, 2005) rather than competitive interactions. It should be noted that even though *magallana gigas* is distributed throughout UK waters following an initial introduction in 1926 (Linke, 1951) there is currently no evidence, in the absence of any targeted studies, that this species is impacting native *Sabellaria spinulosa* or *Sabellaria alveolata* reefs (Crisp, 1964; Hendrick, *et al.* 2011).

When the slipper limpet *Crepidula fornicata* settles in an area it can increase the amount of

pseudofaeces and subsequently the substratum may be altered from hard substratum to soft sediment which will reduce the substratum available for settlement by other species. This was observed when a 28-30% mortality of *Mytilus edulis* occurred after the introduction of *Crepidula fornicata* to mussel beds (Thieltges, 2005). *Crepidula fornicata* has been recorded in association with *Sabellaria spinulosa* reefs at Hastings Shingle Bank (up to 66 individuals per grab, Pearce, 2007) and in lower numbers in the East Coast REC area (maximum 4 per grab (Pearce et al 2011a)). The relationship between *Crepidula fornicata* and *Sabellaria spinulosa* has not been investigated. However, potential impacts on *Sabellaria spinulosa* reefs could occur through changes to substratum suitability or other interactions.

**Sensitivity assessment.** No evidence was found that non-indigenous species are currently significantly impacting *Sabellaria spinulosa* reef biotopes. Based on current evidence, resistance is therefore assessed as 'High' and resilience as 'High' (no impact to recover from), so that all the *Sabellaria spinulosa* reef biotopes are assessed as 'Not Sensitive'. However, it should be noted that *Crepidula fornicata* and *Magellana gigas* may pose a potential threat in terms of competition for food and space and so this assessment may require updating in the future as the distributions and interactions between these species are better understood.

<b>Introduction of microbial pathogens</b>	<b>No evidence (NEv)</b>	<b>No evidence (NEv)</b>	<b>No evidence (NEv)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

No evidence was found for adverse impacts of microbial pathogens on *Sabellaria spinulosa*.

<b>Removal of target species</b>	<b>High</b>	<b>High</b>	<b>Not sensitive</b>
	Q: Low A: NR C: NR	Q: High A: High C: High	Q: Low A: Low C: Low

*Sabellaria spinulosa* may be directly removed or damaged by static or mobile gears that are targeting other species. These direct, physical impacts are assessed through the abrasion and penetration of the seabed pressures. The sensitivity assessment for this pressure considers any biological effects resulting from the removal of target species on *Sabellaria spinulosa* biotopes.

*Sabellaria spinulosa* has no economic value and is not commercially harvested. Gibb *et al.* (2014), evaluated the evidence regarding potential biological effects of the removal of other target species on the *Sabellaria spinulosa* reef biotopes. Experimental laboratory work reported that scallop shells, especially *Pecten maximus*, induced *Sabellaria spinulosa* larvae to settle (Earll & Erwin 1983). However; the settlement-inducing property of *Pecten maximus* shells related mostly to the upper valve which was covered in sand grains (an existing requirement of larvae settlement) As the assessed biotope occurs on rock, boulders or cobbles, the removal of *Pecten maximus* in adjacent sedimentary habitats is unlikely to have a significant negative impact on larval recruitment.

Gibb *et al.* (2014) suggest that the removal of target species that prey on *Sabellaria spinulosa* could potentially be beneficial to this species and *Sabellaria spinulosa* reefs appear to be important nursery areas for commercially targeted flat fish including Dover sole (Bryony Pearce, *pers comm*). Assessment of this indirect effect is limited by the lack of empirical evidence for predator-prey relationships. Stomach analysis of fish by Pearce (2001) found that juvenile flatfish captured in reef areas including Dover sole, dab and plaice fed preferentially on *Sabellaria spinulosa*. Where these species removed as target species (or as by-catch) then predation rates on *Sabellaria spinulosa* could be reduced. However, as the rate of predation on *Sabellaria spinulosa* and



impacts on reefs through population effects and the rate of removal of the predator species are not known, the impact of this potentially beneficial effect could not be assessed.

**Sensitivity assessment.** *Sabellaria spinulosa* has no economic value and is not commercially harvested. The *Sabellaria spinulosa* biotopes are not, therefore directly impacted by this pressure and all biotopes within this group are considered, by default, to be 'Not Sensitive'. The removal of target species that predate on *Sabellaria spinulosa* may have a potentially beneficial effect and the biotope is not considered to be sensitive to ecological effects resulting from their removal.

### Removal of non-target species

**Low**

Q: Low A: NR C: NR

**Medium**

Q: Medium A: Medium C: Medium

**Medium**

Q: Low A: Low C: Low

*Sabellaria spinulosa* biotopes may be removed or damaged by static or mobile gears that are targeting other species. These direct, physical impacts are assessed through the abrasion and penetration of the seabed pressures. Evidence for ecological interactions between *Sabellaria spinulosa* and other species is limited. The removal of *Sabellaria spinulosa* predators as bycatch may be beneficial. Pearce *et al.* (2011b) found that as well as the commercially targeted species described for the removal of target species pressure, butterflyfish *Pholis gunnelis* and dragonet *Callionymus lyra* predated on *Sabellaria spinulosa*. Previous studies have also shown that *Carcinus maenas* feeds on *Sabellaria spinulosa* (Taylor, 1962; Bamber & Irving, 1997). Other invertebrates such as *Pandalus montagui* and *Asterias rubens* found in association with *S. spinulosa* reefs may also be feeding on the worms or on species associated with the reefs rather than *Sabellaria spinulosa*. Due to the limited information available on predator-prey relationships, the impact of predator removal on *Sabellaria spinulosa* reef biotopes cannot be assessed.

Dense aggregations of the brittle star, *Ophiothrix fragilis*, have been suggested to compete with *Sabellaria spinulosa* for space and food and potentially to consume the gametes inhibiting recruitment (George & Warwick 1985). Removal of this species as by-catch could potentially be beneficial to the reef biotopes.

**Sensitivity assessment.** The biogenic structure created by the *Sabellaria spinulosa* worms is the key characterizing feature of this biotope group. Removal of the worms and tubes as by-catch would remove the biotope and hence this group is considered to have a resistance of 'None' to this pressure and to have 'Medium' resilience. Sensitivity is, therefore 'Medium'.

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