Nephtys cirrosa and *Limecola balthica* in variable salinity infralittoral mobile sand

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

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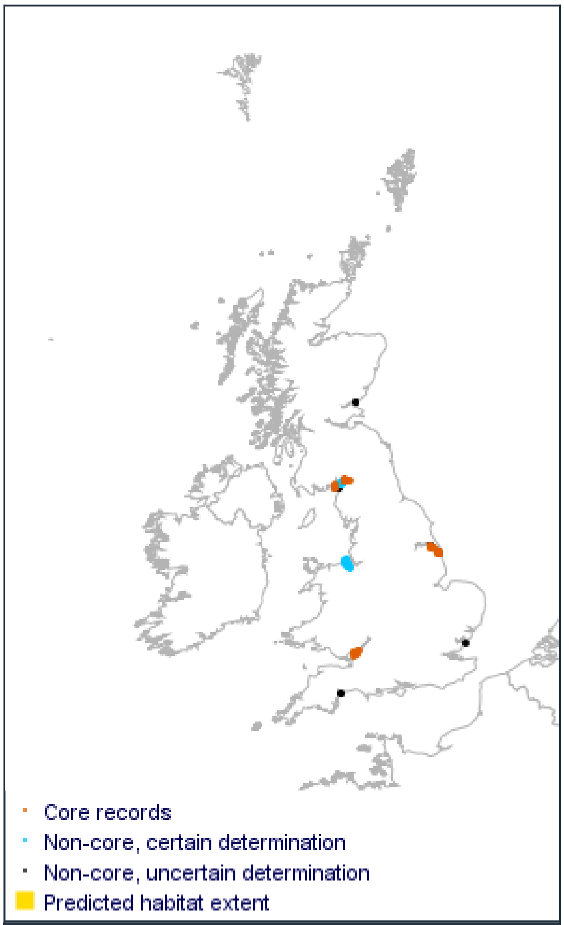

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Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Dr Heidi Tillin & Dr Matt Ashley **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A5.222	*Nephtys cirrosa* and *Macoma balthica* in variable salinity infralittoral mobile sand
JNCC 2015	SS.SSa.SSaVS.NcirLim	*Nephtys cirrosa* and *Limecola balthica* in variable salinity infralittoral mobile sand
JNCC 2004	SS.SSa.SSaVS.NcirMac	*Nephtys cirrosa* and *Macoma balthica* in variable salinity infralittoral mobile sand
1997 Biotope	SS.IGS.EstGS.Ncir	*Nephtys cirrosa* and fluctuating salinity-tolerant fauna in reduced salinity infralittoral mobile sand

Description

Mobile sand in variable salinity conditions where tidal currents create an unstable shifting habitat. Characteristic species include the polychaetes *Nephtys cirrosa* and *Scoloplos armiger* along with amphipods of the genus *Bathyporeia* and *Haustorius arenarius*. The bivalve *Limecola balthica* may occur in more stable examples of this biotope, although not in the abundances found in the NhomMac. The biotope contains relatively few species, each typically in low to moderate abundance. It is found in tidal channels with moderate tidal streams. Care should be taken in identification of this biotope due to the presence juveniles and species washed in during slack water (Information from Connor *et al*., 2004; JNCC, 2015).

Depth range

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

Additional information

-

Listed By

- none -

Further information sources

Search on:

JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and characterizing species are taken from JNCC (2015). This biotope is characterized by mobile clean sand sediments in shallow water The mobility of the sediment leads to a species-poor community, with polychaetes (*Nephtys cirrosa*), the bivalve *Limecola balthica* and burrowing amphipods (*Bathyporeia* spp. characterizing the biotope. The sediments and wave exposure are key factors maintaining the biotope and are considered in the sensitivity assessments where the pressure may alter these.

Resilience and recovery rates of habitat

The species inhabiting this biotope are characteristic of mobile sediments and are adapted to the high levels of disturbance. The species present in the biotope must either be able to withstand mobile sediments through physical robustness, mobility and ability to re-position within sediments such as *Nephtys cirrosa* and the mobile amphipods and/or to recover rapidly to sustain population losses following severe erosion. Characterizing species typically have opportunistic life history strategies, with short life histories (typically two years or less, see below), rapid maturation and extended reproductive periods. Typically they produce juveniles that are either brooded (amphipods and isopds) and are therefore present to repopulate the disturbed habitat directly, or have pelagic larvae (*Nephtys cirrosa*) capable of dispersal within the water column. Adults may also be transported in the water column.

The amphipods characterizing this biotope are found in sediments subject to physical disturbance, as a result of wave action or in wave sheltered biotopes, strong tidal streams. This group is, therefore, tolerant of disturbed environments and can recover quickly. *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.

Nephtys cirrosa is a relatively long-lived polychaete with a lifespan of 6 to possibly as much as 9 years. It matures at 1 year and the females release over 10,000 (and up to 80,000 depending on species) eggs of 0.11-0.12mm from April through to March. These are fertilized externally and develop into an early lecithotrophic larva & a later planktotrophic larva which spends as much as 12 months in the water column before settling from July-September. The genus 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). Adults are mobile and capable of swimming and adults are therefor qable to migrate in and out of this biotope.

The life history characteristics of *Limecola balthica* give the species strong powers of recoverability. Adults spawn at least once a year and are highly fecund (Caddy, 1967). Females are capable of producing 10,000-30,000 eggs (MES, 2010). There is a planktotrophic larval phase which lasts up to 2 months (Fish & Fish, 1996) and so dispersal over long distances is potentially possible given a suitable hydrographic regime. Following settlement, development is rapid and sexual maturity is attained within 2 years (Gilbert, 1978; Harvey & Vincent, 1989). In addition to larval dispersal, dispersal of juveniles and adults occurs via burrowing (Bonsdorff, 1984; Guenther, 1991), floating (Sörlin, 1988) and probably via bedload transport (Emerson & Grant, 1991). It is expected therefore that recruitment can occur from both local and distant populations. Bonsdorff (1984) studied the recovery of a *Limecola balthica* (as *Macoma balthica*) population in a shallow, brackish bay in SW Finland following the removal of the substratum by dredging in the summer of 1976. Recolonization of the dredged area by *Limecola balthica* began immediately after the disturbance to the sediment and by November 1976, the *Limecola balthica* population had recovered to 51 individuals/m□. One year later there was no detectable difference in the *Limecola balthica* population between the recently dredged area and a reference area elsewhere in the bay. In 1976, two generations could be detected in the newly established population indicating that active immigration of adults was occurring in parallel to larval settlement. In 1977, up to six generations were identified, giving further evidence of active immigration to the dredged area.

Resilience assessment. As a consequence of the dynamic nature of the habitat the faunal component of the biotope is very sparse and low in species richness. Therefore, the community might be considered 'mature' only a few days or weeks after the last storm event, as the mobile species displaced from the biotope and those from adjacent area colonize the substratum via the surf plankton. Even following severe disturbances recovery would be expected to occur within a year; biotope resilience is therefore assessed as ‘High’ for any level of impact (e.g. where resistance is ‘None’, ‘Low’ or ‘Medium’).

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

Hydrological Pressures

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

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 temperature tolerances of *Bathyporeia pelagica* and *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 test temperature 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 37.5°C and 39.4°C, respectively. *Bathyporeia pelagica* exhibited lower tolerances and adult males and gravid females had upper lethal temperature tolerances of 33.4 and 34.2°C respectively. These tests measures short-term exposure only and species had 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. *Bathyporeia pelagica* exhibited lower tolerances, 11% of individuals died after 24 hr exposure to 29.5°C and 100% mortality occurred at 30.8°C and above (Preece, 1971).

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.

In Europe, *Limecola balthica* occurs as far south as the Iberian Peninsula and hence would be expected to tolerate higher temperatures than experienced in Britain and Ireland. Oertzen (1969) recorded that *Limecola balthica* could tolerate temperatures up to 49°C before thermal numbing of gill cilia occurred, presumably resulting in death. Ratcliffe *et al.* (1981) reported that *Limecola balthica* from the Humber Estuary, UK, tolerated 6 hours of exposure to temperatures up to 37.5°C with no mortality. Wilson (1981) show that the lethal temperatures for *Limecola balthica* change between seasons as individuals acclimate to seasonal changes. Critical temperatures were studied for a *Limecola balthica* population in Dublin Bay, and a summer maximum of 37.5 and winter maximum of 27.5 were reported (Wilson, 1981). Tolerances were also reported to change with height up the shore, which suggested adaptation to prevailing conditions.

Field observations and laboratory experiments showed that *Limecola balthica* spawns (criterion: 50% spent) in spring when the gradual increase of the mean (monthly averaged) water temperature surpasses 8.3°C. The success of spawning and recruitment is affected by the timing of the spring phytoplankton bloom and avoidance of the main settlement of the predator *Crangon crangon* on intertidal shores (Philippart *et al*., 2003). A mismatch in spawning cues due to an acute increase in temperature could result in low recruitment or recruitment failures

Despite apparent adaptation to regional temperature ranges, Barda *et al.* (2014) studied populations of *Limecola balthica (as Macoma balthica*) in the Baltic Sea and found that increased temperature reduced growth rates. Beukema *et al.* (2014) also warn that increasing water temperatures as a result of global warming are likely to shorten the growing season (typically late winter to early spring) if warmer spring and summer water temperatures are experienced. Jansen *et al.* (2007) suggest that temperature increases in the Spanish coast along the Bay of Biscay over the past 40 years caused loss of *Limecola balthica* populations, due to short-term but frequent exposure to >30° C in the Spanish estuaries, which induced elevated maintenance rates in *Limecola balthica*, and ultimately starvation. Repeated recruitment failure also occurred after mild winters in a comparable North Sea location, probably due to enhanced survival of predators(Beukema, 1992, Schueckel & Kroencke, 2013; Beukema *et al*., 2001). As a result, Jansen *et al.* (2007) predict the southern limit of the species will progressively shift north if temperatures continue to rise.

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. For *Bathyporeia* spp. temperature increases above 30°C appear to be critical based on Preece (1971). Biotope resistance is therefore assessed as '**High**' and resilience as '**High**' so that the biotope is assessed as '**Not sensitive**'.

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

Crisp (1964) reported that species of amphipod and isopods 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.

Preece (1971) tested the temperature tolerances of *Bathyporeia pelagica* and *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. Lower lethal short-term tolerances *of Bathyporeia pilosa* and *Bathyporeia pelagica* were -13.6°C and -6.4°C respectively. Sensitivity to longer-term exposure is greater, especially for *Bathyporeia pelagica*. *Bathyporeia pilosa* individuals could withstand temperatures as low as -1°C for 24 hours, while 42% of *Bathyporeia pelagica* died. At -3°C 5% of *Bathyporeia pilosa* died (100% of *Bathyporeia pelagica*) but this rose to 82% at -5°C.

Nephtys cirrosa reaches its northern limit in Scotland, and German Bight of the North Sea. A decrease in temperature is likely to result in loss of the species from the SS.SSa.SSaVS biotope in Scotland.

The geographical distribution of *Limecola balthica* suggests that it is very tolerant of low temperature. The species occurs in the Gulfs of Finland and Bothnia where the sea freezes for several months of the year (Green, 1968). It must, therefore, resist much lower temperatures than it experiences in Britain and Ireland. Furthermore, *Limecola balthica* was apparently unaffected by the severe winter of 1962/3, which severely affected many other bivalve species (Crisp, 1964), and De Wilde (1975) noted that Limecola balthica (as *Limecola balthica*) kept at 0°C maintained a high level of feeding activity. It is likely, therefore, that in seas around the UK and Ireland,Colder winter temperatures have been shown to benefit *Limecola balthica* population dynamics. Recruitment success increased following colder winters and repeated recruitment failure has occurred after mild winters in comparable North Sea location (Beukema, 1992, Schueckel & Kroencke, 2013; Beukema *et al*., 2001). In Friedrichskoog, Germany, König (1943) found a high accumulation of dead *Cerastoderma edule* biomass after a severe winter 1936/1937 but high numbers of *Limecola balthica* (80,000 individuals/m▯) spat in following years (winter 1939). Winter water surface temperatures in the Wadden Sea (Netherlands) have increased 1.5°C since the 1980s (Oost *et al*., 2009). During milder winters greater body weight loss and production of fewer and smaller eggs has been observed in *Limecola balthica* (van der Meer *et al*., 2003). It is noted in the literature however, that reduced recruitment success during milder winters may also be due to increased predation as juvenile *Crangon crangon* have shown increased abundance in relation to milder winters (Beukema & Dekker, 2005). *Limecola balthica* would resist decreases in temperature at the pressure benchmark level.

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 on for a month may be tolerated by the characterizing species supported by deeper burrowing and/or migration to deeper waters. For *Bathyporeia* spp. seawater temperature decreases below -1°C appear to be critical based on Preece (1971). Biotope resistance is therefore assessed as '**Medium**' and resilience as '**High**' so that biotope sensitivity is assessed as '**Low**'.

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

This biotope is found in variable salinity (18-35 ppt) habitats (JNCC, 2015), a change at the pressure benchmark is therefore assessed as a change to full salinity conditions (30-35ppt). The characterizing spcis are all tolerant of full salinity and an increase in salinity may result in an increase in species richness and biotope reclassificaton to SS.SSaIFiSa.NcirBat, which is a similar biotope found in full salinity.

Sensitivity assessment. An increase in salinity at the pressure benchmark is likely to result in biotope reclassification, biotope resistance is, therefore, assessed as **'Low'.** Resilience is assessed as **'High'** (following restoration of salinity regime) and sensitivity is assessed as '**Low**'.

Salinity decrease (local)	None Q: High A: Medium C: High	High Q: High A: Low C: High	Medium Q: High A: Low C: High

The biotope is found in variable salinity habitats (JNCC, 2015). A change at the pressure benchmark refers to a decrease from variable to low salinity (<18 ppt). *Bathyporeia pelagica* migrates seaward in response to reduced salinities, the effect of which is enhanced by higher temperature (Preece, 1970). *Bathyporeia pilosa* is, however, more tolerant of low salinities and is capable of reproducing at salinities as low as 2 (Khayrallah, 1977). Populations of *Bathyporeia pilosa* within the upper reaches of the Severn Estuary experience wide fluctuations in salinity ranging from 1-22 depending on the season and tidal cycle (Mettam, 1989). The physiological stress for this environment affects size and reproduction (Mettam, 1989). Speybroeck *et al.* (2008) noted that *Bathyporeia pilosa* tends to occur subtidally in estuarine and brackish conditions. Local populations may be acclimated to the prevailing salinity regime and may exhibit different tolerances to other populations subject to different salinity conditions and, therefore, caution should be used when inferring tolerances from populations in different regions.

McLusky & Allan (1976) conducted salinity survival experiments with *Limecola balthica* (as *Macoma balthica*) over a period of 150 days. Survival times declined with decreased salinity. At 12 psu specimens survived 78 days, whilst specimens at 8.5 psu survived 40 days. Some specimens of *Limecola balthica* survived 2.5 days at 0.8 psu, which was apparently due to the animal's ability to clamp its valves shut in adverse conditions. McLusky & Allan (1976) also reported that *Limecola balthica* failed to grow (increase shell length) at 15 psu. *Limecola balthica* is found in brackish and fully saline waters (Clay, 1967b) so may tolerate a state of flux. Its distribution in combination with the experimental evidence of McLusky & Allan (1976) suggests that *Limecola balthica* is likely to be resistant to decreased salinity over a short period. A decline in salinity in the long-term may have implications for the species viability in terms of growth, and the distribution of the species may alter as specimens at the extremes retreat to more favourable conditions. Metabolic function should, however, quickly return to normal when salinity returns to original levels. Decreased salinity may also affect the ability of *Limecola balthica* to tolerate contaminants such as heavy metals (see Bryant *et al*., 1985 & 1985a). Usually, contaminants become more toxic at low salinity (Langston, W.J. pers comm.).

A reduction in salinity at the pressure benchmark could result in the loss of species or changes in abundance and biotope reversion to a biotope dominated by polychaetes and oligochaets tolerant of low salinity.

Sensitivity assessment. A decrease in salinity is likely to lead to changes in species abundance and richness and may lead to biotope reclassification. Biotope resistance is assessed as ‘**None**’ and resilience as ‘**High**’ (following restoration of typical habitat conditions). Sensitivity is therefore assessed as ‘**Medium**’.

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

Water movement is a key factor physically structuring this biotope although exposure to wave action may be more significant for many examples than tidal streams. This biotope is recorded where tidal streams are weak (<0.5 m/s) or moderately strong (0.5-1.5 m/s) (JNCC, 2015), in areas where flows are lower, wave action may be more important in maintaining the sediment mobility that structures the biotope. An increase in disturbance may lead to biotope reversion to the similar biotope SS.SSa.IFiSa.IMoSa which occurs in more disturbed areas. A decrease in disturbance may lead to changes to SS.SSa.IMuSa.FfabMag, where finer sediments are deposited.

Sensitivity assessment. The sediments that characterize this biotope and sub-biotopes are mobile sands that range from medium to fine, a change at the pressure benchmark (increase or decrease) may lead to some changes in sediment sorting. Based on the range of water flows experienced, biotopes occurring in habitats at the middle of the range are considered to be '**Not sensitive**' to an increase or decrease in flow at the pressure benchmark. Changes in water flow in areas sheltered from wave action could. however, lead to changes in biotope classification due to the increase in sediment stability.

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

Not relevant to sublittoral biotopes.

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

Water movement is a key factor physically structuring this biotope, with sediment sorting and mobilisation by tidal streams and wave action modifying the sediments present and the level of disturbance. The assessed biotope is found in habitats that rang from moderately exposed to sheltered from wave action (JNCC, 2015).

Sensitivity assessment. Wave action is a key factor structuring this biotope through sediment mobility. As the biotope occurs across two wave exposure categories (JNCC, 2015) this is considered to indicate, by proxy, that a change in wave exposure at the pressure benchmark is less than the natural range of wave heights experienced. Biotope resistance to this pressure is therefore assessed as 'High' and resilience as 'High (by default) so that the biotope is considered to be 'Not sensitive' at the pressure benchmark.

Chemical Pressures

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

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

Levels of contaminants that exceed the pressure benchmark may cause impacts. For most metals, toxicity to crustaceans increases with decreased salinity and elevated temperature, therefore marine species living within their normal salinity range may be less susceptible to heavy metal pollution than those living in salinities near the lower limit of their salinity tolerance (McLusky *et al*., 1986). Jones (1973; 1975b) found that mercury (Hg) and copper (Cu) reacted synergistically with changes in salinity and increased temperature (10°C) to become increasingly toxic to species of isopod, including *Eurydice pulchra*.

Hydrocarbon & PAH contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

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

Synthetic compound contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

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

In general, crustaceans are widely reported to be intolerant of synthetic chemicals (Cole *et al*., 1999) and intolerance to some specific chemicals has been observed in amphipods. Powell (1979) inferred from the known susceptibility of Crustacea to synthetic chemicals and other non-lethal effects, that there would probably also be a deleterious effect on isopod fauna as a direct result of chemical application. All were killed at about 10 ppm BP 1002 after 24 hours exposure, whilst at 5 ppm four out of five individuals survived when transferred to clean seawater.

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

No evidence.

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

This pressure is **Not assessed**.

De-oxygenation

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

Information concerning the reduced oxygen tolerance of *Nephtys cirrosa* was not 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.

Laboratory studies by Khayrallah (1977) on *Bathyporeia pilosa*, indicated that it has a relatively poor resistance to conditions of hypoxia in comparison to other interstitial animals. However, Mettam (1989) and Sandberg (1997) suggest that *Bathyporeia pilosa* can survive short-term hypoxia.

Limecola balthica appears to be relatively tolerant of de-oxygenation. Brafield & Newell (1961) frequently observed that, in conditions of oxygen deficiency (e.g. less than 1 mg O_2/l), *Limecola balthica* (as *Macoma balthica*) displayed survivability of low oxygen concentrations and shell growth continued (Jansson *et al*., 2015). Although, sub-lethal effects of hypoxia have been identified as individual *Limecola balthica* moved upwards to fully expose itself on the surface of the sand or buried at shallower depths, leaving them at greater risk of predation (Long *et al*., 2014). Specimens lay on their side with the foot and siphons retracted but with valves gaping slightly allowing the mantle edge to be brought into full contact with the more oxygenated surface water lying between sand ripples. In addition, *Limecola balthica* was observed under laboratory conditions to extend its siphons upwards out of the sand in to the overlying water when water was slowly deoxygenated with a stream of nitrogen. The lower the oxygen concentration became the further the siphons extended.

This behaviour, an initial increase in activity stimulated by oxygen deficiency, is of interest because the activity of lamellibranchs is generally inhibited by oxygen deficient conditions (Brafield & Newell, 1961). Dries & Theede (1974) reported the following LT50 values for *Limecola balthica* (as *Macoma balthica*) maintained in anoxic conditions: 50 - 70 days at 5°C, 30 days at 10°C, 25 days at 15°C and 11 days at 20°C. Theede (1984) reported that *Limecola balthica* to resist extreme oxygen deficiency was mainly due to anaerobic metabolism. *Limecola balthica* is, therefore very tolerant of hypoxia, although it may react by reducing metabolic activity and predation risk may increase. Metabolic function should quickly return to normal when oxygen levels are resumed and so recovery is expected.

Sensitivity assessment. This biotope is characterized by mobile sands in areas that experience strong water flows or are wave exposed. The mixing effect of wave action and water movement will limit the intensity and duration of exposure to deoxygenated waters. The species characterizing the biotope are also mobile and able to migrate vertically or shorewards to escape unsuitable conditions. Biotope resistance is therefore assessed as '**High**' and resilience as '**High**' (by default) so that the biotope is considered to be '**Not sensitive**'.

Nutrient enrichment

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

In-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). The amphipods feed on epipsammic diatoms attached to the sand grains (Nicolaisen & Kanneworff, 1969). Both these groups may benefit from slight nutrient enrichment if this enhanced primary production.

Sensitivity assessment. Nutrient level is not a key factor structuring the biotope at the pressure benchmark. In general, however, primary production is low and this biotope is species poor and characterizing species may be present at low abundances (depending on sediment mobility). Biotope resistance is therefore assessed as 'High', resilience as 'High' (by default) and the biotope is considered to be 'Not sensitive'.

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

The biotope occurs in mobile sand sediments where wave action leads to particle sorting, in-situ primary production is restricted to microphytobenthos although sediment mobility may restrict production levels (Delgado *et al*., 1991).

case studies suggest that *Limecola balthica* populations are resistent to mild enrichment. *Limecola balthica* (as *Macoma balthica*) have been shown experimentally to be able to resist periods of up to 9 weeks under algal cover, their long siphon allowing them to reach oxygenated water, although other bivalves decreased in abundance (Thiel *et al*., 1998). Organic enrichment from waste-water discharge in the Dutch Wadden Sea resulted in positive effects on *Limecola balthica* abundance, biomass, shell growth and production. These effects were concluded to be due to increased food supply (Madsen & Jensen, 1987).

Sensitivity assessment. At the pressure benchmark organic inputs are unlikely to significantly affect the structure of the biological assemblage or impact the physical habitat, due to remobilisation and transport by wave or currents. Biotope sensitivity is therefore assessed as '**High**' and resilience as '**High**' (by default) and the biotope is therefore considered to be '**Not sensitive**'.

Physical Pressures

	Resistance	Resilience	Sensitivity
Physical loss (to land or freshwater habitat)	None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

All marine habitats and benthic species are considered to have a resistance of '**None**' to this pressure and to be unable to recover from a permanent loss of habitat (resilience is '**Very Low**'). Sensitivity within the direct spatial footprint of this pressure is therefore '**High**'. Although no specific evidence is described confidence in this assessment is 'High', due to the incontrovertible nature of this pressure.

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

The biotope is characterized by the sedimentary habitat (JNCC, 2015), a change to an artificial or rock substratum would alter the character of the biotope leading to reclassification and the loss of the sedimentary community including the characterizing polychaetes and amphipods.

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

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

The pressure benchmark refers to the simplified Folk classification developed by Long (2006) and the UK Marine Habitat Classification Littoral and Sublittoral Sediment Matrices (Connor *et al*., 2004). The biotope occurs on mobile sands, a change at the pressure benchmark refers to a change to sandy muds or muddy sands or to coarser gravel sediments. Experiments by Van Tomme *et al*. (2013) have shown that the optimal sedimentary habitats for some of he species that characterize this biotope vary slightly. *Bathyporeia pilosa* prefer the finest sediments, although at a subtidal dredge disposal site the change to a finer sediment led to a reduction in the abundance of *Bathyporeia pilosa* (Witt *et al*., 2004). *Bathyporeia sarsi* has a broader preference and also occurred in medium-coarse sediments (Van Tomme *et al*., 2013).

Nepthys cirrosa occurs in fine to coarser sands, with 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 this 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).

Limecola balthica is likely to tolerate increased gravel content as sediment was not shown to affect burrowing (Tallqvist, 2001), however, growth, shell size and body mass were greatest in higher sand content sediment and lower in higher gravel content sediments (Azouzi *et al*. 2002), suggesting long-term health and abundance may be affected by a permanent increase in gravel content

Sensitivity assessment. A change to either a finer muddy sediment or a coarser sediment, is likely to lead to changes in the abundance and identity of the characterizing species . Based on the loss of the biotope, resistance is assessed as '**None**', recovery is assessed as '**Very low**' (as the change at the pressure benchmark is permanent and sensitivity is assessed as '**High**'.

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

Bathyporeia pelagica lives infaunally in the uppermost 3 cm of sandy substrata as does the isopod *Eurydice pulchra* (Fish, 1970). Extraction of the sediment to 30cm is likely to remove the characterizing polychaetes, amphipods and isopods within the footprint (although if disturbed some may be able to escape).

Sensitivity assessment. Biotope resistance to extraction of sediment and characterizing species is assessed as 'None. Resilience is assessed as 'High', as sediment recovery will be enhanced by wave action and mobility of sand. The characterizing species are likely to recover through transport of adults in the water column or migration from adjacent patches. Biotope sensitivity is therefore assessed as ‘Medium’.

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

This biotope group is present in mobile sands, the associated species are generally present in low abundances and adapted to frequent disturbance suggesting that resistance to surface abrasion would be high. The amphipod and isopod species present are agile swimmers and are characterized by their ability to withstand sediment disturbance (Elliott *et al.* 1998). Similarly, the polychaete *Nephtys cirrosa* is adapted to life in unstable sediments and lives within the sediment. This characteristic is likely to protect this species from surface abrasion.

Comparisons between shores with low and high levels of trampling found that the amphipod *Bathyporeia pelagica* is sensitive to abrasion and compaction from 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).

Sensitivity assessment. Resistance to a single abrasion event is assessed as ‘Low’ based on the evidence for trampling from Reyes-Martínez *et al.* (2015). Resilience is assessed as ‘High’, based on migration from adjacent populations and in-situ reproduction by surviving amphipods. Sensitivity is therefore assessed as ‘Low’. This assessment may underestimate sensitivity to high-levels of abrasion (repeated events within a short period). The trampling evidence and the evidence for penetration from mobile gears (see below) differ in the severity (resistance) of impact. This may be due to different levels of intensity (multiple trampling/abrasion events vs single penetration/towed gear impacts) or the nature of the pressure. Abrasion from trampling also involves a level of compaction that could collapse burrows and damage species through compression. Penetration may, however, break sediments open allowing mobile species to escape or species may be pushed forwards from towed gear by a pressure wave where this is deployed subtidally (Gilkinson *et al.*, 1998). Both risk assessments are considered applicable to single events based on the evidence and the sensitivity assessment for both pressures is the same although resistance differs.

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

This biotope group is present in mobile sands, the associated species are generally present in low abundances and adapted to frequent disturbance suggesting that resistance to abrasion and penetration and disturbance of the sediment would be high. The amphipod species present are agile swimmers and are characterized by their ability to withstand sediment disturbance (Elliott *et al.*, 1998).

Bergman and 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 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 1 day (Constantino *et al*. 2009). Experimental hydraulic dredging for razor clams resulted in no statistically significant differences in *Bathyporeia elegans* abundances between treatments after 1 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 that other habitat types with higher proportions of fine sediment (Dernie *et al*., 2003).

Sensitivity assessment. Based on the evidence above it is considered that *Bathyporeia* spp. and other characterizing species will have '**Medium**' resistance (mortality <25%) to abrasion, their small size, infaunal position and mobility enabling a large proportion of the population to escape injury. Recovery is assessed as '**High**' and sensitivity is therefore categorised as '**Low**'.The trampling evidence (see above) and the evidence for penetration from mobile gears differ in the severity (resistance) of impact. This may be due to different levels of intensity (multiple trampling/abrasion events vs single penetration/towed gear impacts) or the nature of the pressure. Abrasion from trampling also involves a level of compaction that could collapse burrows and damage species through compression. Penetration may, however, break sediments open allowing mobile species to escape or species may be pushed forwards from towed gear by a pressure wave where this is deployed subtidally (Gilkinson *et al*., 1998).

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

Amphipods may be regular swimmers within the surf plankton, where the concentration of suspended particles would be expected to be higher (Fincham, 1970a). Furthermore, during the winter, when *Bathyporeia pelagica* extends its distribution into the mouths of estuaries the species may encounter concentrations of suspended sediment measurable in grams per litre (benchmark is mg/l) (Cole *et al*. 1999).

Limecola balthica is able to burrow both vertically and horizontally through the substratum. It is likely that *Limecola balthica* is not sensitive to smothering by a layer of sediment 5 cm thick as it is a mobile species able to burrow upwards and surface from a depth of 5 - 6 cm (Brafield & Newell, 1961; Brafield, 1963; Stekoll *et al*., 1980). Turk and Risk (1981) investigated the effect of experimentally induced sedimentation (through fences and boxes that induced sediment deposition on intertidal mudflats in the Bay of Fundy), of 1-3.5 cm at a rate of 1.9-10.2 cm/month.

The results showed that *Limecola balthica* was generally unaffected.

Sensitivity assessment. Increased inorganic suspended solids may increase abrasion but it is likely that the infaunal species would be unaffected. The biotope is considered to be ‘Not sensitive’ to a decrease in suspended solids that does not affect sediment transport and supply to the biotope. Biotope resistance is assessed as ‘Medium’ as some effects on feeding and diatom productivity may occur from increases in suspended solids, resilience is assessed as ‘High’, following a return to usual conditions and sensitivity is assessed as ‘Low’. This more precautionary assessment is presented in the table. Indirect effects such as deposition, erosion and associated sediment change that may result from changes in suspended solids in the long-term are assessed separately.

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

Evidence for the effects of siltation by thick layers of added sediment from beach nourishment is described for the heavy deposition pressure below. The pressure benchmark for light deposition refers to the addition of a relatively thin layer of deposits in a single event. Species adapted to coarse sediments may not be able to burrow through fine sediments, or experienced reduced burrowing ability. For example, 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.

Sensitivity assessment. As the biotope is associated with wave exposed habitats or those with strong currents, some sediment removal will occur, mitigating the effect of deposition. The mobile polychaete *Nephtys cirrosa* and amphipods are likely to be able to burrow through a 5cm layer of fine sediments. Biotope resistance is therefore assessed as ‘High’ and resilience as ‘High’ (by default). The biotope is therefore considered to be ‘Not sensitive’ to this pressure. Repeated deposits or deposits over a large area or in sheltered systems that were shifted by wave and tidal action may result in sediment change (see physical change pressure).

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

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.

A thick layer of sediment has a smothering effect and in most instances buried species will die although some polychaetes can escape up to 90cm of burial In response to nourishment (Speybroek *et al*., 2007, references therein). Peterson *et al*. (2000) found that the dominant macrofauna were reduced by 86-99% 5-10 weeks after the addition of sediment that was finer than the original sediments but with a high shell content.

Little empirical information was found for the ability of characterizing species to reach the surface after burial. 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.

Leewis *et al.* (2012) investigated the recovery of *Bathyporeia sarsi*, following beach nourishment by comparing beaches that had been exposed at different times. The lengths of beach nourished varied from 0.5 kn to > 7 km. Recovery to original abundances appeared to occur within one year for the characterizing species which were in agreement with other studies (Leewis *et al.*, 2012 and references therein).

Repeated events are not considered at the pressure benchmark but it is noted that annual beach nourishment can alter beach sediments (see physical change pressure) and result in suppression of macroinvertebrate populations (Manning *et al.*, 2014).

Witt *et al.* (2004) identified an increase in *Limecola balthica* (as *Macoma balthica*) abundance in areas of disposal of dredge waste spoil, possibly due to nutrient input at the disposal site. This suggests *Limecola balthica* responds opportunistically to this pressure.

Sensitivity assessment. The thickness of sediment applied during beach nourishment is likely to exceed the 30cm pressure benchmark but the results from studies on the activity are informative, particularly with regard to recovery rate. Sediment removal by wave action could mitigate the level of effect but overall smothering by fine sediments is likely to result in mortality of characterizing amphipods and isopods and possibly *Nephtys cirrosa*. Biotope resistance is therefore assessed as 'Low' and resilience as High (based on Leewis *et al.*, 2012), biotope sensitivity is therefore assessed as 'Low'.

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

This pressure is not assessed. Amphipods may also consume microplastics although no negative effects have been documented. Ugolini *et al.* (2013) found that *Talitrus saltator* could consume polyethylene microspheres. Most microspheres were expelled in 24 h. and were totally expelled in one week. microsphere ingestion on the survival capacity in the laboratory. Analyses carried out on faeces of freshly collected individuals revealed the presence of polyethylene and polypropylene, confirming that microplastic debris could be swallowed by *Talitrus saltator* in natural conditions. The talitrid *Orchestia gammarellus* has also been recorded as ingesting microplastics in the size range 20-200μm (Thompson *et al.*, 2004).

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

No evidence for the characterizing species was found to assess this pressure. For some amphipods there is evidence for geomagnetic orientation being inhibited or disrupted by the presence of electromagnetic fields or by changing magnetic fields. Arendse & Barendregt (1981) manipulated magnetic fields to alter orientation of the talitrid amphipod *Orchestia cavimana*.

Deep-water amphipods *Gondogenia arctica* have been shown to be sensitive to even weak electromagnetic fields which cancel magnetic orientation (Tomanova & Vacha, 2016). Loss of orientation was observed at a radiofrequency electromagnetic field of 2 nT (0.002 μT) (Tomanova & Vacha, 2016).

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

Not relevant.

Introduction of light or shading	Medium Q: High A: Low C: Low	High Q: High A: Low C: High	Low Q: High A: Low C: Low

As this feature is not characterized by the presence of primary producers it is not considered that shading would alter the character of the habitat. No specific evidence was found to assess the sensitivity of the characterizing species to this pressure. Changes in light level may, however, affect activity rhythms of the invertebrates. Amphipods within the biotope prefer shade and therefore an increase in light may inhibit activity, particularly at night when they emerge from the sediment and are most active (Jelassi *et al*., 2015; Ayari, 2015). Hartwick (1976) found that artificial lighting interfered with learning or orientation cues by Talitrids.

Orientation by light has been well studied for intertidal amphipods (particularly *Talitrus saltator)*. Intertidal amphipods orientate themselves by a range of factors that include (but are not limited to) visual cues based on solar or astronomic cues such as the moon and the geomagnetic field (Scapini, 2014). Activity patterns are also linked to internal biological clocks that respond to diel, tidal, lunar and seasonal cycles, so that animals are active during the most suitable time of day or night (Scapini, 2014). The introduction of light or an increase in shading could, therefore, alter behavioural patterns and navigation.

Changes in light and level of shade may indirectly affect the characterizing *Bathyporeia* spp. through changes in behaviour and food supply via photosynthesis of diatoms within sediments. Benthic microalgae play a significant role in system productivity and trophic dynamics, as well as habitat characteristics such as sediment stability (Tait & Dipper, 1998). Shading could prevent photosynthesis leading to death or migration of sediment diatoms altering sediment cohesion and food supply to the grazing amphipods.

Sensitivity assessment. Changes in light are not considered to directly affect the biotope however, some changes in behaviour or food supply for *Bathyporeia* spp could result. Sensitivity is assessed as ‘Medium’ and resilience is assessed as ’High’. Biotope sensitivity is, therefore, assessed as ‘Low’.

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

As the amphipods and isopods that characterize this biotope have benthic dispersal strategies (via brooding), water transport is not a key method of dispersal over wide distances, as it is for some marine invertebrates that produce pelagic larvae such as the characterizing *Nephtys cirrosa*. Barriers that limit tidal excursion and flushing may reduce connectivity or help to retain larvae.

Sensitivity assessment. The biotope (based on the biological assemblage) is considered to have ‘High’ resistance to the presence of barriers that lead to a reduction in tidal excursion, resilience is assessed as 'High' (by default) and the biotope is considered to be 'Not sensitive'.

Death or injury by collision	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant' to seabed habitats. NB. Collision by grounding vessels is addressed under 'surface abrasion.

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

The characterizing species are likely to be able to detect light and some movement but are unlikely to have any visual acuity and are considered to not be sensitive to this factor. The amphipods emerge from the sediments at night and are unlikely to be disturbed although like many species they may flee from movements.

Sensitivity assessment. Biotope resistance is assessed as 'High' and resilience as 'High' so that the biotope is assessed as 'Not sensitivie'.

Biological Pressures

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

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

Introduction or spread of invasive non-indigenous species	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

The North American amphipod *Gammarus tigrinus* was detected in the north-eastern Baltic Sea in 2003 and has rapidly expanded into European waters since (Jänes *et al.*, 2015). Native gammarids, such as *Gammarus salinus* have almost disappeared from some habitats of the northeastern Baltic Sea and the competition for space between the invasive *Gammarus tigrinus* the native *Gammarus salinus* has been a contributing factor in certain habitats (Kotta *et al.*, 2011). Competition for space alone did not explain the mass disappearance of *Gammarus salinus* as *Gammarus tigrinus* did not out-compete *Gammarus salinus* in all Baltic Sea habitats, limiting confidence in the evidence. However, *Gammarus tigrinus* has been identified in many UK estuaries and coasts and appears likely to influence species composition in the biotope (NBN Gateway 2016). This species prefers lower salinities and is typical of brackish waters (Kotta *et al.*, 2013) and is therefore not considered a threat to this biotope where salinities are unaltered from the usual full salinity conditions.

Sensitivity assessment. The sediments characterizing this biotope are mobile and frequent disturbance limits the establishment of marine and coastal invasive non-indigenous species as the habitat conditions are unsuitable for most species, as exemplified by the low species richness characterizing this biotope.This biotope is therefore considered to have 'High' resistance to this pressure and high resilience (by default), and is assessed as 'Not sensitive' to this pressure.

Introduction of microbial pathogens	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

Amphipods may also be infected by a number of parasites or pathogens that alter population numbers through changes in host condition, growth, behaviour and reproduction (Green Extabe & Ford, 2014). Infection by acanthocephalan larvae, for example, may alter behaviour and responses of gammarid amphipods (Bethel & Holmes, 1977).

No evidence was found for pathogen/parasite outbreaks that may result in mass-mortalities in the characterizing species and this pressure is not assessed.

Removal of target species	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Subtidal fringe populations of *Nepthys cirrosa* may be targeted by bait diggers. There is limited information on the effect of digging directly on *Nephtys cirrosa* populations, however there is evidence on effects on another *Nephtys* species: *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 very 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).

Sensitivity assessment. Although *Nephtys cirrosa* may be targeted by bait differs where this species occurs intertidally, subtidal populations are not considered to be impacted unless there was a change in emergence regime. This pressure is, therefore considered to be 'Not relevant' to the assessed biotope.

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

The loss of the key characterizing species through unintentional removal would alter the character of the biotope. The ecosystem services such as secondary production and food for higher trophic levels would be lost. The polychaete *Nephtys cirrosa* and the amphipods are predated on by flat fish and other invertebrate predators during tidal inundation (Speybroeck *et al.*, 2007; Van Tomme *et al.*, 2014).

McLusky *et al.* (1983) found that *Limecola balthica* populations were unaffected in dug areas, following bait digging for lugworms suggesting the biotope would recover from this impact if it occurred over a limited spatial scale. However, Hiddink (2003) shows density of *Limecola balthica* was reduced in areas in the Wadden sea (Netherlands) that had experienced suction dredging for cockles, which removes the surface sediment.

Sensitivity assessment. Biotope resistance to loss of the characterizing species is assessed as 'Low' as the burrowing lifestyle and mobility of species mean that a proportion of the population may escape incidental removal. Resilience is assessed as 'High' based on in-situ recovery and migration from adjacent populations and sensitivity is therefore assessed as 'Low'. Despite the loss of a high proportion of the characterizing species the biotope would still be classified as belonging to the LS.LSa.MoSa group as some examples, particularly those that are very exposed to wave action, contain few species at low abundance (JNCC, 2015).

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