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Aphelochaeta spp. and *Polydora* spp. in variable salinity infralittoral mixed sediment

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

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2016-06-19

This review can be cited as:
De-Bastos, E. & Tyler-Walters, H., 2016. [Aphelochaeta] spp. and [Polydora] spp. in variable salinity infralittoral 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.114.1

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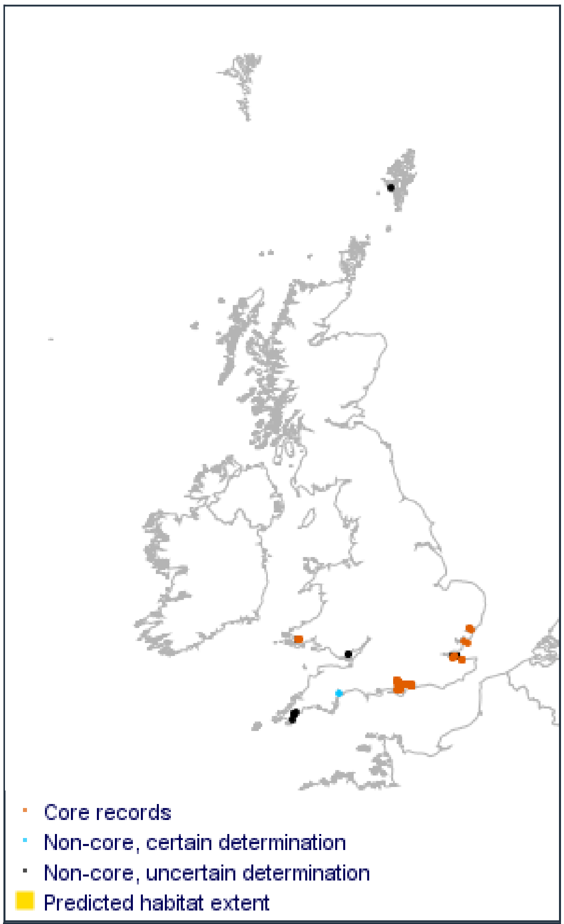

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Eliane De-Bastos & Dr Harvey Tyler-Walters **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A5.421	*Aphelochaeta* spp. and *Polydora* spp. in variable salinity infralittoral mixed sediment
JNCC 2015	SS.SMx.SMxVS.AphPol	*Aphelochaeta* spp. and *Polydora* spp. in variable salinity infralittoral mixed sediment
JNCC 2004	SS.SMx.SMxVS.AphPol	*Aphelochaeta spp.* and *Polydora spp.* in variable salinity infralittoral mixed sediment
1997 Biotope	SS.IMX.EstMx.PolMtru	*Polydora ciliata*, *Mya truncata* and solitary ascidians in variable salinity infralittoral mixed sediment

Description

In sheltered muddy mixed sediments in estuaries or marine inlets with variable or reduced/low salinity communities characterized by *Aphelochaeta marioni* and *Polydora ciliata* may be present.

Other important taxa may include the polychaetes *Nephtys hombergii*, *Caulleriella zetlandica* and *Melinna palmata*, tubificid oligochaetes and bivalves such as *Abra nitida*. Conspicuous epifauna may include members of the bivalve family *Cardiidae* (cockles) and the slipper limpet *Crepidula fornicata*. This biotope is often found in polyhaline waters (Information taken from the Marine Biotope Classification for Britain and Ireland, Version 15.03; Connor *et al.*, 2004).

Depth range

-

Additional information

None entered

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Habitat review

Ecology

Ecological and functional relationships

This biotope occurs in the lower estuary where the hydrodynamic regime allows a suitable environment to develop. The presence of a suitable substratum is probably the primary structuring force, rather than the interspecific relationships. Mixed sediment provides a stable substratum for the epifauna such as solitary and colonial ascidians while the soft sediment supports infaunal annelids, crustaceans and bivalves. Sediment is the most extensive sub-habitat within the biotope and hence infauna dominate.

- In areas of mud, the tubes built by *Polydora ciliata* can agglomerate and form layers of mud up to an average of 20 cm thick, occasionally to 50 cm. These layers can eliminate the original fauna and flora. Daro & Polk (1973) state that the formation of layers of *Polydora ciliata* tend to eliminate original flora and fauna. The species readily overgrows other species with a flat morphology and feeds by scraping its palps outside its tubes, which would inhibit the development of settling larvae of other species.
- Burrowing deposit feeding species potentially disturb and mobilize the sediment, but the presence of mats of *Polydora ciliata* and the burrowing piddock *Petricola pholadiformis* suggests that the sediment is relatively stable. Tube building, e.g. by *Lanice conchilega* and *Lagis koreni*, probably stabilizes the sediment and arrests the shift towards a community dominated by deposit feeders. Many of the infaunal polychaetes within the biotope are surface deposit feeders (e.g. the terebellids and cirratulids).
- Amphipods, e.g. *Corophium* sp., and the infaunal annelid species in this biotope probably interfere strongly with each other. Adult worms probably reduce amphipod numbers by disturbing their burrows, while high densities of amphipods can prevent establishment of worms by consuming larvae and juveniles (Olafsson & Persson, 1986). For example, *Arenicola marina* was shown to have a strong negative effect on *Corophium volutator* due to reworking of sediment causing the amphipod to emigrate (Flach, 1992).
- Hard substrata support suspension feeding ascidians such as *Ascidiella scabra*, *Ascidiella aspera*, *Molgula* spp. and *Dendrodoa grossularia* and tubeworms e.g. *Spirobranchus triqueter*, while infaunal suspension feeders include the bivalves *Abra alba* and *Mya truncata* and *Mya arenaria* and tubeworms e.g. *Lanice conchilega*.
- *Carcinus maenas* is a significant predator in the biotope. It has been shown to reduce the density of *Mya arenaria*, *Cerastoderma edule*, *Abra alba*, *Tubificoides benedii*, *Aphelochaeta marioni* and *Corophium volutator* (Reise, 1985). A population of *Carcinus maenas* from a Scottish sea-loch preyed predominantly on annelids (85% frequency of occurrence in captured crabs) and less so on molluscs (18%) and crustaceans (18%) (Feder & Pearson, 1988).
- Carnivorous annelids such as *Nephtys hombergi*, *Eteone longa*, *Glycera* spp. and *Harmothoe* spp. operate at the trophic level below *Carcinus maenas* (Reise, 1985). They predate the smaller annelids, such as *Exogone naidina*, and crustaceans, such as *Corophium volutator* and *Cumacea* sp.

Seasonal and longer term change

Seasonal changes occur in the abundance of the fauna due to seasonal recruitment processes. Variation in abundance is very pronounced in the polychaete *Aphelochaeta marioni*. In the Wadden

Sea, peak abundance occurred in January (71,200 individuals per m^2) and minimum abundance occurred in July (22,500 individuals per m^2) following maximum spawning activity between May and July (Farke, 1979). However, the spawning period varies according to environmental conditions and so peak abundances will not necessarily occur at the same time each year. Adult densities of the bivalve, *Abra alba*, may exceed 1000 per m^2 in favourable conditions but typically fluctuate widely from year to year due to variation in recruitment success or adult mortality (see review by Rees & Dare, 1993). However, the sea squirt *Ascidiella scabra* showed regular annual recruitment onto artificial and scraped natural substrata and was described as an 'annual ascidian' by Svane (1988).

One of the key factors affecting benthic habitats is disturbance which, in shallow subtidal habitats increases in winter due to weather conditions. Storms may cause dramatic changes in 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.*, 1977; Hall, 1994) and by reducing success of recruitment by newly settled spat or larvae (see Hall, 1994 for review). For example, during winter gales along the North Wales coast large numbers of *Abra alba* were cast ashore and over winter survival rate was as low as 7% in the more exposed locations, whilst the survival rates of the polychaetes *Eteone longa* and *Nephtys hombergi* were 29% and 22% respectively (Rees *et al.*, 1977). Soft bodied epifauna, such as ascidians, are likely to be very sensitive to storm damage and will probably suffer high mortality during winter storms. Rapid recolonization occurs in summer and therefore abundances are likely to vary considerably due to physical disturbance. Sediment transport and the risk of smothering also occurs. A storm event at a silt/sand substratum site in Long Island Sound resulted in the deposition of a 1 cm layer of shell fragments and quartz grains (McCall, 1977).

Habitat structure and complexity

The biotope consists of hard substrata such as cobbles and pebbles or shell debris sitting in or on consolidated sediments. The mixed substrata provides habitats for a diverse assemblage of epifaunal and infaunal species. Most of the species that occur in the biotope are not closely associated with the community and it is probably transitional between other biotopes such as *Aphelochaeta marioni* (e.g. IMU.AphTub), or bivalves (e.g. IMX.VsenMtru).

- The mixed sediment in this biotope is the important structural component, providing the complexity required by the associated community. Epifauna attached to the gravel and pebbles and infauna burrow in the soft underlying sediment. Sediment deposition, and therefore the spatial extent of the biotope, is dictated by the physiography and underlying geology coupled with the hydrodynamic regime (Elliot *et al.*, 1998).
- The presence of both sediment and hard substrata increases the range of substrata available for settlement by organism with different habitat requirements; both infaunal and epifaunal species may be abundant . Attrill *et al.* (1996) described a "biodiversity hot spot" in similar situations of mixed substrata in the Thames estuary.
- There is a traditional view that the distribution of infaunal invertebrates is correlated solely with sediment grain size. In reality, and in this biotope, it is likely that a number of additional factors, including organic content, microbial content, food supply and trophic interactions, interact to determine the distribution of the infauna (Snelgrove & Butman, 1994).
- Structural complexity is provided by the many tube building species in the biotope. The tubes built by *Polydora ciliata* for example are embedded in the sediment and the ends extend a few millimetres above the substratum surface. The resultant mats of

agglomerated sediment may be up to 50 cm thick.
- Reworking of sediments by deposit feeders increases bioturbation and potentially causes a change in the substratum characteristics and the associated community (e.g. Rhoads & Young, 1970). The presence of tube builders, such as *Lanice conchilega*, stabilizes the sediment and provides additional structural complexity.
- The burrows of large bivalves (e.g. *Mya* spp.) and piddocks provide additional complexity to the biotope and probably increase the depth to which the sediment is oxygenated.

Productivity

The majority of the productivity in the biotope is secondary, derived from detritus and organic particulates. Primary production is derived from phytoplankton and converted into secondary productivity by the suspension feeders. The benthos is supported predominantly by pelagic production and by detrital materials emanating from the coastal fringe (Barnes & Hughes, 1992). Secondary productivity is probably high given the high densities attained by some species and the diversity of species within the biotope, however no specific information was found.

Recruitment processes

The recruitment processes exhibited by the major groups within the biotope are demonstrated by the examples below.

- The lifecycle of *Aphelochaeta marioni* varies according to environmental conditions. In Stonehouse Pool, Plymouth, *Aphelochaeta marioni* (studied as *Tharyx marioni*) spawned in October and November (Gibbs, 1971) whereas in the Wadden Sea, Netherlands, spawning occurred from May to July (Farke, 1979). The embryos developed lecithotrophically and hatched in about 10 days (Farke, 1979). Under stable conditions, adult and juvenile *Aphelochaeta marioni* will disperse by burrowing (Farke, 1979).
- The spawning period for *Polydora ciliata* in northern England is from February until June and three or four generations succeed one another during the spawning period (Gudmundsson, 1985). After a week, the larvae emerge and are believed to have a pelagic life from two to six weeks before settling (Fish & Fish, 1996). The larvae settle preferentially on substrata covered with mud (Lagadeuc, 1991).
- *Nephtys hombergi* exhibits variable spawning success with failures in some years (Olive *et al.*, 1997).
- The mating system of amphipods is polygynous and several broods of offspring are produced, each potentially fertilized by a different male. There is no larval stage and embryos are brooded in a marsupium, beneath the thorax. Embryos are released as sub-juveniles with incompletely developed eigth thoracopods and certain differences in body proportions and pigmentation. 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 un-colonized areas of substratum before the eggs hatch (Mills, 1967).
- The tube building polychaetes, e.g. *Pygospio elegans*, generally disperse via a pelagic larval stage (Fish & Fish, 1996) and therefore recruitment may occur from distant populations, aided by bed load transport of juveniles (Boström & Bonsdorff, 2000). However, dispersal of some of the infaunal deposit feeders, such as *Scoloplos armiger*, occurs through burrowing of the benthic larvae and adults (Beukema & De Vlas, 1979; Fish & Fish, 1996). Recruitment must therefore occur from local populations or by longer distance dispersal

during periods of bedload transport. Recruitment is therefore likely to be predictable if local populations exist but patchy and sporadic otherwise.
- *Mya arenaria* demonstrates high fecundity, increasing with female size, with long life and hence high reproductive potential. The high potential population increase is offset by high larval and juvenile mortality. Juvenile mortality reduces rapidly with age (Brousseau, 1978b; Strasser, 1999). Strasser *et al.* (1999) noted that population densities in the Wadden Sea were patchy and dominated by particular year classes. Therefore, although large numbers of spat may settle annually, successful recruitment and hence recovery may take longer than a year. Recruitment of shallow burrowing infaunal species can depend on adult movement by bedload sediment transport and not just spat settlement. Emerson & Grant (1991) investigated recruitment in *Mya arenaria* and found that bedload transport was positively correlated with clam transport. They concluded that clam transport at a high energy site accounted for large changes in clam density. Furthermore, clam transport was not restricted to storm events and the significance is not restricted to *Mya arenaria* recruitment. Many infauna, e.g. polychaetes, gastropods, nematodes and other bivalves, will be susceptible to movement of their substratum.
- Ascidians such as *Ascidiella scabra* and *Molgula manhattensis* have external fertilization but short lived larvae (swimming for only a few hours), so that dispersal is probably limited (see *MarLIN* reviews). *Ascidiella scabra* has a high fecundity and settles readily, probably for an extended period from spring to autumn. Svane (1988) describes it as "an annual ascidian" and demonstrated recruitment onto artificial and scraped natural substrata. Eggs and larvae are free-living for only a few hours and so recolonization would have to be from existing individuals no more than a few km away. It is also likely that *Ascidiella scabra* larvae are attracted by existing populations and settle near to adults (Svane *et al*., 1987) . Fast growth means that a dense cover could be established within about 2 months. Where neighbouring populations are present recruitment may be rapid but recruitment from distant populations may take a long time.

Most other macrofauna in the biotope breed several times in their life history (iteroparous) and are planktonic spawners producing large numbers of gametes. Dispersal potential is high. Overall recruitment is likely to be patchy and sporadic, with high spat fall occurring in areas devoid of adults, perhaps lost due to predation or storms. The presence of fast growing space occupying species, e.g. *Polydora ciliata* and *Ascidiella scabra* suggests that competition for space for settling larvae is probably intense, with recruitment dependent on the coincidence of factors that free space (e.g. death of short-lived species or storm related physical disturbance) with larval supply. The presence of numerous suspension feeders and surface deposit feeders suggests that post-settlement mortality of larvae would be high.

Time for community to reach maturity

The community is dominated by fast growing opportunistic polychaete and ascidian species and the community most likely reaches maturity within one year of space becoming available. In an experimental study investigating recovery of a range of species characteristically found in this biotope after copper contamination, Hall & Frid (1995) found that recovery took up to a year. Hall & Frid (1998) found that colonization by many of the polychaetes associated with this biotope did not vary significantly with season, although recruitment of *Tubificoides benedii* and *Ophyrotrocha hartmanni* did vary significantly with season. *Polydora ciliata* is another short-lived species that reaches maturity within a few months and has three or four spawnings during a breeding season of several months. For example, in colonization experiments in Helgoland (Harms & Anger, 1983), *Polydora ciliata* settled on panels within one month in the spring. The bivalve *Abra alba* demonstrates an 'r' type life-cycle strategy and is able to rapidly exploit any new or disturbed substratum available for colonization through larval recruitment, secondary settlement of post-metamorphosis juveniles or re-distribution of adults. For example, *Abra alba* recovered to former densities following loss of a population from Keil Bay owing to deoxygenation within 1.5 years, as did *Lagis koreni*, taking only one year (Arntz & Rumohr, 1986). *Mya arenaria* has a high fecundity and reproductive potential but larval supply is sporadic and juvenile mortality is high, so that although large numbers of spat may settle annually, successful recruitment and hence recovery may take longer than a year. For example, Beukema (1995) reported that a population of *Mya arenaria* in the Wadden Sea, drastically reduced by lugworm dredging took about 5 years to recover. Therefore, the polychaete infauna, ascidian and tube worm epifauna would probably colonize the habitat rapidly, producing a recognizeable biotope within 1-2 years, while the abundance of some species, e.g. *Mya* sp. would take up to 5 years to develop.

Additional information

None.

Preferences & Distribution

Habitat preferences

Depth Range	
Water clarity preferences	
Limiting Nutrients	Data deficient
Salinity preferences	
Physiographic preferences	
Biological zone preferences	
Substratum/habitat preferences	
Tidal strength preferences	
Wave exposure preferences	
Other preferences	None known

Additional Information

The full development of this biotope requires relatively stable mixed muddy sediments. For example, *Polydora ciliata* is only found in areas of soft rock, such as limestone and chalk, and firm muds and clay where it can make its burrows.

Species composition

Species found especially in this biotope

- *Mya arenaria*
- *Mya truncata*
- *Polydora ciliata*

Rare or scarce species associated with this biotope

-

Additional information

The MNCR recorded 398 species within records of this biotope, although not all species occurred in all records (JNCC, 1999).

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

SS.SMx.SMxVS.AphPol is a sublittoral biotope occurring in sheltered, very sheltered and extremely sheltered areas with moderately strong and weak tidal streams (Connor *et al.*, 2004). The biotope occurs in muddy mixed sediment, in reduced and variable/low salinities that are experienced due to its locations in estuaries and marine inlets. These conditions allow the occurrence of *Aphelochaeta* spp. in high abundances, as well as *Polydora* spp. that characterize this biotope. Therefore, these species are considered as important characterizing species and are the focus of this assessment. Other characteristic taxa include a numbers of polychaete and tubificid oligochaetes and bivalves. These contribute to species richness and diversity but are not considered important characterizing, defining or structuring species and are not considered within the assessment. More information on these species can be found in other biotope assessments available on this website.

The mixed sediment in this biotope is the important structural component, providing the complexity required by the associated community. Sediment deposition and, therefore, the spatial extent of the biotope, is dictated by the physiography and underlying geology coupled with the hydrodynamic regime (Elliot *et al.*, 1998). There is a traditional view that the distribution of infaunal invertebrates is correlated solely with sediment grain size. In reality, and in this biotope, it is likely that a number of additional factors, including organic content, microbial content, food supply and trophic interactions, interact to determine the distribution of the infauna (Snelgrove & Butman, 1994).

Little direct evidence for *Aphelochaeta* spp. was found to undertake this assessment. Most of the evidence found related to occurrence and distribution data so confidence in the assessments may be low in cases.

Resilience and recovery rates of habitat

Aphelochaeta marioni is a thin, thread like, segmented worm, typically between 2 and 3.5 cm in length, although, individuals can reach 10 cm in length (Rayment, 2007a). It lives buried in the upper 4 cm of soft sediments, with the smaller animals nearer the surface. *Aphelochaeta marioni* can live up to 2-3 years and its lifecycle varies according to environmental conditions (Rayment, 2007a). In Stonehouse Pool, Plymouth Sound, *Aphelochaeta marioni* (studied as *Tharyx marioni*) spawned in October and November (Gibbs, 1971) whereas in the Wadden Sea, Netherlands, spawning occurred from May to July (Farke, 1979). Laboratory observation reported spawning occurring at night, with females that rose up into the water column with their tail end in the burrow, and shed eggs within a few seconds that sank to form puddles on the sediment (Farke, 1979). Fertilization was not observed, probably because the male does not leave the burrow. The embryos developed lecithotrophically and hatched in about 10 days (Farke, 1979). The newly hatched juveniles were ca 0.25 mm in length and immediately dug into the sediment. Where the sediment depth was not sufficient for digging, the juveniles swam or crawled in search of a suitable substratum (Farke, 1979). In the laboratory, juvenile mortality was high (ca 10% per month) and most animals survived for less than a year (Farke, 1979). In the Wadden Sea, the majority of the cohort reached maturity and spawned at the end of their first year, although, some slower developers did not spawn until the end of their second year (Farke, 1979). However, the population of *Aphelochaeta marioni* in Stonehouse Pool spawned for the first time at the end of their second year (Gibbs, 1971). There was no evidence of a major post-spawning mortality and it was suggested that individuals may survive to spawn over several years. Gibbs (1971) found that the number of eggs laid varied from 24-539 (mean=197) and was correlated with the female's number of genital segments and, hence, female size and age.

Polyodra spp. 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 1 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 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).

A *Polydora* biotope is likely to reach maturity very rapidly because *Polydora ciliata* is a short lived species that reaches maturity within a few months and has three or four spawnings during a breeding season of several months. 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. The tubes built by *Polydora* sometimes agglomerate to form layers of mud up to an average of 20 cm thick.

The settling of the first generation in April is followed by the accumulation and active fixing of mud continuously up to a peak during the month of May. The following generations do not produce a heavy settlement due to interspecific competition and heavy mortality of the larvae (Daro & Polk, 1973). 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.

Resilience assessment: The community is dominated by fast growing opportunistic polychaetes and is likely to reach maturity within one year of space becoming available. Seasonal changes may, however, occur in the abundance of the fauna due to seasonal recruitment processes. For example, variation in abundance is very pronounced in the polychaete *Aphelochaeta marioni*. In the Wadden Sea, peak abundance occurred in January (71,200 individuals per m^2) and minimum abundance occurred in July (22,500 individuals per m^2) following maximum spawning activity between May and July (Farke, 1979). *Polydora ciliata* is a short lived species that reaches maturity within a few months and has three or four spawnings during a breeding season of several months, so is likely to reach maturity very rapidly. For example, in colonization experiments in Helgoland (Harms & Anger, 1983) *Polydora ciliata* settled on panels within one month in the spring. Removal of the characterizing species *Aphelochaeta* and *Polydora* would likely result in the biotope being lost and re-classified. Where a disturbance event removes part of the community (resistance High, Medium or Low) and recruitment of the characterizing species is possible by adult migration or recruitment from the remaining members of the community, resilience is likely to be **High**. However, *Aphelochaeta marioni* has no pelagic phase in its lifecycle, and dispersal is limited to the slow burrowing of the adults and juveniles (Farke, 1979). So where the community is severely reduced (resistance None), recruitment is likely to depend on dispersal by hydrodynamic conditions. The low energy conditions experienced by the biotope may limit immediate re-colonization. However, as long as the substratum nature of the biotope remains suitable for the settlement of *Aphelochaeta* and *Polydora* recruits, the community is likely to reach maturity within 2-10 years, so resilience is likely to be **Medium**.

NB: The resilience and the ability to recover from human induced pressures is a combination of the environmental conditions of the site, the frequency (repeated disturbances versus a one-off event) and the intensity of the disturbance. Recovery of impacted populations will always be mediated by stochastic events and processes acting over different scales including, but not limited to, local habitat conditions, further impacts and processes such as larval-supply and recruitment between populations. Full recovery is defined as the return to the state of the habitat that existed prior to impact. This does not necessarily mean that every component species has returned to its prior condition, abundance or extent but that the relevant functional components are present and the habitat is structurally and functionally 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: High A: Medium C: High	High Q: High A: High C: High	Not sensitive Q: High A: Medium C: High

Aphelochaeta marioni is distributed over a wide temperature range. It has been recorded from the Mediterranean Sea and Indian Ocean (Farke, 1979). Therefore, the species must be capable of tolerating higher temperatures than it experiences in Northern Europe. For example, Covazzi Harriague *et al.* (2007) reported *Aphelochate marioni* occurring in the Rapallo Harbour (Ligurian Sea, NW Mediterranean) at 24°C. Furthermore, *Aphelochaeta marioni* lives infaunally and so is likely to be insulated from rapid temperature change. An increase in temperature would be expected to cause some physiological stress but no mortality. 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* in 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 temperature rises. For example at Whitstable in Kent, Dorsett (1961) found that a rapid increase in growth of *Polydora ciliata* coincided with the rising temperature of the seawater during March.

Most organisms in the biotope are distributed to the north and south of Britain and Ireland and unlikely to be affected adversely by long-term temperature change. In addition, subtidal and especially infaunal species are likely to be protected from acute temperature change. Nevertheless, an increase in temperature may indirectly affect some species as microbial activity within the sediments will be stimulated increasing oxygen consumption and promoting hypoxia (see de-oxygenation pressure).

Sensitivity assessment: Typical surface water temperatures around the UK coast vary seasonally from 4-19°C (Huthnance, 2010). No information was found on the maximum temperature tolerated by the characterizing species *Aphelochaeta marioni* and *Polydora ciliata*. However, it is likely that the species are able to resist a long-term increase in temperature of 2°C and may resist a short-term increase of 5°C. Resistance and resilience are therefore assessed as **High** and the biotope is judged as **Not Sensitive**.

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

Aphelochaeta marioni is distributed over a wide temperature range. It has been recorded from the western Baltic Sea, South Atlantic Ocean and North Sea (Farke, 1979). Therefore the species must be capable of tolerating low temperatures. *Aphelochaeta marioni* lives buried in sediment and is therefore well insulated from decreases in temperature. In the Wadden Sea, the population was apparently unaffected by a short period of severe frost in I973 (Farke, 1979). Kędra *et al.* (2010) reported *Aphelochaete marioni* occurring in the Svalbard Archipelago where temperatures below zero may be experienced in the winter. A decrease in temperature would be likely to cause some physiological stress but no mortality.

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* in temperatures of 7.5 to 11.5°C and in Whitstable in 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 apparently unaffected, when temperature anomalies of between 2.5-5.8°C were observed (Crisp, 1964).

Sensitivity assessment: Typical surface water temperatures around the UK coast vary seasonally from 4-19°C (Huthnance, 2010). *Aphelochaeta marioni* and *Polydora ciliata* 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. Temperature may act as a spawning cue and an acute or chronic decrease may result in some delay in spawning, however this is not considered to impact the adult population and may be compensated by later spawning events. Resistance and resilience are therefore assessed as **High** and the biotope judged as **Not Sensitive**.

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

Populations of *Aphelochaeta marioni* inhabit the open coast where seawater is at full salinity. Covazzi Harriague *et al.* (2007) reported *Aphelochate marioni* in the Rapallo Harbour (Ligurian Sea, NW Mediterranean) at salinities above 38 psu. Farke (1979) studied the effects of changing salinity on *Aphelochaeta marioni* (studied as *Tharyx marioni*) in a microsystem in the laboratory. Over several weeks, the salinity in the microsystem was increased from 25-40 psu and no adverse reaction was noted. However, when individuals were removed from the sediment and displaced to a new habitat, they only dug into their new substratum if the salinities in the two habitats were similar. If the salinities differed by 3-5 psu, the worms carried out random digging movements, failed to penetrate the sediment and died at the substratum surface after a few hours. This would suggest that *Aphelochaeta marioni* can tolerate salinity changes when living infaunally but may not resist an increase in salinity when removed from its habitat.

Polydora ciliata is an euryhaline species inhabiting fully marine and estuarine habitats. However, there are no records of the species occurring in hypersaline waters.

Sensitivity assessment: In SS.SMx.SMxVS.AphPol, an increase in salinity at the pressure benchmark (one MNCR salinity category above the usual range of the biotope) would represent an increase to full salinity. Based on the evidence presented, both characterizing species occur in environments of full salinity and are likely to resist an increase in salinity at the pressure benchmark level. However, as salinity increases SS.SMx.SMxVS.AphPol may grade into SS.SMu.ISaMu.MelMagThy, with those species characteristic of the latter increasing in abundance (Connor *et al*., 2004), so the biotope may be gradually lost and eventually re-classified at the pressure benchmark level that assumes a change in salinity for one year. Resistance is therefore assessed as **Low** (loss 25-75%) and resilience is likely to be **High**, so the biotope is considered to have **Low** sensitivity to an increase in salinity at the pressure benchmark level.

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

Aphelochaeta marioni thrives in estuaries and is therefore likely to be tolerant of decreases in salinity. It has been recorded from brackish inland waters in the Southern Netherlands with a salinity of 16 psu, but not in areas permanently exposed to lower salinities (Wolff, 1973). However, it also penetrates into areas exposed to salinities as low as 4 psu for short periods at low tide when freshwater discharge from rivers is high (Farke, 1979). In the Severn Estuary, *Aphelochaeta marioni* (studied as *Tharyx marioni*) characterized the faunal assemblage of very poorly oxygenated, poorly sorted mud with relatively high interstitial salinity (Broom *et al*., 1991).

Polydora ciliata is an 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).

Overall, the important characterizing species are likely to tolerate a short-term change in salinity from e.g. variable to low salinity and a long-term change from variable to reduced salinity. The species richness of the biotope may decline but the biotope will probably not be adversely affected.

Sensitivity assessment: Records indicate SS.SMx.SMxVS.AphPol occurs in areas of reduced (18-30 ppt), variable (18-35 ppt) and low (<18 ppt) salinity (Connor *et al*., 2004). The characterizing species *Aphelochaeta marioni* and *Polydora ciliata* are therefore likely to resist a decrease in salinity at the pressure benchmark level. Resistance is therefore assessed as **High** and resilience as **High** (by default) and the biotope is considered **Not Sensitive** to a decrease in salinity at the pressure benchmark level.

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

Aphelochaeta marioni has been recorded in the Wadden Sea with flow rates up to 0.45 m/s (Compton *et al*., 2013), and in the Westerscheld estuary (SW Netherlands) where spring current velocities vary between 0.1-0.58 m/s (Van Colen *et al*., 2010a). *Polydora ciliata* colonized test panels in Helgoland in three areas, two exposed to strong tidal currents and one site sheltered from currents (Harms & Anger, 1983). Very strong water flows may sweep away *Polydora* colonies, where these are present as a thick layer of mud on a hard substratum.

The hydrographic regime is an important structuring factor in sedimentary habitats. An increase in water flow rate is not likely to affect *Aphelochaeta marioni* directly as it lives infaunally. The most damaging effect of increased flow rate would be the erosion of the substratum as this could eventually lead to loss of the habitat. Orvain *et al.* (2007) investigated the spatio-temporal variations in intertidal mudflat erodibility in Western France and suggested a potential link between *Polychaeta* and bed erodibility given the high polychaete abundances observed in the study.

Increased water flow rates is likely to change the sediment characteristics in which the species live, primarily by re-suspending and preventing deposition of finer particles (Hiscock, 1983). The characterizing species prefer habitats with silty/muddy substrata which would not occur in very strong tidal streams. Additionally, the consequent lack of deposition of particulate matter at the sediment surface would reduce food availability. Decreased water movement would result in increased deposition of suspended sediment (Hiscock, 1983). An increased rate of siltation resulting from a decrease in water flow may result in an increase in food availability for the characterizing species and therefore growth and reproduction may be enhanced, but only if food was previously limiting.

Sensitivity assessment: Sand particles are most easily eroded and likely to be eroded at about 0.20 m/s (based on Hjulström-Sundborg diagram, Sundborg, 1956). Although having a smaller grain size than sand, clays and silts require greater critical erosion velocities because of their cohesiveness. SS.SMx.SMxVS.AphPol is recorded in moderately strong (0.5-1 m/s) and weak (>0.5 m/s) tidal streams (Connor *et al*., 2004). A change in water flow rate at the pressure benchmark level of 0.1-0.2 m/s is considered to fall within the range of flow speeds experienced by populations in the middle of their range. Resistance and resilience are, therefore, assessed as **High** and the biotope considered **Not Sensitive** to a change in water flow at the pressure benchmark level.

Emergence regime changes	Medium Q: Medium A: Low C: High	High Q: High A: Medium C: Medium	Low Q: Medium A: Low C: Medium

SS.SMx.SMxVS.AphPol occurs in the infralittoral so only the upper extent of shallow examples of the biotope is likely to be emersed on extreme low tides. *Aphelochaeta marioni* lives in the intertidal zone in significant numbers (Gibbs, 1969; Farke, 1979), and *Polydora ciliata* occur in the mid to low intertidal. Both characterizing species would probably survive an increase in emergence. However, the species can only feed when immersed and therefore likely to experience reduced feeding opportunities. Over the course of a year, the resultant energetic cost is likely to cause some mortality. In addition, increased emergence is likely to increase the vulnerability to predation from shore birds. A decrease in emergence is likely to allow the biotope to extend its upper limit, where suitable substrata exist.

Sensitivity assessment: Some mortality of the characterizing species is likely to occur because of emergence regime changes. Resistance is therefore assessed as **Medium** and resilience is likely to be **High**, so the biotope is considered to have **Low** sensitivity to emergence regime changes at the pressure benchmark level.

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

The biotope is found in sheltered, very sheltered and extremely sheltered sites (Connor *et al.*, 2004). Strong wave action is likely to cause damage or withdrawal of delicate feeding and respiration structures resulting in loss of feeding opportunities and compromised growth of *Aphelochaeta marioni* and *Polydora ciliata*, and changes in wave exposure may also influence the supply of particulate matter for tube building *Polydora*. Decreases in wave exposure may influence the supply of particulate matter because wave action may have an important role in re-suspending the sediment that is required by the species to build its tubes. Furthermore, *Aphelochaeta marioni* characteristically inhabits soft sediments in sheltered areas (Broom *et al.*, 1991), so individuals may be damaged or dislodged by scouring from sand and gravel mobilized by increased wave action.

Sensitivity assessment: Hydrographic regimes are an important structuring factor in sedimentary habitats, and an increase in wave exposure could result in fine sediments being eroded (Hiscock, 1983), resulting in the likely reduction of the habitat and a decrease in food availability. Some erosion will occur naturally and storm events may be more significant in loss and damage of the substratum than changes in wave height at the pressure benchmark. SS.SMx.SMxVS.AphPol occurs in sheltered, very sheltered and extremely sheltered areas (Connor *et al.*, 2004), and a change at the benchmark level is likely to fall within the range experienced by the mid-range examples of this biotope. The biotope is therefore considered to have **High** resistance to changes at the pressure benchmark where these do not lead to increased erosion of the substratum. Resilience is therefore assessed as **High** and the biotope is considered to be **Not Sensitive** at the pressure benchmark.

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.

Evidence suggests that polychaetes are fairly resistant to the effects of heavy metals (Bryan, 1984). *Aphelochaeta marioni* is tolerant of heavy metal contamination occurring in the heavily polluted Restronguet Creek (Bryan & Gibbs, 1983) and it is also an accumulator of arsenic (Gibbs *et al.*, 1983). *Polydora ciliata* occurs 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).

Taking account of the variable salinity conditions that affect this biotope (in general, for estuarine animals, heavy metal toxicity increases as salinity decreases and temperature increases: McLusky *et al.*, 1986), it seems possible that some polychaete species at least in the biotope might be adversely affected by high contamination by heavy metals.

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.

Cirratulids seem to be mostly immune to oil spills, probably because their feeding tentacles are protected by a heavy secretion of mucus (Suchanek, 1993). This is supported by observations of *Aphelochaeta marioni* following the *Amoco Cadiz* oil spill in March, 1978 (Dauvin, 1982, 2000). Prior to the spill, *Aphelochaeta marioni* (studied as *Tharyx marioni*) was present in very low numbers in the Bay of Morlaix, western English Channel. Following the spill, the level of hydrocarbons in the sediment increased from 10 mg/kg dry sediment to 1443 mg/kg dry sediment 6 months afterwards. In the same period, *Aphelochaeta marioni* increased in abundance to a mean of 76 individuals/m^2, which placed it among the top five dominant species in the faunal assemblage. It was suggested that the population explosion occurred due to the increased food availability because of accumulation of organic matter resulting from high mortality of browsers. Six years later, abundance of *Aphelochaeta marioni* began to fall away again, accompanied by gradual decontamination of the sediments.

In 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).

ng> Overall, hydrocarbon contamination is likely to adversely affect some members of the community, resulting in more tolerant or opportunistic species to increase in abundance, and consequent reduction in species richness.

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.

There is little evidence directly relating to the effects of synthetic chemicals on *Aphelochaeta marioni*. Waldock *et al.* (1999) reported that the species diversity of polychaete infauna, including *Aphelochaeta marioni*, in the Crouch estuary increased in the three years after the use of TBT was banned within the estuary, suggesting that TBT had suppressed their abundance previously.

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 distilling and petrochemical industrial waste in Scotland.

Furthermore, Beaumont *et al.* (1989) concluded that TBT had a detrimental effect on the larval and/or juvenile stages of infaunal polychaetes.

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

No Evidence is available on which to assess this pressure.

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

Connor *et al.* (1997a) described sediments in which *Aphelochaeta marioni* is commonly found as usually with a "black anoxic layer close to the sediment surface". Broom *et al.* (1991) recorded that *Aphelochaeta marioni* (studied as *Tharyx marioni*) characterized the faunal assemblage of very poorly oxygenated mud in the Severn Estuary. They found *Aphelochaeta marioni* to be dominant where the redox potential at 4 cm sediment depth was 56 mV and, therefore, concluded that the species was tolerant of very low oxygen tensions. It is likely that feeding, growth and reproduction would be impaired under sustained low oxygen conditions.

Polydora ciliata is frequently 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 discharges of waste waters (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 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.

Sensitivity assessment: 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.** Opportunistic *Polydora* spp. have also repeatedly been reported amongst the first to recover hypoxia events (Hansen *et al.*, 2002; Van Colen *et al.*, 2010). Resilience of the biotope is likely to also be **High** 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	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

Raman & Ganapati (1983) studied the distribution of *Aphelochaeta marioni* (studied as *Tharyx marioni*) in relation to a sewage outfall in Visakhaptnam Harbour, Bay of Bengal. Increased nutrients often derive from sewage inputs and presence of species such as *Aphelochaeta marioni* in such situations (for instance Broom *et al.*, 1991) may reflect tolerance to high nutrients or to de-oxygenated conditions or both. *Aphelochaeta marioni* was found to be dominant in the 'semi-healthy zone' characterized by low nutrients (nitrate 0.02 mg/l, phosphate 0.88 mg/l). *Aphelochaeta marioni* was not found in high numbers in the polluted zone close to the sewage outfall, characterized by high nutrients (nitrate 0.042-0.105 mg/l, phosphate 2.35-3.76 mg/l) (Rayment, 2007a). This would suggest that *Aphelochaeta marioni* is intolerant of eutrophication. However, it would be expected that an increase in organic nutrients would lead to increased food availability for the deposit feeding *Aphelochaeta marioni*. Furthermore, Dauvin (1982, 2000) recorded an increase in abundance of *Aphelochaeta marioni* following an oil spill, which resulted in an explosion of plant growth due to high mortality of grazers. Therefore, the available evidence on the resistance of *Aphelochaeta marioni* to nutrient changes does not allow consistent conclusions to be drawn.

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 growth 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: Nutrient enrichment may reduce the abundance of *Aphelochaeta marioni* while *Polydora* is probably resistant. However, the biotope is considered **Not Sensitive** at the pressure benchmark that assumes compliance with good status as defined by the WFD.

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

Kędra *et al.* (2010) reported *Aphelochaeta mariori* that occurred in the Hornsundfjord, Svalbard, where primary production has been recorded as 120 gC/m^2/yr. Covazzi-Harriague *et al.* (2007) reported *Aphelochaeta mariori* at sites with organic matter sedimentation as high as 359 mg/m^2/hr in the Ligurian Sea, Italy. Furthermore, Markert *et al.* (2010) compared macrofaunal communities in the Wadden Sea in reefs dominated by *Mytilus edulis* and *Cassostrea gigas* and found *Aphelochaeta mariori* as a dominate species throughout the study site, which suggested the species was unlikely to be affected by organic enrichment.

In colonization experiments in an organically polluted fjord receiving effluent discharge from Oslo, *Polydora ciliata* settled in large numbers within the first month (Green, 1983; Pardal *et al.*, 1993). 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/d. *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. It should be noted that the organic matter input from the mussel farm exceeds the pressure benchmark. 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 of 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 2.5 to 1.4 µg C/ml depending on larval size, and energetic carbon requirements of 0.09 to 3.15 µg C l/d, respectively. On the other hand, *Polydora ciliata* can also occur in organically poor areas (Pearson & Rosenberg, 1978).

Borja *et al.* (2000) and Gittenberger & Van Loon (2011) both assigned *Aphelochaeta marioni* and

Polydora ciliata to their AMBI Ecological Group IV 'Second-order opportunistic species present in slight to pronounced unbalanced situations'.

Sensitivity assessment: The evidence presented suggests the characterizing species may not be affected by organic enrichment at the benchmark level. Resistance and resilience are therefore assessed as **High** and the biotope is considered **Not Sensitive** to organic enrichment (deposit of 100 gC/m^2/yr).

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 mixed sediment that characterizes this biotope were replaced with rock substrata, this would represent a fundamental change to the physical character of the biotope. The characterizing species would no longer be supported and the biotope would be lost and/or reclassified.

Sensitivity assessment: Resistance to the pressure is considered **None**, and resilience **Very Low**. 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)	Low Q: Medium A: Medium C: High	Very Low Q: High A: High C: High	High Q: Medium A: Medium C: High

Aphelochaeta marioni has been recorded from a variety of different sediment types. In the intertidal area of the Wadden Sea, it achieved highest abundance where the sediment fraction smaller than 0.04 mm diameter was greater than 10% of the total sediment (Farke, 1979). Where a change in sediment type results in decrease of the mud fraction in the sediment, tube building for the characterizing species *Polydora ciliata* could be compromised.

Sensitivity assessment: Some mortality of the characterizing species *Polydora ciliata* may occur where a change in sediment type by one Folk class results in decrease of the mud fraction in the sediment. Resistance to the pressure is therefore considered **Low**. Resilience, however, is likely to be **Very Low** given the permanent nature of the pressure. Sensitivity has been assessed as **High**.

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

Aphelochaeta marioni lives buried in soft sediments with the majority of individuals found in the upper 4 cm of the sediment (Rayment, 2007a). The tubes built by *Polydora* sometimes agglomerate to form layers of mud up to an average of 20 cm thick (Hill, 2007). Removal of the substratum to 30 cm would result in the loss of the characterizing species. Resistance to the pressure is considered **None**, and resilience **Medium**. Sensitivity has been assessed as **Medium**.

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

Aphelochaeta marioni is a soft bodied organism which exposes its palps and cirri at the surface while feeding (Rayment, 2007a). The species lives infaunally in soft sediment, usually within a few centimetres of the sediment surface. Physical disturbance, such as dredging or dragging an anchor, would be likely to penetrate the upper few centimetres of the sediment and cause physical damage to *Aphelochaeta marioni*. De Biasi & Pacciardi (2008) compared macrobenthic communities in a commercial fishing ground exploited by otter trawling with an area closed to fishing for over 10 years in the Adriatic Sea. The authors found that polychaetes, including *Aphelochaeta* spp. were among the species dominating the disturbed areas, which is likely to result from the ability of the species to recolonize disturbed areas rapidly, rather than indicate that the polychaetes are resistant to disturbance of the seabed surface.

The tubes of characterizing species *Polydora* spp. are also likely to be removed by abrasion as these project above the surface and are not physically robust. A thick *Polydora* mud may crumble away and be swept away by water currents.

Sensitivity assessment: The characterizing community in this biotope is considered likely to be damaged and removed by abrasion. As a soft bodied species, both *Aphelochaeta marioni* and *Polydora ciliata* are likely to be crushed and killed by an abrasive force or physical blow. Resistance to abrasion is considered **Low**. However, the community is likely to be able to re-establish rapidly, so resilience of the biotope is assessed as **High** with the biotope considered to have **Low** sensitivity to abrasion or disturbance of the surface of the seabed.

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

Activities that penetrate below the surface would remove a significant proportion of the characterizing species within the direct area of impact (see evidence under 'abrasion' above). Biotope resistance is therefore assessed as **Low** and recovery is assessed as **High** based on the assumption that the suitable substratum to support the community of the characterizing species would not be lost. Sensitivity is therefore assessed as **Low**.

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

This biotope is probably exposed to the high levels of suspended sediment characteristic of estuarine conditions. Therefore, the resident species are probably adapted to high suspended sediment levels. *Aphelochaeta marioni* lives infaunally and is a surface deposit feeder (Rayment, 2007a), therefore relying on a supply of nutrients at the sediment surface. An increased rate of siltation may result in an increase in food availability and therefore growth and reproduction of *Aphelochaeta marioni*. However, food availability would only increase if the additional suspended sediment contained a significant proportion of organic matter and the population would only be enhanced if food was previously limiting. A decrease in the suspended sediment would result in a decreased rate of deposition on the substratum surface and therefore a reduction in food availability for *Aphelochaeta marioni*. This would be likely to impair growth and reproduction.

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 is able to tolerate different levels of suspended solids (Read *et al*., 1982; Read *et al*., 1983). Occasionally, in certain places siltation is speeded up when *Polydora ciliata* is present because the species actually produces a 'mud' as it perforates soft rock and chalk habitats and larvae settle preferentially on substrates covered with mud (Lagadeuc, 1991). Suspended sediment and siltation of particles is important for tube building in *Polydora ciliata* so a decrease in suspended solids may reduce tube building or the thickness of the mud surrounding the 'colonies'. 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.

An increase in turbidity, reducing light availability may reduce primary production by phytoplankton in the water column. A reduction in primary production in the water column and by the microphytobenthos on the sediment surface may result indirectly in reduced food supply to the characterizing species, 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 suspended matter in the biotope could result in limitation of material for tube building of *Polydora* and in the substratum being no longer suitable for colonization by new recruits. Resistance of the biotope is therefore assessed as **Low** (loss of 25-75%) and resilience is **High** (following a return to normal conditions), so the biotope is considered to have **Low** sensitivity to a decrease in suspended solids at the pressure benchmark level.

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

Aphelochaeta marioni lives infaunally in soft sediments and moves by burrowing. It deposit feeds at the surface by extending contractile palps from its burrow. An additional 5 cm layer of sediment would result in a temporary cessation of feeding activity, and therefore growth and reproduction are likely to be compromised. However, *Aphelochaeta marioni* would be expected to quickly relocate to its favoured depth, with no mortality. Kędra *et al.* (2010) reported *Aphelochaeta mariori* to occur in the Hornsundfjord, Svalbard, where sedimentation rates can vary between 0.1-35 cm/yr.

Adults of *Polydora ciliata* produce a 'mud' resulting from the perforation of soft rock substrates (Lagadeuc, 1991). 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 to reach the surface, or leave 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 it was possible that the individuals 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.

In the low energy environment where the biotope occurs, a 'light' deposition of sediments is likely to be cleared in a few tidal cycles.

Sensitivity assessment: The characterizing species of this biotope are considered likely to resist smothering by 5 cm of sediment. Resistance and resilience are therefore assessed as **High** and the biotope is considered **Not Sensitive** to a 'light' deposition of up to 5 cm of fine material in a single discrete event.

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

Aphelochaeta marioni lives infaunally in soft sediments and moves by burrowing. It deposit feeds at the surface by extending contractile palps from its burrow. An additional layer of sediment would result in a temporary cessation of feeding activity, and therefore growth and reproduction are likely to be compromised. However, *Aphelochaeta marioni* would be expected to quickly relocate to its favoured depth, with no mortality. Kędra *et al.* (2010) reported *Aphelochaeta mariori* to occur in the Hornsundfjord, Svalbard, where sedimentation rates can vary between 0.1-35 cm/yr. Furthermore, Do *et al.* (2012) studied the macrobenthos recovery in the Arcachon Bay (France) following a deposition of sediment up to 10 cm thick that resulted from dredging activities. The authors reported *Aphelochaeta marioni* as considerably reduced or absent from impacted areas characterized mainly by mud substrata.

Adults of *Polydora ciliata* produce a 'mud' resulting from the perforation of soft rock substrates (Lagadeuc, 1991). 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 leave 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 it was possible that the individuals 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.

Sensitivity assessment: Polychaete species have been reported to migrate through depositions of sediment greater than the benchmark (30 cm of fine material added to the seabed in a single discrete event) (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** and resilience as **High**, and the biotope is 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	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No Evidence is available on which to assess this pressure.

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

None of the species in the biotope are likely to be sensitive to noise or vibration at the benchmark level and no information was found concerning the intolerance of *Aphelochaeta marioni* to noise. *Polydora ciliata* may respond to vibrations from predators or bait diggers by retracting their palps into their tubes. However, the characterizing species are unlikely to be affected by noise pollution and so the biotope is assessed as **Not Sensitive.**

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

Changes in light availability impact primary production by phytoplankton in the water column and by the microphytobenthos on the sediment surface, which in turn may affect food availability for the characterizing species. However, SS.SMx.SMxVS.AphPol is not directly dependent on sunlight so the biotope is considered to have **High** resistance and, by default, **High** resilience and therefore is **Not Sensitive** to the introduction of light or shading.

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

Most species will respond to the shading caused by the approach of a predator, however, their visual acuity is probably very low. Farke (1979) noted that *Aphelochaeta marioni* is intolerant to visual disturbance in a microsystem in the laboratory, possibly due to its nocturnal life habits (Farke, 1979). In order to observe feeding and breeding in the microsystem, the animals had to be gradually acclimated to lamp light. Even then, additional disturbance, such as an electronic flash, caused the retraction of palps and cirri and cessation of all activity for some minutes. *Polydora ciliata* exhibits shadow responses withdrawing its palps into its burrow, believed to be a defence against predation. However, since the withdrawal of the palps interrupts feeding and possibly respiration the species also shows habituation of the response (Kinne, 1970).

Sensitivity assessment: Nevertheless, the characterizing species are unlikely to have the visual acuity to respond of visual disturbance and defined in the pressure. Resistance and resilience are therefore assessed as **High** and the biotope 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

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

Introduced organisms (especially parasites or pathogens) are a potential threat in all coastal ecosystems. Little information was found regarding microbial infection of polychaetes, although Gibbs (1971) recorded that nearly all of the population of *Aphelochaeta marioni* in Stonehouse Pool, Plymouth Sound, was infected with a sporozoan parasite belonging to the acephaline gregarine genus *Gonospora*, which inhabits the coelom of the host. No evidence was found to suggest that gametogenesis was affected by *Gonospora* infection and there was no apparent reduction in fecundity. No information was found on microbial pathogens affecting *Polydora ciliata*.

Sensitivity assessment. The biotope is judged to have **High** resistance to this pressure. By default resilience is assessed as **High** and the biotope is classed as **Not Sensitive**.

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

SS.SMx.SMxVS.AphPol is currently not targeted by commercial fisheries and hence not directly affected by this pressure. This pressure is therefore considered **Not Relevant**.

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

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 this biotope, 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). Hall & Harding (1997) demonstrated that commercial cockle harvesting by suction dredging had significant effects on soft-sediment infaunal communities. Following dredging, species numbers were reduced by up to 30% and abundances by up to 50%.

Sensitivity assessment. Removal of the characterizing species would result in the biotope being lost or re-classified. Therefore, the biotope is considered to have a resistance of **Low** to this pressure and to have **High** resilience, resulting in the sensitivity being judged as **Low**.

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