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Information on the species and habitats around the coasts and sea of the British Isles

Capitella capitata and *Tubificoides* spp. in reduced salinity infralittoral muddy sediment

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

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Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/habitats/detail/32]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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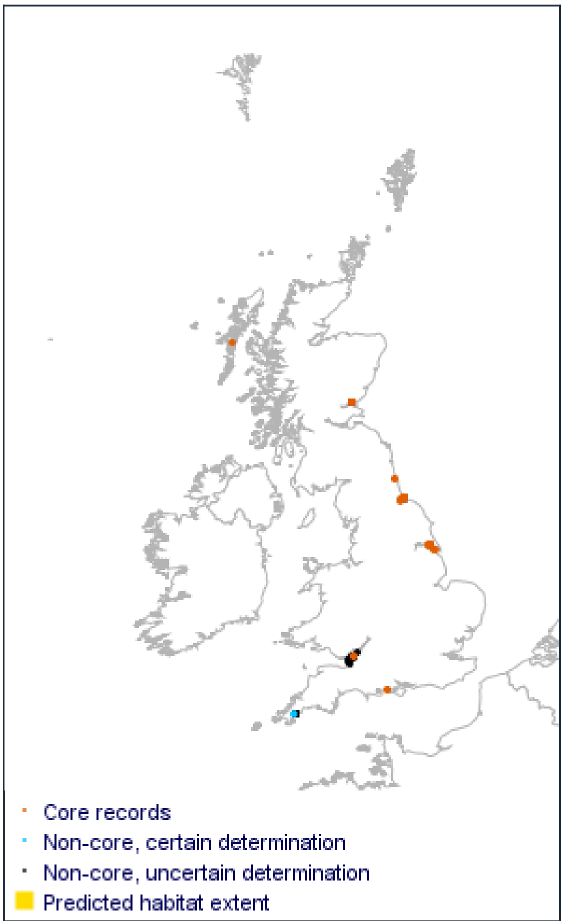

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Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Dr Heidi Tillin **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A5.325	*Capitella capitata* and *Tubificoides* spp. in reduced salinity infralittoral muddy sediment
JNCC 2015	SS.SMu.SMuVS.CapTubi	*Capitella capitata* and *Tubificoides* spp. in reduced salinity infralittoral muddy sediment
JNCC 2004	SS.SMu.SMuVS.CapTubi	*Capitella capitata* and *Tubificoides spp*. in reduced salinity infralittoral muddy sediment
1997 Biotope	SS.IMU.EstMu.CapTub	*Capitella capitata* and *Tubificoides spp*. in reduced salinity infralittoral muddy sediment

Description

Reduced salinity, muddy sediment dominated by the polychaete *Capitella capitata* with a very low species richness. Large numbers of the oligochaetes *Tubificoides* spp. May be found in conjunction with the *Capitella capitata*. The biotope is found in the muddier sediments, usually with a high organic content, away from tidal channels in estuaries. On occasion relatively large numbers of *Capitella capitata* can be found in sandier sediments within a more mobile habitat although these are thought largely to be imported by tidal streams from nearby populations (a definition of a separate biotope may be appropriate). A similar biotope IMU.Tub can be separated from IMU.CapTub by a swap in the dominant species from *Capitella capitata* to *Tubificoides* spp. and may occur in lower salinity. More mobile muds which occur in areas with an extremely high suspended particulate component to the water column, IMU.MobMud, may contain a similar suite of species to IMU.CapTub although in lower abundance. Only a description of the sediment consistency in the field would allow positive classification. The presence of dense *Capitella capitata* has classically been associated with organically enriched and physically disturbed habitats in the marine environment (Warren, 1977; Pearson & Rosenberg, 1978). In estuaries the presence of this biotope may be associated with other natural factors including the occurrence of a competitive refuge for *Capitella capitata* in the reduced-salinity environment (Wolff, 1973).

Depth range

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

Additional information

-

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and characterizing species are taken from JNCC (2015). Reduced or variable salinity muddy sediment characterized by the *Capitella capitata* species complex with a relatively low species richness. The sensitivity assessments focus on the characterizing *Tubificoide*s spp. and *Capitella capitata*. Other species such as *Marenzellaria* sp., *Macoma balthica*, *Arenicola marina* and *Eteone longa* occur in the biotope at low abundance or frequencies and are not considered characterizing.

Resilience and recovery rates of habitat

Capitella capitata is a classic opportunist species possessing life history traits of rapid development, many reproductions per year, high recruitment and high death rates (Grassle & Grassle, 1974; McCall, 1977). Experimental studies using defaunated sediments have shown that on small scales *Capitella* can recolonize to background densities within 12 days (Grassle & Grassle, 1974; McCall, 1977). In Burry Inlet, Wales, tractor towed cockle harvesting led to a reduction in density of some species but *Capitella capitata* had almost trebled its abundance within the 56 days in a clean sandy area (Ferns *et al*., 2000).

In favorable conditions, maturity can be reached in <3 months and growth rate is estimated to be 30 mm per year. Adult potential dispersal is up to 1 km. The species complex displays reproductive variability and planktonic larvae are able to colonize newly disturbed patches but after settlement the species can produce benthic larvae brooded within the adult tube to rapidly increase the population before displacement by more competitive species (Gray, 1979). Bolam & Fernandes (2002) and Shull (1997) noted that *Capitella capitata* can colonize azoic sediments rapidly in relatively high numbers. Shull (1997) also demonstrated that this occurs by larval settlement, bedload transport and by burrowing. Thus, when conditions are suitable, the time for the community to reach maturity is likely to be less than six months.

Other species within the biotope may recolonize more slowly. Tubificid populations tend to be large and to be constant throughout the year, although some studies have noticed seasonal variations (Giere & Pfannkuche, 1982). Many species, including *Tubificoides benedii* and *Baltidrilus costata* have a two-year reproductive cycle and only part of the population reproduces each season (Giere & Pfannkuche, 1982). Populations of *Tubificoides benedii* in the Fourth Estuary have not demonstrated clear seasonality in recruitment (Bagheri & McLusky, 1982), although mature *Tubificoides benedii* (studied as *Peloscolex benedeni*) in the Thames Estuary were reported to occur in December with a maximum in late February (Hunter & Arthur, 1978), breeding worms increased from April and maximum cocoon deposition was observed in July (Hunter & Arthur, 1978). Tubificids exhibit many of the traits of opportunistic species; it is dominant, often reaching huge population densities in coastal areas that are enriched in organic matter and is often described as an 'opportunist' species adapted to rapid environmental fluctuations and stress (Giere, 2006; Bagheri & McLusky, 1982). However, unlike other opportunist species, it has a long-lifespan (a few years, Giere, 2006), a prolonged reproductive period from reaching maturity to maximum cocoon deposition, and exhibits internal fertilization with brooding rather than pelagic dispersal. These factors mean that recolonization is slower than for some opportunistic species such as *Capitella capitata* and nematodes which may be present in similar habitats.

Resilience assessment. A *Capitella capitata* dominated biotope is likely to reach maturity very rapidly because the species of the complex are short lived, reaching maturity within about four months and reproducing throughout the year. Other species within the biotope may colonize more slowly but the biotope is considered likely to have recovered within two years for any level of impact based on the characterizing Capitella and Tubificoides spp.

Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

Capitella capitata is a cosmopolitan species in coastal marine and estuarine soft sediment systems. Grassle & Grassle (1976) used electrophoretic enzyme analysis to determine that the global population is actually made up of several genetically distinct (and apparently genetically isolated) sibling species whose distributions overlap such that local *Capitella capitata* populations actually consist of a number of co-occurring sibling species. Within the complex, tolerances may vary and local acclimation is possible. *Capitella capitata* has also been recorded in extreme environments around hydrothermal vents (Gamenick & Giere, 1997), which suggests that the species complex would be relatively tolerant to an increase in temperature.

Bamber & Spencer (1984) observed that *Tubificoide*s were dominant species in an area affected by thermal discharge in the River Medway estuary. *Capitella capitata* were seasonal dominants at one station affected by heated effluent. Sediments were exposed to the passage of a temperature front of approximately 10°C between heated effluent and estuarine waters during the tidal cycles.

Experimental evaluation of the effects of combinations of varying salinities and temperature on *Capitella capitata* were carried out by Redman (1985) and Warren (1977). Redman (1985) found that length of life decreased as follows: 59 weeks at mid-temperature and salinity (15°C, 25 ppt); 43 weeks at high temperature and high salinity (18°C, 30 ppt); 33 weeks at lower temperature and high salinity (12°C, 30 ppt); 17 weeks at high temperature and low salinity (18°C, 20 ppt). Redman (1985) also found that net reproduction (Ro: the mean number of offspring produced per female at the end of the cohort) decreased as follows: 41.75 control; 36.69 under high salinity, high temperature; 2.19 high temperature, low salinity; 2.16 low temperature, high salinity. Therefore, a combination of changes in temperature and salinity may decrease the viability of the population. Warren (1977) used individual worms collected from Warren Point (south west England) to test response to high and low temperatures. Worms were acclimated to 10°C for 10 days and subsequently heated in a water bath to experienced a rise in temperature of 1°C per 5 min. When the temperature had reached 28°C worms were removed at 0.5°C intervals and returned to a constant temperature of 10°C. The percentage mortality after 24 h was calculated. Larvae were removed from the maternal tube and tested using the same method. The experiments indicated that temperatures above 30°C were most critical; the upper lethal temperature was 31.5°C for adult worms and a little higher for the larvae.

Sensitivity assessment. Typical surface water temperatures around the UK coast vary seasonally from 4-19°C (Huthnance, 2010). The biotope, based on the characterizing species, is considered to tolerate a 2°C increase in temperature for a year. The experimental studies by Redman (1985) suggest that changes in temperature may reduce the life-span of *Capitella capitata*, however, this effect is not considered to alter the character of the biotope as the short life cycle of this species should lead to rapid replenishment of the population. The experiments by Warren (1977) suggest that both the chronic and acute increases in temperature would not exceed the thermal tolerance of *Capitella capitata*. The dominance of *Tubificoides* spp. in sediments exposed to heated effluent suggests that this genus would be highly resistant to an increase in temperature at the pressure benchmark. Biotope resistance based on the characterizing and associated *Tubificoides* spp. is therefore assessed as 'High' and resilience as 'High' (by default), so the biotope is considered to be 'Not sensitive'.

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

Capitella capitata is a cosmopolitan species in coastal marine and estuarine soft sediment systems. Grassle & Grassle (1976) used electrophoretic enzyme analysis to determine that the global population is actually made up of several genetically distinct (and apparently genetically isolated) sibling species whose distributions overlap such that local *Capitella capitata* populations actually consist of a number of co-occurring sibling species. Within the complex, tolerances may vary and local acclimation is possible. Wu *et al*. (1988) collected animals at seawater temperatures of -2°C that harboured mature oocytes indicating reproductive activity even under low temperatures.

Warren (1977) used individual worms collected from Warren Point (south west England) to test response to high and low temperatures. Worms were acclimated to 10°C for 10 days prior to testing. The worms were cooled in a water bath to experience a decrease in temperature of 1°C per 5 min. When the final temperature was reached, worms were removed at 0.5°C intervals and returned to a constant temperature of 10°C. The percentage mortality after 24 h was calculated. Each experiment was repeated once. Larval *Capitella capitata* were removed from the maternal tube and tested using the same method. Both adults and larvae were tolerant of low temperatures, 50% of the adults and 65% of the larvae surviving at -1°C.

Most littoral oligochaetes, including tubificids and enchytraeids, can survive freezing temperatures and can survive in frozen sediments (Giere & Pfannkuche, 1982). *Tubificoides benedii* (studied as *Peloscolex benedeni*) recovered after being frozen for several tides in a mudflat (Linke, 1939).

Sensitivity assessment. Typical surface water temperatures around the UK coast vary, seasonally from 4-19°C (Huthnance, 2010). The biotope, based on the characterizing species, is considered to tolerate a 2°C decrease in temperature for a year. The experiments by Warren (1977) suggest that both the chronic and acute decreases in temperature would not exceed the thermal tolerance of *Capitella capitata*. Biotope resistance based on the characterizing and associated *Tubificoides* spp. is therefore assessed as 'High' and resilience as 'High' (by default), so the biotope is considered to be 'Not sensitive'.

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

The biotope occurs in variable (18-35 ppt) and reduced salinity (18-30ppt) (JNCC, 2015). Given the wide salinity tolerance, biotopes found in the middle of the range would not be sensitive to an increase from variable to full salinity. No evidence was found to assess an increase in salinity above full.

Sensitivity assessment. The biotope is considered to have high resistance to a change to full salinity from variable or redcued, although some mortality may occur before species acclimation. *Capitella capitata* and other associated species occur intertidally and in areas with limited water exchange such as lagoons; these habitats may experience short-term increases in salinity due to evaporation and some tolerance is therefore expected with local acclimation possible. A similar biotope characterized by *Capitella* and *Tubificoides* also occurs with enriched sediments in fully marine waters (SS.SMu.ISaMu.Cap) Biotope resistance to this pressure is therefore assessed as 'High' and resilience as 'High' (by default), so the biotope is considered to be 'Not sensitive'.

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

This biotope is present in reduced (18-30 ppt) and variable (18-35 ppt) salinity habitats (JNCC, 2015); a change at the pressure benchmark, therefore, represents a change from reduced to low (<18 ppt) salinity. Oligochaete dominated biotopes are recorded from a range of salinity regimes from full (LS.LSa.MoSa.Ol; LS.LSa.MoSa.Ol.FS), variable (SS.SMu.SMuVS.CapTubi) reduced (SS.SMu.SMuVS.CapTubi; LS.LMu.UEst.Tben) and low (SS.SMu.SMuVS.LhofTtub) habitats (JNCC,2015). In very low salinities from <15 to 0 ‰ species such as *Limnodrilus* spp. and *Tubifex tubifex* are found (Giere & Pfannkuche, 1982). It is therefore considered that a decrease in salinity at the pressure benchmark would result in replacement by oligochaete species more tolerant of lower salinities such as *Limnodrilus hoffmeisteri* and *Tubifex tubifex* that characterize the low salinity biotope SS.SMu.SMuVS.LhofTtub. This would result in the loss of the characterizing biotope.

Warren (1977) used individual worms collected from Warren Point (south-west England) to test response to reduced salinity. Individual *Capitella capitata* were acclimated to 33 ppt for 1 week prior to exposure to salinities of 1.5 ppt, 5.5 ppt,18 ppt and 33 ppt. Larvae removed from the maternal tube were also tested in groups of 10. The results of tolerance tests showed that adult *Capitella capitata* acclimated at 33 ppt were intolerant of reduced salinities below 20 ppt, all exposed adults died within 4 days when exposed at 18 ppt and within 1 day at 9 ppt. The larvae were more tolerant, living for 10 days at 15.5 ppt with little apparent ill effect.

Sensitivity assessment. A reduction in salinity at the pressure benchmark may lead to species replacement and biotope reclassification to SS.SMu.SMuVS.LhofTtub. Biotope resistance is therefore assessed as 'Low' and resilience as 'High' (following a return to usual habitat conditions), so that biotope sensitivity is assessed as 'Low'.

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

Increases and decreases in water velocity may lead to increased erosion or deposition. The associated pressures alteration to sediment type and siltation are assessed separately. Experimental increases in near-bed current velocity were achieved over intertidal sandflats by placing flumes on the sediment to accelerate water flows (Zuhlke & Reise, 1994). The increased flow led to the erosion of up to 4 cm depth of surface sediments. No significant effect was observed on the abundance of *Capitella capitata* and numbers of *Tubificoides benedii* and *Tubificoides pseudogaster* were unaffected, as they probably avoided suspension by burrowing deeper into sediments. This was demonstrated by the decreased abundance of oligochaetes in the 0-1 cm depth layer and increased abundance of oligochaetes deeper in sediments (Zuhlke & Reise, 1994). A single storm event had a similar result with decreased abundance of oligochaetes in surficial layers, coupled with an increase in deeper sediments (Zuhlke & Reise, 1994). Although *Tubificoides* spp. can resist short-term disturbances, their absence from sediments exposed to higher levels of disturbance indicate that they would be sensitive to long-term changes in sediment mobility (Zuhlke & Reise, 1994).

In the turbid waters of estuaries, where many mud habitats develop, a reduction in water flow is likely to result in a significant increase in siltation increasing the silt and clay content of the substratum. Decreases in water flow with increased siltation of fine particles are considered unlikely to alter the physical character of this habitat type as it is already found in sheltered areas where siltation occurs and where particles are predominantly fine. Reductions in waterflow occurring through the presence of trestles (for off-bottom oyster cultivation) arranged in parallel rows in the intertidal area (Goulletquer & Héral, 1997), reducing the strength of tidal currents (Nugues *et al*., 1996) has been observed to limit the dispersal of pseudofaeces and faeces in the water column and thus increase the natural sedimentation process by several orders of magnitude (Ottman & Sornin, 1985, summarised in Bouchet & Sauriau, 2008). As the characterizing *Capitella capitata* oligochaetes can live relatively deeply buried and in depositional environments with low water flows (based on habitat preferences) and low oxygenation, they are considered to be not sensitive to decreases in water flow.

Sensitivity assessment. Where increased or decreased water flows altered the sediment type, this could lead to sediment reclassification and thus change is assessed in the sedimentary change assessment. As muds tend to be cohesive and the surface tends to be smooth reducing turbulent flow, an increase at the pressure benchmark may not lead to increased erosion. The biotope resistance is assessed as 'Medium' as a precautionary assessment, resilience is assessed as 'High' (following restoration of usual conditions) and sensitivity is assessed as 'Low'. The biotope is not considered to be sensitive to decreased flows due to its presence in sheltered habitats and the tolerance of *Tubificoides benedii* for low oxygen and sediment deposition.

Emergence regime changes	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

'Not relevant' to subtidal biotopes.

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

This biotope occurs in habitats that are sheltered from strong wave action. Disturbance of sediment by waves may reduce oligochaete abundance (Giere, 1977) and oligochaetes may be absent from very wave exposed shores (Giere & Pfannkuche, 1982 and references therein). As this biotope occurs across three wave exposure categories; sheltered, extremely sheltered and very sheltered (JNCC, 2015), this is considered to indicate that mid-range biotopes would tolerate both an increase and decrease in wave exposure at the pressure benchmark. Resistance is therefore assessed as 'High' and resilience as 'High' by default and the biotope is considered to be 'Not sensitive'.

Chemical Pressures

Resistance Resilience Sensitivity

Transition elements & organo-metal contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available.

Contamination at levels exceeding the pressure benchmark may have negative effects. High levels of organic material in intertidal muds, coupled with sub-surface anoxia, may sequester metals reducing bioavailability and hence reducing toxicity. However, sediment disturbance and exposure to oxygenated waters will render metals labile and bioavailable.

Experimental studies with various species suggest that polychaete worms are quite tolerant to heavy metals (Bryan, 1984). High numbers of *Capitella capitata* have been recorded in areas containing high metal concentrations (Petrich & Reish, 1979; Ward & Young, 1982; Olsgard, 1999), although abundance of *Capitella capitata* in Norway has also been noted to have a significant negative correlation between sediment content of Cu and abundance of the species, with an obvious reduction in abundance at approximately 900 ppm Cu (Olsgard, 1999). Some impacts on population size and reproduction of *Capitella capitata* as a result of metal pollution, both in the field and the laboratory, have been observed.

Tests of copper toxicity have been carried out on the characterizing species *Capitella capitata*. Laboratory tests carried out in water may not reflect sediment conditions where, again, copper toxicity and exposure is determined by a number of parameters including the degree to which it is adsorbed on to particles selected as food for deposit feeders. A 2-year microcosm experiment was undertaken to investigate the impact of copper on the benthic fauna of the lower Tyne Estuary (UK) by Hall & Frid (1995). During a 1-year simulated contamination period, 1 mg/l copper was supplied at 2-weekly 30% water changes, at the end of which the sediment concentrations of copper in contaminated microcosms reached 411 µg/g. Toxicity effects reduced populations of the four dominant taxa, including *Capitella capitata*. When copper dosage was ceased and clean water supplied, sediment copper concentrations fell by 50% in less than 4 days, but faunal recovery took up to 1 year, with the pattern varying between taxa. Since the copper leach rate was so rapid it is concluded that after remediation, contaminated sediments show rapid improvements in chemical concentrations, but faunal recovery may be delayed with experiments in microcosms showing faunal recovery taking up to a year.

Rygg (1985) classified *Capitella capitata* as a highly tolerant species, common at the most copper polluted stations (copper >200 mg/kg) in Norwegian fjords.

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.

Contamination at levels exceeding the pressure benchmark may have negative effects. Suchanek (1993) reviewed the effects of oil spills on marine invertebrates and concluded that, in general, on soft sediment habitats, infaunal polychaetes, bivalves and amphipods were particularly affected. However, high numbers of *Capitella capitata* have been recorded in hydrocarbon contaminated sediments (Ward & Young, 1982; Olsgard, 1999; Petrich & Reish, 1979) and colonization of areas defaunated by high hydrocarbon levels may be rapid (Le Moal, 1980). After a major spill of fuel oil in West Virginia, *Capitella* increased dramatically alongside large increases in *Polydora ligni* and *Prionospio* sp. (Sanders *et al*., 1972 cited in Gray, 1979). Experimental studies adding oil to sediments have found that *Capitella capitata* increased in abundance initially, although it was rarely found in samples prior to the experiment (Hyland, 1985).

Capitella capitata is able to withstand relatively high hydrocarbon concentrations and may even take advantage of any available space, caused by mortality of other species.

Tubificoides benedii also appears to bemore tolerant and was found in UK waters near oil refineries as the sole surviving member of the macrofauna. Populations were, however, apparently reduced and the worms were absent from areas of oil discharge and other studies indicate sensitivity to oiling (Giere & Pfannkuche, 1982 and references therein).

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.

Mendez (2006) showed that the effects of exposing *Capitella* to sediment spiked with environmentally relevant concentrations of teflubenzuron (another chemical used to control infestations of sea lice) caused mortality in one species of *Capitella* and reduced the egestion rate of another.

Radionuclide contamination	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence.

Introduction of other substances	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed**.

De-oxygenation	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

Capitella capitata exhibits a relatively high tolerance for sediment hypoxia, hydrogen sulphide concentration, and other sediment conditions avoided by many infauna (Henriksson, 1969). Forbes & Lopez (1990) experimentally demonstrated that reduced oxygen concentrations (pO_2 = 20 mm Hg or less) led to decreased *Capitella capitata* growth rates and cessation of burrowing and feeding activity even when an abundance of food was provided. The authors hypothesize that animals rely solely on anaerobic metabolism once this threshold is crossed. Magnum & Van Winkle (1973) similarly observed that *Capitella capitata* oxygen uptake ceased when pO_2 fell to between 0-34 mm Hg. The fact that experimental worms lost body mass under these conditions supports the contention that full aerobic metabolism cannot be sustained at very low ambient oxygen conditions despite a very high affinity of *Capitella capitata* hemoglobin for oxygen.

Tubificoides benedii has a high capacity to tolerate anoxic conditions, its extreme oxygen tolerance is based on an unusually low respiration rate (Giere *et al*., 1999). Respiration rates of *Tubificoides benedii* measured at various oxygen concentrations showed that aerobic respiration is maintained even at very low oxygen concentrations (Giere *et al*., 1999). Birtwell & Arthur (1980) showed that *Tubificoides benedii* could tolerate anoxia in the Thames Estuary (LT_{50} = 58.8 hours at 20°C, 26.6 hours at 25°C and 17.8 hours at 30°C in experiments with worms acclimated to 20°C).

Sensitivity assessments. Based on the reported tolerances for anoxia for *Capitella capitata* and *Tubificoides*, biotope resistance is assessed as 'High', resilience is assessed as 'High' (by default) and the biotope is considered to be 'Not sensitive'.

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

In very sheltered areas, green algae such as *Ulva* spp. may form mats on the surface of the mud during the summer months, particularly if nutrient enrichment occurs.

Sensitivity assessment. As the benchmark is relatively protective and would not lead to blooms of *Ulva* spp. (although green algae may be present on the surface layers of sediments in the summer), biotope resistance is assessed as 'High', resilience is assessed as 'High' and the biotope is considered to be 'Not sensitive'.

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

Benthic responses to organic enrichment have been described by Pearson & Rosenberg (1978) and Gray (1981). In general, moderate enrichment increases food supply and increases productivity and abundance. Dense *Capitella capitata* populations are frequently located in areas with greatly elevated organic content such as areas of sewage disposal and below fish farms and mussel long lines, even though eutrophic sediments are often anoxic and highly sulfidic (Gray, 1979; Tenore, 1977; Warren, 1977; Tenore & Chesney, 1985; Bridges *et al*., 1994; Haskoning, 2006; Callier *et al*., 2007)

Benthic fauna underneath floating salmon farm cages in a Scottish sea loch showed marked changes in species number, diversity, faunal abundance and biomass in the region of the fish farm (Brown *et al*., 1987). Four 'zones' of effect were identified: in zone 1 directly beneath and up to the edge of the cages there was an azoic zone; in zone 2, from the edge of the cages out to 8 m, the sediments were highly enriched and dominated by *Capitella capitella* and *Scolelepis fuliginosa*. Kutti *et al*. (2008) studied organic enrichment of sediments below a fish farm in a fjord system (Norway), during periods of high organic loading production was mostly by *Capitella capitata*. The threshold for increased infauna production in this deep benthic ecosystem had been reached at an annual flux of 500 g C/m^2 and continuous loadings at this magnitude over time might cause organic overloading of fish farm sediments.

The oligochaetes *Tubificoides benedii* and *Baltidrilus costatus* are both very tolerant of high levels of organic enrichment and often dominate sediments where sewage has been discharged or other forms of organic enrichment have occurred (Pearson & Rosenberg, 1978; Gray, 1971; McLusky *et al*., 1980).

Sensitivity assessment. Above evidence indicates that increased organic matter levels associated with aquaculture can favour *Capitella capitata* and *Tubificoides* spp., resistance is therefore considered to be 'High', resilience 'High' (by default) and the species is 'Not sensitive'. It should be noted, however, that sensitivity is greater to gross organic enrichment levels within the spatial footprint of activities.

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

The biotope is characterized by the sedimentary habitat (JNCC, 2015), and a change to an artificial or rock substratum would alter the character of the biotope leading to reclassification and the loss of the sedimentary community including the characterizing *Capitella capitata*, other polychaetes and oligochaetes that live buried within the sediment.

Sensitivity assessment. Based on the loss of the biotope, resistance is assessed as 'None', recovery is assessed as 'Very Low' (as the change at the pressure benchmark is permanent, and sensitivity is assessed as 'High'.

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

Capitella capitata can survive in a range of habitats including fine sands and areas with boulders, a change in sediment type was not judged to completely reduce habitat suitability for this species. An increase of sediment coarseness to sand would not exclude this species, based on published habitat preferences, but may have population level effects as habitat suitability may be reduced. Recovery would depend on the return of previous habitat conditions.

Tubificoides benedii (studied as *Peloscolex benedeni*) are found in a range of substratum types from sandy mixed habitats, fine sands and coarse sands (Giere & Pfannkuche, 1982 and references therein). Giere & Pfannkuche (1982) suggest that factors that correlate to substratum types such as organic matter availability, size and shape of the intertstitial space between grains, the level of sediment disturbance and water content, rather than the sediment type alone are the key factors influencing distribution.

Sensitivity assessment. A change in sediment type to mixed or coarser particles could lead to changes in the density of *Capitella capitata*, other burrowing polychaetes and oligochaetes depending on species-specific responses. However, the loss of the muddy sediment that characterizes this habitat would change the character of the biotope, and decrease habitat suitability for the characterizing species, with potentially an increase in bivalves or crustaceans. Based on a change in character, the biotope is considered to have 'No' resistance to this pressure, resilience is assessed as 'Very Low' as a change at the pressure benchmark is permanent and biotope sensitivity is assessed as 'High'.

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

Sedimentary communities are likely to be highly intolerant of substratum removal, which will lead to partial or complete defaunation, exposing underlying sediment which may be anoxic and/or of a different character or bedrock and lead to changes in the topography of the area (Dernie *et al*., 2003). Any remaining species, given their new position at the sediment/water interface, may be exposed to conditions to which they are not suited. Removal of 30 cm of surface sediment will remove the polychaete and oligochaete community and other species present in the biotope. Recovery of the biological assemblage may take place before the original topography is restored, if the exposed, underlying sediments are similar to those that were removed. Hydrodynamics and sedimentology (mobility and supply) influence the recovery of soft-sediment habitats (Van Hoey *et al*., 2008).

Sensitivity assessment. Extraction of 30 cm of sediment will remove the characterizing biological component of the biotope. Resistance is assessed as 'None' and biotope resilience is assessed as 'High''. Biotope sensitivity is therefore 'Medium'.

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

Capitella capitata is a soft bodied, relatively fragile species inhabiting mucus tubes close to the sediment surface. Abrasion and compaction of the surficial layer may damage individuals. *Capitella capitata* and *Pygospio elegans* have been categorised through literature and expert reviews as AMBI fisheries Group IV- 'A second-order opportunistic species, which are sensitive to fisheries in which the bottom is disturbed. Their populations recover relatively quickly however and benefit from the disturbance, causing their population sizes to increase significantly in areas with intense fisheries' (Gittenberger & Van Loon, 2011). Chandrasekara & Frid (1996) found that in intertidal muds, along a pathway heavily used for five summer months (ca 50 individuals a day), some species including *Capitella capitata* reduced in abundance. Bonsdorff & Pearson (1997) found that sediment disturbance forced *Capitella capitata* deeper into the sediment, although the species was able to burrow back through the sediment to the surface again.

Tubificoides benedii can be relatively deeply buried and could avoid direct exposure to abrasion although sediment disturbance and compaction could damage these soft-bodied species. Oligochaetes in general are not found in high abundances in sediments with high levels of disturbance from wave action.

Sensitivity assessment. Abrasion may damage or kill a proportion of the population of the characterizing *Capitella capitata* and associated species. *Tubificoides* spp. that are generally buried more deeply within sediments are likely to be more resistant. Biotope resistance is assessed as

'Medium' and resilience as 'High', so sensitivity is assessed as 'Low'.

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

Rabaut *et al.* (2008) found that beam trawling on intertidal *Lanice conchilega* reefs reduced the abundance of *Capitella capitata*. Ferns *et al.* (2000), however, found that tractor-towed cockle harvesting had little effect on *Capitella capitata*, but species that are present at the surface were more badly affected. The tractor dredging removed 83% of *Pygospio elegans* (initial density 1850/m^2). These results are supported by work by Moore (1991) and Rostron (1995) who also found that cockle dredging can result in reduced densities of some polychaete species, including *Pygospio elegans*.

Whomersley *et al.* (2010) conducted experimental raking on intertidal mudflats at two sites (Creeksea Crouch Estuary, England and Blackness lower Forth Estuary, Scotland), where *Tubificoides benedii* were dominant species. For each treatment, 1 m^2 plots were raked twice to a depth of 4 cm (using a garden rake). Plots were subject to either low intensity treatments (raking every four weeks) or high (raking every two weeks). The experiment was carried out for 10 months at Creeksea and a year at Blackness. The high and low raking treatments appeared to have little effect on *Tubificoides benedii* (Whomersley *et al.*, 2010). These results are supported by observations that two experimental passes of an oyster dredge that removed the sediment to a depth of between 15-20 cm did not significantly affect *Tubifcoides benedii* (EMU, 1992).

Sensitivity assessment. *Capitella capitata* is present in the surface layers of sediment and may be damaged, displaced or killed by penetration and disturbance of the sediment. Resistance is assessed as 'Low' and resilience as 'High', so sensitivity is assessed as 'Low'.

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

Estuaries, where this biotope is often found, can be naturally turbid systems due to sediment resuspension by wave and tide action and inputs of high levels of suspended solids, transported by rivers. The level of suspended solids depends on a variety of factors including: substrate type, river flow, tidal height, water velocity, wind reach/speed and depth of water mixing (Parr *et al.*, 1998). Transported sediment including silt and organic detritus can become trapped in the system where the river water meets seawater. Dissolved material in the river water flocculates when it comes into contact with the salt wedge pushing its way upriver. These processes result in elevated levels of suspended particulate material with peak levels confined to a discrete region (the turbidity maximum), usually in the upper-middle reaches, which moves up and down the estuary with the tidal ebb and flow. Intertidal mudflats depend on the supply of particulate matter to maintain mudflats and the associated biological community is exposed naturally to relatively high levels of turbidity/particulate matter.

Sensitivity assessment. The biological assemblage characterizing this biotope is infaunal and consists of sub-surface deposit feeders. Increased suspended solids are unlikely to have an impact and resistance is assessed as 'High' and resilience as 'High', so the biotope is considered to be 'Not sensitive'. A reduction in suspended solids may reduce deposition and supply of organic matter, resistance to a decrease is therefore assessed as 'Medium', as a shift between deposition and erosion could result in the net loss of surficial sediments. A reduction in organic matter as suspended solids could also reduce production within this biotope. Resistance is assessed as 'Medium', as over a year the impact may be relatively small, and resistance is assessed as 'High', following restoration of usual conditions. Biotope sensitivity is therefore assessed as 'Low'.

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

Subtidal mudflats occur in sheltered environments and, in general, are accreting environments meaning that deposition rather than erosion is the dominant process, this means that the assemblages present (primarily deposit feeders) are adapted to natural levels of siltation through life history traits and can withstand burial (by repositioning in sediment or similarly extending tubes or feeding and respiration structures above the sediment surface). *Capitella capitata* has been categorised through expert and literature review, as AMBI sedimentation Group IV – 'A second-order opportunistic species, insensitive to higher amounts of sedimentation. 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). The effects of siltation will depend on the amount and rate that particles are added. *Capitella capitata* is sedentary and adults are judged unlikely to have any mechanism to escape from large inputs. A deep covering of sediment will prevent feeding. Where inputs are at low rates and similar to background sediments then adults may be able to extend tubes to reach the surface to feed.

Tubificoides live relatively deeply buried and can tolerate periods of low oxygen that may occur following the deposition of a fine layer of sediment. In addition, the presence of this species in areas experiencing deposition, such as estuaries, indicate that this species is likely to have a high tolerance to siltation events. *Tubificoides* spp. showed some recovery through vertical migration following the placement of a sediment overburden 6cm thick on top of sediments (Bolam, 2011).

Whomersley *et al*. (2010) experimentally buried plots on intertidal mudflats at two sites (Creeksea Crouch Estuary, England and Blackness lower Forth Estuary, Scotland), where *Tubificoides benedii* were dominant species. For each treatment, anoxic mud was spread evenly to a depth of 4 cm on top of each treatment plot. The mud was taken from areas adjacent to the plots, and was obtained by scraping off the surface oxic layer and digging up the underlying mud from approximately 20 cm depth. Plots were subject to either low intensity treatments (burial every four weeks) or high (burial every two weeks). The experiment was carried out for 10 months at Creeksea and a year at Blackness. At Creeksea numbers of *Tubificoides benedii* increased in both burial treatments until the third month (high burial) and sixth month (low burial). At Blackness increased numbers of*Tubificoides benedii* were found in both burial treatments after one month (Whomersley *et al*., 2010).

Sensitivity assessment. Biotope resistance to siltation based on *Capitella capitata* is judged to be 'Low' with regard to the rapid addition of silts to a depth of <5 cm. Resilience is assessed as 'High' recovery is predicted to be rapid. Sensitivity is therefore assessed as 'Low'. At lower levels of siltation, sensitivity will be likely to be lower.

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

The pressure benchmark (30 cm deposit) represents a significant burial event and the deposit may remain for some time in a sheltered mudflat. *Capitella capitata* populations are likely to be significantly impacted. Some impacts on *Tubificoides benedii* and other oligochaetes may occur and it is considered unlikely that signficiant numbers of the population could reposition, based on (Bolam, 2011). Placement of the deposit will, therefore, result in a defaunated habitat until the deposit is recolonized. Biotope resistance is therefore assessed as 'Low' as some removal of deposit and vertical migration through the deposit may occur. Resilience is assessed as 'High' as migration and recolonization of *Capitella capitata* and oligochaetes is likely to occur within two years, biotope sensitivity is therefore assessed as 'Low'.

Litter	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

Not assessed.

Electromagnetic changes	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence.

Underwater noise changes	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

'Not relevant'.

Introduction of light or shading	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

As the characterizing biological assemblage occurs within the sediment and can be deeply buried (to 10 cm or more), an increase in light or shading is considered 'Not relevant'. However, shading may reduce the microphytobenthos component of this infralittoral biotope. Mucilaginous secretions produced by these algae may stabilize fine substrata (Tait & Dipper, 1998). Shading will prevent photosynthesis leading to death or migration of sediment microalgae, which may alter sediment cohesion and food supply to higher trophic levels. As this biotope occurs in areas of high turbidity, where light penetration may be limited, an increase in shading is not considered to significantly alter the character of the habitat.

Barrier to species movement	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

The key characterizing species *Capitella capitata* and the associated species *Pygospio elegans* are capable of both benthic and pelagic dispersal. In the sheltered waters where this biotope occurs, with reduced water exchange, in-situ reproduction may maintain populations rather than long-range pelagic dispersal. As the tubificid oligochaetes that characterize this biotope have benthic dispersal strategies (via egg cocoons laid on the surface (Giere & Pfannkuche, 1982)), water transport is not a key method of dispersal over wide distances. The biotope (based on the biological assemblage) is considered to have 'High' resistance to the presence of barriers that lead to a reduction in tidal excursion, resilience is assessed as 'High' (by default) and the biotope is considered to be 'Not sensitive'.

	Resistance	Resilience	Sensitivity
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

Visual disturbance is not considered relevant to this biotope.

Biological Pressures

	Resistance	Resilience	Sensitivity
Genetic modification & translocation of indigenous species	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

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

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

No evidence found. Invasion by the slipper limpet *Crepidula fornicata* may lead to biotope reversion to SS.SMx.SMxVS.CreMed suggesting high intolerance as the original biotope would be lost. Species richness might decline as *Crepidula* may dominate the seabed. Experimental relaying of mussels on intertidal fine sand sediments increased fine sediment proportions and led to colonization by *Capitella capitata* (Ragnarsson & Rafaelli, 1999), so that sediment modification by bivalves may not render habitats unsuitable for *Capitella capitata*.

Sensitivity assessment. Reclassification of the biotope following invasion would result in loss of the biotope, resistance is therefore assessed as 'None', as recovery will not occur until the invasive species is eradicated, recovery is assessed as 'Very Low' and biotope sensitivity is 'High'.

Introduction of microbial pathogens	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

Marine oligochaetes host numerous protozoan parasites without apparent pathogenic effects even at high infestation levels (Giere & Pfannkuche, 1982 and references therein).

Sensitivity assessment. Based on the lack of evidence for mass mortalities in *Capitella capitata* and oligochaetes from microbial pathogens, resistance is assessed as 'High' and resilience as 'High' (by default), so that the biotope is assessed 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

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

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

Incidental removal of the characterizing species would alter the character of the biotope and the delivery of ecosystem services such as secondary production and bioturbation. Populations of oligochaetes provide food for macroinvertebrates fish and birds. For example, up to 67% of flounder and plaice stomachs examined from the Medway Estuary (UK) (Van den Broek, 1978) contained the remains of *Tubificoides benedii (*studied as *Peloscolex benedeni)* and shrimps which in turn support higher trophic levels (predatory birds and fish). For some migratory birds, the characterizing species *Tubificoides benedii* can form an important part of the diet during winter (Bagheri & McLusky, 1984). Polychaetes and crustaceans are also predators of oligochaetes and may significantly reduce numbers (Giere & Pfannkuche, 1982 and references therein). The loss of the oligochaete population could, therefore, impact other trophic levels.

Sensitivity assessment. Removal of the characterizing species would alter the character of the biotope. Resistance is therefore assessed as 'Low' and resilience as 'High', so sensitivity is categorized as 'Low'.

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