Sabellaria spinulosa on stable circalittoral mixed sediment

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

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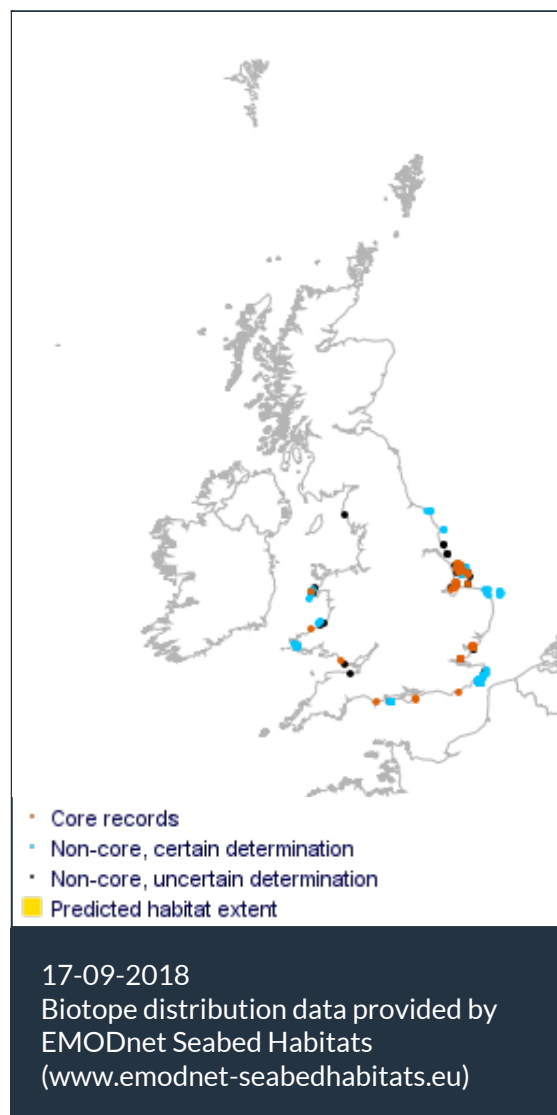
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Close up of *Sabellaria spinulosa* **mound showing worm tubes composed of cemented sand grains and shell fragments.**
Photographer: Ken Collins
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- Core records
- Non-core, certain determination
- Non-core, uncertain determination
- Predicted habitat extent

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

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Summary

≡ UK and Ireland classification

EUNIS 2008	A5.611	*Sabellaria spinulosa* on stable circalittoral mixed sediment
JNCC 2015	SS.SBR.PoR.SspiMx	*Sabellaria spinulosa* on stable circalittoral mixed sediment
JNCC 2004	SS.SBR.PoR.SspiMx	*Sabellaria spinulosa* on stable circalittoral mixed sediment
1997 Biotope	SS.CMX._.SspiMx	*Sabellaria spinulosa* and *Polydora spp.* on stable circalittoral mixed sediment

🏷 Description

The tube-building polychaete *Sabellaria spinulosa* at high abundances on mixed sediment. These 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 fragilis*, *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 (Tait and Dipper, 1998; Wilson, 1929). These reefs are particularly affected by dredging or trawling and in heavily dredged or disturbed areas an impoverished community may be left (e.g. SS.SCS.CCS.Pkef) particularly if the activity or disturbance is prolonged. However, it is likely that reefs of *Sabellaria spinulosa* can recover quite quickly from short-term or intermediate levels of disturbance as found by Vorberg (2000) in the case of disturbance from shrimp fisheries and recovery will be accelerated if some of the reef is left intact following disturbance as this will assist larval settlement of the species. (Information from Connor *et al.*, 2004; JNCC, 2015).

↓ Depth range

10-20 m, 20-30 m

🏛 Additional information

-

✔ Listed By

- none -

❧ Further information sources

Search on:

G 🔱 **G** JNCC

Habitat review

⟳ Ecology

Ecological and functional relationships

As a result of the complex habitat created by the *Sabellaria spinulosa* tubes (see Habitat Complexity), there are a wealth of different species associated with SS.SBR.PoR.SspiMx. *Sabellaria spinulosa* crusts also occur amongst sediment so that a mixture of sessile or sedentary epifauna is mixed with burrowing fauna in the sediment. In the Thames estuary, Attrill *et al.* (1996) discovered that, in an area where *Sabellaria spinulosa* was among the most abundant fauna, species richness in this area was much higher than in surrounding areas due to the stability of the sediment and the high number of available niches. >200 species of invertebrates were recorded over a three year period in <5 m⬚ (Attrill *et al.*, 1996). The relationships between members of the associated community are not especially complex but the roles of various fauna have been elucidated below.

- Aside from *Sabellaria spinulosa*, the community is dominated by various different polychaetes. These include deposit feeders such as *Caulleriella zetlandica*, *Mediomastus fragilis*, *Scalibregma inflatum*, *Scoloplos armiger* and *Spiophanes bombyx*. Carnivorous species may also be common including *Eteone longa*, *Eumida sanguinea*, *Lumbrineris gracilis* and *Nephtys hombergi*, the latter of which is also a scavenger.
- Suspension feeders are diverse and may include dead man's fingers *Alcyonium digitatum*, the acorn barnacle *Balanus crenatus*, the tubeworm *Spirobranchus triqueter* and the baked bean ascidian *Dendrodoa grossularia*. Several suspension feeding bivalves may also be present, especially *Abra alba*, *Hiatella arctica* (a boring bivalve), *Kurtiella bidentata*, *Modiolus modiolus* and *Sphenia binghami*. Some of these are also deposit feeders as is the bivalve *Nucula nitidosa*. *Sphenia binghami* may be found nestled in crevices attached by a weak byssus. Other suspension feeders include the brittlestars *Ophuira* sp, especially *Ophiura albida*, amphipods such as *Ampelisca* sp. and bryozoans including *Flustra foliacea* and *Alcyonidium diaphanum*. *Ampelisca tenuicornis* is primarily a deposit feeder but is also capable of suspension feeding.
- Mobile epibenthic predators include hermit crabs such as *Pagurus bernhardus* and pycnogonids. *Pagurus bernhardus* is an active omnivore that scavenges and preys upon various food items. It is also capable of suspension feeding. The pycnogonid *Achelia echinata* preys upon the bryozoan *Flustra foliacea*.
- No macroalgae are associated with the biotope since it occurs below the compensation zone for photosynthesis for most algal species. Also, the turbid habitat within which the biotope is found may be detrimental to many algal species both in terms of increased light attenuation and physical abrasion caused by the scouring of the sand on the fronds.
- Although *Sabellaria spinulosa* is, by its nature, an ephemeral species, the stable nature of the substratum associated with SS.SBR.PoR.SspiMx mean that the crusts of *Sabellaria spinulosa* may be well established, certainly more than one year old. George & Warwick (1985) found that most of the worms in the aggregation of *Sabellaria spinulosa* they studied in the Bristol Channel were more than one year old. Furthermore, the species associated with them were found to be slow growing. The associated community are likely to depend on the frequency of the disturbance to the habitat. Furthermore, areas of SS.SBR.PoR.SspiMx that have recently disturbed are likely to be characterised by a very different fauna to a well established and undisturbed variant.

Seasonal and longer term change

Sabellaria spinulosa are known as 'r'-strategists and are adapted to live in frequently disturbed environments. Despite the stable nature of the sediment on which SS.SBR.PoR.SspiMx is found, winter storms may be expected to break up the *Sabellaria spinulosa* matrix every few years although given the depth at which the biotope is found, it will be affected comparatively less than shallower mixed sediment communities. In areas where the biotope is periodically destroyed by storm events, a cyclical shift in biotopes from SspiMx to other biotopes e.g. SS.SCS.CCS.Pkef or SS.SSa.CMuSa.AalbNuc , with re-establishment of the *Sabellaria* colonies in the following year, may occur (Connor *et al.*, 2004). Crusts of *Sabellaria spinulosa* are likely to reform within 1-3 years. George & Warwick (1985) found that most of the worms in the aggregation of *Sabellaria spinulosa* they studied in the Bristol Channel were more than one year old. Furthermore, the species associated with them were found to be slow growing. Due to the lack of algal species, little change is to be expected in terms of floral growth. The most likely source of seasonal changes is species composition because some short lived species such as *Chaetozone setosa* will die off over the winter months and, therefore, species diversity can be expected to decrease in winter. The time taken to develop, longevity and importance as a habitat of raised reefs of *Sabellaria spinulosa* is not established but is now (2005) the subject of studies.

Habitat structure and complexity

At the Bristol Channel location studied by George & Warwick (1985), densities in excess of 4,000/m☐ for loosely aggregated *Sabellaria spinulosa* were recorded. The *Sabellaria* at their study site was loosely aggregated and not extended above the seabed in a 'reef' formation, that is, their study focused on a biotope more representative of SS.SBR.PoR.SspiMx.

In the UK SACs Biogenic Reef volume (Holt *et al.*, 1998), CMX.SspiMx has been described as a biogenic reef and, although it may be destroyed by winter storms, will offer a stabilizing effect on the substratum. In addition to the stabilizing effect of the tubes, the physical structure of the mass of tubes themselves provides a matrix of burrows, nooks and crannies which are ideal for offering protection for nestling and cryptic species. Other tube building polychaetes include *Lanice conchilega*. *Lanice conchilega* tubes provide structure to the sediment, very much like a hollow rod stabilising the sediment (Jones & Jago, 1993). Tube building amphipods such as *Ampelisca* sp. will also contribute to the habitat complexity, as will the bryozoan *Flustra foliacea*. The matrix of various tubes and other erect structures will trap sediment providing food for deposit feeders. The trapped sediment also means that the biotope will be composed of habitats similar to both sedimentary and hard substratum environments, thereby increasing the number of potential niches. The aggregation provides shelter and protection for small species in an otherwise 'exposed' (in terms of nowhere to hide) sedimentary landscape.

Productivity

Sabellaria spinulosa 'reefs' can support a highly diverse fauna. George and Warwick (1985), reported that the total production of extensive reefs of *Sabellaria spinulosa* in the Bristol Channel was 34.1 g dry wt / m☐ / year. 96 % of production attributed to suspension feeders, of which *Ophiothrix fragilis* dominated. This species is not though to be particularly common in CMX.SspiMx although *Ophiura* sp., especially *Ophiura albida* may be abundant. *Sabellaria spinulosa* itself has a rather low rate of production (George & Warwick, 1985).

Recruitment processes

Recruitment processes are described for dominant and representative species.

Wilson (1970b) stated that the larvae of *Sabellaria spinulosa* spend between six weeks and two months in the plankton. Reproductive seasonality is unclear but George & Warwick (1985) and Wilson (1970a) have both reported larval settlement in March in the Bristol Channel and Plymouth areas respectively. George & Warwick (1985) also reported a secondary smaller settlement in November in the Bristol Channel. Wilson (1970a) found that the spawning period extended from January to March in Plymouth. Fecundity and recruitment may be variable (Holt *et al.*, 1998) but may be similar to *Sabellaria alveolata*. Settlement of *Sabellaria spinulosa* is thought to be strongly influenced by the presence of existing *Sabellaria spinulosa* (Wilson, 1970a). The presence of *Ophiothrix fragilis* can greatly reduce recruitment (Holt *et al.*, 1998). However, *Ophiothrix fragilis* is not commonly associated with SS.SBR.PoR.SspiMx although *Ophuira* sp. may have a similar effect.

Epifauna

- Hayward & Ryland (1995b) and Segrove (1941) suggested that breeding of *Spirobranchus triqueter* probably takes place throughout the year. However, Hayward & Ryland (1995b) noted a breeding peak in spring and summer and records from Port Erin by Moore (1937) indicated that breeding only took place in April in this location. Castric-Fey (1983) studied variations in settlement rate and concluded that, although the species settled all year round, very rare settlement was observed during winter and maximum settlement occurred in April, June, August and Sept-Oct. Studies in Bantry Bay (Cotter *et al.*, 2003) revealed a single peak in recruitment during summer (especially July and August) with very little recruitment at other times of the year. Larvae are pelagic for about 2-3 weeks in the summer. However, in the winter this amount of time increases to about 2 months (Hayward & Ryland, 1995b).
- Hornwrack *Flustra foliacea* is likely to be the most abundant of the bryozoan species associated with the biotope. *Flustra foliacea* bears both male and female zooids and is presumably hermaphrodite (see *MarLIN* review). Fertilization in brooding species such as *Flustra foliacea* is probably internal (Hayward & Ryland, 1998). Released sperm are entrained by the tentacles of feeding polypides and may not disperse far, resulting in self-fertilization. However, genetic cross-fertilization is assumed in oviparous and brooding bryozoans, although there is evidence of self fertilization (Hayward & Ryland, 1998). Dalyell (cited in Hincks, 1880) stated that ca 10,000 larvae were released from a specimen of *Flustra foliacea* within 3 hrs. Larvae are positively phototactic on release, and swim for only short periods. Daylength is an important cue for larval release in some species of bryozoa, and *Flustra foliacea* releases larvae in spring (February- April) (Eggleston, 1972a; Hayward & Ryland, 1998). The short larval life probably results in good local but poor long-range dispersal.
- *Alcyonium digitatum* spawns during December and January. Gametes are released into the water and fertilization occurs externally. The embryos are neutrally buoyant and float freely for 7 days. The embryos give rise to actively swimming lecithotrophic planulae which may have an extended pelagic life before they eventually settle (usually within one or two further days) and metamorphose to polyps (Matthews, 1917; Hartnoll, 1975). In laboratory experiments, several larvae of *Alcyonium digitatum* failed to settle within 10 days, presumably finding the conditions unsuitable. These larvae proved to be able to survive 35 weeks as non-feeding planulae. After 14 weeks some were still swimming and

after 24 weeks the surface ciliation was still active although they rested on the bottom of the tanks, by the end of the experiment at 35 weeks the larvae had shrunk to a diameter of 0.3 mm. This ability to survive for long periods in the plankton may favour the dispersal and eventual discovery of a site suitable for settlement (Hartnoll, 1975).

- *Balanus crenatus* is an obligate cross-fertilizing hermaphrodite. Nauplii larvae are released from the barnacle between February and September, with peaks in April and late summer when phytoplankton levels are highest. Nauplii larvae are planktotrophic and develop in the surface waters stages before eventually developing into a cyprid larva. Peak settlement occurs in April and declines until October. Metamorphosis usually takes place within 24 hours of settlement. April-settled individuals may release larvae the same July and reach full size before their first winter.

- *Ampelisca spinipes* is likely to be have direct development. Recruitment is therefore likely to be high in local areas and although the dispersal of juveniles is relatively low, adults are highly motile.

- The timing of reproduction and recruitment in the baked bean ascidian *Dendrodoa grossularia* depends partly on geographic location but the general patterns is of annual episodic reproduction with major periods of settlement occurring in spring and autumn (Millar, 1954). Fertilised eggs are brooded until an advanced larvae stage.

Infauna

- Two types of development have been reported in *Scoloplos armiger*: a holobenthic type and a pelagic larvae. The holobenthic type crawls out from a cocoon fixed on the substratum and burrows immediately, usually associated with intertidal populations in North Sea region and adjacent waters and a pelagic larvae associated with subtidal populations (Kruse *et al.*, 2003; Kruse *et al.*, 2004). At the Isle of Sylt, North Sea, egg cocoons are found on intertidal flats between Feb-April (Kruse *et al.*, 2004). Spawning varies with location. In North Sea, main spawn March, secondary (pelagic) spawn from offshore in Oct (Kruse *et al.*, 2004). At Whitstable, spawned four times in one year, main late Feb-April (Gibbs, 1968). 600-1920 / m⬚ Oosterschelde (Coosen *et al.*, 1994), 800 / m⬚ at Whitstable (Gibbs, 1968). *Scoloplos armiger* does not mature until 2 years of age. Many other polychaete species will be found in this biotope.

- The larvae of *Lanice conchilega* spend up to 60 days in the plankton, so that larvae could potentially disperse over a great distance, depending on the hydrographical regime. Heuers & Jaklin (1999) found that areas with adult worms or artificial tubes were settled and areas without these structures were not.

- Species such as *Spiophanes bombyx* are regarded as a typical 'r' selecting species with a short lifespan, high dispersal potential and high reproductive rate.

Time for community to reach maturity

Sabellaria spinulosa is a fast growing annual species. Areas where *Sabellaria spinulosa* had been lost due to winter storms appeared to recolonize up to a maximum of 2.4 cm during the following summer (R. Holt, pers. comm in Jones *et al.*, 2000). However, George & Warwick (1985) found that, in the Bristol Channel, the reef was comprised mostly of worms over one year old. They also noted that the diverse small species found nestling within the reef were slow growing. Since SS.SBR.PoR.SspiMx is characterized only by the presence of *Sabellaria spinulosa*, the biotope is likely to 'mature' into the recognisable biotope within one year. However, the epibiotic species typically associated with the special features of *Sabellaria spinulosa* crusts are likely to take longer to develop. In stable conditions the community may continue to mature into a more diverse community over several years.

Additional information

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🖼 Preferences & Distribution

Habitat preferences

Depth Range	10-20 m, 20-30 m
Water clarity preferences	
Limiting Nutrients	
Salinity preferences	Full (30-40 psu)
Physiographic preferences	
Biological zone preferences	Circalittoral
Substratum/habitat preferences	Mixed
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Strong 3 to 6 knots (1.5-3 m/sec.)
Wave exposure preferences	Moderately exposed, Sheltered
Other preferences	

Additional Information

Reported from moderately wave exposed or sheltered areas with moderately strong to strong tidal streams. *Sabellaria spinulosa* requires sand grains which it uses to construct its tubes. Therefore, it is only found in areas with turbid water (Jones *et al.*, 2000). Although *Sabellaria spinulosa* may be found individually in the intertidal, reefs are only found subtidally.

🐾 Species composition

Species found especially in this biotope

Rare or scarce species associated with this biotope

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Additional information

The MNCR recorded 283 species in 10 records of CMS.SspiMx although not all the species occurred in all records of the biotope (JNCC, 1999).

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. Although a wide range of species are associated with reef biotopes, which provide habitat and food resources, these characterizing species occur in a range of other biotopes and were, therefore, not considered by Gibb *et al*. (2014) to characterize the sensitivity of this biotope. The reef and individual *Sabellaria spinulosa* worms are not dependent on 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 intertidal 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, 1970a; 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, 1970a&b). 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) suggested that this represented 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 Februarry 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 *et al*., 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 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.

NB: 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
Temperature increase (local)	High	High	Not sensitive
	Q: Medium A: Low C: NR	Q: High A: High C: High	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
Temperature decrease (local)	High	High	Not sensitive
	Q: High A: Medium C: NR	Q: High A: High C: High	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 (1.8m) below low water (equinoctial spring tide) and the lowest temperature recorded was -1.8°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
Salinity increase (local)	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 for the range of physiological tolerances to salinity changes was 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	Medium	Medium
	Q: Medium A: Low C: NR	Q: Medium A: Medium C: 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 *et al*., 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 to variable salinity 18-35 ppt or reduced salinity 18-30 ppt) may result in extensive losses. 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 recovery, is therefore assessed as 'Medium'.

Water flow (tidal current) changes (local)	High	High	Not sensitive
	Q: High A: Low C: High	Q: High A: High C: High	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 increased 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). All the biotopes within this biotope group are therefore considered to be 'Not sensitive'.

Emergence regime changes	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

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

Wave exposure changes (local)	High	High	Not sensitive
	Q: Low A: NR C: NR	Q: High A: High C: High	Q: Low A: Low C: Low

No empirical evidence was found to assess this pressure. Intertidal *Sabellaria spinulosa* are directly exposed to breaking waves and water movements generated by waves can also potentially affect subtidal *Sabellaria spinulosa* reefs. 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. As *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. 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'. Intertidal populations of *Sabellaria spinulosa* would be more exposed to the impacts of wave exposure but the corresponding biotopes for these habitats are not included in this assessment.

⚗ Chemical Pressures

	Resistance	Resilience	Sensitivity
Transition elements & organo-metal contamination	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.

	Resistance	Resilience	Sensitivity
Hydrocarbon & PAH contamination	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.

	Resistance	Resilience	Sensitivity
Synthetic compound contamination	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.

	Resistance	Resilience	Sensitivity
Radionuclide contamination	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

No evidence.

	Resistance	Resilience	Sensitivity
Introduction of other substances	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**.

	Resistance	Resilience	Sensitivity
De-oxygenation	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

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.

Nutrient enrichment

<table>
<tr><td>High</td><td>High</td><td>Not sensitive</td></tr>
<tr><td>Q: Low A: NR C: NR</td><td>Q: High A: High C: High</td><td>Q: Low A: Low C: Low</td></tr>
</table>

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

<table>
<tr><td>High</td><td>High</td><td>Not sensitive</td></tr>
<tr><td>Q: Medium A: High C: NR</td><td>Q: High A: High C: High</td><td>Q: Medium A: High C: Low</td></tr>
</table>

Limited direct evidence was found to assess the effects of this pressure. The presence and enhanced growth of *Sabellaria spinulosa* adjacent to a sludge dumping area in Dublin (Walker & Rees 1980) suggest that *Sabellaria spinulosa* reef biotopes are resistant to a high level of organic enrichment. Information on the levels of organic matter in Dublin Bay was 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 (up to 1 m/s from (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 in 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) and the biotope is considered to be 'Not Sensitive' at the pressure benchmark.

Physical Pressures

	Resistance	Resilience	Sensitivity
Physical loss (to land or freshwater habitat)	None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

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: Medium A: Low C: NR	Very Low Q: High A: High C: High	High Q: Medium A: Low C: Low

The introduction of artificial hard substratum or the exposure of natural hard substratum is considered at the pressure benchmark level and it is noted that *Sabellaria spinulosa* can colonise bedrock and artificial structures (Mistakidis, 1956). An increase in the availability of hard substratum may, therefore, be beneficial in areas where sedimentary habitats were previously unsuitable for colonisation.

Sensitivity assessment. Based on reported habitat preferences the species (rather than the biotope) is considered to be 'Not Sensitive' as the resulting habitat is suitable for the development of reefs (however these would be classified as a different biotope type). The resistance of the biotope 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**. The more precautionary assessment for the biotope, rather than the species, is presented in the table as it is considered that any change from a sedimentary habitat to a rock reef habitat would alter the biotope classification and hence the more sensitive assessment is appropriate.

Physical change (to another sediment type)	None Q: Medium A: Low C: NR	Very Low Q: High A: High C: High	Medium Q: Medium A: Low C: Low

Dredging and dumping of sediment and infrastructure developments can lead to changes in sediment character. The impact of the change will depend on the sediment changes that result. Foster-Smith (2001b) reported that the best *Sabellaria spinulosa* reefs identified in an area of the Wash were associated with ground clearly scarred by dredging activities. It is believed that this was most likely due to a reduction in the overburden of sand resulting in a substratum more suitable for reef formation (Foster-Smith, 2001b).

Sabellaria spinulosa biotopes that occur on mixed sediments are not considered to be affected by a change in sediment type of one Folk class that leads to a change to 'coarse sediments' characterized as gravel, sandy gravel or gravelly sand (based on the Long (2006) simplified Folk classification) or a change to sands and muddy sand as this species is found on sands (George & Warwick, 1985). It should be note, that changes in substratum type and water flows, that resulted in a loss of supply of suitable tube-building materials, would negatively impact this biotope. However, this biotope is considered to be negatively impacted by a change to the

fine sediment e.g. a change in the sediment classification to 'mud and sandy mud'. This assessment is based on the lack of records of reefs occurring on these sediment types and 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. Based on reported habitat preferences and evidence from Foster-Smith (2001b), where a change in one Folk class results in increased coarseness (e.g. a change to a coarse sediment of gravel, sandy gravel or gravelly sand) then the biotope is considered to be 'Not Sensitive' as the resulting habitat is suitable for this species. However, an increase in fine sediments to the degree that sediments are re-classified as mud or sandy mud would severely reduce habitat suitability. Therefore, resistance has been assessed as '**None**', resilience as **Very low** (the pressure is a permanent change), and sensitivity as **High.**

Habitat structure changes - removal of substratum (extraction)	None	Medium	Medium
	Q: High A: High C: High	Q: Medium A: High C: Medium	Q: High A: High C: High

The removal of sediment or substratum down to 30 cm depth is likely to remove the whole *Sabellaria spinulosa* reef within the extraction footprint. For example, no reefs were present in the active dredge zone when dredging was taking place at the Hastings Shingle Bank (Pearce *et al.*, 2007). Therefore resistance to this pressure is assessed as 'None'. However, if suitable substrata were to remain (as specified in the pressure benchmark), reef recovery would depend on larval settlement and survival.

Hill *et al.*, (2011) reviewed the recoverability of seabed sediments following marine aggregate extraction. Rapid recovery was reported in areas with high levels of sediment mobility (8 months) which is likely to include the habitat that *Sabellaria spinulosa* is commonly found in (Holt *et al.*, 1998). For example, in areas such as the Bristol Channel (where *Sabellaria spinulosa* is currently distributed), physical traces of dredging that had been carried out in mobile sandy habitats disappeared within a few tidal cycles (Newell *et al.*, 1998). Similarly, dredge tracks at an area of the North Sea exposed to high levels of wave action disappeared in less than a year (Hill *et al.*, 2011). With regards to *Sabellaria spinulosa* specifically, rapid recovery after the cessation of dredging has been observed at high dredging intensity zones in the Hastings Shine Bank area (new establishment observed in less than a year) (Pearce *et al.*, 2007).

Sensitivity assessment. As *Sabellaria spinulosa* reefs are present on the surface they will be directly removed by extraction of the sediment, resistance to this pressure is therefore assessed as 'None'. Resilience informed by (Pearce *et al.*, 2007) is considered to be 'Medium' to allow for the establishment of reef structure and the potential for variable recruitment and this biotope is therefore considered to have 'Medium' sensitivity to this pressure.

Abrasion/disturbance of the surface of the substratum or seabed	Low	Medium	Medium
	Q: Low A: NR C: NR	Q: Medium A: High C: Medium	Q: Low A: Low C: Low

Sabellaria spinulosa reef biotopes are directly exposed to physical damage that affects the surface. 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, localised 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 3m 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 sunbstratum, 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	Medium	Medium
	Q: Medium A: High C: High	Q: Medium A: High C: Medium	Q: Medium A: High 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 is considered to be 'Medium'.

Changes in suspended solids (water clarity)	High	High	Not sensitive
	Q: High A: Low C: High	Q: High A: High C: High	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) and 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 (see benchmark) *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 an increase or decrease at the pressure benchmark is therefore assessed as 'High' and resilience as 'High' (no impact to recover from).

Smothering and siltation rate changes (light)	High	High	Not sensitive
	Q: High A: Medium C: NR	Q: High A: High C: High	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 (2cm), medium (5cm) and deep (7cm). 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 ~1 mm 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	Medium	Medium
	Q: Low A: NR C: NR	Q: High A: Low C: High	Q: Low A: Low C: Low

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 ~1 mm 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 1 km 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^2 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.

Electromagnetic changes	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

No evidence.

Underwater noise 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

Not relevant.

Introduction of light or shading	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.

Barrier to species movement	Medium Q: Low A: NR C: NR	High Q: Medium A: Low C: Medium	Low 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.

Death or injury by collision	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'.

Visual disturbance	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
Genetic modification & translocation of indigenous species	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

Sabellaria spinulosa is not farmed or translocated and, therefore, this pressure is 'Not relevant' to this biotope.

Introduction or spread of invasive non-indigenous species	High	High	Not sensitive
	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 cinerea* 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. 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.

Sabellaria spinulosa reefs support a variety of attached epifauna including species of bryozoans, hydroids and sponges. As *Sabellaria spinulosa* reefs are known to support encrusting organisms without apparent adverse effect, the stalked sea squirt *Styela clava*, as a solitary sea squirt is considered unlikely to have greater negative impacts than native species.

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 *Crassostrea 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 (Diederich, 2005; 2006) 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 *Magallana 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.

Introduction of microbial pathogens	No evidence (NEv)	Not relevant (NR)	No evidence (NEv)
	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.*

Removal of target species	High	High	Not sensitive
	Q: Low A: NR C: NR	Q: High A: High C: High	Q: Low A: NR C: NR

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) reviewed 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) and given the diverse range of substrata that *Sabellaria spinulosa* have been reported in (see physical change pressure below) it is unlikely that the removal of scallops will 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. Assessment of this indirect effect is limited by the lack of empirical evidence for predator-prey relationships. *Sabellaria spinulosa* reefs appear to be important nursery areas for commercially targeted flat fish including Dover sole (Bryony Pearce, *pers comm*). Stomach analysis of fish by Pearce (2011b) found that juvenile flatfish captured in reef areas including Dover sole, dab and plaice fed preferentially on *Sabellaria spinulosa*. Where these species are removed as target species (or as by-catch, given that commercial fisheries are unliklely to focus on juveniles), then predation rates on *Sabellaria spinulosa* could be reduced.

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	None	Medium	Medium
	Q: Low A: NR C: NR	Q: High A: Medium C: High	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, butterfish *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 *Sabellaria 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. A further potential interaction has been identified between *Sabellaria spinulosa* and the sand mason *Lanice conchilega*. It has been observed that sand stabilised by the sand mason *Lanice conchilega* is stable enough for colonization by *Sabellaria alveolata* (Larsonneur *et al*. 1994). It is believed that the same may also be possible for *Sabellaria spinulosa*, as *Lanice conchilega* and *Sabellaria spinulosa* are sometimes found together (Holt *et al*. 1997). However, a decline in *Sabellaria spinulosa* numbers was coincident with an increase in *Lanice conchilega* numbers (see Limpenny *et al*., 2010 and references therein). It is not clear from the available evidence therefore whether removal of *Lanice conchilega* would have any impact on *Sabellaria spinulosa* reefs (Foster-Smith 2001a).

Sensitivity assessment.The biogenic structure created by the *Sabellaria spinulosa* worms is the key characterizing feature of this biotope. 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' recovery. Sensitivity is, therefore 'Medium'.

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