Sabellaria alveolata on variable salinity sublittoral mixed sediment

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

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The Marine Life Information Network, Marine Biological Association of the United Kingdom.

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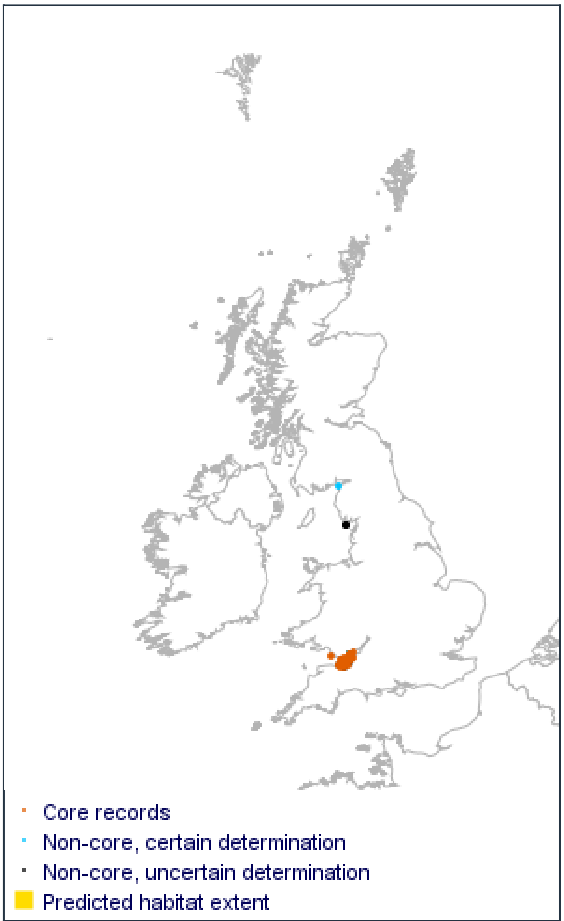

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Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Dr Heidi Tillin **Refereed by** Dr Andrew Davies

Summary

UK and Ireland classification

EUNIS 2008	A5.612	*Sabellaria alveolata* on variable salinity sublittoral mixed sediment
JNCC 2015	SS.SBR.PoR.SalvMx	*Sabellaria alveolata* on variable salinity sublittoral mixed sediment
JNCC 2004	SS.SBR.PoR.SalvMx	*Sabellaria alveolata* on variable salinity sublittoral mixed sediment
1997 Biotope		

Description

Tide-swept sandy mixed sediments with cobbles and pebbles, in variable salinity or fully marine conditions, may be characterized by surface accumulations of the reef building polychaete *Sabellaria alveolata*. The presence of *Sabellaria* sp. has a strong influence on the associated infauna as the tubes bind the surface sediments together and provide increased stability. Such reefs may form large structures up to a metre in height although they are considerably less extensive than the intertidal reefs formed by this species (Salv). Other associated species may include the polychaete *Melinna cristata*, itself often as dense aggregations, mobile surface feeding polychaetes including *Typosyllis armillary* and *Eulalia tripunctata*. Other polychaetes may include *Mediomastus fragilis* and *Pygospio elegans* whilst amphipods such as *Harpinia pectinata* and tubificid oligochaetes may also be found (Connor *et al.*, 2004).

Depth range

0-5 m, 5-10 m

Additional information

-

Listed By

- none -

Further information sources

Search on:

G G JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

As *Sabellaria alveolata* is the species that creates the reef habitat the sensitivity assessments are based on *Sabellaria alveolata* 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 the reef biotopes which provide habitat and food resources, these associated species occur in a range of other biotopes and are therefore not considered to be species characterizing the sensitvity of this biotope. The reef and individual *Sabellaria alveolata* worms are not dependent on associated species to create or modify habitat, provide food or other resources.

Resilience and recovery rates of habitat

Empirical evidence to assess the likely recovery rate of *Sabellaria alveolata* reefs from impacts is limited and significant information gaps regarding recovery rates, stability and persistence of *Sabellaria alveolata* reefs were identified for the biotope LS.LBR.Sab.Salv. No evidence was found regarding recovery of subtidal *Sabellaria* reefs on sediment and the resilience assessments are based on evidence for intertidal or shallow subtidal reefs on rock. Although the recovery mechanisms and life-history information should be applicable, the more limited extent of subtidal biotopes may restrict larval supply and the biotope will be more affected by sediment and water column conditions.

Studies carried out on reefs of *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. 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. Although it should be noted that these recovery rates are as a result of short-term effects following once-only disturbance. 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, severe 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.

Where reefs are extensively removed, recovery will rely on recolonization of the site by larvae. *Sabellaria alveolata* are gonochoristic (sexes separate), reproductive maturity is reached within the first year of life and the species reproduces by external fertilisation of shed gametes. The larvae are free-living within the plankton where they are transported by water movements. Some control over dispersal may be exerted through vertical migration in the water column allowing exposure to different current speeds during daily tidal cycles. *Sabellaria alveolata* larvae can be stimulated to settle by the presence of adult tubes, tube remnants or the mucoid tubes of juveniles (Quian, 1999). The presence of living *Sabellaria alveolata* or tubes therefore will promote the recovery of reefs and their absence may delay recovery of otherwise suitable habitats. Although larvae may be present every year the degree of settlement varies annually. In 14 years of observations (1961 to 1975), Wilson (1976) observed only three heavy settlements, in North Cornwall in 1966, 1970 and

1975 and all were in the period from September to November or December. Observations from other populations agree that intensity of settlement is extremely variable from year to year and place to place (Cunningham *et al*., 1984; Gruet, 1982). Settlement occurs mainly on existing colonies or their dead remains. Chemical stimulation seems to be involved, and this can come from *Sabellaria spinulosa* tubes as well as *Sabellaria alveolata* (Cunningham *et al*., 1984; Gruet, 1982; Wilson, 1971).

The spawning season and duration of the planktonic phase appear to be variable with authors reporting conflicting results from different populations. Dubois *et al*. (2007) found larvae in the plankton at Bay of Mont-Saint-Saint Michel (France) from the end of April to October, with peak spawning occurring in May, followed by a smaller spawning peak in September. Mean planktonic lifetime was calculated between 4 and 10 weeks from samples taken within the bay (Dubois *et al*. 2007). These observations fit broadly with those of Gruet and Lassus (1983, cited from Dubois *et al*. 2007) who indicated two long spawning periods for a population along the French Atlantic coast (Noirmoutier Island): March to April and June to September. In the Bassin d'Arcachon (French Atlantic coast), *Sabellaria alveolata* larvae were reported in plankton samples mainly from October to March (Cazaux 1970, cited from Dubois et al. 2007), with an estimated larval lifespan of about 12 weeks. However, Wilson (1971) reported a short, single spawning period in July in North Cornwall and suggested that larvae spent between 6 weeks and 6 months in the plankton (Wilson, 1968; Wilson, 1971) so that dispersal could potentially be widespread. Culloty *et al*. (2010) observed one main spawning period by populations in south-west Ireland that was more protracted (June to September) than that observed in North Cornwall by Wilson. Differences between spawning regimes may be due to different water temperatures, where conditions for more northern population are less favourable to this southern species (Culloty *et al*., 2010).

Growth is rapid, and is promoted by high levels of suspended sand and by higher water temperatures up to 20°C. A mean increase in tube length of up to 12 cm per year has been reported for northern France (Gruet, 1982). Cunningham *et al*. (1984) stated that growth is probably lower than this in Britain due to the lower water temperatures, although Wilson (1971) reported growth rates (tube length) of 10-15 cm per year in several colonies at Duckpool, North Cornwall for first year colonies, and around 6 cm in second year colonies. Wilson (1971) reported that in good situations the worms mature within the first year, spawning in the July following settlement.

A typical lifespan for worms in colonies forming reefs on bedrock and large boulders in Duckpool was 4-5 years (Wilson, 1971), with a likely maximum of around 9 years (Gruet, 1982; Wilson, 1971). Intertidal reefs are dynamic. Dubois et al. (2002 and 2006) described three reef forms, where ball-shaped structures created by newly-settled juveniles later merge to form larger reef platforms, which then decline to become fissured degraded reefs. Wilson (1976) observed one small reef from its inception as three small individual colonies in 1961, through a period between 1966 and 1975 where it existed as a reef rather greater than one metre in extent and up to 60 cm thick, with major settlements of worms occurring in 1966 and 1970. In the long-term, areas with good *Sabellaria* reef development tend to remain so. In Ireland, Simkanin *et al*. (2005) reported no significant change in the intertidal abundance of this species from 1958 to 2003, on the 28 shores compared around the coast.

Resilience assessment. The evidence for recovery rates of *Sabellaria alveolata* reefs from different levels of impact is very limited, for most pressures there are no examples of rates at which reefs recover from different levels of impact. Recovery rates are likely to be determined by a range of factors such as degree of impact, season of impact, larval supply and local environmental factors including hydrodynamics and sediment stability and supply.

Observations by Vorberg (2000) and Cunningham *et al.*, (1984) suggest that areas of limited damage on a *Sabellaria alveolata* reef can be repaired rapidly (within weeks) through the tube-building activities of adults. The assessment of resilience in this instance is 'High', indicating that recovery could occur within 2 years but is relatively precautionary. Predicting the rate of recovery following extensive removal of existing *Sabellaria alveolata* reef is more problematic. Some thin crusts may be 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). 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). Where resistance is assessed as 'Medium', resilience is considered to be 'High', based on repair and rapid recolonization facilitated by adults, but recovery from significant impacts (where resistance is assessed as 'None' or 'Low') is predicted to be 'Medium' (2-10 years).

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 Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

Sabellaria alveolata are a southern species reaching their northern limit in Britain and Ireland and whose global distribution extends south to Morocco (Gruet, 1982). Studies at Hinkley Point, Somerset, found that growth of the tubes in the winter was considerably greater in the cooling water outfall, where the water temperature was raised by around 8-10 °C, than at a control site, although the size of the individual worms themselves seemed to be unaffected (Bamber & Irving, 1997). Dubois *et al.* (2007) observed that in autumn where water temperatures are 8 °C higher than in spring, a shorter period was required for larvae to metamorphose.

Differences between spawning regimes which may be due to different water temperatures have been observed, where conditions for more northern population are less favourable and lead to single annual spawning events of shorter duration (Culloty *et al.*, 2010). Intertidal populations of *Sabellaria alveolata* are susceptible to low temperatures in winter.

Sensitivity assessment. Based on distribution and temperature enhancement of duration and frequency of spawning, metamorphosis and growth rates, *Sabellaria alveolata* is considered to be 'Not sensitive' to an increase in temperature at the pressure benchmark (resistance and resilience are therefore both considered to be 'High').

Temperature decrease (local)	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

Sabellaria alveolata are a southern species reaching their northern limit in Britain and Ireland. Studies at Hinkley Point, Somerset, found that growth of the tubes in the winter was considerably greater in the cooling water outfall, where the water temperature was raised by around 8-10 °C, than at a control site, although the size of the individual worms themselves seemed to be unaffected (Bamber & Irving, 1997).

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Sensitivity assessment. Based on distribution and reported temperature effects on duration and frequency of spawning, metamorphosis and growth rates. The effects of acute decreases in temperature at the benchmark will depend on the seasonality of occurrence. Decreases in winter are likely to stress populations more than decreases in summer (although there may be effects on larval supply). At the centre of their UK range, adult *Sabellaria alveolata* are considered to have 'High' resistance to both an acute and chronic change at the pressure benchmark as subtidal populations will be buffered from large changes in temperature and protected from frost.

Salinity increase (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 the impact of increases in salinity on subtidal, reef forming populations. This biotope occurs in areas of variable salinity from 18-35 ppt (Connor *et al.*, 2004). Based on the tolerance of intertidal populations for full salinity is is likely that this biotope would not be sensitive to a change to full salinity. However, it should be noted that reefs could be sensitive to hyper saline conditions above this benchmark. Quintino *et al.* (2008) examined through laboratory experiments the sub-lethal endpoints of brine exposure on *Sabellaria alveolata* larvae. Natural seawater where salinities had been increased using commercial salts used to prepare artificial seawater were used as the control. At a salinity of 36 (natural seawater artificially concentrated) 20% of *Sabellaria alveolata* developed abnormally, at a salinity of 40 this increased to about about 70% of the larvae developed abnormally, clearly indicating the effect of increasing salinity on larvae. Although not directly relevant to the pressure benchmark the experiments do suggest that increasing salinity would lead to sub-lethal effects on larvae. It is not clear how these supply effects would ramify at the population level. Recruitment success varies between years (see resilience information) and a shortfall in one year may be compensated in another year when salinity returns to normal, providing the source population is unaffected.

Sensitivity assessment. This biotope has only been recorded from areas of variable salinity but intertidal reefs are present in areas of full salinity (Connor *et al.*, 2004), it is therefore considered that subtidal reefs would have a similar tolerance, resistance is therefore assessed as 'High' and resilience as 'High' (by default). This biotope is therefore considered to be 'Not sensitive'.

Salinity decrease (local)	Low Q: Low A: NR C: NR	Medium Q: High A: Low C: Medium	Medium Q: Low A: Low C: Low

It is likely that *Sabellaria alveolata* can tolerate small declines in salinity as it occurs intertidally where freshwater inputs may lower salinity, either on a semi-permanent basis where rivers discharge into estuaries and bays, or where rainfall and land run-off cause an acute lowering of salinity. In the Bay of Mont-Saint-Michel , for example, where large reefs are found salinities are lower (at <34.8) than in the open sea. (Dubois *et al*., 2007). This biotope is reported to occur in areas experiencing variable salinity (Connor *et al*., 2004). Lancaster (1993, cited from Holt *et al*., 1998) also found extensive, healthy hummocks of *Sabellaria* at Drigg, Cumbria, where there is a large freshwater input from the Drigg BNFL plant. However, based on a lack of records from habitats experiencing reduced (18-30ppt) or Low (18ppt) salinity regimes this biotope is considered likely to be sensitive to reduced salinity at the benchmark level.

Sensitivity assessment. Based on distribution with only occasional records within estuaries, this biotope is considered likely to be sensitive at the lower limits of the pressure benchmark (a change to reduced or low salinity; 18-35ppt or <18 ppt). Resistance is therefore assessed as 'Low', as a reduction in salinity at the pressure benchmark is considered to result in the loss of most of the reef. Resilience (following habitat recovery) is assessed as 'Medium'. Sensitivity is therefore 'Medium'. The observed distribution of this biotope may be based on other factors than salinity, such as availability of suitable sediments, and confidence in this assessment is low.

Water flow (tidal current) changes (local)	High Q: High A: High C: Medium	High Q: High A: High C: High	Not sensitive Q: High A: High C: Medium

Water flow will be a key driver of habitat suitability for subtidal *Sabellaria alveolata*, due to the requirement for suspended sand for tube building and the supply or organic particles for food. Tests on the mechanical strength and properties of *Sabellaria alveolata* tubes were performed by Le Cam *et al*. (2011). These found that the biomineralised cement the worms produce to cement sand grains to form tubes confer wave resistance. Although thresholds of resistance are not known, the visco-elastic behaviour of the cement enables tubes to dissipate the mechanical energy of breaking waves and presumably also confers resistance to increased water flow rates (Le Cam *et al*. 2011).

In general sediment re-suspension and transport models indicate that sands are suspended by currents around 0.20-0.25 m/s and will stay in suspension until flow drops below 0.15-0.18 m/s (ref). *Sabellaria alveolata* may be relatively insensitive to changes above these flow rates (although the upper tolerance limit is not clear). In sheltered habitats where the water flow rates are approaching the lower limits of water flow tolerance a further reduction at the pressure benchmark may have negative impacts. Desroy *et al*., (2011) suggested that modifications to hydrodynamics (where current speed decreased downstream of new mussel farming infrastructure installations facing the reef) indirectly impacted sedimentary patterns and led to increased silt deposition resulting in the deterioration of *Sabellaria alveolata* reefs in the Bay of Mont-Saint Michel, France.

Tillin (2010) used logistic regression to develop statistical models that indicate how the probability of occurrence of *Sabellaria alveolata* changes over environmental gradients within the Severn Estuary. 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 the results should be interpreted with caution, the modelled habitat suitability for *Sabellaria alveolata* indicates that the range of water flow tolerances is relatively broad.

Changes in water flow potentially also have implications for larval transport and recruitment. *Sabellaria alveolata* is generally absent from very exposed peninsulas such as the Lleyn, Pembrokeshire and the extreme south west of Cornwall, which probably relates to the effect of water movement on recruitment (Cunningham *et al*., 1984, cited from Holt *et al*. 1998). However, behavioural responses by larvae to different flow rates may result in some control over movement. Dubois *et al.* (2007) observed vertical migration of *Sabellaria alveolata* larvae during the tidal cycle, where larvae migrate upwards in the water column to faster near-surface currents and migrate down the water column on the ebb flow to where currents are weaker. This migration enhances landward transport of larvae to more suitable habitats and prevents seaward loss.

Sensitivity assessment. 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 impacts although Tillin (2010) modelled optimal flow speeds of 0.5-1.22 m/s. 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 optimal range. Similarly a reduction in flow may reduce supply of tube-building materials and food but again, given the range of reported tolerances a change at the pressure benchmark, mid-range 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) 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 fully subtidal habitats The shoreward fringes are unlikely to be sensitive to increased emergence as reefs of *Sabellaria alveolata* are found in the intertidal.

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

As the reefs are subtidal they are protected from breaking waves, although wave action may lead to oscillatory water movements at the reef surface. Connor *et al.* (2004) indicate that this biotope is found in locations that vary from wave exposed to sheltered indicating a broad tolerance to a range of wave heights (as wave height is broadly correlated with the degree of wave exposure). Tests on the mechanical strength and properties of *Sabellaria alveolata* tubes found that the biomineralised cement the worms produce to cement sand grains to form tubes confer wave resistance preventing the reef from breaking (Le Cam *et al*. 2011).

Sensitivity assessment. At the pressure benchmark, *Sabellaria alveolata* are considered to be able to mechanically withstand an increase in wave exposure and to be unaffected by a decrease. The biotope group is therefore considered to be 'Not Sensitive' at the pressure benchmark (resistance and resilience are assessed as 'High' by default).

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.

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.

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.

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

Mauchline *et al*. (1964) examined concentration of radioactive isotopes by organisms on Windscale beach. *Sabellaria alveolata* built reefs with the smaller particles on the beach which adsorb the greatest amount of radioactivity per weight (due to surface-area effects). Thus *Sabellaria* reefs could concentrate radioactivity. However, the study by Mauchline *et al.* (1964) did not look for or identify any potential negative effects on the worms such as changes in reproductive success or mortality rates.

Sensitivity assessment. No evidence.

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.**

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

No direct evidence was found to assess this pressure.

Nutrient enrichment	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

No evidence was found to assess this pressure, however the benchmark is relatively protective and the worms may benefit from localised increases in phytoplankton supported by enrichment and are unlikley to be affected by opprtunistic algae due to depth and suspended sediment concentrations. Resistance is therefore assessed as 'High' and resilience as 'HIgh' (by default). The biotope is therefore considered to be 'Not sensitive'.

Organic enrichment	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

No 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 alveolata* would be able to consume re-suspended particulate organic matter. This conclusion is supported by the enhanced growth rates observed in the congener *Sabellaria spinulosa* 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), resulting in a sensitivity of 'Not sensitive'.

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 and the rate and confidence in resilience are not assessed.

Physical change (to another seabed type)	None Q: Low A: NR C: NR	High 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 bedrock and artificial structures in the intertidal. An increase in the availability of hard substratum may therefore be beneficial in areas where sedimentary habitats were previously unsuitable for colonization.

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. 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 to a sedimentary habitat from 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: High A: Low C: Medium	Very Low Q: High A: High C: High	High Q: High A: Low C: Medium

Sabellaria alveolata biotopes that occur on mixed sediments are not considered to be affected by a change in sediment type of 1 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 an intertidal *Sabellaria alveolata* reefs are found on this species is found on sands (George & Warwick 1985). Larsonneur *et al.* (1984), working in the Bay of St Michel in Normandy, noted that the sand mason *Lanice conchilega* can stabilize sand well enough to allow subsequent colonization by *Sabellaria alveolata*. Settlement is also enhanced by the presence of existing colonies or their dead remains (Holt *et al.* 1998).

This biotope is, however, considered to be negatively impacted by a change to the finest sediment class e.g. a change in the sediment classification to 'mud and sandy mud' (based on the Long, (2006) classification). 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 (2001), 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, although the biotope character would alter. A change in sediments would alter the biotope and an increase in fine sediments to the degree that sediments are re-classified as mud or sandy mud would severely reduce habitat suitability for the species. Biotope resistance to a change in fine sediments or sediment type is, therefore, assessed as 'None' (loss of >75% of extent), resilience as Very low (the pressure is a permanent change), and sensitivity as High.

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

The removal of substratum down to 30 cm depth is likely to remove the whole *Sabellaria alveolata* reef within the extraction footprint. At an expert workshop convened to assess the sensitivity of marine features to support MCZ planning, *Sabellaria alveolata* reefs were assessed as having no resistance to extraction of the feature (benchmark was the removal of feature/substratum to 50 cm depth) (Tillin *et al.* 2010).

Sensitivity assessment. As *Sabellaria alveolata* reefs are surface features they will be directly removed by extraction of the reef to 30 cm depth. Resistance to this pressure is, therefore, assessed as 'None'. Resilience 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. Confidence in this assessment is assessed as 'High' due to the incontrovertible nature of the pressure.

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

Impacts of surface abrasion from fishing trawls and trampling have been investigated on shallow subtidal and intertidal reefs and the evidence is considered applicable to the subtidal biotopes. 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 although the trawl had left impressions and 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. These recovery rates are as a result of short-term effects following once-only disturbance. Cunningham *et al.* (1984) examined the effects of trampling on *Sabellaria alveolata* reefs. The reef recovered within 23 days from the effects of trampling, (i.e. treading, walking or stamping on the reef structures) repairing minor damage to the worm tube porches. However, severe damage, estimated 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.

Sensitivity assessment. Based on the evidence above resistance to abrasion was assessed as 'Medium' as the tubes are able to withstand some damage and be rebuilt, recovery to a single event was considered to take place through tube repair by adults so recovery was assessed as 'High' and sensitivity was categorised as 'Low'. The scale and intensity of impacts would influence the level of resistance and the mechanism of recovery. Where reefs suffer extensive spatial damage requiring larval settlement to return to pre-impact conditions then recovery would be prolonged (years).

Penetration or disturbance of the substratum subsurface	Low Q: Low A: NR C: NR	Medium Q: High A: Medium C: Medium	Medium Q: Low A: Low C: Low

This pressure will result in the surface disturbance effects outlined above but effects will be compounded by the penetration and sub-surface damage aspect of this pressure. No empirical evidence was found to assess impacts however it is considered that the deeper and more significant the damage, the higher the risk of removing complete tubes and limiting recovery of the reefs.

Sensitivity assessment. Based on the evidence cited above for abrasion, resistance was assessed as 'Low' (taking into account deeper penetration of the disturbance), recovery was assessed as 'Medium' (2-10 years) to take into account that larval recruitment may be necessary for the reef structure to recover although small, localised areas of repair would take place within months.

Sensitivity is therefore assessed as 'Medium'.

Changes in suspended solids (water clarity)	Low Q: Medium A: Low C: Medium	Medium Q: High A: Low C: Medium	Medium Q: Medium A: Low C: Medium

Sabellaria alveolata do not rely on light penetration for photosynthesis and their visual perception is believed to be limited. Changes in light penetration or attenuation associated with this pressure are, therefore, not relevant to the *Sabellaria alveolata* reef biotope. However alterations in the availability of suspended organic matter that can be used as food and the availability of suspended sediment for tube building could either increase or decrease habitat suitability for *Sabellaria alveolata* reefs.

The effect of increased seston concentration on *Sabellaria alveolata* clearance rates was investigated by Dubois *et al.* (2009). The range of experimental suspended particulate matter (SPM) concentrations (65-153.8 mg/l) correspond to clear to medium turbidity at the pressure benchmark scale. The number of polychaetes actively feeding increased between SPM 6.5-12.3 mg/l and no change was observed between SPM 12.3 and 55.5 mg/l. At higher levels of SPM clearance rates were reduced, the decline in filter feeding efficiency (measured as a clearance rate) declined at around SPM 45 mg/l and thereafter remained relatively stable.

Tillin (2010) used logistic regression to develop statistical models that indicate how the probability of occurrence of *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. The upper levels of these modelled optima broadly correspond with observations by Cayocca *et al.* (2008, cited in Dubois *et al.* 2009) who recorded SPM peaks ranging between 200 and 1000 mg/l depending on the flow and ebb conditions, in the vicinity of the largest *Sabellaria alveolata* reef in the Bay of Mont-Saint-Michel. Outside of these peaks the SPM remained around 50 mg/l the level at which Dubois *et al.* (2009) recorded changes in clearance rate.

Sensitivity assessment. *Sabellaria alveolata* is adapted to turbid systems and can maintain its filtering activity under high seston loads (Dubois *et al.*, 2009). A supply of suspended sediment is a requirement for the development of reefs (Cunningham *et al.* 1984). Based on Cayocca *et al.* (2008, cited in Dubois *et al.*, 2009) the normal range of SPM in which *Sabellaria alveolata* reefs occur is probably in the intermediate range (based on UKTAG, 2014 ranks). It is therefore considered that *Sabellaria alveolata* reef biotoes are 'Not sensitive' to increases in peak suspended sediment concentration to the medium turbidity level (100-300 mg/l) at the pressure benchmark . However, if the increase was constant then reductions in filtration efficiency may negatively affect a proportion of the population , resistance was therefore assessed as 'Medium' and recovery as 'High' following habitat recovery. Sensitivity is therefore considered to be 'Low'. But, a reduction from intermediate levels to clear (<10 mg/l) where the reduction is due to a reduced supply of organic matter and particulate matter suitable for tube building and food may restrict reef development and reduce the food supply to this species. Resistance was assessed as 'Low' and recovery as 'Medium' so that overall sensitivity is considered to be 'Medium'.

Smothering and siltation rate changes (light)	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

Sabellaria alveolata was reported to survive short-term burial for days and even weeks in the south west of England as a result of storms that altered sand levels up to two meters. They were, however killed by longer-term burial (Earll & Erwin 1983). In Brittany intensive mussel cultivation on ropes wound around intertidal oak stakes affected nearby *Sabellaria alveolata* reefs by smothering with faeces and pseudofaeces, though it was not clear if this resulted in any harm (cited from Holt *et al.* 1998, no reference given). It should be noted that if siltation is associated with altered water flows to allow accumulation, then long-term habitat suitability for this species would be unfavourably altered .

Sensitivity assessment. Where siltation does occur, currents are likely to rapidly remove silty deposits. As reefs have some resistance to periodic smothering and burial, resistance to siltation is assessed as 'High' and recovery as 'High', so that this biotope is considered to be 'Not Sensitive'.

Smothering and siltation rate changes (heavy)	Low Q: High A: Low C: Low	Medium Q: High A: Low C: Medium	Medium Q: High A: Low C: Low

Sabellaria alveolata was reported to survive short-term burial for days and even weeks in the south west of England as a result of storms that altered sand levels up to two meters. they were, however killed by longer-term burial (Earll & Erwin 1983). *Sabellaria alveolata* has been identified as sensitive to changes in sediment regime in the Mediterranean Gulf of Valencia, Spain, where *Sabellaria alveolata* populations were lost as a result of sand level rise resulting from the construction of seawalls, marinas/harbours, and beach nourishment projects (Porras *et al.*, 1996). It is likely that the length of survival, while dependent on length of burial, may be influenced by temperatures and oxygen levels so that seasonality and the depth and character of overburden partially determine sensitivity.

Sensitivity assessment. Natural events such as storms may lead to episodic burial by coarse sediments with subsequent removal by water action and the degree of mortality will depend on a number of factors including the length of burial. As fine sediments may be relatively cohesive and as water and air penetration is limited the addition of an overburden of 30 cm is considered to potentially lead to some mortality if large areas are impacted. Resistance is therefore assessed as 'Low' and recovery is assessed as 'Medium', and sensitivity to this pressure is 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	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.

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

Barriers that reduce the degree of tidal excursion may reduce the supply of *Sabellaria alveolata* larvae moving landwards to suitable habitats from source populations. However the presence of barriers may enhance local population supply by preventing the seaward loss of larvae. The residual tidal currents in Bay of Mont-Saint-Saint Michel (France) naturally prevent the loss of larvae from the bay and are believed to enhance settlement locally (Dubois et al., 2007). 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'.

Death or injury by collision	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 seabed habitats. NB. Collision by grounding vessels is addressed under 'surface abrasion'.

Visual disturbance	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.

Biological Pressures

	Resistance	Resilience	Sensitivity

Genetic modification & translocation of indigenous species	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 alveolata is not farmed or translocated, therefore this pressure is 'Not relevant'.

Introduction or spread of invasive non-indigenous species	Medium Q: High A: High C: Medium	High Q: Medium A: Medium C: Medium	Low Q: High A: Low C: Medium

Sabellaria alveolata reefs in the shallow subtidal may be colonized by the non-native pacific oyster, *Magallana gigas*, In the Bay of Mont Saint-Michel, France, Dubois *et al*. (2006) found that *Magallana gigas* had escaped from adjacent aquaculture facilities and were growing on *Sabellaria alveolata* reefs. Diversity of associated species was highest on the reefs with oysters. There were also some differences in the age structure of these reefs suggesting that there may have been negative effects on *S. alveolata* recruitment. Studies have suggested that *Crassostrea gigas* could increase the probability of interception of *Sabellaria alveolata* larvae sinking or swimming down to the water column, as demonstrated by flume settlement experiments and models (Soniat e*t al*., 2004) a potential beneficial effect. However, Green & Crowe (2013) conducted manipulative experiments in the intertidal where live and dead *Crassostrea gigas* were attached to boulders and observed that the presence of living and dead shells reduced settlement of *Sabellaria alveolata* in comparison with control boulders.*Crassostrea gigas* may smother *Sabellaria alveolata by* growing over the tube ends and could out-compete the larvae, juveniles, and adults for space. In addition, *Crassostrea gigas* and *Sabellaria alveolata* are both suspension feeders, and they ingest food particles in the same size range (Dubois *et al*., 2003). Oysters have high filtration rates, suggesting that they may out-compete *Sabellaria alveolata* for food (Dubois *et al*. 2006).

Sensitivity assessment. This assessment is based on smothering by *Crassostrea gigas* as no evidence was found for impacts arising from other non-indigenous species, little specific evidence was found on impacts, resistance is assessed as 'Medium' and resilience as 'High' when *Crassostrea gigas* are removed, so that sensitivity is considered to be 'Low'.

Introduction of microbial pathogens	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 found for pathogens or diseases impacting *Sabellaria alveolata*.

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

Sabellaria alveolata biotopes may be removed or damaged through contact with static or mobile gears that are targeting other species. These direct, physical impacts are assessed through the abrasion and penetration of the seabed pressures. No evidence was found for trophic or other ecological interactions between commercially targeted species and *Sabellaria alveolata*.

Sensitivity assessment. As *Sabellaria alveolata* is not commercially targeted the habitat is assessed as 'Not Sensitive'. Resistance is therefore assessed as 'High', resilience as 'High' and sensitivity as 'Not sensitive'.

Removal of non-target species	None Q: Low A: NR C: NR	Medium Q: High A: Medium C: Medium	Medium Q: Low A: Low C: Low

Sabellaria alveolata 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. *Sabellaria alveolata* creates the biogenic reefs that characterise this biotope, removal of this species as by-catch would therefore remove the biotope. No evidence was found for key trophic or other ecological interactions between other species within the biotope and *Sabellaria alveolata*.

Sensitivity assessment. Removal of the worms and tubes as by-catch would remove the biotope and hence this group is considered to have 'None' resistance to this pressure and to have 'Medium' recovery. Sensitivity is therefore 'Medium'.

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