Kurtiella bidentata and *Thyasira* spp. in circalittoral muddy mixed sediment

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

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2016-06-01

This review can be cited as:
De-Bastos, E. & Marshall, C.E. 2016. [Kurtiella bidentata] and [Thyasira] spp. in circalittoral muddy mixed sediment. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. DOI https://dx.doi.org/10.17031/marlinhab.374.1

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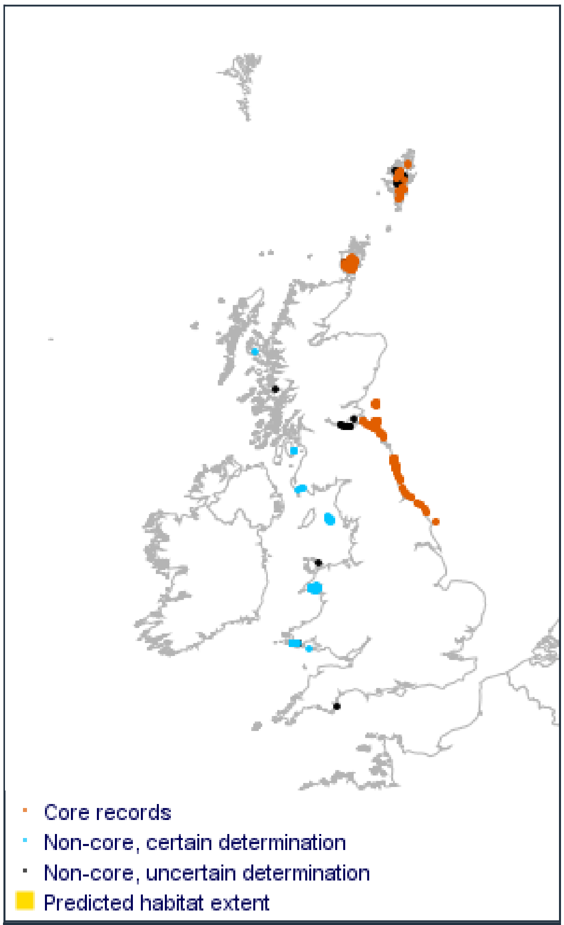

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Eliane De-Bastos & Charlotte Marshall **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A5.443	*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment
JNCC 2015	SS.SMx.CMx.KurThyMx	*Kurtiella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment
JNCC 2004	SS.SMx.CMx.MysThyMx	*Mysella bidentata* and *Thyasira spp.* in circalittoral muddy mixed sediment
1997 Biotope	SS.CMS._.AfilEcor	*Amphiura filiformis* and *Echinocardium cordatum* in circalittoral clean or slightly muddy sand

Description

In moderately exposed or sheltered, circalittoral muddy sands and gravels a community characterized by the bivalves *Thyasira* spp. (often *Thyasira flexuosa*), *Mysella bidentata* and

Prionospio fallax may develop. Infaunal polychaetes such as *Lumbrineris gracilis*, *Chaetozone setosa* and *Scoloplos armiger* are also common in this community whilst amphipods such as *Ampelisca* spp. and the cumacean *Eudorella truncatula* may also be found in some areas. The brittlestar *Amphiura filiformis* may also be abundant at some sites. Conspicuous epifauna may include encrusting bryozoans *Escharella* spp. particularly *Escharella immersa* and, in shallower waters, maerl (*Phymatolithon calcareum*), although at very low abundances and not forming maerl beds (JNCC, 2015)

Depth range

10-20 m, 20-30 m, 30-50 m, 50-100 m

Additional information

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Listed By

- none -

Further information sources

Search on:

G G JNCC

Habitat review

Ecology

Ecological and functional relationships

Deposit feeding and filter feeding represent the two fundamental feeding methods among the fauna of mud and sand (Eltringham, 1971). The community associated with SS.SMx.CMx.MysThyMx is dominated by deposit feeders such as *Scoloplos armiger*, *Prionospio fallax*, *Chaetozone setosa*, *Spiophanes bombyx* and *Owenia fusiformis* that exploit the high levels of organic material. Polychaete worms are dominant infaunal predators that actively pursue prey and are generally opportunistic although they may have size preferences (Elliott *et al.*, 1998). *Nephtys* sp. are usually considered to be carnivorous although they may also scavenge dead material. Both *Nephtys* spp. and *Lumbrineris fragilis* may feed on the larvae of *Kurtiella bidentata* (Ockelmann & Muus, 1978). Other carnivorous worms include *Pholoe inornata* and *Goniada maculata*. Sandier sediment will contain animals such as *Amphiura filiformis*, the large tube dwelling polychaete *Lanice conchilega* and other polychaetes such as *Goniada maculata* (Hughes, 1998b). *Amphiura filiformis* is both a suspension and deposit feeder. It feeds on suspended material in flowing water, but will change to deposit feeding in stagnant water or areas of very low water flow (Ockelmann & Muus, 1978). It feeds on faecal pellets, diatoms, zooplankton and bits of meat (Ockelmann & Muus, 1978). In coarser sediment assemblages, the proportion of suspension feeding species will increase. Other suspension feeders include the bivalves *Kurtiella bidentata* and *Thyasira* sp. which characterize the biotope. *Kurtiella bidentata* has also been described as an indirect deposit feeder (O'Foighill *et al.*, 1984). *Thyasira flexuosa* has endosymbiotic bacteria within its gills which probably contribute to its nutrition (López-Jamar *et al.*, 1987).

Kurtiella bidentata is a very small (ca 3 mm) bivalve. Ockelmann & Muus (1978) reported a significant association between *Kurtiella bidentata* and *Amphiura filiformis*. The bivalve lives in the oxidized layers around the brittlestar's burrow. Not only does this offer the bivalve protection from surface predators but it can steal food collected by *Amphiura filiformis* thereby offering it an additional food source (Ockelmann & Muus, 1978). The depth distribution of *Kurtiella bidentata* was found to depend on that of the *Amphiura* although in shallow depths in sandy bottoms, and without *Amphiura*, the bivalve is free-living. The authors also reported that in shallower water without the *Amphiura*, mortality rate was so high that the number of larvae produced was smaller than the numbers of larvae actually settling in a deeper assemblage with *Amphiura*. *Kurtiella bidentata* rarely leaves the burrow of its host. It is possible that it may survive without its normal host species but probably only if another host species is found that also benefits the commensal (Ockelmann & Muus, 1978).

Given the depth at which the biotope has been recorded, algae are limited to a few red algal species including *Hildenbrandia rubra*, Corallinaceae, and *Phymatolithon calcareum*, that may or may not be present. The maerl *Phymatolithon calcareum*, although at very low abundances and not forming beds (Connor *et al.*, 2004), may nevertheless provide some complexity to the substratum (see Habitat Complexity).

Seasonal and longer term change

Given the depth of SS.SMx.CMx.MysMx it is unlikely to be greatly affected by winter storms that would significantly alter the structure of shallower mixed sediment communities. Also, because of the lack of ephemeral algal species, little change is to be expected in terms of floral growth. The most likely source of seasonal changes is species composition because many of the smaller short lived species such as Chaetozone setosa will die off over the winter months and, therefore, species diversity will be expected to decrease in winter.

Habitat structure and complexity

Physical habitat complexity:

- The mixed nature of the substratum will provide this sedimentary biotope with some heterogeneity. Empty bivalve shells, polychaete tubes and the occasional piece of maerl will also contribute to this complexity and lead to patchiness among the biotope. However, this complexity is on a small scale and no massive structures such as boulders or large erect algal species are likely to be present.
- Below the sediment surface, the burrows and tubes, and the bioturbating activity of various bivalve and polychaete species will result in the mixing of sediment and the transfer of oxygenated water deeper into the sediment and, hence, increased microbial activity and breakdown of organic material. The feeding tubes of *Thyasira* spp., for example, often extended into the anoxic layer (Oliver & Killeen, 2002).
- Muddy sands have a high organic content resulting from the settlement of organic detritus and growth of heterotrophic autotrophic micro-organisms. They also have a high microbial population and high sediment stability due to cohesion. They clay mineral particles provide a massive surface area for microbial growth (M. Kendall, pers. comm.). Allochthonous organic material is derived from anthropogenic activity (e.g. sewerage) and natural sources (e.g. plankton, detritus). Autochthonous organic material is formed by benthic microalgae (microphytobenthos e.g. diatoms and euglenoids) and heterotrophic micro-organism production. Although the surface may be well oxygenated, poor oxygenation lower down in the muds results in low degradation rates and the accumulation of organic material. The mucilaginous secretions of microphytobenthos and bacteria may stabilize the sediment.
- High levels of organic material support large microbial populations. The high oxygen demand of their activity, combined with the fact that much of the sediment is poorly oxygenated, means that much of the organic material undergoes anaerobic degradation releasing hydrogen sulphide, methane and ammonia, together with dissolved organic materials, which can be used by aerobic surface bacteria. Anaerobic degradation produces reducing conditions forming a 'black' layer, the depth of which depends on the depth to which oxygen can permeate (Elliot *et al.*, 1998). Chemoautotrophs are present in the reducing layer and at depth (Libes, 1992).

Factors affecting complexity:

- Given the depth of the biotope, biological forces, e.g. bioturbation, are the dominant factors structuring the substratum as opposed to physical factors such as wave action.
- Decreasing wave exposure is associated with finer sediments which, in turn, support a greater proportion of deposit feeders. Deposit feeders dominate over suspension feeders in areas with high percentages of silt.
- Competitive interactions can play a significant role in determining the temporal and spatial abundance of macrobenthos in muddy sand communities (Peterson, 1977). Organisms may compete for, for example, space and / or food and competitive exclusion may occur. Experimental manipulation revealed that the total abundance of three tube-building polychaetes negatively affected the abundance of a burrowing polychaete (Woodin, 1974). Within particular trophic guilds (feeding types), competition may result in

resource partitioning (Fenchel, 1972).
- The substratum characteristics may be modified by organisms. Spionid tubes and microphytobenthic mats, for example, may stabilize the sediment surface whereas excessive reworking of the sediment (bioturbation) by mobile infauna may destabilize the sediment. Biosedimentation may increase supply of sediment from the water column, e.g. through the activity of suspension feeders such as *Thyasira flexuosa*. Bioturbation by burrowing infauna such as rework sediment bringing material and nutrients to the surface while allowing oxygenated water to reach deeper sediment (Elliott *et al*., 1998; see Hall, 1994 for review).

Productivity

The subtidal sediments associated with SS.SMx.CMx.MysThyMx may not have particularly high productivity although no information was found. Allochthonous organic material is derived from anthropogenic activity (e.g. sewerage) and natural sources (e.g. plankton, detritus). Autochthonous organic material is formed by benthic microalgae (microphytobenthos e.g. diatoms and euglenoids) and heterotrophic micro-organism production. Organic material is degraded by micro-organisms and the nutrients recycled. The high surface area of fine particles provides a surface for microflora. Microphytobenthos, water-column phytoplankton and deep sediment chemoautotrophs provide primary productivity to sediments. However, due to the depth of SS.SMx.CMx.MysThyMx, few algal species are found and most macrofauna productivity is secondary, derived from detritus and organic material.

Recruitment processes

The main features of the key characterizing and important species have been listed below in addition to those of some other polychaetes likely to be found in this biotope.

- The information on *Kurtiella bidentata* is taken entirely from O'Foighill *et al.* (1984) unless otherwise stated. Larvae are planktonic for about 4 weeks giving the species a high dispersal potential, depending on the local hydrographic regime. Reproduction in this species is reported to include mechanisms such as alternate hermaphroditism and brooding. In their first year, both males and hermaphrodites can be found and from the second year onwards only hermaphrodites were present. Fecundity is estimated to be approximately 1000 embryos per large individual. In the Øresund, Ockelmann & Muus (1978) reported egg development between November and February, spawning between July and September, larval release between June & October and main settlement between August and November. In Galway Bay, Ireland, *Kurtiella bidentata* was reported to recruit between August and October (O'Foighill *et al*., 1984). It is not known at what age this species becomes sexually mature.
- *Thyasira flexuosa* has an extended spawning period and peak settlement was found to be between April and May in the Ría de la Coruña, north-west Spain. Thorson (1936) stated that the species produce very large eggs and that the pelagic stage was very short if not absent. In the Ría de la Coruña peak settlement occurred between April and May although there can be two peaks of recruitment per year. It is not known at what age this species becomes sexually mature.
- O'Connor (pers. Comm. In Duineveld *et al*., 1987) reported that ripe female *Amphiura filiformis* can produce a total of 50,000 oocytes. In Galway Bay, Ireland a discrete, relatively short annual breeding period (Jun-Sep) was observed with peak activity in August (Bowmer, 1982). In the same area O'Conner & McGrath (1980) observed that all

large animals spawned during August/September in two consecutive years. Buchanan (1964) reported that *Amphiura filiformis* breeds in July in Britain. Ockelmann & Muus (1978) reported that the species may spawn a couple of time a year. Descriptions of the life history of *Amphiura filiformis* vary greatly in the literature. For example, in a study of *Amphiura filiformis* populations in Galway Bay over a period of 2 years, O'Conner & McGrath (1980) were not able to identify discrete periods of recruitment. However, other studies suggest autumn recruitment (Buchanan, 1964) and spring and autumn (Glémarec, 1979). Muus (1981) shows the mortality of these settlers to be extremely high with less than 5% contributing to the adult population in any given year. In Galway Bay populations, small individuals make up ca. 5% of the population in any given month, which also suggests the actual level of input into the adult population is extremely low (O'Connor *et al.*, 1983). Gerdes (1977) calculated that dispersal to a location 10 km away was within the reach of the larvae. However, dispersal is largely determined by water movements and currents. The species is thought to have a long pelagic life.
- *Spiophanes bombyx* is regarded as a typical 'r' selecting species with a short lifespan, high dispersal potential and high reproductive rate (Kröncke, 1990; Niermann *et al.*, 1990). It is often found at the early successional stages of variable, unstable habitats that it is quick to colonize following perturbation (Pearson & Rosenberg, 1978). Its larval dispersal phase may allow the species to colonize remote habitats.
- *Chaetozone setosa* has annual episodic reproduction although not much else is known about it. Its reproductive period varies with location even on a small scale: spawning in Northumberland ranged from Feb-April or Nov-Jan in intertidal populations to Nov-Dec in a subtidal population (Christie, 1985). June-Sept in English Channel (Hily, 1987). Adults with eggs were found all year in Bay of Brest. Curtis (1977) suggested that a population from west Greenland had direct development. They mature within their first year.
- 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 the North Sea, the main spawning period occurs in March, with a secondary (pelagic) spawn from offshore in Oct (Kruse *et al.*, 2004). At Whitstable, *Scoloplos armiger* spawned four times in one year, the main spawning period occuring from late Feb-April (Gibbs, 1968).
- Not much is known about reproduction or recruitment in *Prionospio fallax*. It reproduces from March to September and the larvae spend ca 6 weeks in the plankton. *Prionospio fallax* is epitokous.

Time for community to reach maturity

Some species associated with SS.SMx.CMx.MysThyMx, including *Spiophanes bombyx*, *Tharyx marioni* and *Mediomastus fragilis* are considered to be 'r' strategists that have a short lifespan, high dispersal potential and high reproductive rate. This part of the community will most probably mature within one year. However, longer lived species exist within this biotope and can take more than a year to become sexually mature such as *Amphiura filiformis*. Furthermore, the age at which the two key characterizing species *Kurtiella bidentata* and *Thyasira flexuosa* is no known. It is possible that the biotope will mature within about five years although in some circumstance this may take longer.

Additional information

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Preferences & Distribution

Habitat preferences

Depth Range	10-20 m, 20-30 m, 30-50 m, 50-100 m
Water clarity preferences	Field Unresearched
Limiting Nutrients	Data deficient, Field unresearched
Salinity preferences	Full (30-40 psu)
Physiographic preferences	Enclosed coast / Embayment, Open coast
Biological zone preferences	Circalittoral
Substratum/habitat preferences	Muddy gravel, Muddy sand, Muddy sandy gravel
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Moderately exposed, Sheltered
Other preferences	

Additional Information

Species composition

Species found especially in this biotope

Rare or scarce species associated with this biotope

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Additional information

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and characterizing species are taken from JNCC (2015). The biotope is characterized by moderately exposed or sheltered, circalittoral muddy sands and gravels. The sediments are considered to be a key factors structuring and characterizing the biotope and are therefore considered in the sensitivity assessments for pressures that may lead to changes. The biological assemblage is characterized by the bivalves *Thyasira* spp. (often *Thyasira flexuosa*), *Kurtiella bidentata* (now *Kurtiella bidentata*) and the polychaete *Prionospio fallax*. These are considered the key species characterizing the biotope and the sensitivity assessments concentrate on these species. Infaunal polychaetes such as *Lumbrineris gracilis*, *Chaetozone setosa* and *Scoloplos armiger* are also common in this community whilst amphipods such as *Ampelisca* spp. and the cumacean *Eudorella truncatula* may also be found in some areas. The sensitivity of associated species is considered generally.

Resilience and recovery rates of habitat

Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	Medium Q: High A: Low C: Medium	High Q: High A: Medium C: Medium	Low Q: High A: Low C: Medium

Species are widely distributed. *Kurtiella bidentata* is widespread around the British Isles and its distribution ranges from Norway to west Africa and the Mediterranean (Carter, 2008). *Scoloplos armiger* is a species complex as is *Chaetozone setosa*. Both are widely distributed. Until recently *Chaetozone setosa* was considered cosmopolitan with records world-wide, from the intertidal zone to the deep sea. It is now known that there are several species of eyeless *Chaetozone* in the north-east Atlantic and the worldwide distribution is unclear. Chambers *et al*., (2007) assessed numerous records of *Chaetozone setosa* in the north-east Atlantic. The species is frequently found in habitats where the mean minimum winter bottom temperature is 5-10 degrees and the summer maximum is >10°C.

Thyasira flexuosa does not occur in the southernmost part of the North Sea but is distributed from Norway to the Azores, and extends into the Mediterranean (Tillin & Tyler-Walters, 2014). However, *Thyasira* populations in the British Isles are restricted to areas where the bottom waters remain cool all year round (Jackson, 2007).

No specific information concerning temperature tolerances of the biotope and the characterizing species was found, but inferences may be made. For example, *Kurtiella bidentata* (studied as *Mysella bidentata*) was recorded in Kinsale Harbour at temperatures ranging from 7.7-18.8°C (O'Brien & Keegan, 2006), and Künitzer (1989) reported that the main factor affecting the growth rate of *Kurtiella bidentata* (studied as *Mysella bidentata*) was temperature.

Sensitivity assessment. The characterizing species of the biotopes are widely distributed and likely to occur both north and south of the British Isles, where typical surface water temperatures vary seasonally from 4-19°C (Huthnance, 2010). No information was found on the maximum temperature tolerated by the characterizing species. Elevated temperatures may affect growth of some of the characterizing species, but no mortality is expected. It is, therefore, likely that *Kurtiella bidentata* and *Thyasira* spp. are able to resist a long-term increase in temperature of 2°C. However, *Thyasira* spp. may suffer some mortality as a result of an acute increase in temperature so resistance is therefore assessed as 'Medium' (loss <25%). Resilience is likely to be 'High' so the biotopes are considered to have 'Low' sensitivity to an increase in temperature at the pressure benchmark.

Temperature decrease (local)	Low Q: High A: High C: Medium	High Q: High A: Low C: Medium	Low Q: High A: Low C: Medium

There is no information on the response of the biotopes to a decrease in temperature. Species are widely distributed. *Kurtiella bidentata* ranges from Norway to west Africa and the Mediterranean (Carter, 2008). *Thyasira flexuosa* does not occur in the southernmost part of the North Sea but is distributed from Norway to the Azores, and extends into the Mediterranean (Tillin & Tyler-Walters, 2014). However, *Thyasira* populations in the British Isles are restricted to areas where the bottom waters remain cool all year round (Jackson, 2007). No specific information on temperature tolerances of *Thyasira* spp. was found.

Kurtiella bidentata (studied as *Mysella bidentata*) was among the species that suffered high losses that could be related to low temperatures in the Wadden Sea area in 1979, where temperature was 3 degrees below average for 3 months (Beukema, 1979).

Scoloplos armiger is a species complex as is *Chaetozone setosa*. Both are widely distributed. Until recently *Chaetozone setosa* was considered cosmopolitan with records world-wide, from the intertidal zone to the deep sea. It is now known that there are several species of eyeless *Chaetozone* spp. in the north-east Atlantic and the worldwide distribution is unclear. Chambers et al., (2007) assessed numerous records of *Chaetozone setosa* in the north-east Atlantic. The species is frequently found in habitats where the mean minimum winter bottom temperature is 5-10 °C and the summer maximum is >10 °C.

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

This biotope occurs in full salinity (JNCC, 2015). No directly relevant evidence was found to assess this pressure. A study from the Canary Islands indicates that exposure to high salinity effluents (47- 50 psu) from desalination plants alter the structure of biological assemblages, reducing species richness and abundance (Riera *et al*., 2012). Bivalves and amphipods appear to be less tolerant of increased salinity than polychaetes and were largely absent at the point of discharge. Polychaetes, including the genera *Lumbrineris* spp. and *Scoloplos armiger* that occur in this biotope, were present at the discharge point (Riera *et al*., 2012). However, in the western Baltic Sea, *Scoloplos armiger* abundance was greatest between 12 psu and 17 psu and reduced abundance with increasing salinity was observed (Gogina *et al*., 2010). As *Scoloplos armiger* is a species complex and is not a cosmopolitan species, there may be differences in tolerances between populations.

Sensitivity assessment. It is likely that key components of the biotopes communities would not be resistant of an increase in salinity to >40 psu. Resistance is therefore assessed as ‘Low’ (loss of 25-75%) but with low confidence. Once normal conditions are resumed, resilience is probably ‘High’ so that sensitivity is therefore assessed as ‘Low’.

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

According to OBIS data (OBIS, 2014), the minimum and maximum range of salinities for the characterizing species are 18.6 - 38.6 pps for *Kurtiella bidentata.* This data suggests *Kurtiella bidentata* are able to tolerate wider salinity ranges, which confirm records of *Kurtiella bidentata* (studied as *Mysella bidentata*) in Kinsale Harbour at salinities ranging from 19.3-35 (O’Brien & Keegan, 2006). However, Gogina *et al*. (2010a) reported that *Kurtiella bidentata* (studied as *Mysella bidentata*) showed a strong positive correlation with salinity varying at a factor of 8.30-27.10 psu.

Thyasira spp. inhabit waters of reduced salinity with 25-30 psu being optimal. However, adults exposed to lower than optimal salinities produced non-viable or slow developing eggs (Jackson, 2007). No evidence for adult salinity tolerance was found.

Sensitivity assessment. The evidence presented suggests that *Thyasira flexuosa* are unlikely to tolerate a decrease in salinity at the pressure benchmark level. Resistance is therefore assessed as 'Low' (loss of 25-75%) but with low confidence. Once normal conditions are resumed, resilience is probably 'High' so that sensitivity is therefore assessed as 'Low'.

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

This biotope is recorded in areas where tidal flow varies between moderately strong (0.5-1.5 m/s) and weak (>0.5 m/s) (JNCC, 2015).

Sensitivity assessment. This biotope occurs in areas subject to moderately strong and weak water flows, a change at the pressure benchmark (increase or decrease) is unlikely to affect biotopes that occur in mid-range flows and biotope resistance is therefore assessed as 'High'; resilience is assessed as 'High' (by default) and the biotope is 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

'Not relevant' to sublittoral biotopes.

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

As this biotope occurs in circalittoral habitats, it is not directly exposed to the action of breaking waves. Associated polychaete species that burrow are protected within the sediment but the characterizing bivalves would be exposed to oscillatory water flows at the seabed. They and other associated species may be indirectly affected by changes in water movement where these impact the supply of food or larvae or other processes. No specific evidence was found to assess this pressure.

Sensitivity assessment. The range of wave exposures experienced by SS.SMx.CMx.MysThyMx is considered to indicate, by proxy, that the biotope would have 'High' resistance and by default 'High' resilience to a change in significant wave height at the pressure benchmark. The biotope is therefore classed as 'Not sensitive'.

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.

No evidence was found for the key bivalve species. The capacity of bivalves to accumulate heavy metals in their tissues, far in excess of environmental levels, is well known. Reactions to sub-lethal levels of heavy metal stressors include siphon retraction, valve closure, inhibition of byssal thread production, disruption of burrowing behaviour, inhibition of respiration, inhibition of filtration rate, inhibition of protein synthesis and suppressed growth (see review by Aberkali & Trueman, 1985). Bryan (1984) states that Hg is the most toxic metal to bivalve molluscs while Cu, Cd and Zn seem to be most problematic in the field. In bivalve molluscs, Hg was reported to have the highest toxicity, mortalities occurring above 0.1-1 g/l after 4-14 days exposure (Crompton, 1997), toxicity decreasing from Hg > Cu and Cd > Zn > Pb and As > Cr (in bivalve larvae, Hg and Cu > Zn > Cd, Pb, As, and Ni > to Cr).

Experimental studies with various species suggests that polychaete worms are generally quite tolerant of heavy metals (Bryan, 1984). Rygg (1985) classified

Prionospio cirrifera as non-tolerant of Cu (species only occasionally found at stations in Norwegian fjords where copper concentrations were >200 ppm (mg/kg). Total faunal abundance and the density of the polychaete *Prionospio cirrifera* also decreased significantly at experimentally enriched sediment Cu concentrations of 300 mg/kg (Olsgard, 1999). However, *Prionospio malmgreni* appeared to be moderately tolerant and were present at some stations in Norwegian fjords with Cu concentrations >200 ppm (mg/kg).

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.

Suchanek (1993) reviewed the effects of oil spills on marine invertebrates and concluded that, in general, on soft sediment habitats, infaunal polychaetes, bivalves and amphipods were particularly affected. Sub-lethal concentrations may produce substantially reduced feeding rates and/or food detection ability, probably due to ciliary inhibition. Respiration rates may increase at low concentrations and decrease at high concentrations. Generally, contact with oil causes an increase in energy expenditure and a decrease in feeding rate, resulting in less energy available for growth and reproduction. However, the *Abra alba* population affected by the 1978 *Amoco Cadiz* benefited from the nutrient enrichment caused by the oil pollution. The biomass of the fine-sand community remained low in 1979, a year after the spill, owing to the decimation of the *Ampelisca* amphipod population, but the biomass then doubled as a result of an increase in *Abra alba* abundance in 1980 and *Abra alba* remained a dominant species over the 20 year duration over which recovery of the community was monitored (Dauvin, 1998).

After a major spill of fuel oil in West Virginia *Capitella* increased dramatically alongside large increases in *Polydora ligni* and *Prionospio* sp. (Sanders *et al.* 1972, cited in Gray 1979). *Prionospio fallax is* characteristic of sediments enriched with hydrocarbons (May & Pearson, 1975; cited in Hiscock *et al*., 2004).

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

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

A number of animals have behavioural strategies to survive periodic events of reduced dissolved oxygen. These include shell closure and reduced metabolic rate in bivalve molluscs and either decreased burrowing depth or emergence from burrows for sediment dwelling crustaceans, molluscs and annelids.

At oxygen concentrations below ca 0.4 mg O_2/l, *Kurtiella bidentata* eventually emerged from the substratum (Ockelmann & Muus, 1978). Nilsson & Rosenberg (1994) investigated hypoxic responses of benthic communities and reported *Kurtiella bidentata* (studied as *Mysella bidentata)* leaving the sediment at oxygen concentrations of 1.7 mg/l. According to the authors, this is a behaviour that occurs at hypoxic oxygen concentrations slightly higher than those causing mortality, suggesting high levels of stress caused to the organisms. For *Kurtiella bidentata* (studied as *Mysella bidentata*), the median sub-lethal oxygen concentrations reported in experimental assessments was 1 mg/l, and for *Abra* spp. was 0.57 mg/l (Vaquer-Sunyer & Duarte, 2008, references therein).

López-Jamar *et al.* (1987) stated that *Thyasira flexuosa* is adapted to living in reduced sediments and also is found in organically enriched sediments. However, Dando & Spiro (1993, cited in Riley, 2008) found that numbers of the congeners *Thyasira equalis* and *Thyasira sarsi* decreased rapidly following the de-oxygenation of bottom water in the deep basin of the Gullmar fjord in 1979-80.

Rosenberg *et al.* (1991) exposed benthic species from the north east Atlantic to oxygen concentrations of around 1 mg/l for several weeks, including species of small bivalves. After 11 days in hypoxic conditions, bivalve individuals were still alive, although individuals showed increased stretching of siphons out of the sediment. In a meta-analysis study of hypoxia, median sub-lethal oxygen concentrations were reported from experimental assessments of tolerance. Although no specific data was reported for all the characterizing species of these biotopes, the thresholds of hypoxia for different benthic groups was LC50 1.42 mg/l for bivalves, and SLC50 of 1.20 mg/l for annelids (Vaquer-Sunyer & Duarte, 2008, references therein).

Further evidence of sensitivity was available for some of the polychaete species associated with this biotope. Rabalais *et al.* (2001) observed that hypoxic conditions in the north Coast of the Gulf of Mexico (oxygen concentrations from 1.5 to 1 mg/l (1 to 0.7 ml/l) led to the emergence of *Lumbrineris* sp. from the substrate these then lie motionless on the surface. *Prionospio* spp. are often dominant in areas subject to hypoxia/anoxia (Gooday *et al.*, 2009; Ingole, 2010).

Sensitivity assessment: Cole *et al.* (1999) suggest possible adverse effects on marine species below 4 mg/l and probable adverse effects below 2 mg/l. Different species in the biotope will have varying responses to de-oxygenation. Based on the evidence presented, the characterizing species are likely to only be affected by severe de-oxygenation episodes. Resistance to de-oxygenation at the pressure benchmark level is likely to be 'High'. Resilience is assessed as 'High' (by default) and the biotope is therefore considered 'Not sensitive' to exposure to dissolved oxygen concentration of less than or equal to 2 mg/l for 1 week.

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

This pressure relates to increased levels of nitrogen, phosphorus and silicon in the marine environment compared to background concentrations. The pressure benchmark is set at compliance with Water Framework Directive (WFD) criteria for good status, based on nitrogen concentration (UKTAG, 2014). Increased nutrients are most likely to affect abundance of phytoplankton which may include toxic algae (OSPAR, 2009b). This primary effect resulting from elevated nutrients will impact upon other biological elements or features (e.g. toxins produced by phytoplankton blooms or de-oxygenation of sediments) and may lead to 'undesirable disturbance' to the structure and functioning of the ecosystem. With enhanced primary productivity in the water column, organic detritus that falls to the seabed may also be enhanced, which may be utilized by the deposit feeders in the community.

In a report to identify seabed indicator species to support implementation of the EU habitats and water framework directives *Kurtiella bidentata*, have been reported as likely to be favoured by nutrient enrichment.

Sensitivity assessment. At the pressure benchmark, the biotope is considered to have 'High' resistance to this pressure and 'High' resilience, (by default) and is assessed as 'Not sensitive'.

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

Many of the species present are deposit feeders characteristic of organically enriched areas. An input of organic matter at the pressure benchmark is likely to provide a food subsidy to these species.

Thyasira spp. are characteristic of organically enriched offshore sediments with *Capitella capitata* (Connor *et al.*, 2004) and have been identified as a 'progressive' species, i.e. one that shows increased abundance under slight organic enrichment (Leppakoski, 1975, cited in Gray, 1979). In the development of the AMBI index to assess disturbance (including organic enrichment), both Borja *et al.* (2000) and Gittenberger & Van Loon (2011) assigned *Thyasira flexuosa* to their Ecological Group III (defined as 'species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations)'. *Kurtiella bidentata* (referred to as *Mysella bidnetata*) was characterized as AMBI Group I - 'Species very sensitive to organic enrichment and present under unpolluted conditions (initial state)' (Gittenberger & Van Loon, 2011). The evidence for the assessments of *Kurtiella bidentata* was not identified.

Spionid polychaetes are surface deposit feeders and an increase in food at the pressure benchmark could lead to an increase in abundance. *Pronospio* spp. has been identified as a 'progressive' species, i.e. one that shows increased abundance under slight organic enrichment (Leppakoski, 1975, cited in Gray, 1979). Hiscock *et al.* (2004) also identified *Prionospio* spp. as increasing under conditions of organic enrichment based on Pearson (1975), Beneath fishfarms, *Prionospio* spp. were among the most abundant species and in analysis were responsible for differences between those stations and the control condition (Terlizzi *et al*., 2010), i.e. populations were enhanced beneath stations. Elias et al. (2005) identified *Prionospio* spp. as an indicator species of organic enrichment in samples collected during the summer season off Mar del Plata City in Argentina. Weston (1990) found high densities of *Prionospio cirrifera* within organically enriched sediments directly beneath a large aquaculture (although higher densities were found at stations at greater distancesfrom the farm with lower enrichment levels). The Pearson and Black (2001) model of benthic faunal succession from sedimentary loadings (following cessation of fish farming) indicate that *Prionospio fallax* would be expected to be found in moderately enriched sediments (after about 9 months).

Chaetezone setosa and cumaceans were typical of enriched sites off the coast of Barcelona that were subject to effluents and sludge disposal from treatment plants (Corbera & Cardell, 1995).

Borja *et al*. (2000) assessed relative sensitivity of *Scoloplos armiger* as an ABMI Ecological Group II species (indifferent/tolerant to enrichment). Identified as a 'progressive' species, i.e. one that shows increased abundance under slight organic enrichment (Leppakoski, 1975, cited in Gray, 1979).

At high levels of organic input,decreases in abundance of more sensitive species such as *Kurtiella bidentata* may lead to shifts in community composition towards a biotope dominated by tolerant species, such as polychaete worms (Pearson & Rosenberg, 1978). This could lead to biotope reclassification to the enriched SS.SMu.OMu.CapThy. However, this is likely to occur at levels greater than the pressure benchmark. The Marine Ecosystems Research Laboratory studied the fate and effects of sewage solids added to mesocosms. Organic loading rates less than 36 gC/m^2/yr had little effect, rates between 36 and 365 gC/m^2/yr enriched the sediment community, and a loading over 548 gC/m^2/yr produced degraded conditions (Kelly & Nixon, 1984; Frithsen *et al*., 1987; Oviatt *et al*., 1987; Maughan & Oviatt, 1993, cited from Cromey *et al*., 1998).

Sensitivity assessment. The evidence presented suggests that the majority of the characterizing and associated species in the biotopes are likely to be able to utilize additional organic load as food and are present in enriched habitats. Biotope resistance is therefore assessed as 'High' and resilience as 'high' so that the biotope is assessed as '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 a resistance of None to this pressure and to be unable to recover from a permanent loss of habitat (resilience is 'Very low'). Sensitivity within the direct spatial footprint of this pressure is,therefore, 'High'. Although no specific evidence is described confidence in this assessment is 'High' due to the incontrovertible nature of this pressure.

Physical change (to another seabed type)	None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

If the sediment that characterizes the biotopes were replaced with rock or artificial hard substrata, this would represent a fundamental change to the physical character of the biotopes. The characterizing species would no longer be supported and the biotope would be lost and/or re-classified.

Sensitivity assessment. Resistance to the pressure is considered to be 'None', and resilience 'Very low', as the change at the pressure benchmark is permanent. Sensitivity has been assessed as 'High'. Although no specific evidence is described, confidence in this assessment is ‘High’ due to the incontrovertible nature of this pressure and the agreement between classification schemes on the substratum type.

Physical change (to another sediment type)	Low Q: Low A: NR C: NR	Very Low Q: High A: High C: High	High Q: Low A: Low C: Low

This biotope is found in muddy sand and gravel (JNCC, 2015). The change referred to at the pressure benchmark is a change in sediment classification (based on Long, 2006) rather than a change in the finer-scale original Folk categories (Folk, 1954). For mixed sediments, resistance is assessed based on a change to either coarse sediments or sand and muddy sands or mud and sandy muds. The characterizing species within these biotopes have wide ranges of sediment preferences. *Kurtiella bidentata* lives in muddy sand or fine gravel (Carter, 2008), while *Thyasira* spp. prefer fine sediments including mud, muddy sand and sandy mud (Jackson, 2007).

Sensitivity assessment: A change in Folk class from mixed sediments to mud and sandy mud to sand or muddy sand would probably not eliminate the characterizing species which all have habitats preferences that would fall within this range. However, a change in one Folk class to coarse or fully mud sediments is likely to result in loss of some of the characterizing species due to habitat unsuitability and increased competition with species more suited to the changed habitat. A change in sediment type will result in biotope reclassification. Resistance is therefore assessed as ‘Low’ (loss of 25-75%) and resilience is considered 'Very low’ given the permanent nature of this pressure. Sensitivity is therefore assessed 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: Low C: Medium

Sedimentary communities are likely to be ‘Highly' intolerant of substratum removal, which will lead to partial or complete defaunation, expose underlying sediment which may be anoxic and/or of a different character and lead to changes in the topography of the area (Dernie *et al*., 2003). Any remaining species, given their new position at the sediment/water interface, may be exposed to unsuitable conditions. Newell *et al.* (1998) state that removal of 0.5 m depth of sediment is likely to eliminate benthos from the affected area.

Recovery of the sedimentary habitat would occur via infilling, although some recovery of the biological assemblage may take place before the original topography is restored, if the exposed, underlying sediments are similar to those that were removed. Newell *et al.* (1998) indicate that local hydrodynamics (currents and wave action) and sediment characteristics (mobility and supply) strongly influence the recovery of soft sediment habitats.

Sensitivity assessment. Extraction of 30 cm of sediment will remove the characterizing biological component of the biotopes so resistance is assessed as 'None', resilience is therefore judged as 'Medium' based on sediment and species recovery. Sensitivity has been assessed as 'Medium'.

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

The characterizing species are infaunal and hence have some protection against surface disturbance. Bivalves and other species require contact with the surface for respiration and feeding. Siphons and delicate polychaete feeding structures may be damaged or withdrawn as a result of surface disturbance, resulting in loss of feeding opportunities and compromised growth.

Sensitivity assessment. Some soft-bodied organisms and a proportion of the characterizing bivalves are likely to be damaged and removed by abrasion. Resistance to abrasion is therefore considered 'Medium' (loss <25%). Resilience of the biotopes is likely to be 'High'. The biotope is therefore considered to have 'Low' sensitivity to abrasion or disturbance of the surface of the seabed.

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

Activities that disturb the surface and penetrate below the surface would remove /damage infaunal species such as the characterizing species within the direct area of impact. The footprint of the impact will depend on the type of gear used (Hall *et al.*, 2008).

Bergman & van Santbrink (2000a) estimated the direct mortality of benthic macrofauna caused by the single pass of commercial beam and otter trawls. The results showed that a single pass of a 4 m or 12 m beam trawl or an otter trawl, in shallow sandy areas and deep silty sand areas (with 3-10% silt) in the North Sea caused a mortality of 20-65% of bivalves and 5-40% of gastropods, starfish, small-medium sized crustaceans and annelid worms. The mortality of *Kurtiella bidentata* (studied as *Mysella bidentata*) was reported as 4%. Some mortality was not caused directly by the passage of the trawl, but instead by disturbance, exposure and subsequent predation. Ball *et al.* (2000a) reported on the short-term effects of fishing on benthos from a mud patch in the northwestern part of the Irish Sea investigated in 1994–1996 by means of samples taken both before and shortly after (ca. 24 hr) fishing activity. *Kurtiella bidentata* (studied as *Mysella bidentata*) was one of the species that was common at the inshore site and for which estimates of mortality were calculated and was uncommon or totally absent on the offshore fishing ground. Direct mortality from passage of an otter trawl was estimated as 72%. The direct mortality (percentage of initial density) of *Thyasira flexuosa* was estimated as 0-28%, based on samples taken with a Day grab before and 24 hours after trawling (Ball *et al*., 2000b).

The shells of *Thyasira* spp. are thin and fragile and penetration and disturbance of the sediment is likely to lead to damage and mortality within the population. Sparks-McConkey & Watling (2001) found that trawler disturbance resulted in a decline of *Thyasira flexuosa* in Penobscot Bay, Maine. However, the population recovered after 3.5 months.

Ferns *et al*. (2000) investigated the effect of tractor dredging for cockles on an intertidal muddy sand at Burry Inlet, South Wales mechanical cockle harvesting. A decline of 31% in populations of *Scoloplos armiger* (initial density 120 m^2) was recorded in muddy sands, *Scoloplos armiger* demonstrated recovery >50 days after harvesting (Ferns *et al*., 2000).

Tuck *et al*. (1998) found that following trawl disturbance, abundances of *Chaetozone setosa* had recovered and became greater at treatment sites than undisturbed sites 10 months after disturbance. *Scoloplos armiger*, however, had declined at disturbed sites.

Sensitivity assessment. A proportion of the characterizing species in these biotopes is likely to be lost or severely damaged, depending on the scale of the activity (see abrasion pressure). Therefore, a resistance of 'Low' (>75% loss) is suggested based on *Mysella bidentata*. Muddy sand habitats have been reported as having the longest recovery times, whilst mud habitats had an 'intermediate' recovery time (compared to clean sand communities which had the most rapid recovery rate) (Dernie *et al*., 2003). Resilience is probably 'High', and therefore the biotopes' sensitivity to this pressure if likely to be 'Low'.

Changes in suspended solids (water clarity)	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

A change in turbidity at the pressure benchmark is assessed as an increase from intermediate (10-100 mg/l) to medium (100-300 mg/l) and a change to clear (<10 mg/l). The venerid bivalves are active suspension feeders, trapping food particles on their gill filaments (ctenidia).

Lethal effects on *Kurtiella bidentata* are considered unlikely given the occurrence of this species in estuaries where turbidity is frequently 'High' from suspended organic and inorganic matter. As *Thyasira flexuosa* are buried within the sediment and are fed by symbiotic bacteria they are considered insensitive to a change in suspended solids.

Sensitivity assessment. No direct evidence was found to assess impacts on the characterizing bivalves and associated polychaete species. Based on infaunal position and the dominance of deposit feeders biotope resistance is likely to be 'High'. Resilience is assessed as 'High' (by default) and the biotope is therefore considered 'Not sensitive'.

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

Bijkerk (1988, results cited from Essink, 1999) indicated that the maximal overburden through which small bivalves could migrate was 20 cm in sand for *Donax* and approximately 40 cm in mud for *Tellina* sp. and approximately 50 cm in sand. No further information was available on the rates of survivorship or the time taken to reach the surface. This suggests that characterizing species such as *Kurtiella bidentata* and *Thyasira* spp. may be able to burrow through similar overburdens. *Thyasira flexuosa* have 'highly extensible feet' (Dando & Southward, 1986) allowing them to construct channels within the sediment and to burrow to 8 cm depth.

Sensitivity assessment. Beyond re-establishing burrow openings or moving up through the sediment, there is evidence of synergistic effects on burrowing activity of marine benthos and mortality with changes in time of burial, sediment depth, sediment type and temperature (Maurer *et al*., 1986). However, the biotopes are likely to resist smothering at the benchmark level since the majority of associated fauna are burrowing infauna. Resistance is therefore assessed as 'High', and resilience is also 'High' (by default) so that the biotopes are considered 'Not Sensitive' to a 'light' deposition of up to 5 cm of fine material added to the seabed in a single, discrete event.

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

Bijkerk (1988, results cited from Essink, 1999) indicated that the maximal overburden through which small bivalves could migrate was 20 cm in sand for *Donax* and approximately 40 cm in mud for *Tellina* sp. and approximately 50 cm in sand. No further information was available on the rates of survivorship or the time taken to reach the surface. This suggests that characterizing species *Kurtiella bidentata* and *Thyasira* spp. may be able to burrow through similar overburdens, although sudden smothering with 30 cm of sediment would temporarily halt feeding and respiration, compromising growth and reproduction owing to energetic expenditure. *Thyasira flexuosa* have 'highly extensible feet' (Dando & Southward, 1986) allowing them to construct channels within the sediment and to burrow to 8 cm depth.

Bijkerk (1988, results cited from Essink 1999) indicated that the maximal overburden through which *Scoloplos* could migrate was 50 cm in sand and mud. No further information was available on the rates of survivorship or the time taken to reach the surface. Warner (1971) simulated the effects of dredge disposal of different thicknesses on animals in aquaria or plastic cores for 2 weeks. In core experiments at temperatures ranging from 14 to 18°C and 20 to 21°C, there was a relationship between vertical migration distance and sediment depth for the congener *Scoloplos fragilis*. This species could vertically migrate through 30 cm of sand. In other core experiments in silt-clay at temperatures of 17°C to 18°C, there was a suggestion of reduced efficiency of burrowing in finer grained sediment where even the smallest amount of silt-clay proportion tested (20%) affected the burrowing ability of this species.

Sensitivity assessment: Beyond re-establishing burrow openings or moving up through the sediment, there is evidence of synergistic effects on burrowing activity of marine benthos and mortality with changes in time of burial, sediment depth, sediment type and temperature (Maurer *et al*., 1986). Bivalve and polychaete species have been reported to migrate through depositions of sediment greater that the benchmark (30 cm of fine material added to the seabed in a single discrete event) (Bijkerk, 1988; Powilleit *et al*., 2009; Maurer *et al*., 1982). However, it is not clear whether the characterizing species are likely to be able to migrate through a maximum thickness of fine sediment because muds tend to be more cohesive and compacted than sand. Some mortality of the characterizing species is likely to occur. Resistance is therefore assessed as 'Low' (25-75% loss) and resilience as 'High' and the biotopes are considered to have 'Low' sensitivity to a 'heavy' deposition of up to 30 cm of fine material in a single discrete event.

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

Changes in light levels are not considered likely to affect adult stages, although little evidence is available to support this conclusion. This pressure is, therefore, assessed as 'Not relevant'.

Barrier to species movement	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

This pressure is considered to be 'Not relevant' to biotopes that occur only in open waters, rather than coastal bays and estuaries.

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

The characterizing species of the biotopes live infaunally, so are likely to have poor or no visual perception and unlikely to be affected by visual disturbance such as shading.

Sensitivity assessment. The characterizing species are likely to be tolerant of visual disturbance. Resistance and resilience are therefore assessed as 'High' and the biotopes judged as 'Not sensitive' to visual disturbance.

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

Key characterizing species within this biotope are not cultivated or translocated. This pressure is therefore considered ‘Not relevant’ to this biotope group.

Introduction or spread of invasive non-indigenous species	None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

The slipper limpet *Crepidula fornicata* may settle on stones in substrates and hard surfaces such as bivalve shells and can sometimes form dense carpets which can smother bivalves and alter the seabed, making the habitat unsuitable for larval settlement. Dense aggregations trap suspended silt, faeces and pseudofaeces altering the benthic habitat. Where slipper limpet stacks are abundant, few other bivalves can live amongst them (Fretter & Graham, 1981; Blanchard, 1997). Muddy and mixed sediments in wave sheltered areas are probably optimal, but *Crepidula fornicata* has been recorded from a wide variety of habitats including clean sands and areas subject to moderately strong tidal streams (Blanchard, 1997; De Montaudouin & Sauriau, 1999).

Sensitivity assessment. The slipper limpet may colonize this habitat resulting in habitat change and potentially classification to the biotope which is found in similar habitats SS.SMx.IMx.CreAsAn. Based on *Crepidula fornicata*, biotope resistance is assessed as ‘None’ and resilience as ‘Very Low’ (as removal of established non-native is unlikely), so biotope sensitivity is assessed as ‘High’.

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

More than 20 viruses have been described for marine bivalves (Sinderman, 1990). Bacterial diseases are more significant in the larval stages and protozoans are the most common cause of epizootic outbreaks that may result in mass mortalities of bivalve populations. Parasitic worms, trematodes, cestodes and nematodes can reduce growth and fecundity within bivalves and may in some instances cause death

(Dame, 1996).

Little information specifically concerning the effects of microbial pathogens and parasites on the viability of the characterizing species was found. A viral infection of the mutualist bacterium living on the gills of *Thyasira gouldi* has been suggested as the reason for a major decline in the Loch Etive population (Jackson, 2007, references therein),

Sensitivity assessment. No direct evidence of the biotopes being affected by the introduction of microbial pathogens was found to assess this pressure.

Removal of target 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

No species within the biotope are targeted by commercial or recreational fishers or harvesters. This pressure is therefore considered ‘Not relevant’.

Removal of non-target species	Low Q: Low A: NR C: NR	High Q: High A: Low C: Medium	Low Q: Low A: Low C: Low

Direct, physical impacts are assessed through the abrasion and penetration of the seabed pressures, while this pressure considers the ecological or biological effects of by-catch. Species in these biotopes, including the characterizing species, may be damaged or directly removed by static or mobile gears that are targeting other species (see abrasion and penetration pressures). Loss of these species would alter the character of the biotope resulting in re-classification, and would alter the physical structure of the habitat resulting in the loss of the ecosystem functions such as secondary production performed by these species.

Sensitivity assessment. Removal of the characterizing species would result in the biotopes being lost or re-classified. As many species are relatively small and the bivalves may be displaced by sediment disturbance but survive (see physical damage pressures), the biotope is considered to have a resistance of ‘Low’ to this pressure and to have ‘High’ resilience, so that sensitivity is assessed as ‘Low’.

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