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

Nephtys hombergii and *Limecola balthica* in infralittoral sandy mud

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

Matthew Ashley & Georgina Budd

2007-09-04

(page left blank)

17-09-2018
Biotope distribution data provided by
EMODnet Seabed Habitats
(www.emodnet-seabedhabitats.eu)
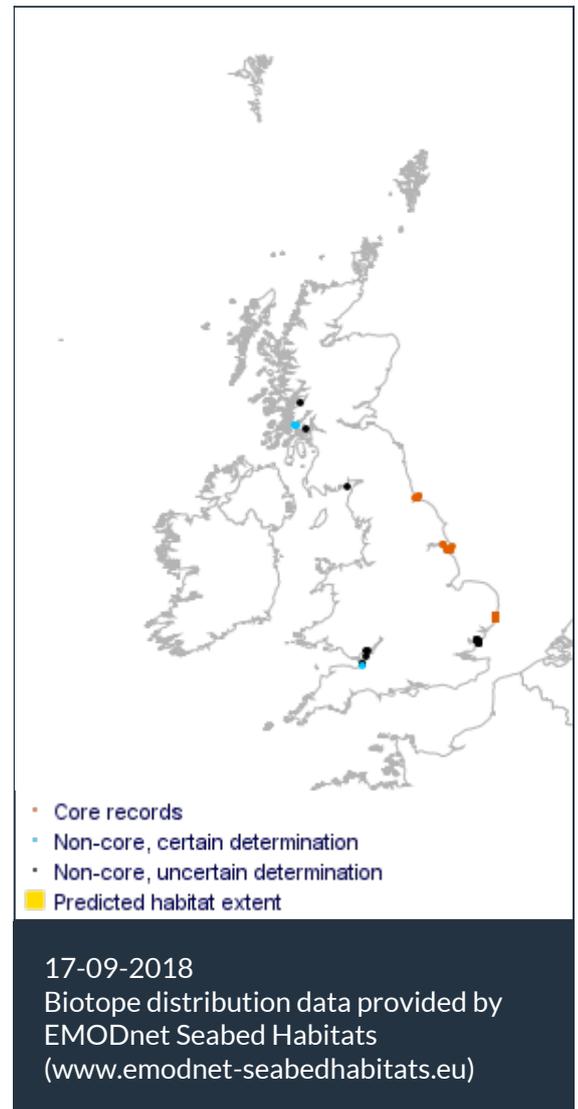
Researched by   Matthew Ashley & Georgina Budd   **Refereed by**   Admin

Summary

☰ UK and Ireland classification

EUNIS 2008	A5.331	*Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud
JNCC 2015	SS.SMu.ISaMu.NhomLim	*Nephtys hombergii* and *Limecola balthica* in infralittoral sandy mud
JNCC 2004	SS.SMu.ISaMu.NhomMac	*Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud
1997 Biotope	SS.IMS.FaMS.MacAbr	*Macoma balthica* and *Abra alba* in infralittoral muddy sand or mud

🏷 Description

Near-shore shallow sandy muds and muds, and sometimes mixed sediments, may be characterized by the presence of the polychaete *Nephtys hombergii* and the bivalve *Limecola balthica*. *Abra*

alba and *Nucula nitidosa* may also be important although they may not necessarily occur simultaneously or in high numbers. Other taxa include *Spiophanes bombyx, Lagis koreni,* and *Echinocardium cordatum.* In some areas *Scoloplos armiger* and *Crangon crangon* may also be present. The community appears to be quite stable (Dewarumez *et al.,* 1992) and the substratum is typically rich in organic content. This community has been included in the 'Boreal Offshore Muddy Sand Association' of Jones (1950) and is also described by several other authors (Petersen, 1918; Cabioch & Glaçon, 1975). A similar community may occur in deep water in the Baltic (Thorson, 1957). This biotope may occur in slightly reduced salinity estuarine conditions where *Mya* sp. may become a significant member of the community (Thorson, 1957) (Information from JNCC, 2015).

⭳ Depth range

5-10 m, 10-20 m

🏛 Additional information

No text entered.

✔ Listed By

- none -

❡ Further information sources

Search on:

G g G JNCC

Habitat review

⟳ Ecology

Ecological and functional relationships

- Predation in the biotope can be an important structuring force. Predators in the biotope may include small fish (*Pomatoschistus microps* and *Pomatoschistus minutus*) and juvenile flatfish (*Platichthys flesus*) in addition to the burrowing polychaete *Nephtys hombergii*, and the shrimp *Crangon crangon*.
- The brown shrimp *Crangon crangon* is one of the most important epibenthic predators on shallow sandy bottom communities. Mattila *et al.*, (1990) found that *Crangon crangon* had a great potential to affect many infaunal species. For instance, the presence of *Crangon crangon* in experimental studies affected both the densities and size frequencies of *Limecola balthica*. At times when the shrimp is most abundant it may have some importance as a regulating predator on shallow soft substratum communities (Mattila *et al.*, 1990).
- However, surface and sub-surface deposit feeders are particularly characteristic of this biotope. Bivalve molluscs that inhabit muddy low energy environments tend to deposit feed, although several species including *Limecola balthica* and *Abra alba* may also suspension feed. For instance, switching between the modes of feeding in *Limecola balthica* was directly affected by food availability in the over-lying water (Lin & Hines, 1994). When deposit feeding, bivalves remove phytoplankton, microzooplankton, organic and inorganic particles, and microbes including bacteria, fungi and microalgae. They also probably absorb dissolved organic materials in much the same manner as when filter feeding (Dame, 1996). Deposit feeding bivalves adopt two approaches to feeding; bulk feeding and particle sorting. Some may ingest large amounts of sediment in a relatively nonselective manner, or may sort particles before they are ingested and reject the majority as pseudofaeces. Deposit feeding bivalves may process up to 20 times their body weight in sediments per hour with as much as 90 % of the sediment egested as pseudofaeces (Lopez & Levinton, 1987). Consequently, the resultant bioturbation is likely to alter the characteristics of the substratum and possibly the associated infaunal community. Furthermore, as a result of feeding and metabolism, bivalve molluscs excrete both particulate and dissolved materials that may be utilized by the benthos and plankton. Thus bivalves play an important role in the cycling of nutrients in such systems (Dame, 1996).
- When suspension feeding, bivalves pump large volumes of water and concentrate many chemicals by several orders of magnitude greater in their body tissues than are found in surrounding seawater (Dame, 1996).
- *Limecola balthica* is not normally considered to be toxic but may transfer toxicants through the food chain to predators. *Limecola balthica* was implicated in the Mersey bird kill in the late 1970's, owing to bioconcentration of alklyC-lead residues (Bull *et al.*, 1983).

Seasonal and longer term change

Seasonal changes are likely to occur in the abundance of fauna in the biotope due to seasonal recruitment processes and variations in recruitment success. For example, in the case of *Limecola balthica*, Bonsdorff *et al.* (1995) reported juvenile density in the Baltic Sea following settlement in late summer to be 300,000/m decreasing to a stable adult density of 1,000/m, and Ratcliffe *et al.* (1981) reported adult densities in the Humber Estuary, UK, to be between 5,000/m and 40,000/m

depending on time since a successful spatfall. Furthermore, *Limecola balthica* may make seasonal migrations in response to environmental conditions. Beukema & De Vlas (1979) reported that 30% of the *Limecola balthica* population migrated into the subtidal during winter apparently in response to low temperatures. Migration was achieved by burrowing (Bonsdorff, 1984; Guenther, 1991) and/or floating (Sörlin, 1988).

One of the key factors affecting benthic habitats is disturbance which, in shallow subtidal habitats, may increase in winter due to adverse weather conditions. Storms may cause dramatic changes in distribution of infauna by washing out dominant species, opening the sediment to recolonization by adults and/or available spat/larvae (Eagle, 1975; Rees *et al.*, 1977; Hall, 1994) and by reducing success of recruitment by newly settled spat or larvae (see Hall, 1994 for review).

Habitat structure and complexity

- The muddy sand / mud substratum of the biotope has little structural diversity provided by either physiographic features or the biota. Some 3-dimensional structure is provided by the burrows of infauna e.g. *Nephtys hombergii*, whilst *Lagis koreni* builds itself a rigid tube of sand grains which lies either diagonally or nearly upright in the sediment (Fish & Fish, 1996). Most species living within the sediment are limited to the area above the anoxic layer, the depth of which will vary depending on sediment particle size and organic content. However, the presence of burrows allows a larger surface area of sediment to become oxygenated, and thus enhances the survival of a considerable variety of small species (Pearson & Rosenberg, 1978).

- Reworking of sediments by deposit feeders increases bioturbation and potentially causes a change in the substratum characteristics and the associated community (e.g. Rhoads & Young, 1970). For example, Widdows *et al*. (1998) reported that typical abundances (ca 100 - 1000 per m²) of *Limecola balthica* increased sediment re-suspension and/or erodability four fold and that there was a significant positive correlation between density of the species and sediment resuspension.

  Productivity

  Macroalgae are absent from IMS.MacAbr and consequently productivity is mostly secondary derived from detritus and organic material, although shallower sites may develop an extensive growth of benthic diatoms in the summer. Allochthonous organic material may be derived from anthropogenic activity (e.g. sewerage) and natural sources (e.g. plankton, detritus). Autochthonous organic material is formed by benthic microalgae (microphytobenthos e.g. diatoms and euglenoids) and heterotrophic micro-organism production. Organic material is degraded by micro-organisms and the nutrients recycled. The high surface area of fine particles provides substratum for the microflora.

  Recruitment processes

  Bivalve molluscs:
  - The bivalves which characterize the biotope are capable of high recruitment and rapid recovery. For example, adult *Limecola balthica* spawn at least once a year and are highly fecund (Caddy, 1967). 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). The exact time at which maturity was attained depended upon the size of the individual, but it seemed that a minimum shell length of between 7-9 mm was typical (Nott, 1980). Normally, for *Abra alba* there two distinct spawning periods, in July and September and according to the season of settlement, individuals differ in terms of growth and potential lifespan (Dauvin & Gentil, 1989). Autumn settled individuals from the Bay of Morlaix, France, initially showed no significant growth; they were not collected on a 1 mm mesh sieve until April, 5 to 7 months after settlement. Such individuals were expected to have a maximum lifespan of 21 months and could produce two spawnings. In contrast, veliger larvae that settled during the summer grew very rapidly and were collected on a 1 mm mesh sieve just one month after settlement. They lived about one year and spawned only once (Dauvin & Gentil, 1989).

- Recruitment in bivalve molluscs is influenced by larval and post-settlement mortality. Typically bivalves are fecund and egg production increases with female size, however, the high potential population increase is offset by high larval and juvenile mortality, but, juvenile mortality rapidly decreases with age (Brousseau, 1978b; Strasser, 1999). Larval mortality results from predation during pelagic stages, predation from suspension feeding macrofauna (including conspecific adults) during settlement and from deposition in unsuitable habitats. Mortality of the juveniles of marine benthic invertebrates can exceed 30% in the first day, and several studies report 90% mortality (Gosselin & Qian, 1997). 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.
  For specific information concerning the reproduction and longevity of *Limecola balthica*, *Abra alba*, *Fabulina fabula* and *Mya arenaria*, refer to *MarLIN* reviews for these species.

Polychaete worms:
- *Lagis koreni* has separate sexes and breeding occurs during spring and summer. The larvae have a planktonic life of about one month and total length of life is thought to be about one year. The worms breed once then die (Fish & Fish, 1996).
- *Nephtys hombergii* matures between two and three years of age and breeds during April and May. The worms remain in situ within the sediment during spawning and eggs and sperm are released on to the surface of the sediment, fertilization occurs when gametes are mixed by the incoming tide or by water currents. Larval development occurs within the plankton. *Nephtys hombergii* may live for up to six years (Fish & Fish, 1996).

Crustaceans:
- The brown shrimp, *Crangon crangon*, reaches maturity after 1-2 years and the sexes are believed to be separate, although there are suggestions that the species is a protandrous hermaphrodite. Once hatched the larval life lasts for five weeks. A typical lifespan is three years and during that time a female may produce over 30,000 eggs (Fish & Fish, 1996).

Echinoderms:
- Subtidal populations of *Echinocardium cordatum* are reported to reproduce sporadically. One population recruited in only three years over a ten year period (Buchanan, 1966). The species is fecund (> 1,000,000 eggs), breeds between spring and summer, with a lifespan of between 10 and 20 years.

Time for community to reach maturity

The life history characteristics of the species which characterize the biotope suggest that the biotope would recover from major perturbations and be recognisable as the biotope within 5 years. For instance, *Abra alba* and *Limecola balthica* demonstrate an 'r' type life-cycle strategy and are able to rapidly exploit any new or disturbed substratum available for colonization through larval recruitment, secondary settlement of post-metamorphosis juveniles or re-distribution of adults. Bonsdorff (1984) studied the recovery of a *Limecola balthica* population in a shallow, brackish bay in SW Finland following 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, 2 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 6 generations were identified, giving further evidence of active immigration to the dredged area. *Abra alba* recovered to former densities following loss of a population from Keil Bay owing to deoxygenation within 1.5 years, as did *Lagis koreni*, taking only one year (Arntz & Rumohr, 1986). Such evidence suggests that recoverability of the key functional and important characterizing species of the IMS.MacAbr biotope would be typically be high. However, the recovery of *Echinocardium cordatum* may take longer owing to recruitment that is frequently unsuccessful (Rees & Dare, 1993).

Additional information

No text entered.

🖼 Preferences & Distribution

Habitat preferences

Depth Range	5-10 m, 10-20 m
Water clarity preferences	Field Unresearched
Limiting Nutrients	Field unresearched
Salinity preferences	Full (30-40 psu), Variable (18-40 psu)
Physiographic preferences	
Biological zone preferences	Infralittoral
Substratum/habitat preferences	Sandy mud
Tidal strength preferences	Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered, Moderately exposed, Sheltered
Other preferences	organically enriched

Additional Information

No text entered.

🐾 Species composition

Species found especially in this biotope

Rare or scarce species associated with this biotope

-

Additional information

No text entered

Species composition

Species found especially in this biotope

Rare or scarce species associated with this biotope

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

Near-shore shallow sandy muds and muds, and sometimes mixed sediments, may be characterized by the presence of the polychaete *Nephtys hombergii* and the bivalve *Limecola balthica*. *Abra alba,* and *Nucula nitidosa* may also be important although they may not necessarily occur simultaneously or in high numbers. Other taxa include *Spiophanes bombyx, Lagis koreni,* and *Echinocardium cordatum.* In some areas *Scoloplos armiger* and *Crangon crangon* may also be present. The community appears to be quite stable (Dewarumez *et al.* 1992) and the substratum is typically rich in organic content. This community has been included in the 'Boreal Offshore Muddy Sand Association' of Jones (1950) and is also described by several other authors (Petersen 1918; Cabioch & Gla‡on 1975). A similar community may occur in deep water in the Baltic (Thorson 1957). This biotope may occur in slightly reduced salinity estuarine conditions where*Mya* sp. may become a significant member of the community (Thorson 1957).

Resilience and recovery rates of habitat

Streblospio shrubsolii and Tubificoides benedii are considered opportunistic species and exhibit shorter lifespans and faster growth rates. *Streblospio shrubsolii* displays a flexible life history and is viewed as an indicator species, where presence in abundance indicates stressed environments (Borja *et al.*, 2000).*Tubificoides benedii* is likely to rapidly increase in abundance in disturbed sediments and polluted conditions (Gray *et al.*, 1990, Borja *et al.*, 2000, Gogina *et al.*, 2010).

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). *Nephtys hombergii* has a 3-10 year lifespan, and reaches maturity at 1-2 years and these traits suggest the species is likely to require longer to recover than more opportunistic (shorter lifespan, earlier age at maturity).

In general, recovery of sandy mud biotopes is dependent on the return of suitable sediment and recruitment of individuals. When sandy mud assemblages are disturbed, recruitment comes from a combination of adult migration and larval immigration with larval importance increasing with the size of the spatial footprint. Overall recovery will vary according to site-specific factors including hydrographic regime and sediment supply. Once suitable substratum returns, initial recolonization is likely to be rapid, especially for rapidly reproducing species such as polychaetes, oligochaetes and some amphipods and bivalves. The important characterizing species, *Limecola balthica* and *Nephtys hombergii* have lifespans of 3-10 years, exhibit generation times of 1-2 years and reach maturity at 1-2 years. Hence recovery is

probably approximately 2 years (High resilience) but full population recovery, following large scale removal of a population may take >2 years (resilience is Medium).

Recovery of the opportunistic species characterizing the biotope is likely to occur within months in the case of *Streblospio shrubsolii and Tubificoides benedii*. It is important to consider that recovery times and so resilience will depend on presence of suitable habitat, typically higher mud content sediment and the opportunity for larvae to enter a region through larvae transport pathways.

Hydrological Pressures

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

Found from the northern Atlantic, from such areas as the Barents Sea, the Baltic and the North Sea, to the Mediterranean. *Nephtys hombergii* has been reported from as far south as South Africa, suggesting the species can tolerate temperatures above even a 5°C increase in UK and Irish coasts. Records are limited but Emery & Stevensen (1957) found that *Nephtys hombergii* could withstand summer temperatures of 30-35°C.

Environmental factors, such as temperature, day-length, and tidal or lunar cycles, have been implicated in the timing of spawning of Nephtyidae, in particular the spring tide phase of the lunar cycle (Bentley et al., 1984). In the Tyne Estuary spawning of *Nephtys hombergii* occurred in May and September, whilst in Southampton Water the species spawned throughout the year with peaks in July and November (Wilson, 1936; Oyenekan, 1986). In Århus Bay, Denmark, *Nephtys hombergii* spawned in August and September, but a decrease in the number of individuals bearing gametes in May and June suggested that at least part of the population spawned in early summer (Fallesen & Jørgensen, 1991). A 5°C increase in temp for one month period, or 2°C for one year is likely to impact timing of reproduction in these areas, although the combination of environmental factors appearing to influence timing (in particular spring tides) may limit the impact of changes in temperature on timing of spawning events.

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* (as *Macoma 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* (as *Limecola balthica*) from the Humber Estuary, UK, tolerated six hours of exposure to temperatures up to 37.5°C with no mortality. However, Barda *et al.* (2014) found that increased temperature reduced growth rates in populations in the Baltic Sea . 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 have 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. 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). It is likely that the species are able to resist a long-term increase in temperature of 2°C and may resist a short-term increase of 5°C. Resistance and resilience are therefore assessed as '**High**' and the biotope is judged as '**Not Sensitive**'.

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

Nephtys hombergii are found as far north as the Barents Sea, and would be expected to be resistant to a 5°C decrease in temp for one month period, or 2°C for one year. Environmental factors, such as temperature, day-length, and tidal or lunar cycles, have been implicated in the timing of spawning of the Nephtyidae, in particular the spring tide phase of the lunar cycle (Bentley *et al.*, 1984). Olive *et al.* (1997) found that relative spawning success in a North sea (Newcastle on Tyne) population of *Nephtys hombergii* was positively correlated with winter sea and air temperatures. This suggests a 5°C decrease in temp for a one month period, occurring in winter, or 2°C for one year are likely to impact spawning success.

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 tolerate much lower temperatures than it experiences in Britain and Ireland. Furthermore, *Limecola balthica* was apparently unaffected by the severe winter of 1962/3 which decimated populations of many other bivalve species (Crisp, 1964), and De Wilde (1975) noted that *Limecola balthica* (as *Macoma balthica*) kept at 0°C maintained a high level of feeding activity. It is unlikely, therefore, that in seas around the UK and Ireland *Limecola balthica* would be intolerant of decreases in temperature at the benchmark level.

Sensitivity assessment Typical surface water temperatures around the UK coast vary, seasonally from 4-19°C (Huthnance, 2010). *Streblospio shrubsolii* and *Nephtys hombergii* are likely to be able to resist a long-term decrease in temperature of 2°C and may resist a short-term decrease of 5°C. Temperature may act as a spawning cue and an acute or chronic decrease may result in some delay in spawning, however this is not considered to impact the adult population and may be compensated by later spawning events. Resistance and resilience are therefore assessed as '**High**' and the biotope judged as '**Not Sensitive**'.

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

This biotope occurs on the mid and lower shore of sheltered estuaries, with salinities within the MNCR categories of reduced (18-30ppt) to variable (18-35 ppt) (Connor *et*

al., 2004; Hiscock *ed* 1996). Maximum salinity would be expected to be approximately 18-35‰. An increase of one MNCR salinity category would be to fully marine 30-40 ‰. Environmental fluctuations in salinity are only likely to affect the surface of the sediment, and not deeper buried organisms, since the interstitial or burrow water is less affected. However, under longer term or permanent increase in salinity, sediment waters would be expected to also adjust.

Nephtys hombergii is considered to be a brackish water species (Barnes, 1994) but where the species occurs in open coastal locations the species would have to tolerate salinities of 25 psu and above. Within a few months of the closure of a dam across the Krammer-Volkerak estuary in the Netherlands, Wolff (1971) observed that species with pelagic larvae or a free-swimming phase, expanded rapidly with a concomitant increase of salinity to 9-15 psu everywhere. Prior to the closure of the dam the estuary demonstrated characteristics of a typical 'salt-wedge' estuary with a salinity gradient from 0.3 to 15 psu. Hence, *Nephtys hombergii* is likely to survive increases in salinity within estuarine environments. In fully marine locations *Nephtys hombergii* may still be found but, may be competitively inferior to other species of Nephtyidae (e.g. *Nephtys ciliata* and *Nephtys hystricis*) and occur in lower densities. An increase to fully marine (30-40 ‰) would therefore be likely to lead to a reduction in density of *Nephtys hombergii*.

Streblospio shrubsolii occurred in subtidal areas of the Thames estuary as well as intertidal flats, suggesting the species is resistant to higher salinities than the 'variable' levels occurring higher in estuaries (Attrill, 1998). Likewise *Tubificoides benedii* has been recorded in high abundance in offshore areas of the North Sea (Gray *et al.*, 1990). Although evidence was limited on response of these species to rapid increases in salinity it is likely they would be resistant to an increase to the fully marine category (30-40 ‰). Conde *et al.* (2013) found that *Streblospio shrubsolii* were a dominant species in low salinity, estuarine conditions (5-9‰) in the Tagus estuary, Portugal. In Ria de Averio, western Portugal, *Streblospio shrubsolii* and *Tubificoides benedii* were characterizing species of communities in estuarine sample sites further upstream with lower salinity, suggesting a high resistance to a decrease in salinity (Rodrigues *et al.*, 2011). *Streblospio shrubsolii* occurred in subtidal areas of the Thames estuary as well as intertidal flats, suggesting the species is resistant to higher salinities than the 'variable' levels occurring higher in estuaries (Attrill, 1998). Likewise *Tubificoides benedii* has been recorded in high abundance in offshore areas of the North Sea (Gray *et al.*, 1990). Although evidence was limited on response of these species to rapid increases in salinity it is likely they would be resistant to an increase to the fully marine category (30-40 ‰).

Limecola balthica is found in brackish and fully saline waters but is more common in brackish waters (Clay, 1967b) so may tolerate a state of flux. Seitz (2011) found *Limecola balthica* (as *Macoma balthica*) distribution across a salinity gradient between a minimum and maximum of 8.8psu to 19 psu in Cheaspeake Bay was not influenced by salinity. Instead, resource availability was the principal influence on *Limecola balthica* at a broad scale, suggesting changes in one MNCR salinity category would have limited impact. McLusky & Allan (1976) reported that *Limecola balthica* (as *Macoma balthica*) failed to grow at 41 psu. It is likely that *Limecola balthica* would be tolerant of an increase in salinity category to fully marine but further increases to >40‰ are likely to affect growth and condition.

Sensitivity assessment. *Nephtys hombergii* are likely to decrease in abundance and *Limecola balthica* growth rates are liekly to reduce at highest salinities. Resistance is assessed as **'Low'**, resilience '**Medium**' and sensitivity as '**Medium**'. Increase in salintiy is likely to lead to changes to the biotope LS.LMu.MEst.HedLim As the associated HedLim communities occur further down estuaries towards the open coast, in more saline conditions. The infauna in LS.LMu.MEst.HedLim is similar, though the ragworm *Hediste diversicolor* is always abundant, and both *Nephtys hombergii* and *Streblospio shrubsolii* are often absent. The bivalve assemblage tends to be more diverse LS.LMu.MEst.HedLim (Conner *et al.*, 2004).

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

This biotope occurs on the mid and lower shore of sheltered estuaries, with salinities within the MNCR categories of reduced (18-30ppt) to variable (18-35 ppt) (Connor *et al.*, 2004; Hiscock *ed* 1996). Maximum salinity would be expected to be approximately 18-35‰. A decrease of one MNCR salinity category would be to 'Low' category <18‰.

Environmental fluctuations in salinity are only likely to affect the surface of the sediment, and not deeper buried organisms, since the interstitial or burrow water is less affected. However, under longer term or permanent increase in salinity, sediment waters would be expected to also adjust.

Nephtys hombergii is considered to be a brackish water species, and has been reported to extend in to estuarine locations where salinity is less than 18 psu (Barnes, 1994). Clark & Haderlie (1960) found *Nephtys hombergii* in the Bristol Channel at salinities between 15.9 psu and 25.1 psu. If the salinity were to become intolerable to the polychaete it is likely that as a mobile species, able to both swim and burrow, *Nephtys hombergii* would avoid the change in salinity by moving away and localized densities would decline.

Conde *et al.* (2013) found that *Streblospio shrubsolii* were a dominant species in low salinity, estuarine conditions (5-9‰) in the Tagus estuary, Portugal. In Ria de Averio, western Portugal *Streblospio shrubsolii and Tubificoides benedii* were characterizing species of communities in estuarine sample sites further upstream with lower salinity, suggesting a high resistance to a decrease in salinity (Rodrigues *et al.*, 2011).

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 animals 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 very tolerant to a 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, return quickly 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.).

Sensitivity assessment. The characterizing species within the biotope occupy between 'variable' and 'fully marine' category salinities and can tolerate greater osmotic stress for short periods, caused by decreases in salinity below 18⑀/⑀⑀ (the upper limit for 'reduced' category salinity). Resistance to this decrease in salinity from variable to low is probably '**Low**', so that resilience is also '**High**' (following habitat restoration) and the biotope is assessed as having 'Low' sensitivity at the benchmark level.

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

The biotope occurs in weak tidal streams (JNCC comparative tables) suggesting the species characterizing the biotope can adapt to a range of tidal currents, aided by each species burrowing traits.

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

Increased water flow rates is likely to change the sediment characteristics in which the species live, primarily by re-suspending and preventing deposition of finer particles (Hiscock, 1983). The characterizing species prefer habitats with silty/muddy substrata which would not occur in very strong tidal streams. Coarser sediments are likely to remain in areas of strongest flow velocity (where finer particles have been re-suspended) (Coates *et al.*, 2014). Species such as *Tubificoides benedii* and other opportunist polychaetes that tolerate coarser particle size will possibly increase in abundance.

Additionally, the consequent lack of deposition of particulate matter at the sediment surface would reduce food availability. Decreased water movement would result in increased deposition of suspended sediment (Hiscock, 1983). An increased rate of siltation resulting from a decrease in water flow may result in an increase in food availability for the characterizing species and therefore growth and reproduction may be enhanced, but only if food was previously limiting.

Limecola balthica is likely to experience greater impact from increased water flow as the species thrives in low energy environments, such as estuaries that characterize the biotope (Tebble, 1976). *Limecola balthica* also shows preference for substratum that has a high proportion of fine sediment (Budd & Rayment, 2001). Increased water

flow rate is likely to change the sediment characteristics in this biotope, primarily by re-suspending and preventing deposition of finer particles (Hiscock, 1983). This would result in erosion of the preferred habitat, which may cause mortality of some portion of the population of *Limecola balthica*. Higher current velocity (0.18 m/s) recorded in flume experiments conducted in the Isle of Sylt (North Sea) led to juvenile *Limecola balthica* being washed out of the sediment (Zuhlke & Reise, 1994). Green (1968) recorded that towards the mouth of an estuary where sediments became coarser and cleaner, *Limecola balthica* was replaced by another tellin species, *Tellina tenuis*.

Sensitivity assessment. A decrease in water flow may result in accretion of fine sand, and, thereby, a change to muddy sand and mud. As the biotope occurs in association with muddy sand or fine sand a decrease in water flow is unlikely to impact the biotope (although under an excessive deposition of mud or silt, mud communities, e.g. HedLim, or UEst.Tben may replace the biotope, but this is unlikely at the benchmark levels).

Finer sediment has a predicted threshold velocity (flow velocity at which fine grain size sediment would be picked up from the sea bed) of ~0.05 m/s (Gray and Elliott, 2009), therefore an increase of 0.1-0.2 m/s may cause a significant change in grain size of sediments. Although Resistance is '**None'** if cases occurred where *Limecola balthica* were replaced by another tellin species and the biotope would be altered, Resistance is '**Low'**, Resilience is '**High'**. The resulting sensitivity score is '**Low**' given the potential scenario that an increase in peak mean spring bed flow velocity of between 0.1m/s to 0.2m/s for more than 1 year may result in a characterizing species, *Limecola balthica* being replaced by another species.

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

Not relevant to sublittoral biotopes.

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

Nephtys hombergii lives infaunally but may sometimes partially emerge to seek and capture food but does not present a significant surface area to wave action to sustain physical damage. Clark & Haderlie (1960) and Clark, Alder & McIntyre (1962) suggested that strong wave action limited the distribution of *Nephtys hombergii*. Increased wave action for long durations (e.g. 1 year) may ultimately change the nature of the substratum that the polychaete inhabits and its distribution may consequently alter.

Limecola balthica occurs in the upper regions of the intertidal (Tebble, 1976) and is therefore likely to be tolerant of prolonged emergence. It is a bivalve and can close tightly by contraction of the adductor muscle, storing moisture inside the shell. The silty sediments in which the species lives have a high water content and are therefore resistant to desiccation. Furthermore, *Limecola balthica* is mobile and able to relocate in the intertidal by burrowing (Bonsdorff, 1984) or floating (Sörlin, 1988). It would be

expected to react to an increase in emergence by migrating down the shore to its preferred position. There may be an energetic cost to this migration but it is not expected that mortality would result. *Limecola balthica* should quickly recover from the energetic cost of relocation.

Limited zoobenthic biomass has been recorded in areas exposed to strong currents and wave action (Beukema, 2002), limiting food availability to species such as *Nephtys hombergii*, however impacts from this pressure at the benchmark levels may be low for this biotope, as the biotope is limited to sheltered locations. Increases in wave action may therefore remain within the limits of the species tolerance but factors such as sediment redistribution may alter the physical biotope.

Sensitivity assessment. Resistance to a change in nearshore significant wave height >3% but <5% of the main characterizing species *Nephtys hombergii*, and *Limecola balthica* is 'High', given that the biotope occurs in very sheltered locations and an increase in nearshore significant wave height of >3% but <5% would continue to result in sheltered conditions which are within the species tolerance limits. At the highest benchmark pressure (5% increase) the species exhibit '**High**' resistance through their traits to live in the sediment. Resilience (recoverability) is also '**High**' giving a Sensitivity of '**Not Sensitive**'. Due to limited evidence, confidence in this assessment is Low and the potential for long-term changes to the substratum following continued increase in wave action should be considered.

⚗ Chemical Pressures

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

The biotope is likely to be '**not sensitive'** at the pressure benchmark that assumes compliance with all relevant environmental protection standards. Although contamination at levels greater than the pressure benchmark may adversely affect the biotope.

The characterizing species display some resistance to heavy metal concentration. *Aphelochaeta marioni* is tolerant of heavy metal contamination occurring in the heavily polluted Restronguet Creek , Falmouth, UK (Bryan & Gibbs, 1983) and it is also an accumulator of arsenic (Gibbs *et al.*, 1983). *Nephtys hombergii* is also recorded in Restronguet Creek.

The levels of Cu, Zn, As and Sn in the sediments of Restronguet Creek are highly contaminated, in the order of 1500-3500 µg/g (Bryan & Gibbs, 1983). Concentrations of dissolved Zn typically range from 100-2000 µ g/l, Cu from 10-100 µg/l and Cd from 0.25-5.0 µg/l (Bryan & Gibbs, 1983). Analyses of organisms from Restronguet Creek revealed that some species contained abnormally high concentrations of heavy metals. *Nephtys hombergii* from the middle and lower reaches of the creek contained appreciably higher concentrations of Cu (2227 µg/g dry wt), Fe and Zn than comparable specimens of *Hediste diversicolor* (as *Nereis diversicolor*). However, amongst polychaetes within the creek, there was evidence that some metals were

regulated. In *Nephtys hombergii* 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). Bryan & Gibbs (1983) suggested that since the area had been heavily contaminated with metals for > 200 years, there had been adequate time for metal-resistant populations to develop especially for relatively mobile species.

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.

1 year after the spill contributed to much greater impact upon the habitat than that caused by the initial spill. Effects are likely to be prolonged as hydrocarbons incorporated within the sediment by bioturbation will remain for a long time owing to slow degradation under anoxic conditions. Oil covering the surface and within the sediment would prevent oxygen transport to the infauna and promote anoxia as the infauna utilise oxygen during respiration. Although *Nephtys hombergii* is relatively tolerant of hypoxia and periods of anoxia, a prolonged absence of oxygen would probably result in the death of it and other infauna.

McLusky (1982) found that petrochemical effluents, including organic solvents and ammonium salts, released from a point source to an estuarine intertidal mudflat of the Forth Estuary, Scotland, caused severe pollution in the immediate vicinity. Beyond 500 m distance the effluent contributed to an enrichment of the fauna in terms of abundance and biomass similar to that reported by Pearson & Rosenberg (1978) for organic pollution; *Nephtys hombergii* was found in the area with maximum abundance of species and highest total biomass at 500 m from the discharge. It seems likely that significant hydrocarbon contamination would kill affected populations of the species. On return to prior conditions recolonization is likely via adult migration and larval settlement.

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.

No evidence concerning the specific effects of chemical contaminants on *Nephtys hombergii* was found. 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. Specific effects of synthetic chemicals have been reported for other species of polychaete. Exposure of *Hediste diversicolor* and *Arenicola marina* to Ivermecten resulted in significant mortality (Collier & Pinn, 1998).

At concentrations of 1-3 µg/l of TBT there was no significant effects on the

abundance of *Hediste diversicolor* after 9 weeks in a microcosm. However, no juvenile polychaetes were retrieved from the substratum suggesting that TBT had an effect on the larval and/or juvenile stages of these polychaetes, effects may therefore also be present on juveniles of characterizing species of this biotope.

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

Insufficient information was available in relation to characterizing species to assess this pressure. Limited evidence is available on species with similar traits. Beasley & Fowler (1976) and Germain et al., (1984) examined the accumulation and transfers of radionuclides in *Hediste diversicolor* from sediments contaminated with americium and plutonium derived from nuclear weapons testing and the release of liquid effluent from a nuclear processing plant. Both concluded that the uptake of radionuclides by *Hediste diversicolor* was small. Beasley & Fowler (1976) found *that Hediste diversicolor* accumulated only 0.05% of the concentration of radionuclides found in the sediment. Both also considered that the predominant contamination pathway for *Hediste diversicolor* was from the interstitial water.

Sensitivity assessment: There is insufficient information available on the biological effects of radionuclides to comment further upon the intolerance of characterizing species to radionuclide contamination. Assessment is given as **'No Evidence'**

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

This pressure is **Not assessed**.

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

Nephtys hombergii inhabits intertidal areas where resistance to low oxygen is needed and sulphide levels can reach up to 1mM (Giere, 1992; Thierman, 1996). As with other characterizing polychaete species *Nephtys hombergii* exhibits the ability to switch from aerobic to anerobic respiration, which provides some protection from the toxic effects of sulphide.

Nephtys hombergii has adapted to such conditions by utilising several strategies. Arndt & Schiedek (1997) found *Nephtys hombergii* to have a remarkably high content of phosphagen (phosphoglycocyamine), which is the primary energy source during periods of environmental stress. With increasing hypoxia, energy is also provided via anaerobic glycolysis, with strombine as the main end-product. Energy production via the succinate pathway becomes important only under severe hypoxia, suggesting a biphasic response to low oxygen conditions which probably is related to the polychaete's mode of life. The presence of sulphide resulted in a higher anaerobic energy flux and a more pronounced energy production via glycolysis than in anoxia alone. Nevertheless, after sulphide exposure under anaerobic conditions of <24 h, Arndt & Schiedek (1997) observed *Nephtys hombergii* to recover completely. Although *Nephtys hombergii* appears to be well adapted to a habitat with short-term

fluctuations in oxygen and appearance of hydrogen sulphide, its high energy demand as a predator renders it likely to limit its survival in an environment with longer lasting anoxia and concomitant sulphide exposure. For instance, Fallesen & Jørgensen (1991) recorded *Nephtys hombergii* in localities in Århus Bay, Denmark, where oxygen concentrations were permanently or regularly low, but in the late summer of 1982 a severe oxygen deficiency killed populations of Nephtys species (*Nephtys hombergii* and *Nephtys ciliata*) in the lower part of the bay. However, *Nephtys hombergii* recolonized the affected area by the end of autumn the same year. Alheit (1978) reported a LC50 at 8°C of 23 days for *Nephtys hombergii* maintained under anaerobic conditions.

Nephtys hombergii have tolerated extreme hypoxia, leaving the sediment only after 11 days (Nilsson & Rosenberg, 1994). *Nephtys hombergii* in artificially created anoxic conditions were shown to survive for at least 5d (Schöttler, 1982) and do not switch from aerobic to anerobic metabolic pathways until oxygen saturation decreases <12% (Schöttler, 1982).

Streblospio shrubsolii characteristic species communities in polluted environments (Cooksey & Hyland, 2007) and in Ria de Averio, western Portugal *Streblospio shrubsolii and Tubificoides benedii* were characterizing species of communities in estuarine sample sites further upstream where exposure to dissolved oxygen concentration was likely to be lowest (Rodrigues *et al.*, 2011).

Sensitivity assessment. The characterizing species are adapted to intertidal areas where resistance to low dissolved oxygen concentration is required and therefore resistance is assessed as '**High**' and resilience as '**High**' and the biotope is assessed as '**Not sensitive**' at the pressure benchmark level.

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

The biotope is likely to be **not sensitive** to the pressure at the benchmark levels, however evidence was available on responses to further reductions in water quality.

Nephtys hombergii showed resistance to increased pollution in studies along the Spanish Catalan coast. Changes in species composition parallel to the shoreline showed greatest abundance of *Nephtys hombergii* occurred at sample sites closer to water sewage discharges and river outflow (in comparison to non-polluted sites) (Cardell *et al.*, 1999). For the entire species communities, these sites contained greater biomass but reduced species diversity suggesting *Nephtys hombergii* was amongst a small number of species that could exploit these conditions. *Nephtys hombergii* lives infaunally between a depth of 5 and 15 cm where light is not transmitted. An increase in turbidity, associated with is unlikely to have a detectable effect on the viability of the species.

Streblospio shrubsolii occurred amongst other pollution tolerant species including the polychaetes *Capitella capitata*, *Polydora ciliata*, and *Manayunkia aestuarina* and the oligochaetes *Peloscolex benendeni* and *Tubifex pseudogaste* in the Tees estuary during periods of gross pollution in 1971-1973 (Gray, 1976).

Sensitivity assessment. The characterizing species show **High** resistance to increased pollution and turbidity, resilience is therefore also **High,** and the biotope is assessed as **'Not sensitive'.**

Organic enrichment

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

The infaunal habit of *Nephtys hombergii* and its ability to burrow relatively rapidly through, and into the substratum are likely to aid the species in its avoidance of unsuitable conditions. *Nephtys spp.* were present in organically enriched sediments along the Catalan Spanish coast (Cardell *et al.,* 1999) suggesting the species is likely to be resistant to some organic enrichment.

In Ria de Averio, western Portugal *Streblospio shrubsolii and Tubificoides benedii* were characterizing species of communities further upstream in estuarine sample sites, at sites with increased organic matter (Rodrigues *et al.*, 2011). *Streblospio shrubsolii* are also considered characteristic species communities in polluted environments, suggesting the species is likely to be resistant to increased organic enrichment (Cooksey & Hyland, 2007).

Sensitivity assessment. The characterizing species show **High** resistance to increased organic enrichment, resilience is therefore also **High,** and the biotope is assessed as **'Not sensitive'.**

⚓ Physical Pressures

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

This biotope is only found in sediment, in particular sandy mud and the burrowing organisms, *Nephtys hombergii* and *Limecola balthica*, would not be able to survive if the substratum type was changed to either a soft rock or hard artificial type. Consequently, the biotope would be lost altogether if such a change occurred.

Sensitivity assessment. 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 sediment type)	Low	Very Low	High
	Q: Medium A: Medium C: Medium	Q: High A: High C: High	Q: Medium A: Medium C: Medium

At the pressure benchmark a change in one Folk class refers to a change in classification to adjacent categories in the modified Folk triangle (Long, 2006). For this biotope three adjacent categories are relevant, these include a change from sandy mud to i) muddy sand, mud or ii) gravelly mud or a change from sand to iii) gravelly sand (Folk 1954; cited in Long 2006).

High densities of *Nephtys hombergii* were found in substrata of 0.3% particles >0.25mm and 5.8% <0.125mm in diameter but the worm tolerated up to 3.8% 0.25mm and 2.2-15.9% <0.125mm (Clark et al.,1962). *Nephtys hombergii* may be found in higher densities in muddy environments and this tends to isolate it from *Nephtys cirrosa*, which is characteristic of cleaner, fairly coarse sand. An increase in gravel content, although tolerated by *Nephtys hombergii* may lead to increased abundance of *Nephtys cirrosa* and decreased abundance of *Nephtys hombergii*. Degraer *et al.* (2006) summarise that the higher the medium grain size of the sediment the lower the relative occurrence of *Nephtys hombergii* and in gain sizes over 0.5mm the species was absent in the Belgium part of the North Sea.

Sensitivity assessment. Characterizing species are resistant to increases in mud content although changes in lower salinity regions may lead to changes to the biotope . Increase in gravel content may have a greater impact on the biotope and lead to replacement of *Nephtys hombergii* by *Nephtys cirrosa*, which is characteristic of cleaner, fairly coarse sand. Resistance is assessed as '**Low'**, resilience as **Very low** (the pressure is a permanent change) and sensitivity is assessed as **High**.

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

The substratum of this biotope consists of soft wet mud with a fine sand fraction (Conner *et al.*, 2004). The characterizing species burrow into the sediment, or tunnel to depths not exceeding 30cm. 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 soft wet mud with a fine sand fraction.

The characterizing species *Nephtys hombergii* and *Limecola balthica* burrow into the sediment, to depths not exceeding 30cm. 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 fine sand and muddy sand sediments with scattered pebbles, boulders and cobbles. Recovery of benthic infauna communities from an impact such as extraction of substratum (from activities such as use of bottom towed fishing gears, aggregate dredging or storm impacts) is predicted to follow succession from initial colonization community of opportunistic species that reproduce rapidly, have small body sizes, short lifespans and early reproductive ages, through to a transitional community and finally an equilibrium community of slower growing, longer lived, larger species (Newell *et al.*, 1998).

Arenicola marina and *Limecola balthica* are more likely to occur in the late transitional and the equilibrium communities that rely on more stable sediments that have recovered from disturbance (Newell *et al.*, 1998). Therefore, even if hydrological conditions allow for re-establishment of fine sand and muddy sand, recovery times to an equilibrium community, from an impact such as dredging are predicted to be between 2-3 years minimum and often 5-10 years (Newell *et al.*, 1998).

Hiddink (2003) showed that the density of *Limecola balthica* (as *Macoma balthica*) was reduced in areas in the Wadden sea (Netherlands) that had experienced suction dredging for cockles, which removes the surface sediment, The disturbance to the sediment also appeared to leave the habitat less suitable for settlement of young *Limecola balthica* (Hiddink, 2003).

Smaller scale extraction of patches of substratum through activities such as bait digging may have impacts over finer spatial scales within the biotope. If the impact is not spread over a larger area the effects are likely to occur within the dug area. McLusky *et al.* (1983) found that *Arenicola marina* rapidly recolonize basins created by bait digging but populations were reduced in the dug mounds. *Limecola balthica* populations were unaffected suggesting the biotope would recover from this impact if it occurred over a limited spatial scale.

Sensitivity assessment. Resistance to the pressure is considered '**None'**, and resilience '**Very Low'** based on the loss of suitable substratum to support the community of the characterizing species. Sensitivity has been assessed as '**High'**. Although no specific evidence is described confidence in this assessment is '**High**', due to the incontrovertible nature of this pressure.

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

Damage to seabed surface features may occur due to human activities such as bottom towed fishing gear (trawling and dredging) and natural disturbance from storms.

Collie *et al.* (2000) identified that well established intertidal communities (such as this biotope) suffered the greatest impact from bottom towed 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). However, the burrowing and tunnelling traits of the characterizing species may provide some resistance to this pressure.Kaiser *et al.* (2001) carried out experimental hand raking, similar to that used in inter tidal 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 *Nephtys hombergii* displayed a negative effect on abundance as a result of fishing activities and mean response of infauna and epifauna communities to fishing activities was much more negative in mud and sand communities than other habitats. *Nephtys hombergii* abundance also significantly decreased in areas of the Solent, UK, where bait digging (primarily for *Nereis virens*)

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).

Aphelochaeta marioni, *Streblospio shrubsolii* and *Tubificoides benedii* rapidly colonise disturbed sediments, which will reduce recovery times. This was displayed by Biasi & Pacciardi (2008) in the Adriatic Sea, where polychaetes, including *Aphelochaeta* spp. were among the species dominating the areas disturbed by fishing activity (otter trawling).

Boat moorings were demonstrated to also impact species communities close to the mooring buoy in a case study in the Fal and Helford estuaries (south west UK). Coarser sediment was exposed close to mooring buoys, caused by suspension of fine sediments by movement of the chain (Latham *et al.*, 2012). However, fine sand and muddy sediments displayed the least influence from disturbance from moorings, suggesting a smaller impact to this biotope than other intertidal biotopes.

Scouring around wind farm and other renewable energy device bases has been shown to reveal coarser sediment close to bases and deposition of fine material in the direction of the dominant current.

Species poor communities were revealed in coarser material and higher densities of macrobenthic organisms occurred where finer sediment was deposited (further from the base) (Coates *et al.*, 2014). This process created a shift in macrobenthic communities around the wind farm tower (influenced by the direction fine material had settled) (Coates *et al.*, 2014).

Boat moorings were demonstrated to also impact species communities close to the mooring buoy in a case study in the Fal and Helford estuaries (south west UK). Coarser sediment was exposed close to mooring buoys, caused by suspension of fine sediments by movement of the chain (Latham *et al.*, 2012). However, fine sand and muddy sediments displayed the least influence from disturbance from moorings, suggesting a smaller impact to this biotope than other intertidal biotopes.

Sensitivity assessment. The biotope will be impacted if damage to seabed surface features is widespread, as, although, motile and opportunistic fauna, such as *Streblospio shrubsolii* and *Tubificoides benedii* may recover quickly *Nephtys hombergii* shows a greater negative impact (Collie *et al.*, 2000, Ferns *et al.*, 2000, Kaiser *et al.*, 2001). Resistance is assessed as '**Low**', Resilience is assessed as '**Medium**', providing a sensitivity assessment of '**Medium**'.

It is important to consider the extent and duration of the cause of abrasion. For instance, long-term change in distribution of sediment grain sizes may occur following continual trawling effort or around the base of a renewable energy device, this would alter the biotope within the footprint of the activity and sensitivity would therefore be greater.

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

Penetration and or disturbance of the substratum would result in similar, if not identical results as 'abrasion' or 'removal' of this biotope. As the characterizing species are burrowing species the impact from damage to the sub-surface sea bed would be greater than damage to the sea bed surface. Consequently the pressure has been given the same sensitivity assessment as removal.

Sensitivity assessment. Resistance of the biotope is assessed as '**Low**', although the significance of the impact for the biotope will depend on the spatial scale of the pressure footprint. Resilience is assessed as '**Low**', and sensitivity is assessed as '**High**'.

Changes in suspended solids (water clarity)	High	High	Not sensitive
	Q: Medium A: Medium C: Medium	Q: Medium A: Medium C: Medium	Q: Medium A: Medium C: Medium

This biotope is probably exposed to the high levels of suspended sediment characteristic of estuarine conditions. Therefore, the resident species are probably adapted to high suspended sediment levels.

Changes in light penetration or attenuation associated with this pressure are not relevant to *Nephtys hombergii* and *Limecola balthica* biotopes. As the species live in the sediment they are also likely to be adapted to increased suspended sediment (and turbidity). However, alterations in the availability of food or the energetic costs in obtaining food or changes in scour could either increase or decrease habitat suitability for characterizing species.

Increases in turbidity may reduce benthic diatom productivity and productivity of phytoplankton in the water column. Increased clarity, however, may increase primary production. In cases of increased turbidity impacts may be small for *Nephtys hombergii* as the species feeds on a range of prey in the sediment and reductions in phytoplankton may be mitigated but may liit prey resources.

An increase in suspended solids (inorganic or organic) may also increase food availability of deposit feeders if sediment containing meiofauna, bacteria or organic particles is transported in the water column. However, higher energetic expenditure to unclog the feeding apparatus may occur, which may alter habitat suitability.

An increase in food availability through either increased phytoplankton abundance (under increased water clarity) or increased food resources suspended in the water column (under increased turbidity) may enhance growth and reproduction of both suspension and deposit feeding species.

Sensitivity assessment Resistance is '**High**' as no significant negative effects are identified and potential benefits from increased food resources may occur, based on expert judgement, utilising evidence of species traits and distribution. Resilience is also '**High**' as no recovery is required under the likely impacts. Sensitivity of the biotope is therefore, assessed as '**Not Sensitive'**.

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

The biotope is located mainly in soft wet mud with a fine sand fraction, on the mid and lower shore of sheltered estuaries (Connor *et al.*, 2004). These locations would be likely to experience some redistribution of fine material during tidal cycles. Although the biotope occurs in sheltered locations some mixing from wave action may also be expected. The characterizing species *Nephtys hombergii* , *Aphelochaeta marioni* , *Streblospio shrubsolii* and *Tubificoides benedii* live in the sediment, to depths to 15cm and would be expected to be well adapted to these conditions.

Longer term deposition of fine material (e.g. continuous deposition) would be expected to lead to higher densities of macrobenthic organisms. For example, in the North Sea (Belgium) deposition of fine particle sediment, disturbed by scour around the base of a wind farm tower led to higher macrobenthic densities and created a shift in macrobenthic communities around the wind farm tower (influenced by the direction fine material had settled) (Coates *et al.*, 2014).

Within a Marine Biotic Index compiled by Borja *et al.* (2000) the characterizing species *Nephtys hombergii* is classified within 'Group II' which includes species that are indifferent to enrichment, *Streblospio shrubsolii is 'Group III'* which includes species that tolerate disturbance and excess organic content and *Tubificoides benedii* 'Group V' which tolerate high enrichment and polluted conditions. (*Aphelochaeta marioni* was not assessed).

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

Contamination, for example from hydrocarbons may be an added impact if deposited sediment has been carried from a source of pollution such as oil drilling sites. These impacts are considered in the 'pollution and other chemical changes' section.

Sensitivity assessment. As the exposure to the pressure is for a single discrete event resistance is assessed as '**High**', resilience is also '**High**' and sensitivity is assessed as '**Not Sensitive**'. Confidence in this assessment is lower as the assessment is based on traits of the species characterizing the biotope and the relevant direct case studies present examples where impacts are not from single discrete events.

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

Limited evidence was found on responses of characterizing species to a deposition of up to 30 cm of fine material. Evidence is therefore assessed for evidence of deposits of fine material from sources such as dredge waste spoil.

Bolam (2011) showed that *Streblospio shrubsolii* vertical migration capability was reduced by deposition of just 6 cm simulated dredged material. *Tubificoides benedii* showed good recovery following deposition of material.

Rosenberg (1977) found recruitment of benthic species was heavily reduced in the vicinity of a dredged area, suggesting the increased turbidity was likely to be responsible. Contamination, for example from hydrocarbons may be an added impact if deposited sediment has been carried from a source of pollution such as oil drilling sites (Gray *et al.*, 1990). These impacts are considered in the 'pollution and other chemical changes' section.

The characterizing species *Nephtys hombergii* is classified within AMBI 'Group II' which includes species that are indifferent to enrichment, *Streblospio shrubsolii* is 'Group III' which includes species that tolerate disturbance and excess organic content and *Tubificoides benedii* is 'Group V' which tolerate high enrichment and polluted conditions (*Aphelochaeta marioni* was not assessed) (Borja *et al.*, 2000).

Sensitivity assessment. Deposition of up to 30 cm of fine material is likely to provide different impacts for the different species characterizing the biotope. Behavioural traits suggest the characterizing species are resistant to this pressure as they are mobile within the sediment, although recruitment and survival of juveniles is likely to be impacted. Case studies show *Tubificoides benedii* are likely to be able to exploit the increased nutrient input and rapidly colonise the deposited sediment.

Opportunistic species are likely to colonise the biotope if heavy deposition of fine material occurs. The deposited sediment is likely to release large quantities of organic materials enhancing population density but with the risk that pre-impacted communities will shift to a different state (Coates *et al.*, 2014, Coates *et al.*, 2015). Recovery to pre-impact communities, given the pressure occurs as a single discrete event is likely to require succession through transitional communities before an equilibrium community is reached, taking up to 10 years (Newell *et al.*, 1998).

Resistance is assessed as **'Medium'** as recruitment and survivability of juveniles of characterizing species may be impacted. Resilience is assessed as '**Medium**'. The final sensitivity is therefore, **'Medium'**.

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

No evidence was returned on the impact of litter on characterizing species for this biotope, although studies show impacts from ingestion of micro plastics by sub surface deposit feeding worms (*Arenicola marina)* and toxicants present in cigarette butts have been shown to impact the burrowing times and cause DNA damage in ragworms *Hediste diversicolor.*

Litter, in the form of cigarette butts has been shown to have an impact on Ragworms. *Hediste diversicolor* showed increased burrowing times, 30% weight loss and a >2 fold increase in DNA damage when exposed to water with toxicants (present in cigarette butts) in quantities 60 fold lower than reported from urban run-off (Wright *et al.*, 2015).Studies are limited on impacts of litter on infauna and this UK study suggests

health of infauna populations are negatively impacted by this pressure.

Studies of sediment dwelling, sub surface deposit feeding worms, a trait shared by species abundant in this biotope, showed negative impacts from ingestion of micro plastics. For instance, *Arenicola marina* ingests micro-plastics that are present within the sediment it feeds within. Wright *et al.* (2013) carried out a lab study that displayed presence of micro-plastics (5% UPVC) 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 colonisation of sediment by other species, reducing diversity in the biotopes the species occurs within.Wright *et al.* (2013) also present a case study based on their results, that in the intertidal regions of the Wadden Sea, where *Arenicola marina* is an important ecosystem engineer, *Arenicola marina* could ingest 33m⃞ of micro-plastics a year.

Sensitivtiy assessment. 'No evidence' was returned to complete a sensitivity assessment, however, both microplastics and the toxicants present in cigarette butts are likely to have negative impacts on the characterizing species.

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 was found on effects of electric and magnetic fields on the characterizing species.

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 species which are predators of many polychaete species including dab *Limanda limanda* and sole *Solea solea* 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 available to complete a sensitivity assessment, however, responses by flatfish and elasmobranchs suggest changes in predator behaviour are possible. There is currently no evidence but effects may occur

on predator prey dynamics as further marine renewable energy devices are deployed, these are likely to be over small spatial scales and not impact the biotope.

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

Species within the biotope can probably detect vibrations caused by noise and in response may retreat into the sediment for protection. However, at the benchmark level the community is unlikely to be sensitive to noise and this pressure is considered 'Not relevant'.

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

There is no direct evidence of effects of changes in incident light on the characterizing species of this biotope. All characterizing species live in the sediment and do not rely on light levels directly to feed or find prey so limited direct impact is expected. As this biotope is not characterized by the presence of primary producers it is not considered that shading would alter the character of the habitat directly.

More general changes to the productivity of the biotope may, however, occur. Beneath shading structures there may be changes in microphytobenthos abundance. Littoral muddy sands support microphytobenthos on the sediment surface and within the sediment. The microphytobenthos consists of unicellular eukaryotic algae and cyanobacteria that grow within the upper several millimetres of illuminated sediments, typically appearing only as a subtle brownish or greenish shading. Mucilaginous secretions produced by these algae may stabilise fine substrata (Tait & Dipper, 1998).

Shading will prevent photosynthesis leading to death or migration of sediment microalgae altering sediment cohesion and food supply to higher trophic levels. The impact of these indirect effects is difficult to quantify.

Sensitivity assessment. Based on the direct impact, biotope resistance is assessed as '**High**' and resilience is assessed as '**High**' (by default) and the biotope is considered to be '**Not sensitive**'.

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

Barriers that reduce the degree of tidal excursion may alter larval supply to suitable habitats from source populations. Barriers may also act as stepping stones for larval supply over greater distances (Adams *et al.*, 2014). Conversely, the presence of barriers at brackish waters may enhance local population supply by preventing the loss of larvae from enclosed habitats to environments, which are unfavourable, reducing settlement outside of the population. If a barrier (such as a tidal barrier) incorporated renewable energy devices such as tidal energy turbines, these devices may affect hydrodynamics and so migration pathways for larvae into and out of the biotope (Adams *et al.*, 2014). Evidence on this pressure is limited.

Sensitivity assessment. Resistance to this pressure is assessed as '**High**' and resilience as '**High**' by default. This biotope is therefore considered to be '**Not sensitive**'.

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

'**Not relevant'** to seabed habitats. NB. Collision by interaction with bottom towed fishing gears and moorings are addressed under 'surface abrasion'.

Visual disturbance	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	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.

🦬 Biological Pressures

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

The key characterizing species in the biotope are not cultivated or likely to be translocated. This pressure is therefore considered **Not Relevant**.

Introduction or spread of invasive non-indigenous species	Low	Very Low	High
	Q: High A: High C: High	Q: Low A: NR C: NR	Q: Low A: Low C: Low

Intertidal flats may be colonized by the invasivs non-indigenous species *Crepidula fornicata* and the pacific oyster *Crassostrea giga*s. 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 (OSPAR, 2009). Colonization of the upper shore by cord grass, *Spartina anglica,* may result in loss of characterizing biotopes. This species is not-strictly an invasive species as it is a fertile hybrid of between native and non-native

In the Wadden Sea, the Pacific oyster *Magallana gigas* has colonized intertidal flats (Smaal *et al*., 2005). This species may consume larvae including the pelagic larvae of *Cerastoderma edule* and *Limecola balthica* and other species reducing recruitment (Smaal *et al*., 2005). Troost *et al.* (2009) investigated whether *Magallana gigas* had a competitive feeding advantage over *Cerastoderma edule* and concluded that differences in feeding current characteristics were small and not considered to lead to significant differences in feeding efficiency. The most severe effects are likely to occur from impacts on sediment, where *Magallana gigas* create reefs on sedimentary flats that will prevent recruitment of juveniles and will restrict access of infauna to

the sediment-water interface impacting respiration and feeding.

The Manila clam (*Tapes philippinarium*), which was introduced to Poole Harbour for aquaculture in 1998, has become a naturalised population on the intertidal mudflats (occurring at densities of 60 clams/m^2 in some locations within the harbour (Jensen *et al.* 2007, cited in Caldow *et al.* 2007). Densities of *Cerastoderma edule* and *Abra tenuis* had increased since the introduction of the Manila clam although the abundance of *Scrobicularia plana* and *Limecola balthica* declined (Caldow *et al.*, 2005), although the decline of these species may have been caused by tri-butyl tin pollution (Langston et al. 2003) and may have facilitated the naturalization of the Manila clam.

The burrowing lifestyle of *Eteone longa* and other infaunal polychaetes may confer some protection from changes to the sediment surface and may provide some new habitat (as this species has been found among oyster banks).

The predatory veined whelk (*Rapana venosa*) and *Hemigrapsus takinei* are not established in the UK (although *Hemigrapsus takinei* has been recorded at two locations) and these species could become significant predators of bivalves and other invertebrates associated with the biotope in the future.

Sensitivity assessment. Intertidal mixed sediments may be exposed to invasive species which can alter the character of the habitat (primarily *Crepidula fornicata* at the sublittoral fringe and *Magallana gigas*) leading to re-classification of this biotope, the biotope is considered to have 'Low' resistance and 'Very Low' recovery (unless invasive species are removed). Biotope sensitivity is therefore assessed as 'High'.

Introduction of microbial pathogens	Medium	High	Low
	Q: High A: High C: Medium	Q: High A: Low C: Medium	Q: High A: Low C: Medium

No evidence for microbial pathogens on the characterizing polychaetes was found. *Limecola balthica* in Delaware Bay, north-east USA, was found to host *Perkinsus* genus pathogens *Perkinsus andrewsi* and *Perkinsus marinus* (Lindsay *et al.*, 2007). *Cerastoderma edule* has been reported to host approximately 50 viruses, bacteria and fungi, and including turbellaria, digeneans and cestodes (Longshaw & Malham, 2012).

Sensitivity assessment. Based on the evidence for the *Limecola balthica* and *Cerastoderma edule,* it is likely that parasitic infection may indirectly alter the species composition of the biotope. Although less evidence was retuned for the characterizing mollusc species *Limecola balthica,* similar impacts from introduction of pathogens are likely to be experienced for this species. Resistance is assessed as **'Medium**', Resilience as '**High'** and Sensitivity as **'Low'**.

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

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).

Hiddink (2003) found that the density of Limecola balthica (as *Macoma balthica*) was reduced in areas in the Wadden sea (Netherlands) that had experienced suction dredging for cockles, which removes the surface sediment, The disturbance to the sediment also appeared to leave the habitat less suitable for settlement of young *Limecola balthica* (Hiddink, 2003). This study provides evidence of loss of a characterizing species from the biotope and that recovery is unlikely to occur until the sediment characteristics have returned to pre-impact conditions. Removal of target species such as cockles *Cerastoderma edule* or bait digging for *Arenicola marina* is likely to impact the biotope. The extent of the impact will depend on the fishing / removal method and spatial extent.

Sensitivity assessment. Resistance is '**Low**' due to direct removal of a characterising species, that on commercial scales can remove a large proportion of the population (for instance, Neves de Carvalho *et al.*, 2013) calculated that bait digging activities in the Douro estuary, Portugal may remove up to 9.9 tonnes of *Hediste diversicolor*). Resilience is assessed as '**Medium**' as regions that are not regularly harvested may recover rapidly but continued harvesting will impact the population. Sensitivity is assessed as '**Medium**'. 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 imapcts.

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

Incidental removal of the characterizing species would alter the character of the biotope and the delivery of ecosystem services such as secondary production and bioturbation. Populations of characterizing species, such as *Nephtys hombergii* and *Limecola balthica* provide food for macroinvertebrates fish and birds so their removal could lead to wider ecological effects.

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

Bibliography

Aberkali, H.B. & Trueman, E.R., 1985. Effects of environmental stress on marine bivalve molluscs. *Advances in Marine Biology*, **22**, 101-198.

Ambrose, W.G. Jr., 1993. Effects of predation and disturbance by ophiuroids on soft-bottom community structure in Oslofjord: results of a mesocosm study. *Marine Ecology Progress Series*, **97**, 225-236.

Arntz, W.E. & Rumohr, H., 1986. Fluctuations of benthic macrofauna during succession and in an established community. *Meeresforschung*, **31**, 97-114.

Barnes, R.S.K. & Hughes, R.N., 1992. *An introduction to marine ecology*. Oxford: Blackwell Scientific Publications.

Beaumont, A.R., Newman, P.B., Mills, D.K., Waldock, M.J., Miller, D. & Waite, M.E., 1989. Sandy-substrate microcosm studies on tributyl tin (TBT) toxicity to marine organisms. *Scientia Marina*, **53**, 737-743.

Bergman, M.J.N. & Van Santbrink, J.W., 2000b. Fishing mortality of populations of megafauna in sandy sediments. In *The effects of fishing on non-target species and habitats* (ed. M.J. Kaiser & S.J de Groot), 49-68. Oxford: Blackwell Science.

Beukema, J.J. & De Vlas, J., 1979. Population parameters of the lugworm, *Arenicola marina*, living on tidal flats in the Dutch Wadden Sea. *Netherlands Journal of Sea Research*, **13**, 331-353.

Boisson, F., Hartl, M.G.J., Fowler, S.W. & Amiard-triquet, C., 1998. Influence of chronic exposure to silver and mercury in the field on the bioaccumulation potential of the bivalve *Macoma balthica*. *Marine Environmental Research*, **45**, 325-340.

Bonsdorff, E., 1984. Establishment, growth and dynamics of a *Macoma balthica* (L.) population. *Limnologica* (Berlin), **15**, 403-405.

Bonsdorff, E., Norrko, A. & Boström, C., 1995. Recruitment and population maintenance of the bivalve *Macoma balthica* (L.) - factors affecting settling success and early survival on shallow sandy bottoms. In *Proceedings of the 28th European Marine Biology Symposium. Biology and ecology of shallow coastal waters* (ed. A. Eleftheriou, A.D. Ansell and C.J. Smith). Olsen and Olsen.

Bradshaw, C., Veale, L.O., Hill, A.S. & Brand, A.R., 2000. The effects of scallop dredging on gravelly seabed communities. In: *Effects of fishing on non-target species and habitats* (ed. M.J. Kaiser & de S.J. Groot), pp. 83-104. Oxford: Blackwell Science.

Brafield, A.E. & Newell, G.E., 1961. The behaviour of *Macoma balthica* (L.). *Journal of the Marine Biological Association of the United Kingdom*, **41**, 81-87.

Brousseau, D.J., 1978b. Population dynamics of the soft-shell clam *Mya arenaria*. *Marine Biology*, **50**, 67-71.

Bryan, G.W. & Gibbs, P.E., 1991. Impact of low concentrations of tributyltin (TBT) on marine organisms: a review. In: *Metal ecotoxicology: concepts and applications* (ed. M.C. Newman & A.W. McIntosh), pp. 323-361. Boston: Lewis Publishers Inc.

Bryan, G.W., 1984. Pollution due to heavy metals and their compounds. In *Marine Ecology: A Comprehensive, Integrated Treatise on Life in the Oceans and Coastal Waters*, vol. 5. *Ocean Management*, part 3, (ed. O. Kinne), pp.1289-1431. New York: John Wiley & Sons.

Buchanan, J.B., 1966. The biology of *Echinocardium cordatum* (Echinodermata: Spatangoidea) from different habitats. *Journal of the Marine Biological Association of the United Kingdom*, **46**, 97-114.

Bull, K.R., Every, W.J., Freestone, P., Hall, J.R. & Osborn, D., 1983. Alkyl lead pollution and bird mortalities on the Mersey Estuary, UK. *Environmental Pollution (A)*, **31**, 239-259.

Cabioch, L. & Glaçon, R., 1975. Distribution des peuplements benthiques en Manche orientale, de la baie de Some au Pas-de-Calais. *Compte Rendu Hebdomadaire des Seances de l'Academie des Sciences. Paris*, **280**, 491-494.

Caddy, J.F., 1967. Maturation of gametes and spawning in *Macoma balthica* (L.). *Canadian Journal of Zoology*, **45**, 955-965.

Connor, D.W., Dalkin, M.J., Hill, T.O., Holt, R.H.F. & Sanderson, W.G., 1997a. Marine biotope classification for Britain and Ireland. Vol. 2. Sublittoral biotopes. *Joint Nature Conservation Committee, Peterborough, JNCC Report* no. 230, Version 97.06., *Joint Nature Conservation Committee, Peterborough, JNCC* Report no. 230, Version 97.06.

Crisp, D.J. (ed.), 1964. The effects of the severe winter of 1962-63 on marine life in Britain. *Journal of Animal Ecology*, **33**, 165-210.

Crompton, T.R., 1997. *Toxicants in the aqueous ecosystem*. New York: John Wiley & Sons.

Dauvin, J-C. & Gentil, F., 1989. Long-term changes in populations of subtidal bivalves (*Abra alba* and *Abra prismatica*) from the Bay of Morlaix (Western English Channel). *Marine Biology*, **103**, 63-73.

Davies, C.E. & Moss, D., 1998. European Union Nature Information System (EUNIS) Habitat Classification. *Report to European Topic Centre on Nature Conservation from the Institute of Terrestrial Ecology, Monks Wood, Cambridgeshire.* [Final draft with further revisions to marine habitats.], Brussels: European Environment Agency.

de Groot, S.J. & Apeldoorn, J., 1971. Some experiments on the influence of the beam trawl on the bottom fauna.

International Council for the Exploration of the Sea (CM Papers and Reports) CM 1971/B:2, 5 pp. (mimeo).

Dewarumez, J-M., Davoult, D., Anorve, L.E.S. & Frontier, S., 1992. is the 'muddy heterogenous sediment assemblage' an ecotone between the pebbles community and the *Abra alba* community in the Southern Bight of the north Sea? *Netherlands Journal of Sea Research*, **30**, 229-238.

Dries, R.R. & Theede, H., 1974. Sauerstoffmangelresistenz mariner Bodenvertebraten aus der West-lichen Ostsee. *Marine Biology*, **25**, 327-233.

Duineveld, G.C.A. & Jenness, M.I., 1984. Differences in growth rates of the sea urchin *Echinocardium cordatum* as estimated by the parameters of the von Bertalanffy equation applied to skeletal rings. *Marine Ecology Progress Series*, **19**, 64-72.

Elliot, M., Nedwell, S., Jones, N.V., Read, S.J., Cutts, N.D. & Hemingway, K.L., 1998. Intertidal sand and mudflats & subtidal mobile sandbanks (Vol. II). An overview of dynamic and sensitivity for conservation management of marine SACs. *Prepared by the Scottish Association for Marine Science for the UK Marine SACs Project.*

Emerson, C.W. & Grant, J., 1991. The control of soft-shell clam (*Mya arenaria*) recruitment on intertidal sandflats by bedload sediment transport. *Limnology and Oceanography*, **36**, 1288-1300.

Fish, J.D. & Fish, S., 1996. *A student's guide to the seashore.* Cambridge: Cambridge University Press.

Franzen, N.C.M., 1995. Shear wave detection by *Macoma balthica*.

Gilbert, M.A., 1978. Aspects of the reproductive cycle in *Macoma balthica* (Bivalvia). *The Nautilus*, **29**, 21-24.

Gosselin, L.A. & Qian, P., 1997. Juvenile mortality in benthic marine invertebrates. *Marine Ecology Progress Series*, **146**, 265-282.

Guenther, C.P., 1991. Settlement of *Macoma balthica* on an intertidal sandflat in the Wadden Sea. *Marine Ecology Progress Series*, **76**, 73-79.

Hall, S.J., 1994. Physical disturbance and marine benthic communities: life in unconsolidated sediments. *Oceanography and Marine Biology: an Annual Review*, **32**, 179-239.

Harvey, M. & Vincent, B., 1989. Spatial and temporal variations of the reproduction cycle and energy allocation of the bivalve *Macoma balthica* (L.) on a tidal flat. *Journal of Experimental Marine Biology and Ecology*, **129**, 199-217.

Hylland, K., Sköld, M., Gunnarsson, J.S. & Skei, J., 1996. Interactions between eutrophication and contaminants. IV. Effects on sediment-dwelling organisms. *Marine Pollution Bulletin*, **33**, 90-99.

JNCC, 2015. The Marine Habitat Classification for Britain and Ireland Version 15.03. (20/05/2015). Available from https://mhc.jncc.gov.uk/

JNCC, 2015. The Marine Habitat Classification for Britain and Ireland Version 15.03. (20/05/2015). Available from https://mhc.jncc.gov.uk/

JNCC (Joint Nature Conservation Committee), 1999. *Marine Environment Resource Mapping And Information Database (MERMAID): Marine Nature Conservation Review Survey Database.* [on-line] http://www.jncc.gov.uk/mermaid

Jones, N.S., 1950. Marine bottom communities. *Biological Reviews*, **25**, 283-313.

Jorgensen, B.B., 1980. Seasonal oxygen depletion in the bottom waters of a Danish fjord and its effect on the benthic community. *Oikos*, **32**, 68-76.

Kaiser, M.J. & Spencer, B.E., 1995. Survival of by-catch from a beam trawl. *Marine Ecology Progress Series*, **126**, 31-38.

Lin, J. & Hines, A.H., 1994. Effects of suspended food availability on the feeding mode and burial depth of the Baltic clam, *Macoma balthica*. *Oikos*, **69**, 28-36.

Lopez, G.R. & Levinton, J.S., 1987. Ecology of deposit-feeding animals in marine sediments. *Quarterly Review of Biology*, **62**, 235-260.

Luoma, S.N., Cain, D.J., Ho, K. & Hutchinson, A., 1983. Variable tolerance to copper in two species from San Francisco Bay. *Marine Environmental Research*, **10**, 209-222.

Møhlenberg, F. & Kiørboe, T., 1983. Burrowing and avoidance behaviour in marine organisms exposed to pesticide contaminated sediments. *Marine Pollution Bulletin*, **14**, 57-60.

Mackie, A.S.Y., Oliver, P.G. & Rees, E.I.S., 1995. Benthic biodiversity in the southern Irish Sea. *Studies in Marine Biodiversity and Systematics from the National Museum of Wales. BIOMOR Reports*, no. 1.

Mattila, J., 'Olafsson E.B. & Johansson A., 1990. Predation effects of *Crangon* on benthic infauna on shallow sandy bottoms - an experimental study from southern Sweden. In *Trophic relationships in the marine environment. Proceedings of the 24th European Marine Biological Symposium*, (ed. M. Barnes & R.N. Gibson), pp 503-516. Aberdeen: Aberdeen University Press.

McGreer, E.R., 1979. Sublethal effects of heavy metal contaminated sediments on the bivalve *Macoma balthica* (L.). *Marine Pollution Bulletin*, **10**, 259-262.

Nichols, F.H., 1977. Dynamics and production of *Pectinaria koreni* (Malmgren) in Kiel Bay, West Germany. In *Biology of benthic organisms*, (eds. B.F. Keegan, P. O'Ceidigh & P.J.S. Boaden), pp. 453-463.

Nicolaidou, A., 1983. Life history and productivity of *Pectinaria koreni* Malmgren (Polychaeta). *Estuarine, Coastal and Shelf Science*, **17**, 31-43.

Nicolaidou, A., 1988. Notes on the behaviour of *Pectinaria koreni. Journal of the Marine Biological Association of the United Kingdom*, **68**, 55-59.

Nott, P.L., 1980. Reproduction in *Abra alba* (Wood) and *Abra tenuis* (Montagu) (Tellinacea: Scrobiculariidae) *Journal of the Marine Biological Association of the United Kingdom*, **60**, 465-479.

Oertzen, J.A. Von., 1969. Erste Ergebrisse zur experimentellen ökologie von postglazialen Relikten (Bivalvia) der Ostsee. *Limnologica (Berlin)*, **7**, 129-137.

Pearson, T.H. & Rosenberg, R., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology: an Annual Review*, **16**, 229-311.

Petersen, C.G.J., 1918. The sea bottom and its production of fish food. A survey of the work done in connection with valuation of the Denmark waters from 1883-1917. *Report of the Danish Biological Station*, **25**, 1-62.

Ratcliffe, P.J., Jones, N.V. & Walters, N.J., 1981. The survival of *Macoma balthica* (L.) in mobile sediments. In *Feeding and survival strategies of estuarine organisms* (ed. N.V. Jones and W.J. Wolff), pp. 91-108. Plenum Press.

Rauck, G., 1988. What influence have bottom trawls on the seafloor and bottom fauna? *Informationen fur die Fischwirtschaft, Hamberg*, **35**, 104-106.

Rees, E.I.S., Nicholaidou, A. & Laskaridou, P., 1977. The effects of storms on the dynamics of shallow water benthic associations. In *Proceedings of the 11th European Symposium on Marine Biology, Galway, Ireland, October 5-11, 1976. Biology of Benthic Organisms, (ed. B.F. Keegan, P. O'Ceidigh & P.J.S. Boaden), pp. 465-474.*

Rees, H.L. & Dare, P.J., 1993. Sources of mortality and associated life-cycle traits of selected benthic species: a review. *MAFF Fisheries Research Data Report, no. 33.*, Lowestoft: MAFF Directorate of Fisheries Research.

Rhoads, D.C. & Young, D.K., 1970. The influence of deposit-feeding organisms on sediment stability and community trophic structure. *Journal of Marine Research*, **28**, 150-178.

Rosenberg, R. & Loo, L., 1988. Marine eutrophication induced oxygen deficiency: effects on soft bottom fauna, western Sweden. *Ophelia*, **29**, 213-225.

Salzwedel, H., 1979. Reproduction, growth, mortality and variations in abundance and biomass of *Tellina fabula* (Bivalvia) in the German Bight in 1975/1976. *Veroffentlichungen des Instituts fur Meeresforschung in Bremerhaven*, **18**, 111-202.

Smith, J.E. (ed.), 1968. 'Torrey Canyon'. *Pollution and marine life.* Cambridge: Cambridge University Press.

Sörlin, T., 1988. Floating behaviour in the tellinid bivalve *Macoma balthica* (L.). *Oecologia*, **77**, 273-277.

Stickle, W.B. & Diehl, W.J., 1987. Effects of salinity on echinoderms. In *Echinoderm Studies, Vol. 2* (ed. M. Jangoux & J.M. Lawrence), pp. 235-285. A.A. Balkema: Rotterdam.

Strasser, M., 1999. *Mya arenaria* - an ancient invader of the North Sea coast. *Helgoländer Meeresuntersuchungen*, **52**, 309-324.

Stronkhorst, J., Hattum van, B. & Bowmer, T., 1999. Bioaccumulation and toxicity of tributyltin to a burrowing heart urchin and an amphipod in spiked, silty marine sediments. *Environmental Toxicology and Chemistry*, **18**, 2343-2351.

Tait, R.V. & Dipper, R.A., 1998. *Elements of Marine Ecology.* Reed Elsevier.

Thorson, G., 1957. Bottom communities (sublittoral or shallow shelf). *Memoirs of the Geological Society of America*, **67**, 461-534.

Thrush, S.F., 1986. Community structure on the floor of a sea-lough: are large epibenthic predators important? *Journal of Experimental Marine Biology and Ecology*, **104**, 171-183.

Warwick, R.M. & Uncles, R.J., 1980. Distribution of benthic macrofauna associations in the Bristol Channel in relation to tidal stress. *Marine Biology Progress Series*, **3**, 97-103.

Weigelt, M. & Rumohr, H., 1986. Effects of wide range oxygen depletion on benthic fauna and demersal fish in Kiel Bay. *Meeresforschung*, **31**, 124-136.

Widdows, J., Brinsley, M.D., Salkeld, P.N. & Elliott, M., 1998. Use of annular flumes to determine the influence of current velocity and bivalves on material flux at the sediment-water interface. *Estuaries*, **21**, 552-559.

Wilson, W.H., 1991. Competition and predation in marine soft sediment communities. *Annual Review of Ecology and Systematics*, **21**, 221-241.

Wolff, W.J., 1968. The Echinodermata of the estuarine region of the rivers Rhine, Meuse and Scheldt, with a list of species occurring in the coastal waters of the Netherlands. *The Netherlands Journal of Sea Research*, **4**, 59-85.

Ziegelmeier, E., 1978. Macrobenthos investigations in the eastern part of the German Bight from 1950 to 1974. *Rapports et Proces-verbaux des Reunions. Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee. Paris*, 172, 432-444.