Ampelisca spp., *Photis longicaudata* and other tube-building amphipods and polychaetes in infralittoral sandy mud

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

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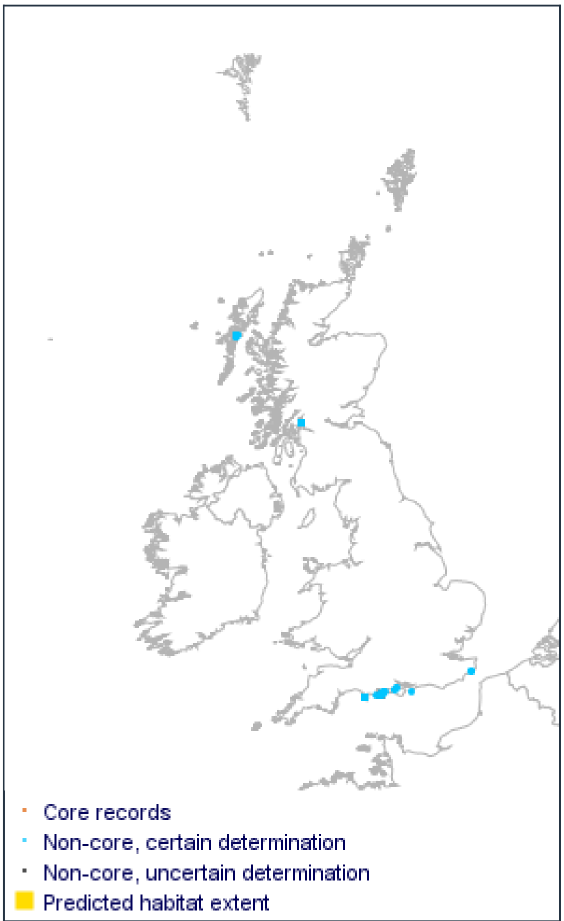

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Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Dr Harvey Tyler-Walters & Eliane De-Bastos **Refereed by** This information is not refereed

Summary

UK and Ireland classification

EUNIS 2008	A5.335	*Ampelisca* spp., *Photis longicaudata* and other tube-building amphipods and polychaetes in infralittoral sandy mud
JNCC 2015	SS.SMu.ISaMu.AmpPlon	*Ampelisca* spp., *Photis longicaudata* and other tube-building amphipods and polychaetes in infralittoral sandy mud
JNCC 2004	SS.SMu.ISaMu.AmpPlon	*Ampelisca spp., Photis longicaudata* and other tube-building amphipods and polychaetes in infralittoral sandy mud
1997 Biotope		

Description

Sublittoral stable cohesive sandy muds occurring over a wide depth range may support large populations of semi-permanent tube-building amphipods and polychaetes. In particular large numbers of the amphipods *Ampelisca* spp. and *Photis longicaudata* may be present along with polychaetes such as *Lagis koreni*. Other important taxa may include bivalves such as *Nucula nitidosa*, *Chamelea gallina*, *Abra alba* and *Kurtiella bidentata* and the echinoderms *Echinocardium cordatum* and *Amphiura brachiata*. In some areas, polychaetes such as *Spiophanes bombyx* and *Polydora ciliata* may also be conspicuously numerous. This community is poorly known, appearing to occur in restricted patches. In some areas, it is possible that AmpPlon may develop as a result of moderate organic enrichment. A similar community in mud has also been reported in the Baltic that is characterized by large populations of amphipods such as *Ampelisca* spp., *Corophium* spp. and *Haploops tubicola* (see Petersen, 1918; Thorson, 1957) and it is not known if SMU.AmpPlon is a UK variant of this biotope.

In some areas of the Irish Sea, this biotope is reported to be a temporal variant of AalbNuc, SsubNhom, and LkorPpel. Some researchers consider these biotopes to be part of a wider muddy sand community that varies temporally depending on changes in sediment deposition and recruitment as was reported in areas of Red Wharf Bay off the Welsh coast (E.I.S. Rees pers. comm. 2002). (Information from Connor *et al.*, 2004; JNCC, 2015).

Depth range

0-5 m, 5-10 m, 10-20 m, 20-30 m

Additional information

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Listed By

- none -

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Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

SS.SMu.ISaMu.AmpPlon is a sublittoral biotope characterized by a tube mat created by large numbers of the tube-building amphipods, *Ampelisca* spp. and *Photis longicaudata* although tube building polychaetes such as *Polydora ciliata* and *Spiophanes bombyx* also occur (Connor *et al*., 2004). It may be similar to the amphipod dominated 'Boreal-Arctic Ampelisca' community described in the Baltic by Thorson (1957) and the *Ampelisca* dominated community in Massachusetts, USA, described by Mills (1967, 1969). Mills (1967, 1969) reported that high numbers of *Ampelisca* colonized sand falts on Barnstable Harbour, Massachusetts in 1960-62. The resultant tube mat was patchy but often covered hundreds of square metres, and the density of individuals was great even in winter. The tube mat also increased the surface complexity of the sandflat, provided surface area for benthic diatoms, and increased the abundance of infaunal polychaetes. In Maine, the amphipod tube mat resulted in an increase in diversity in the previously species-poor habitat. Filter-feeding by *Ampelisca* and the resultant faeces trapped organic particulates at the surface, which in turn increased the organic content between the amphipod tubes which favoured the selective deposit-feeding polychaetes. However, it also decreased the median sedimentary particle size, which caused instability so that minor breaks in the mat were sufficient to cause wash out of the tube mat, especially on windy days, or storms (Mills, 1967, 1969). Mills (1967, 1969) reported that egg-bearing females settled in uncolonized areas so that juveniles avoided competition from remaining adults in the tube mat and colonized areas that were more physically stable. As a result, they abandoned old areas and colonized new spaces. Mills (1969) concluded that the *Ampelisca* community was adapted to a 'dynamic instability' and frequent changes in the area it occupied. However, Mackenzie et al. (2006) reported that dense *Ampelisca* tube mat persisted for at least five years in the deeper waters sheltered from wave action in Raritan Bay, New Jersey. Therefore, it is probably a transient and patchy community, which may be a transient overlay over other biotopes, such as the AalbNuc, SsubNhom and LkorPpel biotopes in the Irish Sea (see Connor *et al*., 2004).

Therefore, the tube-building amphipods such as *Ampelisca* spp. and *Photis longicaudata* are probably the key structural species in the biotope and are the main focus of the sensitivity assessment, as loss of the tube mat would result in the loss of the biotope. The sensitivity of the other tube-builders such as *Polydora ciliata* and *Spiophanes bombyx* are discussed where relevant.

Resilience and recovery rates of habitat

The amphipod genus *Ampelisca* has life history traits that allow them to recovery quickly where populations are disturbed. They do not produce large numbers of offspring but reproduce regularly and the larvae are brooded, giving them a higher chance of survival within a suitable habitat than free-living larvae. *Ampelisca* has a short lifespan and reaches sexual maturity in a matter of months allowing a population to recover abundance and biomass in a very short period (MES, 2008). Experimental studies have shown *Ampelisca abdita* to be an early colonizer, in large abundances of defaunated sediments where local populations exist to support recovery (McCall, 1977) and *Ampelisca abdita* have been shown to migrate to, or from, areas to avoid unfavourable conditions (Mills, 1967, 1969; Nichols & Thompson, 1985). *Ampelisca* spp. are very intolerant of oil contamination and the recovery of then *Ampelisca* populations in the fine sand community in the Bay of Morlaix took up to 15 years following the *Amoco Cadiz* oil spill, probably due to the amphipods' low fecundity, lack of pelagic larvae and the absence of local unperturbed source populations (Poggiale & Dauvin, 2001). Mills (1967) reported that *Ampelisca vadorum* and

Ampelisca abdita produced only one brood per generation but that there were two or more generations per year. In the English Channel, two reproductive patterns were identified. Species such as *Ampelisca tenuicornis* and *Ampelisca typica* produced two generations per year. The juveniles born in May-June were able to brood in September-October (Dauvin, 1988b; Dauvin, 1988c). Species such as *Ampelisca armoricana* and *Ampelisca sarsi* produced only one brood per generation and per year (Dauvin, 1989; Dauvin, 1988d). *Ampelisca brevicornis* showed an intermediate cycle with one generation per year during cold years (cold spring) and two generations per year during warm years (warm spring) and its cycle is intermediate between univoltine cycle and bivoltine cycle (Dauvin, 1988b,c,d,e; Dauvin, 1989; Dauvin & Bellan-Santini, 1990). In addition, Mills (1967, 1969) concluded that *Ampelisca* was a 'vagrant species', adapted to frequent changes in the area occupied and the ability to rapidly colonize new habitat due to the tendency of egg-bearing or gravid females to relocate via the plankton, and its short generation time resulting in dramatic increases in numbers in colonized areas. However, Mackenzie et al. (2006) reported that dense *Ampelisca* tube mat persisted for at least five years in deeper waters sheltered from wave action in Raritan Bay, New Jersey.

Polydora is a small, sedentary, burrowing polychaete worm up to 3 cm long. All *Polydora* spp. make a U-shaped tube from small particles (Hayward & Ryland, 1995b). *Polydora ciliata* usually burrows into substrata containing calcium carbonate such as limestone, chalk and clay, as well as shells or oysters, mussels and periwinkles (Fish & Fish, 1996). The sexes are separate and breeding has been recorded in spring in a number of locations. In northern England, it has been recorded to occur from February until June and three or four generations succeed one another during the spawning period (Gudmundsson, 1985). Eggs are laid in a string of capsules that are attached by two threads to the wall of the burrow (Fish & Fish, 1996). After a week the larvae emerge and are believed to have a pelagic life of 2-6 weeks before settling. Length of life is no more than one year (Fish & Fish, 1996). Almeda *et al.* (2009) suggested low filtration rates and low growth rates despite high food availability for *Polydora ciliata* larvae, which suggested a compromise to ensure efficient larval dispersion. Larvae are substratum specific, selecting rocks according to their physical properties or selecting sediment depending on particle size. Larvae of *Polydora ciliata* have been collected as far as 118 km offshore (Murina, 1997). Adults of *Polydora ciliata* produce a 'mud' resulting from the perforation of soft rock substrata and the larvae of the species settle preferentially on substrata covered with mud (Lagadeuc, 1991). The settling of the first generation in April is followed by the accumulation and active fixing of mud continuously up to a peak during May. The following generations do not produce a heavy settlement due to interspecific competition and heavy mortality of the larvae (Daro & Polk, 1973). The tubes built by *Polydora* sometimes agglomerate to form layers of mud up to an average of 20 cm thick. Later in the year, the surface layer cannot hold the lower layers of the mud mat in place. They crumble away and are then swept away by water currents. The empty tubes of *Polydora* may saturate the sea in June. The early reproductive period of *Polydora ciliata* often enables the species to be the first to colonize available substrata (Green, 1983). For example, in colonization experiments in Helgoland (Harms & Anger, 1983), *Polydora ciliata* settled on panels within one month in the spring.

Other polychaetes in the biotope are likely to also recolonize disturbed areas rapidly. For example, *Spiophanes* (e.g. *Spiophanes bombyx*) have opportunistic life strategies and exhibit small size, rapid maturation and a short lifespan of 1-2 years with the production of large numbers of small propagules. Two years after dredging, abundances of opportunistic species were generally elevated relative to pre-dredging levels while communities had become numerically dominated (50-70 %) by *Spiophanes bombyx* (Gilkinson *et al.*, 2005). Van Dalfsen *et al*. (2000) found that polychaetes recolonized a dredged area within 5-10 months (reference from Boyd *et al*., 2005), with biomass recovery predicted within 2-4 years. *Spiophanes bombyx* is regarded as a typical 'r' selecting species with a short lifespan, high dispersal potential and high reproductive rate (Niermann *et al*., 1990). It is often found at the early successional stages of variable, unstable habitats that it is quick to colonize following a perturbation (Pearson & Rosenberg, 1978). Its larval dispersal phase may allow the species to colonize remote habitats. McLusky *et al.* (1983) examined the effects of bait digging on blow lug populations in the Forth Estuary. Dug and infilled areas and unfilled basins left after digging repopulated within one month, whereas mounds of dug sediment took longer and showed a reduced population. Basins accumulated fine sediment and organic matter and showed increased population levels for about 2-3 months after digging. Overall recovery is generally regarded as rapid. *Pygospio elegans* were significantly depleted for >100 days after harvesting (surpassing the study monitoring timeline) and *Scoloplos armiger* demonstrated recovery >50 days after harvesting in muddy sands (Ferns *et al*., 2000). In summary, these studies suggest recovery from fisheries pressures occurs in four months to >3 years depending upon the harvesting method (such as hand digging or mechanical dredging) and the size of the area impacted. As a tube building polychaete, *Pygospio elegans* aids stabilisation of sediments following disturbance. Recolonization and hence recovery may be aided by bedload transport of juvenile polychaetes and bivalves. Recolonization of *Pygospio elegans* was observed in two weeks by Dittmann *et al*. (1999) following one-month long defaunation of the sediment.

Resilience assessment. Removal of the characterizing species and the 'tube mat' would result in the biotope being lost and/or reclassified. Amphipods brood their young so that dispersal is limited to local movements of these sub-juveniles and migration of the adults and hence recruitment is limited by the presence of local, unperturbed source populations (Poggiale & Dauvin, 2001). Dispersal of sub-juveniles may be enhanced by the brooding females leaving their tubes and swimming to uncolonized areas of substratum before the eggs hatch (Mills, 1967, 1969). Nevertheless, *Ampelicsca* is an early colonizer and brooding of juveniles allows for rapid localized population growth. The tube building polychaetes such as *Polydora ciliata* generally disperse via pelagic larvae (Fish & Fish, 1996) and, therefore, recruitment may occur from distant populations. These are likely to recolonize disturbed areas first, although the actual pattern will depend on the recovery of the habitat, season of occurrence and other factors. Therefore, where perturbation removes a portion of the population or even causes local extinction (resistance High, Medium or Low) resilience is likely to be '**High'** (<2 years) as long as recruitment from neighbouring areas and/or adult migration is possible. However, even in areas of suitable habitat that are isolated, where total extinction of the population occurs (resistance 'None') recovery is likely to depend on favourable hydrodynamic conditions that will allow recruitment from farther away. However, once an area has been recolonized, restoration of the biomass of the characterizing species is likely to occur quickly and resilience is likely to be '**Medium'** (full recovery within 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 before 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 recognizable 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: Medium A: Low C: Medium	High Q: High A: High C: High	Not sensitive Q: Medium A: Low C: Medium

Amphipods were reported to have a low tolerance to temperature changes (Bousfield, 1973) although lethal limits were not given. However, the amphipods that occur within this habitat are mobile and can avoid unfavourable conditions to some extent. *Ampelisca brevicornis* is widespread in the North East Atlantic but is also recorded from the White Sea, south to the Iberian Peninsula and the Mediterranean, and as far as the coasts of South Africa, India, China and the Korean Peninsula (OBIS, 2020). It has been recorded in areas where sea surface temperatures (SST) range from 5 to 30°C, although most records occur in the 10-15°C range (OBIS, 2020). Similarly, *Ampelisca typica* is also recorded from the White Sea, through the North East Atlantic to the Iberian Peninsula, and in areas where the SST ranged from 5-25°C although most records occurred in 10-15°C (OBIS, 2020). However, other species, e.g. *Ampelisca sarsi* have more limited distribution south of the British Isles (OBIS, 2020). *Photis longicaudata* is also widespread in the North East Atlantic but is also recorded from the Barents Sea, south to the Iberian Peninsula and the Mediterranean, and as far as the coasts of South Africa, India, China and the Korean Peninsula, and in the west Atlantic from Florida south to Uruguay and in areas where the SST ranged from minus 5-0°C and 5-30°C although most records occurred in 10-15°C (OBIS, 2020).

Murina (1997) categorized *Polydora ciliata* as a eurythermal species because of its ability to spawn in temperatures ranging from 10.6-19.9°C. This is consistent with a wide distribution in north-west Europe, which extends into the warmer waters of Portugal and Italy (Pardal *et al.*, 1993; Sordino *et al.*, 1989). In the western Baltic Sea, Gulliksen (1977) recorded high abundances of *Polydora ciliata* at temperatures of 7.5 to 11.5°C and in Whitstable, in Kent, where sea temperatures varied between 0.5 and 17°C (Dorsett, 1961). Growth rates may increase if the temperature rises. For example, at Whitstable in Kent, Dorsett (1961) found that a rapid increase in growth coincided with the rising temperature of the seawater during March. No information was found regarding the intolerance of *Spiophanes bombyx* to temperature. *Spiophanes bombyx* is found in the Mediterranean (Hayward & Ryland, 1995b), which is likely to be warmer than the waters around Britain and Ireland.

Sensitivity assessment. Typical surface water temperatures around the UK coast vary seasonally from 4-19°C (Huthnance, 2010). The characteristic tube mat forming species are distributed to the north and south of the British Isles and are likely to be able to resist a long-term increase in temperature of 2°C and may resist a short-term increase of 5°C in UK waters. Resistance and resilience are, therefore, assessed as '**High'** and the biotope assessed as '**Not Sensitive'** at the benchmark level.

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

Amphipods were reported to have a low tolerance to temperature changes (Bousfield, 1973) although lethal limits were not given. However, the amphipods that occur within this habitat are mobile and can avoid unfavourable conditions to some extent. *Ampelisca brevicornis* is widespread in the North East Atlantic but is also recorded from the White Sea, south to the Iberian Peninsula and the Mediterranean, and as far as the coasts of South Africa, India, China and the Korean Peninsula (OBIS, 2020). It has been recorded in areas where sea surface temperatures (SST) range from 5 to 30°C, although most records occur in the 10-15°C range (OBIS, 2020). Similarly, *Ampelisca typica* is also recorded from the White Sea, through the North East Atlantic to the Iberian Peninsula, and in areas where the SST ranged from minus 5-0°C and 5-25°C although most records occurred in 10-15°C (OBIS, 2020). However, other species, e.g. *Ampelisca sarsi* have more limited distribution south of the British Isles (OBIS, 2020). *Photis longicaudata* is also widespread in the North East Atlantic but is also recorded from the Barents Sea, south to the Iberian Peninsula and the Mediterranean, and as far as the coasts of South Africa, India, China and the Korean Peninsula, and in the west Atlantic from Florida south to Uruguay and in areas where the SST ranged from minus 5-0°C and 5-30°C although most records occurred in 10-15°C (OBIS, 2020).

Murina (1997) categorized *Polydora ciliata* as a eurythermal species because of its ability to spawn in temperatures ranging from 10.6-19.9°C. This is consistent with a wide distribution in north-west Europe. In the western Baltic Sea, Gulliksen (1977) recorded high abundances of *Polydora ciliata* at temperatures of 7.5 to 11.5°C and in Whitstable, Kent, abundance was high when winter water temperatures dropped to 0.5°C (Dorsett, 1961). During the extremely cold winter of 1962/63, *Polydora ciliata* was unaffected (Crisp, 1964). *Spiophanes bombyx* is found in waters off Denmark (Thorson, 1946), which are likely to be colder than British and Irish waters.

Sensitivity assessment. Typical surface water temperatures around the UK coast vary seasonally from 4-19°C (Huthnance, 2010). The characteristic tube mat forming species are distributed to the north and south of the British Isles and are likely to be able to resist a long-term decrease in temperature of 2°C and may resist a short-term decrease of 5°C in UK waters. Resistance and resilience are, therefore, assessed as '**High'** and the biotope assessed as '**Not Sensitive'** at the benchmark level.

	Resistance	Resilience	Sensitivity
Salinity increase (local)	Low Q: Low A: NR C: NR	High Q: High A: High C: High	Low Q: Low A: Low C: Low

Monitoring at a Spanish desalination facility where discharges close to the outfall reached a salinity of 53, found that amphipods, including *Ampelisca* spp. were sensitive to the increased salinity and that species free-living in the sediment were most sensitive (De-la-Ossa-Carretero *et al*., 2016). Roberts *et al.* (2010b) reported that the effects of brine discharge were dependent on the receiving environment but that the effects were limited to with 10s of metres of the outfall. In their review, they reported that polychaete abundance and diversity decreased adjacent to a brine outfall in Alicante, Spain and that the family Ampharaetidae were the most sensitive while the family Paraonidae were the least sensitive (Ruso *et al*., 2008 cited in Roberts *et al*., 2010b). *Polydora ciliata* is a euryhaline species inhabiting fully marine and estuarine habitats. It is unlikely that *Spiophanes bombyx* would experience hypersaline conditions, therefore unlikely to be adapted to such conditions.

Sensitivity assessment. The characterizing species of this biotope are euryhaline and likely to be resistant to increases in salinity. However, the biotope occurs full saline conditions (Connor *et al*., 2004) and is unlikely to experience hypersaline conditions. Therefore, exposure to hypersaline effluent (>40) might result in the death of a portion of the individuals in the population, especially *Ampelisca* and some polychaetes species. Therefore, resistance is assessed as '**Low'** but with 'Low' confidence. Resilience is likely to be **High,** so the biotope is assessed as '**Low'** sensitivity to an increase in salinity at the pressure benchmark.

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

Ampelisca brevicornis was recorded from areas where the sea surface salinity (SSS) ranged between 5 and 35 psu although most records were in the range 15-35 psu and *Ampelisca typica* was recorded from areas where the SSS ranged between 15 and 35 psu although most records were in the range 30-35 psu (OBIS, 2020). *Photis longicaudata* was recorded from areas where the sea surface salinity ranged between 10 and 35 psu although most records were in the range 30-35 (OBIS, 2020).

Polydora ciliata is a euryhaline species inhabiting fully marine and estuarine habitats. In an area of the western Baltic Sea, where bottom salinity was between 11.1 and 15.0 psu *Polydora ciliata* was the second most abundant species with over 1000 individuals per m^2 (Gulliksen, 1977). *Spiophanes bombyx* is a euryhaline species (Bailey-Brook, 1976; Maurer & Lethem, 1980), inhabiting fully saline and estuarine habitats.

Sensitivity assessment. SS.SMu.ISaMu.AmpPlon occurs in full salinity conditions (Connor *et al.*, 2004). The evidence from distribution records (OBIS, 2020) suggests that the charactersitic amphipods vary in salinity tolerance but prefer full salinity conditions, except perhaps *Ampelisca brevicornis*, whereas the typical polychaetes are euryhaline. Therefore, a change in salinity regime from 'full' (30-35) to 'reduced' (18-30) might result in a reduction in the amphipod abundance and degradation of the tube mat. Hence, resitance is assessed as **'Medium'** to represent the possible loss of a proportion of the resident community but with 'Low' confidence. Resilience is probably '**High'** so the biotope sensitivity is assessed as '**Low**' to a decrease in salinity at the benchmark level.

Water flow (tidal current) changes (local)	Low	High	Low
	Q: Low A: NR C: NR	Q: High A: High C: High	Q: Low A: Low C: Low

Changes in water flow are likely to change the sediment characteristics in which the biotope occurs, primarily by resuspending and preventing deposition of finer particles (Hiscock, 1983). A decrease in water flow is unlikely to cause any impact on the biotope as species are adapted to incremental deposition, typical of low energy environments such as those where the sandy muds typical of this biotope occur. However, an increase would likely result in a decrease in tube-building material for the characterizing species, and the lack of deposition of particulate matter at the sediment surface would reduce food availability for the deposit feeders in the biotope. The resultant energetic cost over one year would be likely to result in some mortality of tube-builders and infauna. For example, *Polydora ciliata* was present and colonized test panels in Helgoland in three areas; two exposed to strong tidal currents and one site sheltered from currents (Harms & Anger, 1983). However, very strong water flows may sweep away *Polydora* colonies, often in a thick layer of mud on a hard substratum.

The most damaging effect of increased flow rate would be the erosion of the medium to fine muddy sand substratum as this could eventually lead to loss of the habitat. Amphipods are thought to stabilize the intertidal sediments in which they reside (Mouritsen *et al.*, 1998; MacKenzie *et al.*, 2006). Mills (1967, 1969) noted that the tubes of *Ampelisca* increased the surface complexity of the sandflat in Barnstable Harbour, Massachusetts. However, their feeding decreased the median grain size of the sediment, towards fine particulates, and resulted in instability. Mills (1969) stated that minor breaks in the mat of *Ampelisca* tubes were sufficient to cause large areas to wash out, especially on windy days in a rising or falling tide, although no flow rates were given. Emergent species, such as the *Polydora ciliata* tubes that characterize this biotope, may create turbulent flow leading to particle resuspension. Additionally, where a change in water flow rate changes sediment characteristics, with increased deposits of coarser sediments, characterizing species may no longer be supported due to particular substratum preferences.

Sensitivity assessment. SS.SMu.ISaMu.AmpPlon is recorded on sandy muds, which are typical of low energy environments i.e. wave sheltered and/or weak (<0.5 m/s) and very weak (negligible) tidal streams (Connor *et al.*, 2004). Sand particles are likely to be eroded at about 0.20 m/s (based on Hjulström-Sundborg diagram, Sundborg, 1956), although the sandy muds are more cohesive and require higher flow rates to resuspend. Also, the tube mat may help to stabilize the sediment surface, initially, until itself destabilizes due to the build-up of finer particulates (Mills, 1967, 1969). Although a decrease in water flow rate is likely to be irrelevant, an increase in water flow at the pressure benchmark is may result in loss of parts of the characterizing mat of tubes formed by *Ampelisca* spp., and *Polydora.* Furthermore, stronger currents (e.g. due to storms) are likely to wash away the community of semi-permanent tube-building amphipods and polychaetes that characterize the biotope. Therefore, resistance is assessed as '**Low**' and resilience as '**High**' so that sensitivity is assessed as '**Low**' sensitivity to a change in water flow at the pressure benchmark level.

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

SS.SMu.ISaMU.AmpPlon is recorded from 0-30 m (Connor *et al.*, 2004) and is predominately subtidal. Therefore, this pressure is probably **'Not relevant'**.

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

Where the biotope occurs in the shallow subtidal, it is likely to be affected by winter storms. Storms may cause dramatic changes in the distribution of macro-infauna by washing out dominant species, opening the sediment to recolonization by adults and/or available spat/larvae (Eagle, 1975; Rees *et al.*, 1976; Hall, 1994) and by reducing the success of recruitment by newly settled spat or larvae (see Hall, 1994 for review).

Feeding of the characterizing species may be impaired in strong wave action and changes in wave exposure may also influence the supply of particulate matter for tube-building polychaetes and amphipods. Mills (1967, 1969) noted that the tubes of *Ampelisca* increased the surface complexity of the sandflat in Barnstable Harbour, Massachusetts. Also, their feeding decreased the median grain size of the sediment, towards fine particulates, and resulted in instability. Mills (1969) stated that minor breaks in the mat of *Ampelisca* tubes were sufficient to cause large areas to wash out, especially on windy days in a rising or falling tide and reported that *Ampelisca* flats in Barnstable, Massachusetts, were damaged noticeably by winter storms (Mills, 1967, 1969). Mackenzie *et al.* (2006) reported that dense mats of *Ampelisca* persisted in Raritan Bay, New Jersey for at least five years because the mats occupied deeper waters (ca 7 m) and were sheltered from wave action.

Sensitivity assessment. SS.SMu.ISaMu.AmpPlon is recorded on sandy muds, which are typical of low energy environments i.e. wave sheltered and/or weak (<0.5 m/s) and very weak (negligible) tidal streams (Connor *et al.*, 2004). The tube mat that characterizes this biotope is probably very susceptible to damage or removal by during winter storms or on windy days, especially in the shallow examples of the habitat. Mills (1969) considered that the *Ampelisca* dominated tube mat demonstrated 'dynamic instability' due to its need to move from areas of physical disturbance and sediment modification. Although the biotope occurs in low energy conditions (Connor *et al.*, 2004) it is uncertain if a 3-5% change in significant wave height (the benchmark level) would be significant. Therefore, resistance is assessed as '**High'**, resilience as '**High'** and sensitivity is assessed as '**Not Sensitive' at the benchmark level.**

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 any evidence is presented where available.

Experimental studies with various species suggest that polychaete worms are quite resistant to heavy metals (Bryan, 1984). *Polydora ciliata* occurred in an area of the southern North Sea polluted by heavy metals but was absent from sediments with very high heavy metal levels (Diaz-Castaneda *et al.*, 1989). For most metals, toxicity to crustaceans increases with decreased salinity and elevated temperature, therefore marine species living within their normal salinity range may be less susceptible to heavy metal pollution than those living in salinities near the lower limit of their salinity tolerance (McLusky *et al.*, 1986). In laboratory investigations, Hong & Reish (1987) observed 96-hour LC_{50} water column concentrations of between 0.19 and 1.83 mg/l for several species of amphipod. *Corophium volutator* is highly intolerant of metal pollution at levels often found in estuaries from industrial outfalls and contaminated sewage. A concentration of 38 mg Cu/l was needed to kill 50% of *Corophium volutator* in 96-hour exposures (Bat *et al.*, 1998). Other metals are far more toxic to *Corophium volutator*, e.g. zinc is toxic over 1 mg/l and toxicity to metals increases with increasing temperature and salinity (Bryant *et al.*, 1985). Mortality of 50% is caused by 14 mg/l (Bat *et al.*, 1998). Although exposure to zinc may not be lethal, it may affect the perpetuation of a population by reducing growth and reproductive fitness. Mercury was found to be very toxic to *Corophium volutator*, e.g. concentrations as low as 0.1 mg/l caused 50% mortality in 12 days. Other metals known to be toxic include cadmium, which causes 50% mortality at 12 mg/l (Bat *et al.*, 1998); and arsenic, nickel and chromium which are all toxic over 2 mg/l (Bryant *et al.*, 1984; Bryant *et al.*, 1985a; 1985).

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 any evidence is presented where available.

In general, soft-sediment inhabitants, especially infaunal polychaetes, are particularly affected by oil pollution (Suchanek, 1993). For example, Jacobs (1980) investigated the effects of the *Amoco Cadiz* oil spill in 1978 and noted that the numbers of spionidae polychaetes decreased after the spill. In an analysis of kelp holdfast fauna following the *Sea Empress* oil spill in Milford Haven the fauna present, including *Polydora ciliata*, showed a strong negative correlation between numbers of species and distance from the spill (SEEEC, 1998). After the extensive oil spill in West Falmouth, Massachusetts, Grassle & Grassle (1974) followed the settlement of polychaetes in the disturbed area. Species with the most opportunistic life histories, including *Polydora ligni*, were able to settle in the area. This species has some brood protection which enables larvae to settle almost immediately in the nearby area (Reish, 1979). Furthermore, Gray *et al.* (1990) found that *Scoloplos armiger* was a dominant species in uncontaminated soft sediments at a case study site adjacent to the Ekofisk oil field but was not present at contaminated sites, suggesting *Scoloplos armiger* are also intolerant to hydrocarbon contaminates.

Amphipods in general and ampeliscid amphipods, in particular, seem particularly intolerant of contamination with oil. Dauvin (1998) reported reductions in abundance, biomass and production of *Ampelisca* sp. following the *Amoco Cadiz* oil spill. Furthermore, light fractions (C10 - C19) of oils are much more toxic to *Corophium volutator* than heavier fractions (C19 - C40). In exposures of up to 14 days, light fraction concentrations of 0.1 g/kg sediment caused high mortality. It took 9 g/kg sediment to achieve similar mortalities with the heavy fraction (Brils *et al*., 2002). In the Forth Estuary, *Corophium volutator* was excluded for several hundred metres around the outfalls from hydrocarbon processing plants. Roddie *et al.* (1994) found high levels of mortality of *Corophium* at sites contaminated with crude oil.

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 any evidence is presented where available.

In general, crustaceans are widely reported to be intolerant of synthetic chemicals (Cole *et al*., 1999) and intolerance to some specific chemicals has been observed in amphipods. Species of a different genus are likely to differ in their susceptibility to synthetic chemicals and that this may be related to differences in their physiology (Powell, 1979). *Corophium volutator* is paralysed by pyrethrum based insecticide sprayed onto the surface of the mud (Gerdol & Hughes, 1993) and pyrethrum would probably cause significant mortalities if it found its way into estuaries from agricultural runoff. Nonylphenol is an anthropogenic pollutant that regularly occurs in water bodies, it is an oestrogen mimic that is produced during the sewage treatment of non-ionic surfactants and can affect *Corophium volutator* (Brown *et al*., 1999). Nonylphenol is a hydrophobic molecule and often becomes attached to sediment in water bodies. This will make nonylphenol available for ingestion by *Corophium volutator* in estuaries where much of the riverine water-borne sediment flocculates and precipitates out of suspension to form mudflats. Nonylphenol is not lethal to *Corophium volutator* but does reduce growth and has the effect of causing the secondary antennae of males to become enlarged, which can make the amphipods more vulnerable to predators (Brown *et al*., 1999). *Corophium volutator* is killed by 1% ethanol if exposed for 24 hours or more but can withstand higher concentrations in short pulses. Such short pulses, however, have the effect of rephasing the diel rhythm and will delay the timing of swimming activity for the duration of the ethanol pulse (Harris & Morgan, 1984b).

The anti-parasite compound ivermectin is highly toxic to benthic polychaetes and crustaceans (Black *et al*., 1997; Collier & Pinn, 1998; Grant & Briggs, 1998, cited in Wilding & Hughes, 2010). OSPAR (2000) stated that, at that time, ivermectin was not licensed for use in mariculture but was incorporated into the feed as a treatment against sea lice at some farms. Ivermectin has the potential to persist in sediments, particularly fine-grained sediments at sheltered sites. Data from a farm in Galway, Ireland indicated that ivermectin was detectable in sediments adjacent to the farm at concentrations up to 6.8 □m/kg and to a depth of 9 cm (reported in OSPAR, 2000). Infaunal polychaetes have been affected by deposition rates of 78-780 mg ivermectin/m^2. Furthermore, *Polydora ciliata* was abundant at polluted sites close to acidified, halogenated effluent discharge from a bromide-extraction plant in Amlwch, Anglesey (Hoare & Hiscock, 1974). Spionid polychaetes were found by McLusky (1982) to be relatively resistant of distillation and petrochemical industrial waste in Scotland.

Radionuclide contamination	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

Corophium volutator readily absorbs radionuclides such as americium and plutonium from water and contaminated sediments (Miramand *et al*., 1982). However, the effect of contamination of the individuals was not known but accumulation through the food chain was assumed (Miramand *et al*., 1982). There was '**No evidence'** on which to base an assessment.

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	Low Q: Medium A: Medium C: Medium	High Q: High A: High C: High	Low Q: Medium A: Medium C: Medium

Riedel *et al*. (2012) assessed the response of benthic macrofauna to hypoxia advancing to anoxia in the Mediterranean. The hypoxic and anoxic conditions were created for 3-4 days in a box that enclosed in-situ sediments. Polychaetes appeared to be sensitive to hypoxia, as only 10% of polychaetes survived. In general, epifauna were more sensitive than infauna, mobile species more sensitive than sedentary species and predatory species more sensitive than suspension and deposit feeders. The test conditions did not lead to the production of hydrogen sulphide that may have reduced mortalities compared to other observations.

Amphipods appear not to be tolerant of reduced oxygenation. For example, *Ampelisca agassizi* was reported to be intolerant of hypoxia (Diaz & Rosenberg, 1995) and *Jassa falcata*, another tube building amphipod species, was absent from Californian harbours with low oxygen concentrations (0-2.5 mg/l). *Polydora ciliata* is repeatedly found at localities with oxygen deficiency (Pearson & Rosenberg, 1978). For example, in polluted waters in Los Angeles and Long Beach harbours *Polydora ciliata* was present in the oxygen range 0.0-3.9 mg/l and the species was abundant in hypoxic fjord habitats (Rosenberg, 1977). Furthermore, in a study investigating a polychaete community in the north-west Black Sea, *Polydora ciliata* was observed in all four study sites, including those severely affected by eutrophication and hypoxia as a result of the discharge of wastewaters (Vorobyova *et al*., 2008). However, *Polydora ciliata* is unlikely to be able to resist anoxic conditions. Hansen *et al*. (2002) reported near total extinction of all metazoan in the Mariager Fjord (Denmark), including *Polydora* spp. after a severe hypoxia event that resulted in complete anoxia in the water column for two weeks. Additionally, Como & Magni (2009) investigated seasonal variations in benthic communities known to be affected by episodic events of hypoxia. The authors observed that the abundance of *Polydora ciliata* varied seasonally, decreasing during the summer months, and suggested it could be explained by the occurrence of hypoxic/anoxic conditions and sulphidic sediments during the summer. No details of the levels of dissolved oxygen leading to these community responses were provided. Other polychaetes in the biotope are also likely to be able to deal with hypoxia. For example, during low tide, the polychaete *Scoloplos armiger* survives deoxygenation by ascending into the oxidative layer where it can maintain aerobic metabolism. In laboratory conditions, *Scoloplos armiger* survived low oxygen conditions for 40 hours (Schöttler & Grieshaber, 1988).

Nierman *et al.* (1990) reported changes in a fine sand community for the German Bight in an area with regular seasonal hypoxia. In 1983, oxygen levels were exceptionally low (<3 mg O_2/l) in large areas and <1 mg O_2/l in some areas. Species richness decreased by 30-50% and overall biomass fell. *Spiophanes bombyx* was found in small numbers at some, but not all areas, during the period of hypoxia. Once oxygen levels returned to normal *Spiophanes bombyx* increased in abundance. The evidence suggests that at least some individuals would survive hypoxic conditions.

Sensitivity assessment. Cole *et al.* (1999) suggested possible adverse effects on marine species exposed to dissolved oxygen concentrations below 4 mg/l and probable adverse effects below 2 mg/l. The characteristic polychaete *Polydora ciliata* is repeatedly found at localities with oxygen deficiency (Pearson & Rosenberg, 1978) and seems to only be affected by severe deoxygenation episodes. Other polychaetes in the biotope are likely to behave similarly. However, the mortality of tube building *Ampelisca* spp. species is likely. Therefore, resistance to deoxygenation at the pressure benchmark level is assessed as '**Low'** but resilience is likely to be '**High** so that biotope sensitivity is assessed as '**Low'** sensitivity to exposure to a dissolved oxygen concentration of less than or equal to 2 mg/l for 1 week.

Nutrient enrichment	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not sensitive Q: NR A: NR C: NR

Connor *et al.* (2004) suggested that this biotope was associated with moderate organic enrichment. Amphipods appear to be tolerant of and indeed prefer, high nutrient levels. Diaz *et al.* (2008) reported the change in the abundance of Ampelisca tube mats in Boston Harbour, USA when wastewater outfalls were moved from onshore to offshore. Boston Harbour became changed from anaerobic to more aerobic between 1992 and 2006. *Ampelisca* mats became widespread in 1992 and then declined by 2000. Diaz *et al.* (2008) suggested that the optimal organic loading for the maintenance of large areas of amphipod tube mats around 500 gC per square meter per year; above or below which levels, the mats declined.

Polydora ciliata is often found in environments subject to high levels of nutrients. For example, the species was abundant in areas of the Firth of Forth exposed to high levels of sewage pollution (Smyth, 1968), in nutrient-rich sediments in the Mondego Estuary, Portugal (Pardal *et al.*, 1993), and the coastal lagoon Lago Fusaro, Naples (Sordino *et al.*, 1989). The extensive growths of *Polydora ciliata* in mat formations were recorded at West Ganton, in the Firth of Forth, prior to the introduction of the Sewage Scheme (Read *et al.*, 1983). The abundance of the species was probably associated with their ability to use the increased availability of nutrients as a food source and silt for tube building.

Sensitivity assessment. This pressure relates to increased levels of nitrogen, phosphorus and silicon in the marine environment compared to background concentrations. The characterizing species of this biotope are likely to be able to resist and be favoured by nutrient enrichment where increased availability of nutrients may be used as a source of food (Hiscock *et al.*, 2005a). Nevertheless, the biotope is assessed as '**Not Sensitive'** at the pressure benchmark level, which is set at compliance with Water Framework Directive (WFD) criteria for good status, based on nitrogen concentration (UKTAG, 2014).

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

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Polydora ciliata is often found in environments subject to high levels of nutrients. For example, the species was abundant in areas of the Firth of Forth exposed to high levels of sewage pollution (Smyth, 1968), in nutrient-rich sediments in the Mondego Estuary, Portugal (Pardal *et al.*, 1993), and the coastal lagoon Lago Fusaro in Naples (Sordino *et al.*, 1989). The extensive growths of *Polydora ciliata* in mat formations were recorded at West Ganton, in the Firth of Forth, prior to the introduction of the Sewage Scheme (Read *et al.*, 1983). The abundance of the species was probably associated with their ability to use the increased availability of nutrients as a food source and silt for tube building. In colonization experiments in an organically polluted fjord receiving effluent discharge from Oslo, *Polydora ciliata* had settled in large numbers within the first month (Green, 1983). However, Callier *et al.* (2007) investigated the spatial distribution of macrobenthos under a suspended mussel culture, in eastern Canada, where the sedimentation of organic matter to the bottom was approx. 1-3 gC/m^2/day. *Polydora ciliata* was recorded as absent in the sites under the suspended mussel farm after one year and as dominant in reference areas of the study. Como & Magni (2009) investigated seasonal variations in benthic communities known to be affected by episodic events of sediment over-enrichment. The authors observed that abundance of *Polydora ciliata* varied seasonally, and suggested this could be a result major accumulation of organic carbon-binding fine sediments in the study site. Studies by Almeda *et al.* (2009) and Pedersen *et al.* (2010) investigated larval energetic requirements for *Polydora ciliata* and suggested maximum growth rates were reached at food concentrations ranging from 1.4 to 2.5 g C/ml depending on larval size, and energetic carbon requirements of 0.09 to 3.15 g C l/d, respectively. Borja *et al.* (2000) and Gittenberger & Van Loon (2011) both assigned *Polydora ciliata* to their AMBI Group IV 'second-order opportunistic species (slight to pronounced unbalanced situations)', However, *Polydora ciliata* can also occur in organically poor areas (Pearson & Rosenberg, 1978).

Sensitivity assessment. The evidence presented suggests that the characterizing species of this biotope are likely to be stimulated by enrichment and only affected by excessive organic enrichment (above the benchmark level). Therefore, resistance and resilience are assessed as '**High**', and the biotope is assessed as '**Not Sensitive**' to organic enrichment involving deposition of 100 gC/m^2/yr. **It should be noted** that a decrease in organic enrichment may be detrimental as the abundance and extent of *Ampelisca* tube mats require moderate organic enrichment (see Diaz *et al.*, 2008) but a reduction in organic enrichment is not addressed by this pressure.

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

SS.SMu.ISaMu.AmpPlon is characterized by sandy mud substratum. A change to a rock or artificial substratum would result in the loss of suitable habitat and the characterizing species, significantly altering the character of the biotope. The biotope would be lost and/or reclassified.

Sensitivity assessment. Resistance to the pressure is considered '**None'**, and resilience '**Very Low'** based on the permanent loss of suitable substratum to support the community of the characterizing tube-building polychaete and amphipod species. 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.

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

SS.SMu.ISaMu.AmpPlon is characterized by sandy muds only (Connor *et al*., 2004). A change in sediment type by one Folk Class (based on the Long, 2006 simplification) would result in an increase in the fraction of sand and gravel in the substratum. *Ampelisca* tube mat communities are recorded from sandflats (e.g. Mills, 1967, 1969) and could potentially survive a change to a fine sand substratum. However, the biotope would probably transition into its sandy equivalent SS.SSa.IFiSa.TbAmPo and be reclassified. Mackenzie et al. (2006) reported that *Ampelisca abdita* did not occur on medium to coarse sand because they had difficulty using in to build their tubes. A change to coarse sand or gravels would no longer support the characteristic species and the biotope would be lost and/or reclassified.

Sensitivity assessment. Resistance to the pressure is considered '**None'**, and resilience '**Very Low'** based on the permanent loss of suitable substratum to support the community of the characterizing species. Sensitivity has been assessed as '**High'**.

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

Removal of the substratum to 30 cm would result in the loss of the tube mat created by *Ampelisca* spp., and its associated species e.g. *Polydora ciliata* tubes. Recovery of sediments will be site-specific and will be influenced by currents, wave action and sediment availability (Desprez, 2000). Except in areas of mobile sands, the process tends to be slow (Kenny & Rees, 1996; Desprez, 2000). Boyd *et al.* (2005) found that in a site subject to long-term extraction (25 years), extraction scars were still visible after six years and sediment characteristics were still altered in comparison with reference areas with ongoing effects on the biota. The strongest currents are unable to transport gravel. A further implication of the formation of these depressions is a local drop in current strength associated with the increased water depth, resulting in deposition of finer sediments than those of the surrounding substrate (Desprez, 2000).

Sensitivity assessment. Resistance is assessed as '**None'** as the extraction of the sediment will remove the characterizing and associated species present. Resilience is assessed as '**Medium'** (see resilience section) and sediments may need to recover (where exposed layers are different). Biotope sensitivity is, therefore, assessed as '**Medium'**.

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

The tubes of the polychaetes and amphipods are bound only with mucous and are, therefore, likely to be damaged or removed by abrasion. The *Ampelisca* dominated tube mat sits in the surface of the sediment. Mills (1967, 1969) noted that the tubes of *Ampelisca* increased the surface complexity of the sandflat in Barnstable Harbour, Massachusetts. However, their feeding decreased the median grain size of the sediment, towards fine particulates, and resulted in instability. Mills (1969) stated that minor breaks in the mat of *Ampelisca* tubes were sufficient to cause large areas to wash out, especially on windy days in a rising or falling tide. The tube mat would probably be removed easily by the passage of bottom gears. Therefore, resistance to abrasion is assessed as '**Low'** but resilience is probably '**High'** so that sensitivity to surface abrasion is assessed as '**Low'**.

Penetration or disturbance of the substratum subsurface	None Q: Medium A: Medium C: Medium	Medium Q: High A: High C: High	Medium Q: Medium A: Medium C: Medium

Activities that penetrate below the surface are likely to tear up and remove a significant proportion of the tube building community that characterize this biotope. Bergman & Van Santbrink (2000) found that direct mortality of gammarid amphipods, following a single passage of a beam trawl (in silty sediments where penetration is greater) was 28%. Furthermore, stomach analysis of fish caught scavenging in the tracks of beam trawls found parts of *Ampelisca* spp. indicating that these had been damaged and exposed by the trawl (Kaiser & Spencer, 1994). Experiments in shallow, wave disturbed areas, using a toothed, clam dredge, found that deposit-feeding polychaetes were more impacted than carnivorous species. Dredging resulted in reductions of >90% of *Spiophanes bombyx* immediately post dredging compared with before impact samples and the population reduction persisting for 90 days (although results may be confounded by storm events within the monitoring period which caused sediment mobility). The passage of the dredge across the sediment floor will have killed or injured some organisms that will then be exposed to potential predators/scavengers (Frid *et al.*, 2000; Veale *et al.*, 2000) providing a food source to mobile scavengers including these species. Bergman & Hup (1992) carried out a pre and post-experimental investigation using a 12 m beam trawl. The area was trawled three times over two days and samples taken up to two weeks after trawling. Some benthic species showed a

10-65% reduction in density after trawling the area three times. There was a significant lower of density (40-60%) of polychaete worms, including *Spiophanes bombyx*.

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Sensitivity assessment. The evidence presented suggests that the tube mat community and associated infauna may suffer significant mortality (>75%) as a result of penetrative activities of the seabed. Biotope resistance is, therefore, assessed as '**None'** and recovery is assessed as '**Medium** so that sensitivity is assessed as '**Medium'**.

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

The biotope is likely to occur in relatively turbid waters that allow sediment deposition to support the community of characterizing tube-building polychaetes and amphipods, and, therefore, the species in the biotope are likely to be adapted to turbid conditions. Amphipods are tolerant of high turbidity and gather suspended sediment for the construction of tubes. Mills (1967) reported that feeding by *Ampelisca vadorum* and *Ampelisca abdita* were initiated by the turbidity of the water surrounding the tubes. However, the feeding structures of suspension feeders such as *Ampelisca* spp. may become clogged by large increases in suspended sediment or feeding may be terminated, compromising growth. However, Mackenzie *et al.* (2006) noted that the *Ampelisca* mat modified the mud surface substantially. The tube mat stabilized the mud surface, minimised the resuspension of mud by strong currents and the surface of the sediment becomes covered by their faecal pellets that produce little turbidity when in the water column. Mackenzie *et al.* (2006) also noted that suspension feeding by the dense population of *Ampelisca* spp. reduces turbidity locally by capturing silt in their faeces.

Tube-building polychaetes are likely to be tolerant of high turbidity as they normally inhabit waters with high levels of suspended sediment which they actively fix in the process of tube making. For example, in the Firth of Forth, *Polydora ciliata* formed extensive mats in areas that had an average of 68 mg/l suspended solids and a maximum of approximately 680 mg/l indicating the species can tolerate different levels of suspended solids (Read *et al*., 1982; Read *et al*., 1983). Daro & Polk (1973) reported that the success of *Polydora* is directly related to the quantities of muds of any origin carried along by rivers or coastal currents. Deposit feeders and tube builders rely on siltation of suspended sediment. A decrease in suspended sediment will reduce this supply and therefore may compromise growth and reproduction. *Spiophanes bombyx* is found in estuarine regions which experience high levels of turbidity. *Spiophanes bombyx* is a surface deposit feeder and relies on a supply of nutrients at the sediment surface. An increase in turbidity, reducing light availability may reduce primary production by phytoplankton in the water column. Although productivity in the biotope is secondary, a reduction in primary production in the water column may result in reduced food supply to deposit and suspension feeders, which in turn may affect growth rates and fecundity.

Sensitivity assessment. An increase in suspended solids at the pressure benchmark level is unlikely to affect the characterizing species of this biotope. However, a decrease in the suspended matter in the biotope could result in limitation of material for tube building activities and the loss of suitable substratum for colonization by new recruits of *Polydora ciliata*, in particular. Therefore, resistance is assessed as '**Low'** (loss of 25-75%) and resilience is '**High'** so that sensitivity is assessed as '**Low' at the benchmark level.**

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

The tubes of *Ampelisca* spp. are probably several centimetres in length, depending on species, and extend above the sediment surface. For example, the tubes of *Ampelisca abdita* in Barnstable Harbour were about 3.5 cm in length a protruded 1 cm above the sediment surface (Mills, 1967). The tube mats occur in sedimentary, muddy environments so that they are probably adapted to steady rates of sedimentation and require sediment to continue to feed and build their tubes. However, no information on their ability to burrow or 'grow up' through deposited sediment was found. *Ampelisca brevicornis* was characterized by Gittenberger & Van Loon (2011) in their index of sedimentation tolerance as Group II "species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation".

A *Polydora* mud can be up to 50 cm thick, but the animals themselves occupy only the first few centimetres. They either elongate their tubes or have left them to rebuild close to the surface. Munari & Mistri (2014) investigated the spatio-temporal variation pattern of a benthic community following deposition of dredged material, at a maximum thickness of 30–40 cm. *Polydora ciliata* was amongst the first colonizers of the newly deposited sediments. The authors suggested that individuals may have migrated vertically through the deep layer of dredged sand. This was based on the results of Roberts *et al*. (1998) who suggested 15 cm as the maximum depth of overburden through which benthic infauna can successfully migrate. After one year, no adverse impact of sand disposal on the benthic fauna was detected on the study site (Munari & Mistri, 2014). *Spiophanes bombyx* was Group IV species: 'Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong fluctuation in sedimentation' (Gittenberger & Van Loon, 2011).

Sensitivity assessment. The *Ampelisca* tube mat is probably of a similar height to a deposit of 5 cm of fine sediment. *Polydora ciliata* and other characterizing polychaetes are likely to resist or relocate after smothering by 5 cm of sediment. However, this 'light' deposition of fine sediment is may cause some mortality of *Ampelisca* spp.. based on Gittenberger & Van Loon (2011). Therefore, resistance is assessed as '**Medium'** albeit with 'Low' confidence. Resilience is probably '**High'** and biotope sensitivity is assessed as '**Low'** sensitivity to a 'light' deposit of up to 5 cm of fine material in a single discrete event.

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

The tubes of *Ampelisca* spp. are probably several centimetres in length, depending on species, and extend above the sediment surface. For example, the tubes of *Ampelisca abdita* in Barnstable Harbour were about 3.5 cm in length a protruded 1 cm above the sediment surface (Mills, 1967). The tube mats occur in sedimentary, muddy environments so that they are probably adapted to steady rates of sedimentation and require sediment to continue to feed and build their tubes. However, no information on their ability to burrow or 'grow up' through deposited sediment was found. *Ampelisca brevicornis* was characterized by Gittenberger & Van Loon (2011) in their index of sedimentation tolerance as Group II "species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation".

A *Polydora* mud can be up to 50 cm thick, but the animals themselves occupy only the first few centimetres. They either elongate their tubes or have left them to rebuild close to the surface. Munari & Mistri (2014) investigated the spatio-temporal variation pattern of a benthic community following deposition of dredged material, at a maximum thickness of 30–40 cm. *Polydora ciliata* was amongst the first colonizers of the newly deposited sediments. The authors suggested that individuals may have migrated vertically through the deep layer of dredged sand. This was based on the results of Roberts *et al*. (1998) who suggested 15 cm as the maximum depth of overburden through which benthic infauna can successfully migrate. After one year, no adverse impact of sand disposal on the benthic fauna was detected on the study site (Munari & Mistri, 2014). *Spiophanes bombyx* was Group IV species: 'Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong fluctuation in sedimentation' (Gittenberger & Van Loon, 2011).

Sensitivity assessment. The *Ampelisca* tube mat is probably only a few centimetres in height and would be completely buried under a 30 cm deposit of sediment. *Polydora ciliata* and other characterizing polychaetes are likely to resist or relocate after smothering by 30 cm of sediment. However, this 'heavy' deposition of fine sediment is may cause significant mortality of *Ampelisca* spp.. based on Gittenberger & Van Loon (2011). Therefore, resistance is assessed as **'Low'** albeit with 'Low' confidence. Resilience is probably '**High'** and biotope sensitivity is assessed as '**Low'** sensitivity to a 'heavy' deposit 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	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence was available on which to assess this pressure. However, Arendse & Barendregt (1981) manipulated magnetic fields to alter the geomagnetic orientation of the talitrid amphipod *Orchestia cavimana*.

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

There is no evidence to suggest that any of the species that characterize the biotope respond to noise or vibration at the level of the benchmark, so the biotope is assessed as **Not relevant**.

Introduction of light or shading	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

SS.SMU.ISaMu.AmpPlon is a sublittoral biotope (Connor *et al.*, 2004) and therefore not directly dependent on sunlight. Although, the characteristic species may respond to light orientation or shading they do not depend on light for feeding. Shading may decrease the abundance of benthic diatoms and euglenoids but the characteristic *Ampelisca* spp. are suspension-feeders capable of taking a range of organic particulates. The biotope is considered to have '**High**' resistance and, by default, '**High**' resilience and is, therefore, is assessed as '**Not Sensitive**' to the introduction of light.

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

Not Relevant to biotopes restricted to open waters.

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

Polydora ciliata exhibits shadow responses and withdraws its palps into its burrow, which is believed to be a defence against predation. The withdrawal of the palps interrupts feeding and possibly respiration, although the species also shows habituation of the response (Kinne, 1970). *Polydora* is unlikely to be sensitive to visual disturbance caused by passing shipping but may respond to passing divers at close range. Other characterizing polychaetes, such as *Spiophanes bombyx*, also inhabit a tube so its visual range is probably very limited. No information on the visual responses of *Ampelisca spp.* was found. Nevertheless, visual disturbance (as defined by the benchmark) is probably **'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

The important characterizing species in the biotope are not cultivated or likely to be translocated. This pressure is, therefore considered '**Not relevant'**.

Introduction or spread of invasive non-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

There is no evidence on the presence of non-indigenous species or impacts of non-indigenous species relevant to this biotope. This pressure is, therefore considered '**Not relevant'**.

Introduction of microbial pathogens	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

Introduced organisms (especially parasites or pathogens) are a potential threat in all coastal ecosystems. However, no information was found on microbial pathogens affecting *Polydora ciliata*. Amphipods may be infected by a number of parasites or pathogens that alter population numbers through changes in host condition, growth, behaviour and reproduction (Green Extabe & Ford, 2014). For example, infection by acanthocephalan larvae may alter the behaviour and responses of gammarid amphipods (Bethel & Holmes, 1977). The amphipod *Orchestia gammarellus* is host to the parasitic protist *Marteilia* that has a feminizing effect on populations, with higher ratios of females and intersex males in infected, estuarine populations (Ginsburger-Vogel & Desportes, 1979). Studies conducted in the Baltic Sea suggested that increased parasitism by trematode species has a detrimental effect on local amphipods (Meissner & Bick, 1999; Mouritsen & Jensen, 1997; cited in Shim *et al*., 2013).

Sensitivity assessment. There are no records of the biotope being affected by the introduction of microbial pathogens or parasites in the British Isles, and there is not enough evidence to assess sensitivity.

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

None of the characterizing species is known to be targeted directly by commercial or recreational fisheries or harvesting. Therefore, this pressure is assessed as **'Not relevant'**.

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

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. The characterizing species in this biotope are highly likely to be damaged or directly removed by static or mobile gears that are targeting other species (see abrasion and penetration pressures).

Sensitivity assessment. Loss of the characterizing species of this biotope is likely to occur as a result of unintentional removal. Removal of the characterizing species would result in the biotope being lost. Thus, the biotope is considered to have a resistance of '**Low'** to this pressure. However, resilience is probably '**High'** so that sensitivity is assessed as '**Low'**.

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