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

# *Nephtys cirrosa* - dominated littoral fine sand

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

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2020-01-17

This review can be cited as:
Ashley, M., 2020. [Nephtys cirrosa] - dominated littoral fine sand. 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.1202.1

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**Polychaetes in littoral fine sand**
**Photographer:** Eleanor Murray
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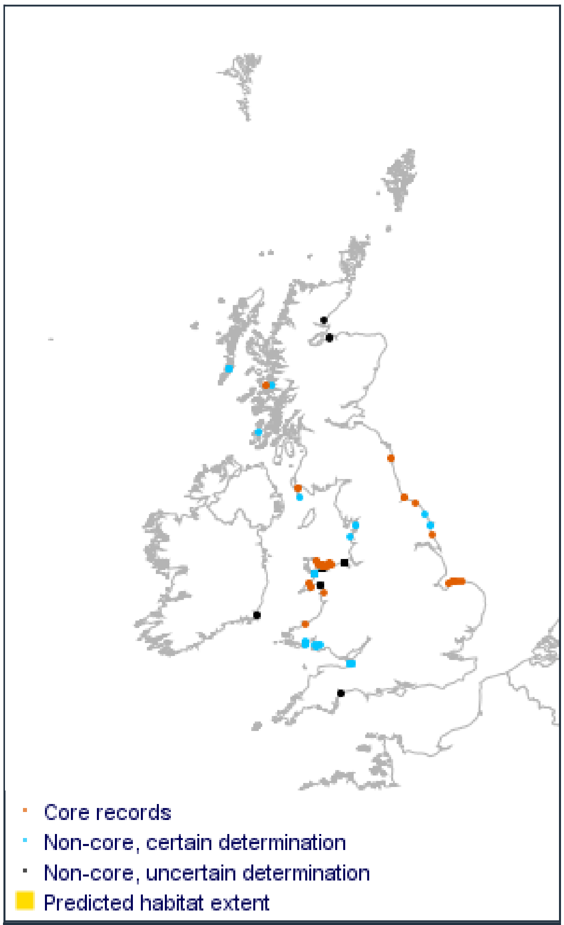

17-01-2020
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

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# Summary

## UK and Ireland classification

| | | |
|---|---|---|
| **EUNIS 2008** | A2.2313 | *Nephtys cirrosa*-dominated littoral fine sand |
| **JNCC 2015** | LS.LSa.FiSa.Po.Ncir | *Nephtys cirrosa* dominated littoral fine sand |
| **JNCC 2004** | LS.LSa.FiSa.Po.Ncir | *Nephtys cirrosa* dominated littoral fine sand |
| **1997 Biotope** | | |

## Description

This biotope LS.LSa.FiSa.Po.Ncir occurs mainly on the mid and lower shore on moderately wave-exposed and sheltered coasts, with medium to fine clean sand which remains damp throughout the tidal cycle and contains little organic matter. The sediment is not usually well sorted and may contain a fraction of coarse sand. It is often rippled and typically lacks an anoxic sub-surface layer. The polychaete infauna is dominated by *Nephtys cirrosa*, *Magelona mirabilis*, *Spio martinensis*, *Spiophanes bombyx* and *Paraonis fulgens*. The presence of polychaetes may be seen as coloured burrows running down from the surface of the sediment. Nemertean worms may be present. The amphipods *Pontocrates* spp. and *Bathyporeia* spp., as well as *Cumopsis goodsiri* and the shrimp *Crangon crangon* are typically present. The bivalve *Macomangulus tenuis* is scarce or absent. Po.Ncir may be present higher up on the shore than Po.Aten, or lower down than AmSco.Eur or Ol.FS. The infaunal community of this biotope may change seasonally, as increased storminess during winter months may reduce sediment stability and the ability of some species to survive. Some species, such as the shrimp *Crangon crangon* avoid these conditions by seasonal migration to deeper water (Moore, 1991). (Information taken from Connor et al., 2004; JNCC, 2015).

## Depth range

Mid shore, Lower shore

## 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 LS.LSa.FiSa.Po occurs on moderately exposed or sheltered beaches of medium and fine, usually clean, sand, though the sediment may on rare occasions contain a small silt and clay fraction. The biotope occurs mainly on the lower part of the shore, and relatively frequently on the mid-shore, remains damp throughout the tidal cycle and contains little organic matter. The infaunal community is dominated by a range of polychaete species such as *Nephtys cirrosa*, *Paraonis fulgens*, *Spio* spp., *Pygospio elegans*, *Ophelia rathkei* and *Scoloplos armiger*. The amphipods *Bathyporeia* spp. and *Pontocrates arenarius* frequently occur, and nemerteans are often present. On some North Wales shores, the presence of *Arenicola* species characterizes the lowest part of the shore, with a range of species characteristic of the shallow sublittoral. These include sparsely distributed *Echinocardium*, *Acrocnida brachiata*, *Ensis siliqua* and *Fabulina fabula*. The Po biotope is split into three sub-biotopes, between which there can be a large degree of overlap. The bivalve *Macomangulus tenuis* sub-biotope is characterized by slightly more stable and fine sediments than the other two sub-biotopes (Conner *et al.* 2004). *Nephtys cirrosa*, *Paraonis fulgens*, *Spio* spp., and *Pygospio elegans* are reviewed as characterizing species although, during stormy winters, the sediment may become de-stabilised, leading to the disappearance of some macroinfaunal species. The lugworm *Arenicola marina* may be present occasionally, usually as a temporary recruitment and is likely to be washed out during storms. *Capitella capitella* is also reviewed as it is a characterizing species of sub-biotopes in more exposed locations.

LS.LSa.FiSa.Po.Pful sub-biotope occurs less often in sheltered locations but mainly on the mid and lower shore of moderately wave-exposed coasts. The medium and fine clean sand may contain less silt fraction but also remains damp throughout the tidal cycle and contains little organic matter. Polychaetes make up the greater part of the community and are dominated by *Paraonis fulgens*, *Capitella capitata*, *Pygospio elegans*, *Ophelia rathkei* and *Eteone longa*. Nemerteans may also be present. The amphipods *Bathyporeia pilosa* and *Bathyporeia sarsi* are often present.

LS.LSa.FiSa.Po.Aten sub-biotope occurs in similar conditions to FiSa.Po, on the mid and lower shore on moderately wave-exposed and sheltered coasts. This sub-biotope contains fine sand (in comparison to the medium and fine sand with small silt content found in FiSa.Po. The infaunal community is dominated by the abundant bivalve *Macomangulus tenuis* together with a range of polychaetes. Polychaetes that are characterizing for this biotope include *Nephtys cirrosa*, *Paraonis fulgens* and *Spio filicornis*. Burrowing amphipods *Bathyporeia* spp. may occur in some samples of this biotope.

LS.LSa.FiSa.Po.Ncir biotope occurs in the same position, mainly on the mid and lower shore on moderately wave-exposed and sheltered coasts. The sediment contains medium to fine clean sand, is not usually well sorted and may contain a fraction of coarse sand. The polychaete infauna is dominated by *Nephtys cirrosa*, *Magelona mirabilis*, *Spio martinensis*, *Spiophanes bombyx* and *Paraonis fulgens*. The presence of polychaetes may be seen as coloured burrows running down from the surface of the sediment. Nemertean worms may be present. The amphipods *Pontocrates* spp. and *Bathyporeia* spp., as well as *Cumopsis goodsiri* and the shrimp *Crangon crangon* are typically present. The bivalve *Macomangulus* is scarce or absent.

Therefore, LS.LSa.FiSa.Po and its sub-biotopes are characterized by the fine to medium sand in a moderately exposed to sheltered wave climate that remains damp throughout the tidal cycle but is occasionally affected by storms. The dominant fauna are polychaetes and mobile burrowing amphipods, although the abundance of bivalve *Macomangulus tenuis* varies between sub-biotopes. Sub-biotopes are mainly distinguished by changes in sediment grain size to either finer or coarser material and changes in silt fraction but otherwise, their sensitivity to pressures is similar. The sensitivity assessment is based on the sensitivity of the dominant polychaetes and to a lesser extent the sensitivity of mobile amphipods and *Macomangulus tenuis* where appropriate.

## Resilience and recovery rates of habitat

*Nephtys cirrosa* is a relatively long-lived polychaete with a lifespan of six to possibly as much as nine years. It matures at one year and the females release over 10,000 (and up to 80,000 depending on species) eggs of 0.11-0.12 mm from April through to March. These are fertilized externally and develop into an early lecithotrophic larva and a later planktotrophic larva which spends as much as 12 months in the water column before settling from July-September. The genus *Nephtys* has a relatively high reproductive capacity and widespread dispersion during the lengthy larval phase. It is likely to have a high recoverability following disturbance (MES, 2010).

*Paraonis fulgens*, is a small polychaete, up to 3 cm in length. *Paraonis fulgens* displays growth and reproduction strategies typical of opportunistic species. It occurred in highly dynamic communities in German estuaries in a community of opportunistic species (Nehmer *et al.*, 2003). Therefore, it is likely to show rapid recovery. *Paraonis fulgens* is thought to feed exclusively on benthic diatoms so that its abundance and recovery is likely to be affected by changes in levels of primary productivity (Gaston *et al.*, 1992). *Spiophanes* spp. (e.g. *Spiophanes filicornis*, *Spiophanes martinensis*, *Spiophanes bombyx*) have opportunistic life strategies (Kröencke, 1980; Niermann *et al.*, 1990). They are characterized by small size, rapid maturation and short-lifespan of 1-2 years and produce large numbers of small propagules. It is often found at the early successional stages of variable, unstable habitats that it is quick to colonize following perturbation (Pearson & Rosenberg, 1978). For example, two years after dredging, the abundance of opportunistic species was generally elevated relative to pre-dredging levels and the communities were numerically dominated (50-70%) by *Spiophanes bombyx* (Gilkinson *et al.*, 2005). Van Dalfsen *et al.* (2000) found that polychaetes recolonized a dredged area within 5-10 months (cited from Boyd *et al.*, 2005) and their biomass was predicted to recover within 2-4 years.

*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). The *Capitella* species complex displays reproductive variability. 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). Shull (1997) demonstrated that recolonization 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. Bolam & Fernandes (2002) and Shull (1997) noted that *Capitella capitata* can colonize azoic sediments rapidly in relatively high numbers and 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 favourable conditions, maturity can be reached in <3 months and growth rate is estimated to be 3 cm per year. Adult potential dispersal is up to 1 km.

The polychaete *Pygospio elegans* has life-history strategies that allow rapid colonization and population increase in disturbed and defaunated patches where there is little competition from other species. *Pygospio elegans* exhibits several reproductive strategies (a trait known as poecilogony). Larvae may develop directly allowing rapid population increase in suitable patches or they may have a planktonic stage (allowing colonization of new habitats). Experimental defaunation studies have shown an increase in *Pygospio elegans*, higher than background abundances within 2 months, reaching maximum abundance within 100 days (Van Colen *et al*. 2008). Following a period of anoxia in the Bay of Somme (north France) that removed cockles, *Pygospio elegans* increased rapidly but then decreased as cockle abundance recovered and sediments were disturbed by cockle movement (Desprez *et al*., 1992). Re-colonization of *Pygospio elegans* was observed in 2 weeks by Dittmann *et al*. (1999) following a 1 month long defaunation of the sediment. However, McLusky *et al*. (1983) found that *Pygospio elegans* were significantly depleted for >100 days after harvesting (surpassing the study monitoring timeline). Ferns *et al*. (2000) found that tractor-towed cockle harvesting removed 83% of *Pygospio elegans* (initial density of 1850 per $m^2$). In muddy sand habitats, *Pygospio elegans* had not recovered their original abundance after 174 days (Ferns *et al*., 2000). These results are supported by work by Moore (1991) who also found that cockle dredging can result in reduced densities of some polychaete species, including *Pygospio elegans*. Rostron (1995) undertook experimental dredging of sandflats with a mechanical cockle dredger, including a site comprised of stable, poorly sorted fine sands with small pools and *Arenicola marina* casts with some algal growths. At this site, post-dredging, there was a decreased number of *Pygospio elegans* with no recovery to pre-dredging numbers after six months. Although numbers may be depleted in the short-term the evidence suggests that Pygospio elegans is likely to recover within two years.

All three sub-biotopes may contain amphipods of the genus *Bathyporeia*. *Bathyporeia* spp. are short-lived, reaching sexual maturity within 6 months with 6-15 eggs per brood, depending on species. Reproduction may be continuous (Speybroeck *et al*., 2008) with one set of embryos developing in the brood pouch whilst the next set of eggs is developing in the ovaries. However, specific reproductive periods vary between species and between locations (Mettam, 1989) and bivoltine patterns (twice yearly peaks in reproduction) have been observed (Mettam, 1989; Speybroeck *et al*., 2008). Adult amphipods are highly mobile in the water column and recolonization by the adults is likely to be a significant recovery pathway. The life-history traits of rapid sexual maturation and production of multiple broods annually support rapid local recolonization of disturbed sediments where some of the adult population remains.

**Resilience assessment.** The biotope is characterized by opportunistic polychaetes and mobile amphipods that are characteristic of biotopes subject to natural and/or anthropogenic disturbance. Biotope resilience is considered to be **High** as populations of the characterizing species are likely to recover within two years, even after severe depletion of the resident populations or community, unless the substratum or other key habitat factors are altered.

## Hydrological Pressures

| | Resistance | Resilience | Sensitivity |
|---|---|---|---|
| **Temperature increase (local)** | High<br>Q: High A: High C: Medium | High<br>Q: High A: High C: High | Not sensitive<br>Q: High A: High C: Medium |

Intertidal species are exposed to extremes of high and low air temperatures during periods of emersion. They must also be able to cope with sharp temperature fluctuations over a short period during the tidal cycle. In winter air temperatures are colder than the sea, conversely in summer air temperatures are much warmer than the sea. Species that occur in the intertidal are therefore generally adapted to tolerate a range of temperatures, with the width of the thermal niche positively correlated with the height of the shore that the animal usually occurs at (Davenport & Davenport, 2005). The geographic distribution of species characteristic of this biotope extends south of the British Isles, further suggesting these species are likely to be resistant to an increase in temperature. Infaunal species are likely to be protected to some extent from direct effects of acute increases in temperature by sediment buffering, although increased temperatures may affect infauna indirectly by stimulating increased bacterial activity and increased oxygen consumption.

Emery & Stevensen (1957) reported that *Nephtys spp.* could withstand summer temperatures of 30-35°C so is likely to withstand the benchmark acute temperature increase. An acute increase in temperature at the benchmark level may result in physiological stress endured by the infaunal species but is unlikely to lead to mortality. *Nephtys cirrosa* is an active worm that can swim short distances and, therefore, it could avoid short-term changes in temperature by migrating away from localised warmer spots.

No direct evidence was found to assess the sensitivity of *Paraonis fulgens*, however, this species is recorded in warmer waters than the UK in the Gulf of Mexico. *Paraonis fulgens* was one of the most abundant macrobenthic organisms collected in the shallow waters off Perdido Key, Florida, where winter water temperatures average 22 °C (Gaston *et al.* 1992). *Angulus tenuis* is found off the Norwegian coasts to the Mediterranean and north-west coast of Africa and is likely to be resistant to temperature changes at the pressure benchmark.

*Spiophanes bombyx* is found in the Mediterranean (Hayward & Ryland, 1995), which is likely to be warmer than the waters around Britain and Ireland.

*Capitella capitata* is a cosmopolitan species in coastal marine and estuarine soft sediment systems. The global population is made up of several genetically distinct (and genetically isolated) sibling species whose distributions overlap such that local *Capitella capitata* populations consist of several co-occurring sibling species (Grassle & Grassle, 1976). 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. 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, 25ppt); 43 weeks at high temperature & high salinity (18°C, 30 ppt); 33 weeks at lower temperature & high salinity (12°C, 30 ppt); 17 weeks at high temperature and low salinity (18°C, 20ppt). 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 at 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.

The amphipods that occur within this habitat are mobile and can avoid unfavourable conditions to some extent. *Bathyporeia* life cycles vary between locations and this is related to temperature (Mettam, 1989). Preece (1971) tested the temperature tolerances of *Bathyporeia pilosa* in the laboratory. Individuals acclimated to 15°C for 24 hours were exposed to temperature increases (water temperature raised by 0.2°C/minute). As the test temperatures were reached individuals were removed, placed in seawater at 4°C and allowed to recover for 24 hours at which point mortalities were tested. Amphipods were also allowed to bury into sediments and held at test temperatures for 24 hours of 32.5°C, 31.8°C and 29.5°C before being allowed to recover in fresh seawater at 15°C for a further 24 hours, before mortalities were assessed. Upper lethal temperatures (the temperature at which 50% of individuals died for adult males and gravid females of *Bathyporeia pilosa* were 39.4°C. These tests measured short-term exposure only and species had a lower tolerance for longer-term (24-hour exposure). No mortality occurred for *Bathyporeia pilosa* individuals held at 29.5°C and 30.8°C; however, 15% of individuals exposed to water temperatures of 31.8°C and 96% at 32.5°C died.

**Sensitivity assessment.** Typical surface water temperatures around the UK coast vary, seasonally from 4-19°C (Huthnance, 2010). A chronic increase in temperature throughout the year of 2°C may fall within the normal temperature variation and an acute increase in water temperatures from 19 to 24°C for a month may be tolerated by the characterizing species supported by deeper burrowing and/or migration. It is likely that the characterizing 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 assessed as '**Not Sensitive'** at the benchmark level.

| | | | |
|---|---|---|---|
| **Temperature decrease (local)** | Medium<br>Q: High A: Medium C: Medium | High<br>Q: High A: Low C: Medium | Low<br>Q: High A: Low C: Medium |

Intertidal species are exposed to extremes of high and low air temperatures during periods of emersion. They must also be able to cope with sharp temperature fluctuations over a short period during the tidal cycle. In winter air temperatures are colder than the sea, conversely in summer air temperatures are much warmer than the sea. Species that occur in the intertidal are therefore generally adapted to tolerate a range of temperatures, with the width of the thermal niche positively correlated with the height of the shore that the animal usually occurs at (Davenport & Davenport, 2005). Some of the characterizing species are found in colder waters that the UK suggesting these can tolerate colder waters than typically encountered. *Paraonis fulgens* occurs in colder waters than Irish and UK seas, such as the Bay of Fundy, Canada where winter temperatures are between 0 and 4 °C (Risk & Tunnicliffe 2006). *Spiophanes bombyx* is found in the waters off Denmark (Thorson, 1946) which are likely to be colder than British and Irish waters. *Macomangulus (syn. Angulus) tenuis* is found off the Norwegian coasts to the Mediterranean and north-west coast of Africa and is likely to be resistant to temperature changes at the pressure benchmark. However, *Nephtys cirrosa* reaches its northern limit in Scotland and German Bight of the North Sea. A decrease in temperature may result in loss of the species from the biotope in these areas.

Wu *et al*. (1988) collected *Capitella capitata* individuals at seawater temperatures of -2° that harboured mature oocytes indicating reproductive activity even under low temperatures. Warren (1977) used *Capitella captitata* adults collected from Warren Point (south-west England) to test response to high and low temperatures. Worms were acclimated to 10°C for 10 days before 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 hr 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 of *Capitella capitata* were tolerant of low temperatures, 50% of the adults and 65% of the larvae surviving at -1°C.

Crisp (1964) reported that species of amphipod seemed to be unharmed by the severe winter of 1962-1963. This may be due to burial in sediments buffering temperature or seasonal migration to deeper waters to avoid freezing. In the winter migrations have also been observed for *Bathyporeia* spp. (Fish & Fish, 1978; Fish & Preece, 1970). Preece (1971) tested the temperature tolerances of *Bathyporeia pilosa* in the laboratory. Individuals acclimated to 15°C for 24 hours were placed in a freezer in wet sediment. As test temperatures were reached individuals were removed and allowed to recover for 24 hours at which point mortalities were tested. Amphipods were also allowed to bury into sediments and held at test temperatures of -1°C, -3°C and -5°C for 24 hours before being allowed to recover in fresh seawater at 15°C for a further 24 hours before mortalities were assessed. The lower lethal short-term tolerances of *Bathyporeia pilosa* were -13.6°C. *Bathyporeia pilosa* individuals could withstand temperatures as low as -1°C for 24 hours, at -3°C, 5% of *Bathyporeia pilosa* died but this rose to 82% at -5°C.

**Sensitivity assessment.** Typical surface water temperatures around the UK coast vary seasonally from 4-19°C (Huthnance, 2010). A chronic decrease in temperature throughout the year of 2°C may fall within the normal temperature variation but an acute decrease in water temperatures from 4°C to -1°C at the coldest part of the year may lead to freezing and lethal effects but may be tolerated by the characterizing species through deeper burrowing and/or migration. However, the abundance of *Nephtys cirrosa* may be reduced in northern examples of the biotope or severe winters. Therefore, biotope resistance is assessed as **Medium**. However, resilience is probably '**High**' and sensitivity is assessed as **Low**.

| | | | |
|---|---|---|---|
| **Salinity increase (local)** | Low<br>Q: High A: NR C: NR | High<br>Q: High A: Low C: Medium | Low<br>Q: Low A: Low C: Low |

This biotope is found in full salinity (30-35 ppt) habitats (18-35 ppt) (JNCC, 2015). A change at the pressure benchmark is therefore assessed as a change to hypersaline conditions (>40 ppt) from full salinity. Little evidence was found to assess responses to hypersalinity. However, monitoring at a Spanish desalination facility where discharges close to the outfall reached a salinity of 53, found that amphipods were sensitive to the increased salinity and that species free-living in the sediment were most sensitive (De-la-Ossa-Carretero *et al*., 2016). Roberts *et al.* (2010) concluded that the reported effects of brine discharges were limited and difficult to compare but identified some trends. Hypersaline effluents tend to disperse quickly in well flushed environments like the habitat this biotope occurs in. However, sediment communities were affected in the immediate vicinity of brine discharges. For example, one of the studies reviewed found that the sediment became dominated by nematodes, with polychaetes, crustaceans and molluscs only fond at a distance from the outfall. Another study noted that the diversity of polychaete communities decreased adjacent to the outfall and that the Ampharetidae were the most sensitive while the Paranoidae were the least sensitive.

**Sensitivity assessment.** No direct evidence was found to assess biotope sensitivity. However, if the biotope was exposed to hypersaline effluents then a proportion of the community may be lost and species diversity and abundances are likely to decrease. Therefore, a biotope resistance of

'**Low**' is suggested. Resilience is probably '**High**' (following the restoration of the usual salinity regime) so that sensitivity is assessed as '**Low**'.

| | | | |
|---|---|---|---|
| **Salinity decrease (local)** | High<br>Q: High A: Medium C: Medium | High<br>Q: High A: Low C: Medium | Not sensitive<br>Q: High A: Low C: Medium |

*Nephtys cirrosa* were most abundant in salinities >30 psu in the German Bight (south-east North Sea) (Meißner *et al*., 2008), while *Spiophanes bombyx* is a euryhaline species (Bailey-Brook, 1976; Maurer & Lethem, 1980), inhabiting fully saline and estuarine habitats. *Spio martinensis* was a characterizing species in estuarine channels and inlets in Germany, suggesting resistance to lower salinities (Nehmer *et al*., 2003)

**Sensitivity assessment.** *Nephtys cirrosa* is possibly the more sensitive to the lower range of the ‘variable’ or ‘reduced’ salinity category, although as a mobile species it will be resistant through being able to move lower down the shore or away from freshwater run-off. *Nephtys cirrosa* displays resistance to the pressure as the species occur at the mouths of estuaries and estuarine lagoons where salinity may fall below 20 psu (Barnes, 1994), so are unlikely to be significantly impacted by a reduction in salinity. In addition, as this biotope LS.LSa.FiSa.Po.Ncir is recorded from both full and variable (18-30) salinity regimes it would probably tolerate 'reduced' salinity conditions for a year. Hence, resistance and resilience are both ‘**High’** and sensitivity is, therefore, assessed as **‘Not sensitive’.**

| | | | |
|---|---|---|---|
| **Water flow (tidal current) changes (local)** | High<br>Q: Low A: NR C: NR | High<br>Q: High A: High C: High | Not sensitive<br>Q: Low A: Low C: Low |

The biotope and sub biotopes occur on moderately exposed or sheltered beaches. Tidal flow velocities from very weak to moderately strong occur in the biotope LS.LSa.FiSa.Po suggesting changes in flow velocity at the benchmark level are unlikely to impact the biotope as characterizing species are likely to be resistant to a very weak to moderately strong flow velocities. Changes in flow velocity are more likely to lead to changes between sub-biotopes. For instance, 21% of records of LS.LSa.FiSa.Po.Ncir occur in moderately strong flow velocities compared to 8% of records of LS.LSa.FiSa.Po.Pful (*Paraonis fulgens*, *Capitella capitata*, *Pygospio elegans*) suggesting a change to the LS.LSa.FiSa.Po.Ncir sub-biotope is more likely under an increase in flow velocity.

**Sensitivity assessment**. The LS.LSa.FiSa.Po biotope (and sub-biotopes) occur in water flow velocities from very weak to moderately strong and in a moderately strong to sheltered wave climate The fine sand in low in mud and organic matter, which suggests it is well sorted and oxygenated by water movement. Species characterizing the biotope are likely to be resistant to changes at the pressure benchmark level (a 0.1-0.2 m/s change in flow) although changes between sub-biotopes may occur if silt or mud content of the substratum changes. Resistance and resilience are assessed as ‘**High’** and sensitivity is assessed as ‘**Not Sensitive’.**

| | | | |
|---|---|---|---|
| **Emergence regime changes** | Medium<br>Q: Low A: NR C: NR | High<br>Q: High A: Low C: Medium | Low<br>Q: Low A: Low C: Low |

*Spiophanes bombyx* is found in the intertidal so may be tolerant to some emersion of the substratum. *Nephtys cirrosa* dominated the low intertidal species community sampled at DePanne, Belgium. There were good affinities with the subtidal *Nephtys cirrosa* species assemblage further offshore, suggesting a decrease in emergence will have a limited impact on the species and the associated biotopes (Degraer *et al*., 1999). A increase in emergence may allow the biotope to extend up the shore if suitable habitat exists. However, a decrease in emergence may result in drying of sediment between tides at the upper limit of the biotope and result in an extension of the BarSa biotope (Connor *et al*., 2004).

**Sensitivity assessment.** A decrease in emergence, and hence, drying of the sediment at the upper limit of the biotope may cause the upper limit of this biotope to move down the shore, reducing its extent. Although the individual polychaete species would probably migrate down the shore, the upper extent of this biotope may be lost. Therefore, resistance is assessed as '**Medium**'. Resilience is probably '**High'** so sensitivity is assessed as '**Low'**.

| | | | |
|---|---|---|---|
| **Wave exposure changes (local)** | High<br>Q: Low A: NR C: NR | High<br>Q: High A: High C: High | Not sensitive<br>Q: Low A: Low C: Low |

The biotope and its sub-biotopes occur on moderately exposed or sheltered beaches. Increases and decreases in wave exposure may lead to increased erosion or deposition. Species in moderately exposed examples of the biotope are likely to be resistant to the dynamic nature of substratum.

Increased wave exposure is likely to resuspend finer material and may lead to reduced abundance of species, such as *Capitella capitata* that are absent when there is no mud content in the substratum. The circulatory motion of wave action may also wash infauna such as *Nepthys cirrosa* and *Capitella capitata* from the sediment in most exposed locations. Although increased wave action is likely to wash some individuals from the sediment, recovery would be rapid.

**Sensitivity assessment.** An increase in significant wave height at the benchmark level is unlikely to create a noticeable impact, where initial conditions are sheltered. Where conditions are moderately exposed, infauna such as *Nepthys cirrosa* are likely to be washed from the sediment by the largest waves. However, the biotope was reported to be naturally disturbed by winter storms (Connor *et al*., 2004) and a 3-5% change in significant wave height (the benchmark) is unlikely to affect the biotope adversely, Therefore, resistance and resilience are assessed as '**High**', and the biotope is assessed as, '**Not Sensitive'** at the benchmark level.

## Chemical Pressures

| | Resistance | Resilience | Sensitivity |
|---|---|---|---|
| **Transition elements & organo-metal contamination** | Not Assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR |

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

Levels of contaminants that exceed the pressure benchmark may cause impacts. Bryan & Gibbs (1983) reported lower sediment-metal concentrations in sandy areas than mud near the mouth of Restronguet Creek, a branch of the Fal Estuary system which is heavily contaminated with metals. Although heavy metals may not accumulate in the substratum to the extent that they would in muddy substrata, characterizing infauna are likely to be susceptible. Bryan & Gibbs (1983) suggested that in populations of polychaetes exposed to heavy metal contamination for a long period, metal resistance could be acquired. For example *Nephtys hombergii* from Restronguet Creek seemed able to regulate copper. The head end of the worm became blackened and x-ray microanalysis by Bryan & Gibbs (1983) indicated that this was caused by the deposition of copper sulphide in the body wall. In the same study, Bryan & Gibbs (1983) presented evidence that *Nephtys hombergii* from Restronguet Creek possessed increased tolerance to copper contamination. Specimens from the Tamar Estuary had a 96 h LC50 of 250 µg/l, whilst those from Restronguet Creek had a 96 h LC50 of 700 µg/l (35 psu; 13°C).

| | | | |
|---|---|---|---|
| **Hydrocarbon & PAH contamination** | Not Assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR |

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

Contamination at levels greater than the pressure benchmark may adversely influence the biotope. 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. Oil spills resulting from tanker accidents have caused deterioration of sandy communities in the intertidal and shallow sublittoral. Subtidal sediments, however, may be at less risk from oil spills unless oil dispersants are used, or if wave action causes dispersion of oil into the water column and sediment mobility drives oil into the sediment (Elliott *et al.*, 1998). Microbial degradation of the oil within the sediment would increase the biological oxygen demand and oxygen within the sediment may become significantly reduced. Species within the biotope have been reported to be intolerant of oil pollution, e.g. amphipods (Suchanek, 1993). After the *Amoco Cadiz* oil spill, there was a reduction in both the number of amphipod species and the number of individuals (Cabioch *et al.*, 1978). Initially, significant mortality would be expected, attributable to toxicity. Amphipod populations have been reported not return to pre-spill abundances for five or more years, which is most likely related to the persistence of oil within sediments (Southward, 1982). *Nephtys* species were amongst the fauna that was eradicated from sediments following the 1969 West Falmouth spill of Grade 2 diesel fuel documented by Sanders (1978). Multivariate analysis showed that the *Prestige* oil spill scarcely affected the macroinfaunal community structure during the study period (2003-2009) and its effect was limited just to the first campaign (2003), six months after the *Prestige* accident (Junoy *et al.*, 2013). Opportunistic species such as *Capitella capitata* have been shown to increase in abundance close to sources of contamination. 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 capitata* increased dramatically alongside large increases in *Polydora ligni* and *Prionospio* sp. (Sanders *et al*. 1972, cited in Gray 1979).

| | | | |
|---|---|---|---|
| **Synthetic compound contamination** | Not Assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR |

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

Boon *et al.* (1985) reported that *Nephtys* species in the North Sea accumulated organochlorines but, based on total sediment analyses, organochlorine concentrations in *Nephtys* species were not correlated with the concentrations in the (type of) sediment which they inhabited.

| | | | |
|---|---|---|---|
| **Radionuclide contamination** | No evidence (NEv)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

**No evidence** was found to assess this pressure.

| | | | |
|---|---|---|---|
| **Introduction of other substances** | Not Assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR |

This pressure is **Not assessed**.

| | | | |
|---|---|---|---|
| **De-oxygenation** | Medium<br>Q: High A: High C: Medium | High<br>Q: High A: Medium C: Medium | Low<br>Q: High A: Medium C: Medium |

No information concerning the reduced oxygen tolerance of *Nephtys cirrosa* was found but evidence (Alheit, 1978; Arndt & Schiedek, 1997; Fallesen & Jørgensen, 1991) indicated a similar species, *Nephtys hombergii*, to be very tolerant of episodic oxygen deficiency and at the benchmark duration of one week. *Nephtys cirrosa* and *Spio spp.* were classified by Borja *et al.* (2000) as being indifferent to enrichment, suggesting some resilience to de-oxygenation. Dense *Capitella capitata* populations are frequently located in areas with greatly elevated organic content, even though eutrophic sediments are often anoxic and highly sulfidic (Tenore 1977; Warren 1977; Tenore & Chesney 1985; Bridges et al. 1994). The polychaetes *Capitella capitata*, *Pygospio elegans* and *Scoloplos armiger* have all been reported to recolonize habitats following periods of anoxia and hypoxia.

*Scoloplos armiger* has been described as being present in low oxygen areas and as a dominant species in the recolonization of previously anoxic areas (Pearson & Rosenberg, 1978). Intertidal *Scoloplos armiger* is, in contrast to subtidal specimens, subject to hypoxia when tidal flats are without oxygenated seawater during low tide (Kruse *et al*., 2004). Tolerance against hypoxia and sulfide is low (Kruse *et al*., 2004), and worms may ascend into the oxic layer during low tide (Schoettler & Grieshaber, 1988). *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* haemoglobin for oxygen. Diaz & Rosenberg (1995) listed *Capitella capitata* as resistant of moderate hypoxia.

*Arenicola marina* is subject to reduced oxygen concentrations regularly at low tide and is capable of anaerobic respiration. The transition from aerobic to anaerobic metabolism takes several hours and is complete within 6-8 hrs, although this is likely to be the longest period of exposure at low tide. Fully aerobic metabolism is restored within 60 min once oxygen returns (Zeber & Schiedek, 1996). This species was able to survive anoxia for 90 hrs in the presence of 10 mmol/l sulphide in laboratory tests (Zeber & Schiedek, 1996). Hydrogen sulphide ($H_2S$) produced by chemoautotrophs within the surrounding anoxic sediment and may, therefore, be present in *Arenicola marina* burrows. Although the population density of *Arenicola marina* decreases with increasing $H_2S$, *Arenicola marina* can detoxify $H_2S$ in the presence of oxygen and maintain a low internal concentration of $H_2S$. At high concentrations of $H_2S$ in the lab (0.5, 0.76 and 1.26 mmol/l) the lugworm resorts to anaerobic metabolism (Zeber & Schiedek, 1996). At 16°C *Arenicola marina* survived 72 hrs of anoxia but only 36 hrs at 20°C. Tolerance of anoxia was also seasonal, and in winter anoxia tolerance was reduced at temperatures above 7°C. Juveniles have a lower tolerance of anoxia but are capable of anaerobic metabolism (Zebe & Schiedek, 1996). However, *Arenicola marina* was reported to be unaffected by short periods of anoxia and to survive for 9 days without oxygen (Borden, 1931 and Hecht, 1932 cited in Dales, 1958; Hayward, 1994). Diaz & Rosenberg (1995) listed *Arenicola marina* as a species resistant of severe hypoxia.

**Sensitivity assessment.** The species characterizing the biotope are mobile and able to migrate vertically to escape unsuitable conditions. The biotope is characterized by well-sorted and oxygenated sands, where the anoxic layer occurs below 10 cm and is patchy where it occurs (Connor *et al.*, 2004). This suggests that the resident species may not be adapted to low oxygen levels but also that deoxygenation of the water column may be short-lived, especially as the biotope is exposed at low tide. Therefore, while some members of the community are known to be tolerant, other species may be lost or reduced in abundance and resistance is assessed as of '**Medium'**. Resilience is probably '**High'** and sensitivity is assessed as **Low.** However, hypoxia or anoxia caused by the bacterial decomposition of organic matter may be detrimental.

| | | | |
|---|---|---|---|
| **Nutrient enrichment** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not sensitive<br>Q: NR A: NR C: NR |

This pressure relates to increased levels of nitrogen, phosphorus and silicon in the marine environment compared to background concentrations. The benchmark is set at compliance with WFD criteria for good status, based on nitrogen concentration (UKTAG, 2014). *In-situ* primary production is limited to microphytobenthos within and on sediments and the high levels of sediment mobility may limit the level of primary production as abrasion would be likely to damage diatoms (Delgado *et al.*, 1991).

**Sensitivity assessment.** The nutrient level is not a key factor structuring the biotope at the pressure benchmark. In general, however, primary production is low, this biotope is species-poor, and characterizing species may be present at low abundances (depending on wave exposure).

| | | | |
|---|---|---|---|
| **Organic enrichment** | High<br>Q: High A: High C: High | High<br>Q: High A: High C: High | Not sensitive<br>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. *Nephtys cirrosa* and *Spio spp.* were classified by Borja *et al.* (2000) as being indifferent to enrichment. 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).

**Sensitivity assessment**. At the benchmark levels, resistance was assessed as '**High'** as the main characterizing species are tolerant of organic enrichment and an input at the pressure benchmark is unlikely to lead to gross pollution effects. A resilience of **'High'** is assigned (by default) and the biotope is assessed as **'Not sensitive'.**

## Physical Pressures

| | Resistance | Resilience | Sensitivity |
|---|---|---|---|
| **Physical loss (to land or freshwater habitat)** | None<br>Q: High A: High C: High | Very Low<br>Q: High A: High C: High | High<br>Q: High A: High C: High |

All marine and estuarine habitats and benthic species within them 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.

| | Resistance | Resilience | Sensitivity |
|---|---|---|---|
| **Physical change (to another seabed type)** | None<br>Q: High A: High C: High | Very Low<br>Q: High A: High C: High | High<br>Q: High A: High C: High |

A change to natural or artificial hard substratum would remove this sedimentary biotope and the species. If pockets of fine sediment accumulate in pockets within the substrata then these areas may be re-colonised by species associated with this biotope but these pockets of sediment would not be equivalent to the biotope. Recovery will depend on the reinstatement of suitable habitat.

**Sensitivity assessment.** Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as **'None'**. Resilience is assessed as **'Very low'** as the pressure benchmark refers to a permanent change. Biotope sensitivity is, therefore **'High'.**

| | Resistance | Resilience | Sensitivity |
|---|---|---|---|
| **Physical change (to another sediment type)** | None<br>Q: Low A: NR C: NR | High<br>Q: High A: High C: High | Medium<br>Q: Low A: Low C: Low |

The benchmark for this pressure refers to a change in one Folk class. The pressure benchmark originally developed by Tillin *et al.* (2010) used the modified Folk triangle developed by Long (2006) which simplified sediment types into four categories: mud and sandy mud, sand and muddy sand, mixed sediments and coarse sediments. The change referred to is, therefore, a change in sediment classification rather than a change in the finer-scale original Folk categories (Folk, 1954). The change in one Folk class is considered to relate to a change in classification to adjacent categories in the modified Folk triangle (Long, 2006). As this biotope occurs within fine sands and muddy sands (JNCC, 2015), the change at the pressure benchmark refers to a potential change to coarse sediments, mixed sediments, sand and muddy sands or mud.

The particle size of sediments and correlated physical and chemical factors (such as drainage, organic matter content and hydrodynamic regime), is a key determinant of the structure of benthic invertebrate assemblages (Van Hoey *et al.*, 2004; Yates *et al.*, 1993). Infauna can be affected by changes in sediment as many are adapted to burrow through certain grades of sediment (Trueman & Ansell, 1969), decreased fine fractions will reduce habitat suitability for species that maintain permanent burrows. Changes in sedimentary features may also influence the proportions of suspension and deposit-feeding animals (Sanders, 1968), with deposit feeders favoured by increases in the proportion of silts and clays. In North America, cultivation of clam species including the Manila clam, *Tapes philippinarum* usually involves some form of habitat modification in the form of adding gravel or gravel and crushed shell over mud and sand beaches, to create a more productive clam habitat (referred to as ‘gravelled clam plots’). Such habitat modifications lead to alterations in the local environment and consequently faunal composition. Simenstad and Fresh (1995, cited in Kaiser & Beadman, 2002) reported that the application of gravel to intertidal sediments resulted in a shift from a polychaete to a bivalve and nemertean dominated community, but emphasised that changes are likely to be site-specific.

Responses are also likely to be species-specific and depend on habitat preferences. *Pygospio elegans* prefers fine sediments such as sand and mud; increased sediment coarseness is likely to render sediments unsuitable for this species. Empirical evidence supporting this view is provided by Bolam (1999) where experimental manipulation of sediments by implanting macroalgae mats led to increased fine sediment fractions (with associated increased organic and water content) which led to the establishment of *Pygospio elegans*. *Capitella capitata* was found in fine and medium grain size sediments and was almost completely absent in sediments without mud in the Belgium part of the North Sea (Degraer *et al*., 2006). This suggests that a change to muddy sand is likely to result in increased abundance but a change to coarser or gravelly sand is likely to lead to reduced abundance.

*Nepthys cirrosa* occurs in fine to coarser sands, with the greatest abundance in the Belgium part of the North Sea recorded in medium grain sizes (Degraer *et al*., 2006). A change to gravelly sand is unlikely to impact the species, however, a change to muddy sand may limit the species abundance as the species displays a slight preference for low mud content levels < 10% (Degraer *et al*., 2006).

Changes to finer sand are likely to result in increased abundance of *Angulus tenuis* and changes to the sub-biotope LS.LSa.FiSa.Po.Aten, particularly in the low intertidal where the substratum remains damp at low tide.

**Sensitivity assessment.** Individual members of the community are found in a range of different sediment types, at different abundances. The character of the habitat is largely determined by the sediment type, changes to this would lead to habitat re-classification. The addition of coarse sand particles or fine particles in sufficient quantities would lead to the development of a different habitat type. Changes in sediment characteristics can lead to changes in community structure. An increase in coarse sediments would lead to the development of a community typical of mixed sediments, clean sands and/or gravels depending on the degree of change. In general, an increase to very coarse sediments may favour some amphipod species rather than burrowing polychaetes and sessile tube-dwelling polychaetes. This change would alter the character of the biotope present leading to re-classification, biotope resistance is assessed as **'None'** and, as the change is permanent, resilience is assessed as **'Very Low'.** Biotope sensitivity is, therefore '**High'.**

| | | | |
|---|---|---|---|
| **Habitat structure changes - removal of substratum (extraction)** | None<br>Q: Low A: NR C: NR | High<br>Q: High A: Low C: Medium | Medium<br>Q: Low A: Low C: Low |

The process of extraction is considered to remove all biological components of the biotope group. If extraction occurred across the entire biotope, loss of the biotope would occur. Recovery would require substratum to return to sand and with a finer silt fraction.

**Sensitivity assessment.** The resistance of the biotope to extraction is probably **‘None’**. Resilience differs between species with slower recovery likely to be displayed by *Nephtys cirrosa*. Resilience is assessed as '**High**' (although if the substratum changed recovery could be prolonged) and biotope sensitivity is assessed as '**Medium**'.

| | | | |
|---|---|---|---|
| **Abrasion/disturbance of the surface of the substratum or seabed** | Medium<br>Q: High A: High C: Medium | High<br>Q: High A: Medium C: High | Low<br>Q: High A: Medium C: Medium |

This biotope is present in disturbed and well sorted sands, the associated species are generally present in low abundances and adapted to frequent disturbance. Therefore, resistance to surface abrasion is probably 'High'. The polychaete *Nephtys cirrosa* is adapted to life in unstable sediments and survives through rapid burrowing (McDermott, 1983, cited from Elliott *et al*., 1998). This characteristic is likely to protect this species from surface abrasion.

*Paraonis fulgens* were found to reduce in abundance in experimental areas exposed to trampling (Reyes-Martínez *et al*., 2015), suggesting a lower resistance of this species to abrasion or surface disturbance. Chandrasekara and Frid (1996) found that some species including *Capitella capitata* and *Scoloplos armiger* reduced in abundance in intertidal muds, along a pathway heavily trampled for five summer months (ca 50 individuals a day 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. Juveniles and adults of *Scoloplos armiger* stay permanently below the sediment surface and freely move without establishing burrows. While juveniles are only found a few millimetres below the sediment surface, adults may retreat to 10 cm depth or more (Reise, 1979; Kruse *et al*., 2004) and are likely to be more protected. The egg cocoons are laid on the surface and hatching time is 2-3 weeks during which these are vulnerable to surface abrasion.

Several studies have assessed the effects of trampling on other intertidal amphipods and these assessments are used as a proxy. Comparisons between shores with low and high levels of trampling found that the amphipod *Bathyporeia pelagica* is sensitive to human trampling, other species including *Pontocrates arenarius* and the isopod *Eurydice affinis* also decreased in response to trampling but *Bathyporeia pelagica* appeared to be the most sensitive (Reyes-Martínez *et al*., 2015). Changes in abundance of talitrid amphipods on urban beaches subject to high levels of recreational use was also observed by Bessa *et al*. (2014), this study compared abundances between samples taken ten years apart and thus the trends observed were not directly attributable to trampling vs beach cleaning or other pressures although they illustrate a general trend in density patterns as recreational use increases. Ugolini *et al*. (2008) carried out a controlled trampling experiment on *Talitrus saltator*. Plastic cylinders of 110 cm diameter (area 0.95 $m^2$) were placed in the sand and all individuals trapped and counted, and 400 steps were made in a cylinder in 15 minutes after the amphipods had reburied. The trampling rate was based on the observed number of beach users and therefore represents a realistic level of exposure. Live individuals were counted at the end of the experiment and 24 hours after. Trampling significantly reduced abundance of the amphipods and after 24 hours the percentage of surviving amphipods dropped to almost zero, while survival rates of control (untrampled) amphipods were unaffected. Abrasion and compaction can, therefore, kill buried amphipods within sediments.

**Sensitivity assessment.** The characterizing species *Paraonis fulgens Capitella capitata* and *Scoloplos armiger* are reduced following abrasion impacts (trampling). However, species in the biotope are adapted to disturbance. Hence, resistance is assessed as **'Medium'.** The resilience of *Capitella* *capitata* and other opportunistic species is very high but *Nephtys cirrosa* is likely to show longer recovery times but overall resilience is assessed as '**High**', although the potential for longer recovery of *Nephtys cirrosa* should be accounted for. Sensitivity is, therefore, assessed as '**Low**'.

| | | | |
|---|---|---|---|
| **Penetration or disturbance of the substratum subsurface** | Low<br>Q: High A: High C: High | High<br>Q: High A: High C: Medium | Low<br>Q: High A: High C: Medium |

*Nephtys cirrosa and Spiophanes bombyx* were characterizing species of infauna assemblages in both control and impact sample sites on the Thornton Bank Belgium (North Sea), before and after dredging occurred as part of the construction process for an offshore wind farm (Coates *et al.* 2015). Recovery of assemblages occurred within one to two years at individual dredged sites. The species potentially display resilience to dredging activities as past aggregate dredging had also occurred before wind farm construction.

*Nephtys cirrosa* was found to be sensitive to experimental trawling disturbance over 18 months (Tuck *et al.*, 1998). *Nephtys cirrosa* is also likely to be vulnerable to dredging but can probably accommodate limited sediment deposition from the dredging process (MES, 2010). Collie *et al.* (2000) found that the abundance of *Nephtys hombergii* was negatively affected by fishing activities. Mean response of infauna and epifauna communities to fishing activities was also much more negative in mud and sand communities (such as this biotope) than other habitats. *Nephtys hombergii* abundance also significantly decreased in areas of the Solent, UK, where bait digging had occurred (Watson *et al.* 2007). Similarly, *Nephtys hombergii* abundance was reduced by 50% in areas where tractor towed cockle harvesting was undertaken on experimental plots in Burry inlet, south Wales, and had not recovered after 86 days (Ferns *et al.*, 2000).

*Capitella capitata*, are 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* were categorised as AMBI fisheries Group IV- as '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).

*Spio filicornis* is a soft-bodied organism that exposes its palps at the surface while feeding. It lives infaunally in sandy sediment and any physical disturbance that penetrates the sediment, for example, dredging or dragging an anchor, would lead to physical damage of *Spio filicornis*. However, adult worms can burrow up to 10 cm and may escape the disturbance. Juveniles can only burrow up to 2 cm into the sediment and are likely to be affected. However, individuals are likely to pass through a passing scallop dredge due to their small size. Bergman & Hup (1992) reported that the total density of spionids actually increased with increased fishing disturbance presumably due to their ability to colonize newly exposed substratum. Hall *et al.* (1990) investigated the impact of hydraulic dredging for razor clams. They reported that any effects only persisted for a short time, with the community restored after approximately 40 days in stormy conditions. The population density of *Spio filicornis* was slightly reduced in the dredged site relative to the control site but its abundance had increased over that of the control site after 40 days. However, the control site showed a similar level of variation in abundance.

Bergman & Santbrink (2000) found that direct mortality of gammarid amphipods, following a single passage of a beam trawl (in silty sediments where penetration is greater) was 28%. Similar results were reported from experiments s in shallow, wave disturbed areas, using a toothed, clam dredge. *Bathyporeia* spp. experienced a reduction of 25% abundance in samples immediately after intense clam dredging, abundance recovered after one day (Constantino *et al*., 2009). Experimental hydraulic dredging for razor clams resulted in no statistically significant differences in *Bathyporeia elegans* abundances between treatments after one or 40 days (Hall *et al*., 1990), suggesting that recovery from effects was very rapid. Ferns *et al*. (2000) examined the effects of a tractor-towed cockle harvester on benthic invertebrates and predators in intertidal plots of muddy and clean sand. Harvesting resulted in the loss of a significant proportion of the most common invertebrates from both areas. In the muddy sand, the population of *Bathyporeia pilosa* remained significantly depleted for more than 50 days, whilst the population in clean sand recovered more quickly. These results agree with other experimental studies that clean sands tend to recover more quickly than other habitat types with higher proportions of fine sediment (Dernie *et al*., 2003).

Bergman & Hup (1992) found that worm species (including *Scoloplos armiger*) showed no change in total density after trawling a subtidal habitat. Conversely, a later study by Bergman & Santbrink (2000) found that the direct mortality of *Scoloplos armiger* from a single passage of a beam trawl in subtidal silty grounds was 18% of the population. Rostron (1995) undertook experimental dredging of sandflats with a mechanical cockle dredger, including a site comprised of stable, poorly sorted fine sands with small pools and *Arenicola marina* casts with some algal growths. At this site, post-dredging *Scoloplos armiger* had disappeared from some dredged plots. Ferns *et al*. (2000) used a tractor-towed cockle harvester, to extract cockles from intertidal plots of muddy sand and clean sand, to investigate the effects on non-target organisms; 31% of the population of *Scoloplos armiger* (initial density of 120 per m2) were removed. Populations of *Scoloplos armiger* remained significantly depleted in the area of muddy sand for more than 50 days after harvesting. Ball *et al*. (2000) found that species including *Scoloplos armiger* showed a significant decrease in abundance of between 56-27% after 16 months of otter trawling at a previously unfished Scottish sea loch. Chandrasekara and Frid (1996, cited in Tyler-Walters & Arnold, 2008) found that along a pathway heavily used for five summer months (ca. 50 individuals/day), *Scoloplos armiger* reduced in abundance. Recovery took place within 5-6 months. These studies suggest that *Scoloplos armiger* is likely to be impacted by sediment disturbance and that recovery to previous densities may require more than two years.

A number of studies have found that the abundance of the polychaete *Pygospio elegans* is reduced by simulated cockle dredging (Hall & Harding, 1998; Moore, 1990; Ferns *et al*., 2000; Rostron, 1995). Ferns *et al*. (2000) found that tractor towed cockle harvesting removed 83% of *Pygospio elegans* (initial density 1850/ m2). In muddy sand habitats, *Pygospio elegans* had not recovered to the original abundance after 174 days (Ferns *et al*.,2000). Rostron (1995) also found that *Pygospio elegans* had not recovered to pre-dredging numbers after six months. Conversely, Hall & Harding, (1998) found that the abundance of *Pygospio elegans* increased significantly over 56 days following suction dredging. *Pygospio elegans* inhabits a fragile tube that projects above the sediment surface and is probably more vulnerable to physical disturbance and abrasion than other, more deeply buried, infaunal species.

**Sensitivity assessment.** The evidence suggests that many of the characteristic species could suffer a significant loss in abundance due to penetrative gear. Therefore, the **r**esistance of the biotope is assessed as '**Low**', as a proportion of the population of characterizing species may be removed. However, species in the biotope are adapted to disturbance and recover quickly so that resilience is assessed as '**High** ' and sensitivity as '**Low**'.

| | | | |
|---|---|---|---|
| **Changes in suspended solids (water clarity)** | High<br>Q: Low A: NR C: NR | High<br>Q: High A: High C: High | Not sensitive<br>Q: Low A: Low C: Low |

The characterizing species live within the sand and are unlikely to be directly affected by an increased concentration of suspended matter in the water column. Within the mobile sands habitat storm events or spring tides may re-suspend or transport large amounts of material and therefore species are considered to be adapted to varying levels of suspended solids. *Bathyporeia* spp. feed on diatoms within the sand grains (Nicolaisen & Kanneworff, 1969), an increase in suspended solids that reduced light penetration could alter food supply. However, diatoms are able to photosynthesize while the tide is out and therefore a reduction in light during tidal inundation may not affect this food source, depending on the timing of the tidal cycle. *Bathyporeia* spp. may be regular swimmers within the surf plankton, where the concentration of suspended particles would be expected to be higher (Fincham, 1970a).

However, the biotope is characterized by a low amount of organic matter and an increase in suspended solids may cause a change in this factor if this is coupled with changes in hydrodynamics that reduce particle re-suspension. Increased suspended solids are unlikely to have a direct impact on infauna but increased organic matter may result in an increase in the abundance of opportunistic species such as *Capitella capitella*. Biotope resistance is assessed as '**High**' and resilience as '**High**' (by default) so that the biotope is assessed to be '**Not sensitive**'.

| | | | |
|---|---|---|---|
| **Smothering and siltation rate changes (light)** | High<br>Q: Low A: NR C: NR | High<br>Q: High A: High C: High | Not sensitive<br>Q: Low A: Low C: Low |

The characterizing species *Pygospio elegans* is limited by high sedimentation rates (Nugues *et al.*, 1996) and the species does not appear to be well adapted to oyster culture areas where there are high rates of accumulation of faeces and pseudo faeces (Sornin *et al.*, 1983; Deslous-Paoli *et al.*, 1992; Mitchell, 2006 and Bouchet & Sauriau, 2008). *Pygospio elegans* is known to decline in areas following the re-deposition of very fine particulate matter (Rhoads & Young, 1971; Brenchley, 1981). Experimental relaying of mussels on intertidal fine sands led to the absence of *Pygospio elegans* compared to adjacent control plots. The increase in fine sediment fraction from increased sediment deposition and biodeposition alongside possible organic enrichment and decline in sediment oxygen levels was thought to account for this (Ragnarsson & Rafaelli, 1999).

Mobile and/or burrowing species (including molluscs and polychaetes such as *Nephtys* spp., and *Scoloplos armiger*) are generally considered to be able to reposition following periodic siltation events or low levels of chronic siltation. *Nephthys cirrosa* occurs in fine to coarser sands, with the greatest abundance in the Belgium part of the North Sea recorded in medium grain sizes (Degraer *et al.*, 2006). A light deposition of fine sediment may lead to small but insignificant changes in abundance as it will reduce the available preferred habitat with medium grain size. As the tidal flow is strong in this biotope, a light deposition of finer sediment is likely to be resuspended. Resistance is likely to be high for *Nephthys cirrosa* at the benchmark level as this species is likely to be able to reposition within sediments.

*Capitella capitata* was categorised as AMBI sedimentation Group IV as 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).

**Sensitivity assessment.** None of the characterizing species is considered likely to be significantly impacted by deposition of up to 5 cm of fine material. Resistance is assessed as '**High', r**esilience as '**High'** and sensitivity is assessed as '**Not sensitive'**.

| | | | |
|---|---|---|---|
| **Smothering and siltation rate changes (heavy)** | Low<br>Q: Medium A: Medium C: Medium | High<br>Q: Medium A: Medium C: Medium | Low<br>Q: Medium A: Medium C: Medium |

Studies have found that beach 'replenishment' or 'nourishment' that involves the addition of sediments on beaches can have a number of impacts on the infauna (Peterson *et al.*, 2000; Peterson *et al.*, 2006). Impacts are more severe when the sediment added differs significantly in grain size or organic content (Nelson *et al.*, 1989; Peterson *et al.*, 2000). For example, Maurer *et al.* (1981) found that the amphipod *Parahaustorius longimerus*, which occurs intertidally in clean, well-sorted sands and is an active, effective burrower, was able to regain the surface after being buried by sand far more easily than when buried under silt/clay mixtures.

*Nephtys cirrosa* is a large infaunal species, with an adult size between 6 cm and 10 cm and capable of moving through the sediment, suggesting some resilience to smothering. *Nephtys cirrosa* is an active worm which demonstrates the characteristic swimming motion (a rapid lateral wriggling, starting from the rear and increasing in amplitude towards the head) of the Nephtyidae. Deposition of up to 30 cm of fine material is likely to bury some individuals beyond the typical 5 to 15 cm depth of tunnels. It is likely *Nephtys cirrosa* close to the surface may be capable of relocating in the sediment although feeding and reproduction activities are likely to be interrupted.

*Nephthys cirrosa* occurs in fine to coarser sands, with the greatest abundance in the Belgium part of the North Sea recorded in medium grain sizes (Degraer *et al.*, 2006). Presence of fine material may lead to small but insignificant changes in abundance as it will reduce the available preferred habitat with medium grain size. As the tidal flow is strong in this biotope, a light deposition of finer sediment is likely to be resuspended. Resistance is likely to be high to the presence of finer material for *Nephthys cirrosa* but initial smothering is likely to cause some mortality and interrupt feeding and reproduction activity at the benchmark level.

*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).

Bijkerk (1988, results cited from Essink, 1999) found that the maximal overburden through which *Bathyporeia* could migrate was approximately 20 cm in mud and 40 cm in sand. No further information was available on the rates of survivorship or the time taken to reach the surface and no information was available for other characterizing species.

**Sensitivity assessment.** Overall smothering by 30 cm of fine sediments may result in mortality of characterizing species. Although some polychaetes may be able to reposition after sedimentation at the pressure benchmark this will depend on the characteristics of the overburden and sedentary species such as *Pygospio elegans* are likely to suffer high levels of mortality**.** The introduction of fine sediment may also alter the sediment typical of the biotope causing a temporary shift in the abundance of species. However, the opportunistic species occurring in the biotope are likely to recover rapidly following sediment recovery. Biotope resistance is, therefore, assessed as '**Low'**, resilience is assessed as **'High',** following habitat recovery to fine sands and biotope sensitivity is assessed as '**Low**'.

| | | | |
|---|---|---|---|
| **Litter** | Not Assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR |

Plastic debris breaks up to form microplastics. Microplastics have been shown to occur in marine sediments and to be ingested by detritivores such as the amphipod *Orchestia gammarellus*, deposit feeders such as *Arenicola marina* and holothurians, as well as by suspension feeders, e.g. *Mytilus edulis* (Wright *et al.*, 2013b; Browne *et al.*, 2015).

Wright *et al.* (2013) showed that the presence of microplastics (5% UPVC) in a lab study significantly reduced feeding activity when compared to concentrations of 1% UPVC and controls. As a result, *Arenicola marina* showed significantly decreased energy reserves (by 50%), took longer to digest food, and as a result decreased bioturbation levels, which would be likely to impact the colonization of sediment by other species, reducing diversity in the biotopes the species occurs within. Wright *et al.* (2013) suggested that in the intertidal regions of the Wadden Sea, where *Arenicola marina* is an important ecosystem engineer, *Arenicola marina* could ingest 33 $m^3$ of microplastics a year.

In a similar experiment, Browne *et al.* (2013) exposed *Arenicola marina* to sediments with 5% PVC particles or sand presorbed with pollutants nonylphenol and phenanthrene for 10 days. PVC is dense and sinks to the sediment. The experiment used Both microplastics and sand transferred the pollutants into the tissues of the lugworm by absorption through the gut. The worms accumulated over 250% more of these pollutants from sand than from the PVC particulates. The lugworms were also exposed to PVC particulates presorbed with plastic additive, the flame retardant PBDE-47 and antimicrobial Triclosan. The worms accumulated up to 3,500% of the concentration of theses contaminants when compared when to the experimental sediment. Clean sand and PVC with contaminants reduced feeding but PVC with Triclosan reduced feeding by over 65%. In the PVC with Triclosan treatments, 55% of the lugworms died. Browne *et al.* (2013) concluded that the contaminants tested reduced feeding, immunity, response to oxidative stress, and survival (in the case of Triclosan).

**Sensitivity assessment.** Impacts from the pressure 'litter' would depend on upon the exact form of litter or man-made object introduced. Browne *et al.* (2015) suggested that if effects in the laboratory occurred in nature, they could lead to significant changes in sedimentary communities as *Arenicola marina* is an important bioturbator and ecosystem engineer in sedimentary habitats. *Arenicola marina* does not reach high abundances in this biotope but other deposit-feeding polychaetes could potentially ingest microplastics, although no evidence is available at present. This pressure is **'Not assessed'** as no benchmark has been defined for this pressure.

| | | | |
|---|---|---|---|
| **Electromagnetic changes** | No evidence (NEv)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

Electric and magnetic fields generated by sources such as marine renewable energy device/array cables may alter behaviour of predators and affect infauna populations. Evidence is limited and occurs for electric and magnetic fields below the benchmark levels, confidence in evidence of these effects is very low.

Field measurements of electric fields at North Hoyle wind farm, North Wales recorded 110μ V/m (Gill *et al.* 2009). Modelled results of magnetic fields from typical subsea electrical cables, such as those used in the renewable energy industry produced magnetic fields of between 7.85 and 20 μT (Gill *et al.* 2009; Normandeau *et al.* 2012). Electric and magnetic fields smaller than those recorded by in-field measurements or modelled results were shown to create increased movement in thornback ray *Raja clavata* and attraction to the source in catshark *Scyliorhinus canicular* (Gill *et al.* 2009).

Flatfish including dab *Limanda limanda* and sole *Solea solea* are predators of many polychaete species. They have been shown to decrease in abundance in a wind farm array or remain at distance from wind farm towers (Vandendriessche *et al.*, 2015; Winter *et al.* 2010). However, larger plaice increased in abundance (Vandendriessche *et al.*, 2015). There have been no direct causal links identified to explain these results.

**Sensitivity assessment. No evidence** was found on the effects of electric and magnetic fields on the characterizing species. However, responses by flatfish and elasmobranchs suggest changes in predator behaviour are possible. There is no evidence currently but if electromagnetic fields affect predator-prey dynamics as further marine renewable energy devices are deployed, these are likely to be over small spatial scales and unlikely to significantly impact the biotope.

| | | | |
|---|---|---|---|
| **Underwater noise changes** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

Species within the biotope can probably detect vibrations caused by noise. However, at the benchmark level the community is unlikely to be sensitive to noise and this pressure is therefore ‘**Not relevant’.**

| | | | |
|---|---|---|---|
| **Introduction of light or shading** | High<br>Q: Low A: NR C: NR | High<br>Q: High A: High C: High | Not sensitive<br>Q: Low A: Low C: Low |

As this feature is not characterized by the presence of primary producers shading is not considered likely to alter the character of the habitat. As the characterizing biological assemblage occurs within the sediment, 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.

**Sensitivity assessment**. Changes in light are not considered to directly affect the biotope. However, some changes in behaviour or food supply for characterizing species could result. Overall, resistance is assessed as **High**. Therefore, resilience is **High** and the biotope is assessed as **Not sensitive.**

| | | | |
|---|---|---|---|
| **Barrier to species movement** | High<br>Q: Low A: NR C: NR | High<br>Q: High A: High C: High | Not sensitive<br>Q: Low A: Low C: Low |

*Nephtys cirrosa* produce pelagic larvae. Barriers that limit tidal excursion and flushing may reduce connectivity but help to retain larvae. *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 occur in 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 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'**

| | | | |
|---|---|---|---|
| **Death or injury by collision** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>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)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

Characterizing species may have some, limited, visual perception. As they live in the sediment the species will most probably not be impacted at the pressure benchmark and this pressure is considered **'Not relevant'.**

## Biological Pressures

| | Resistance | Resilience | Sensitivity |
|---|---|---|---|
| **Genetic modification & translocation of indigenous species** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

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

| | | | |
|---|---|---|---|
| **Introduction or spread of invasive non-indigenous species** | Low<br>Q: High A: High C: High | Very Low<br>Q: Low A: NR C: NR | High<br>Q: Low A: Low C: Low |

Coastal and estuarine areas are among the most biologically invaded systems in the world, especially by molluscs such as the slipper limpet *Crepidula fornicata* and the Pacific oyster *Magallana gigas* (OSPAR, 2009b). The two species have not only attained considerable biomasses from Scandinavian to Mediterranean countries but have also generated ecological consequences such as alterations of benthic habitats and communities, or food chain changes. In the Wadden Sea, the main issue of concern is the pacific oyster (*Magallana gigas*), which has also spread in the Thames estuary and along French intertidal flats. Padilla (2010) predicted that *Magallana gigas* could either displace or overgrown mussels on rocky and sedimentary habitats of low or high energy. In general, littoral sand sediments are mobile and winter storms may remove sediments and wash-out some species (Connor *et al*., 2004) preventing the establishment of larger, longer-lived species and the development of bivalve reefs. However, as some beaches in which the biotope occurs may be relatively sheltered some colonization may occur and sensitivity to invasive molluscs is considered.

In the Wadden Sea and the North Sea, *Magallana gigas* overgrows mussel beds in the intertidal zone (Diederich 2005, 2006; Kochmann *et al*., 2008), although they did show a preference for settling on conspecifics before the mussels and struggled to settle on mussels with a fucoid covering. However, recruitment of *Magallana gigas* was significantly higher in the intertidal than the shallow subtidal, although the survival of adult oysters or mussels in the subtidal is limited by predation.

*Crepidula fornicata* is known to colonize and smother a wide range of sediments in the subtidal, from mixed sediments to mud, especially in prior shellfish beds (e.g. of oysters and mussels) (Blanchard, 1997; Minchin *et al*., 1995). *Crepidula fornicata* larvae may out-compete oyster (*Magallana gigas*) larvae during summer months where the two species co-occur. Trophic competition between adult *Crepidula fornicata* and *Magallana gigas* was reported in France during winter and spring. In Mont Saint-Michel Bay, France, slipper limpet populations have affected flatfish populations. Changes in habitat structure and reduced abundance of suspension-feeding organisms (upon which the flatfish feed) were linked to slipper limpet extent (Decottignies *et al*., 2007; Blanchard *et al.* 2008; and Kostecki *et al*., 2011 cited in Sewell & Sweet, 2011). *Ensis siliqua* occurs on some North Wales shores (Connor *et al*., 2004). This species could co-occur with or be replaced by a similar, but non-native species *Ensis directus*. However, such a change is unlikely to alter the character of the biotope.

**Sensitivity assessment.** *Magallana gigas* is predicted to invade sedimentary habitats, although no direct examples exist to date and *Magallana gigas* recruitment is lower in the subtidal (Diederich 2005, 2006; Padilla, 2010). *Crepdiula fornicata* is a major invader and colonizer of subtidal sediments. However, both species require hard substrata in the form of stones, debris or, preferably, the shells conspecifics to colonize the habitat. This biotope is dominated by fine mud and a shell fraction is not recorded in the description (Connor *et al*., 2004) but if artificial hard debris (e.g. litter) was introduced to the habitat then it may provide an initial point for the colonization of *Crepidula* in particular. Although it would probably take many years, colonization by *Crepidula* would result in the complete modification of the habitat, reclassification and loss of the biotope, although polychaete populations may survive in the sediment itself. Therefore, a precautionary resistance of '**Low**' has been suggested with ‘Low’ confidence due to the lack of direct evidence. Resilience is likely to be '**Very low**' as a bed of *Crepidula* or *Magallana gigas* would need to be removed before recovery could begin. Therefore, sensitivity is assessed as '**High**'.

| | | | |
|---|---|---|---|
| **Introduction of microbial pathogens** | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

**No evidence** was found.

| | | | |
|---|---|---|---|
| **Removal of target species** | Low<br>Q: Medium A: Low C: Medium | High<br>Q: High A: Medium C: High | Low<br>Q: Medium A: Low C: Medium |

*Nephtys cirrosa* is targeted by bait diggers, there is limited information on the effect of targeted removal on *Nephtys cirrosa* populations, however, there is evidence on effects on *Nephtys hombergii*. *Nephtys hombergii* is directly removed through commercial bait digging and by recreational anglers and abundance significantly decreased in areas of the Solent, UK, where bait digging (primarily for *Nereis virens*) had occurred (Watson *et al.* 2007). Recovery of *Nephtys* *hombergii* has been assessed to be high as re-population would occur initially relatively rapidly via adult migration and later by larval recruitment. Dittman *et al.* (1999) observed that *Nephtys hombergii* was amongst the macrofauna that colonized experimentally disturbed tidal flats within two weeks of the disturbance that caused defaunation of the sediment. However, if sediment is damaged recovery is likely to be slower, for instance, *Nephtys hombergii* abundance was reduced by 50% in areas where tractor towed cockle harvesting was undertaken on experimental plots in Burry inlet, south Wales, and had not recovered after 86 days (Ferns *et al.*, 2000).

Removal of *Nephtys cirrosa* by bait digging may cause short-term loss of food resources for predators such as fish species including *Limanda limanda* and *Pleuronectes platessa.* As recovery is medium to high, the long-term impacts on populations are likely to be small but will be dependent upon the scale and frequency of bait digging activities.

**Sensitivity assessment.** Confidence in this assessment about the removal of *Nephtys cirrosa* is 'Low' as it is based on evidence of removal of *Nephtys hombergii*. However, biotope resistance is assessed as '**Low**' based on direct removal of a characterizing species, Resilience is assessed as **'High'** as habitats that are not regularly harvested may recover rapidly, although it should be noted that continued harvesting will inhibit recovery. Biotope sensitivity to a single harvesting event is assessed as **'Low'**. It is important to consider that the spatial extent and duration of harvesting is important to consider when assessing this pressure as smaller scale extraction may not impact the entire extent of the biotope but greater scale extraction over a long period would cause longer-term impacts.

| | | | |
|---|---|---|---|
| **Removal of non-target species** | Low<br>Q: Medium A: Low C: Medium | High<br>Q: Medium A: Low C: Medium | Low<br>Q: Medium A: Low 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).

Collie *et al.* (2000) identified that intertidal communities (such as this biotope) suffered impacts from impact from fishing activities. The review concluded that there were ecologically important impacts from removal of >50% of fauna from bottom towed fishing activity (dredge and trawls) (Collie *et al.*, 2000). Kaiser *et al.* (2001) carried out experimental hand raking, similar to that used in intertidal cockle fisheries. Both small and large raked plots showed changed communities in comparison to control plots, smaller plots recovered in 56 days, whilst larger plots remained in an altered state.

Collie *et al.* (2000) found that the abundance of a *Nephtys hombergii* was negatively affected by fishing activities. Mean response of infauna and epifauna communities to fishing activities was also much more negative in mud and sand communities (such as this biotope) than other habitats. *Nephtys hombergii* abundance also significantly decreased in areas of the Solent, UK, where bait digging had occurred (Watson *et al.* 2007). Similarly, *Nephtys hombergii* abundance was reduced by 50% in areas where tractor towed cockle harvesting was undertaken on experimental plots in Burry inlet, south Wales, and had not recovered after 86 days (Ferns *et al.*, 2000).

**Sensitivity assessment.** The incidental damage or removal of a proportion of the population (e.g. by commercial bait digging) may change the character of the community temporarily. The biotope is disturbed seasonally by storms, (Connor *et al.*, 2004) and may recover quickly. However, long-term disturbance from repeated events e.g. by periodic bait digging (see above) may prolong recovery. Biotope resistance is assessed as '**Low**' based on removal or damage of characterizing species, that on commercial scales can remove a large proportion of the population and lead to an impacted community. Resilience is assessed as **'High'** but it should be noted that continued harvesting will impact the population and *Nephtys cirrosa* will take longer to recover if harvesting is overextended spatial scales. Biotope sensitivity is assessed as **'Low'**. It is important to consider that the spatial extent and duration of areas impacted by removal is important to consider when assessing this pressure, as smaller scale extraction may not impact the entire extent of the biotope but greater scale extraction over a long period would cause longer-term impacts. The type of fishing activity is also important to consider in relation to the type and severity of the impact.

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