Lanice conchilega in littoral sand

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

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Dense *Lanice conchilega* in muddy sand.
Photographer: Anon.
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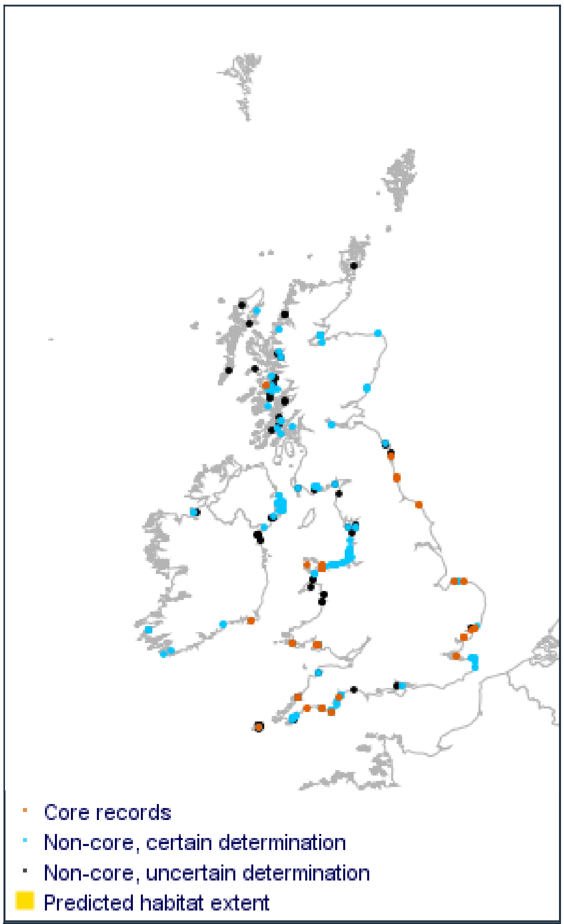

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Rebecca McQuillan & Dr Heidi Tillin **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A2.245	*Lanice conchilega* in littoral sand
JNCC 2015	LS.LSa.MuSa.Lan	*Lanice conchilega* in littoral sand
JNCC 2004	LS.LSa.MuSa.Lan	*Lanice conchilega* in littoral sand
1997 Biotope	LS.LGS.S.Lan	Dense *Lanice conchilega* in tide-swept lower shore sand

Description

This biotope usually occurs on flats of medium fine sand and muddy sand, most often on the lower shore but sometimes also on waterlogged mid shores. The sand may contain a proportion of shell fragments or gravel. Lan can also occur on the lower part of predominantly rocky or boulder shores, where patches of sand or muddy sand occur between scattered boulders, cobbles and pebbles. Conditions may be tide-swept, and the sediment may be mobile, but the biotope usually occurs in areas sheltered from strong wave action. The sediment supports dense populations of the sand mason *Lanice conchilega*. Other polychaetes present are tolerant of sand scour or mobility of the sediment surface layers and include the polychaetes *Anaitides mucosa*, *Eumida sanguinea*, *Nephtys hombergii*, *Scoloplos armiger*, *Aricidea minuta*, *Tharyx* spp. and *Pygospio elegans*. The mud shrimp *Corophium arenarium* and the cockle *Cerastoderma edule* may be abundant. The baltic tellin *Macoma balthica* may be present. On boulder shores, and where pebbles and cobbles are mixed in with lower shore tide-swept sand with dense *Lanice conchilega* between the cobbles, the infaunal component is rarely sampled. The infaunal community under these circumstances, provided that the cobbles are not packed very close together, is likely to be similar to that in areas without the coarse material (JNCC, 2015).

Depth range

Mid shore, Lower shore

Additional information

No text entered.

Listed By

- none -

Further information sources

Search on:

G 𝔤 G JNCC

Habitat review

Ecology

Ecological and functional relationships

The infauna established under the prevailing environmental conditions has the capacity to modify the sedimentary regime through activities that primarily effect the stability of and sedimentation within the habitat, for example by tube building, bioturbation, feeding behaviour and production of faeces and pseudofaeces. Such processes modify the habitat and increase the number of niches available for colonization (Elliott *et al*., 1998). Increased species diversity and abundance are known to occur around biogenic structures, such as the tubes of polychaetes, in otherwise relatively homogenous sedimentary habitats (Woodin, 1978). Studies of *Lanice conchilega* aggregations in the Wadden Sea (Zühlke *et al*., 1998; Dittmann, 1999; Zühlke, 2001) showed that tubes built by *Lanice conchilega* had significant effects on the distribution, density and diversity of other macrobenthic species and meiobenthic nematodes compared to sites with a lower density of *Lanice conchilega* or ambient sediment without biogenic structures. There is considerable interaction between the species in this biotope; some are listed below.

- The polychaete *Harmothoe lunulata* occurs in aggregations of *Lanice conchilega* and is often found inside the polychaetes' tubes, possibly being a commensal associated to *Lanice conchilega* (Zühlke *et al*., 1998).
- Juvenile bivalves (*Mya arenaria*, *Mytilus edulis*, *Limecola balthica*) were more frequent in patches with *Lanice conchilega* and settled especially on the tentacle crown of the worm tubes. The abundance of predatory polychaetes (*Eteone longa*, *Nephtys hombergii*, *Hediste diversicolor*) was higher (Dittmann, 1999).
- In sand, the primitive sea slug *Acteon tornatilis* preys upon tube building polychaetes. A series of choice experiments suggested that the preferred prey items were the polychaetes *Owenia fusiformis* and *Lanice conchilega* (Yonow, 1989).
- The predatory Nephytidae found within the biotope exert a negative effect on prey species. Beukema (1987) observed in long-term data from tidal flats in the westernmost part of the Wadden Sea, that *Nephtys hombergii* reduced the abundance and biomass of polychaetes *Scoloplos armiger* and *Heteromastus filiformis*. Schubert & Reise (1987) also reported similar evidence and concluded *Nephtys hombergii* to be an important intermediate predator.
- The edible cockle, *Cerastoderma edule*, is the dominant bivalve within the biotope. *Cerastoderma edule* disturbs the upper sediment layer due to its crawling and regular "shaking" behaviour. Flach (1996) studied the effects of cockle behaviour on the recruitment of other benthic species, and found that the presence of *Cerastoderma edule* (even at a low density of 125-250 per m^2) significantly reduced the densities of other bivalve species *Limecola balthica*, *Mya arenaria*, *Macomangulus tenuis* and *Ensis* spp., in addition to the worm species *Pygospio elegans*, *Lanice conchilega*, *Etone longa*, *Anaitides* spp., *Nephtys hombergii*, *Heteromastus filiformis*, *Scoloplos armiger*, *Tharyx marioni* and of the amphipods *Corophium volutator* and *Corophium arenarium*.

Seasonal and longer term change

The occurrence of *Lanice conchilega* on tidal flats can be subject to high seasonal variations (Dittmann, 1999). Seasonal storms can cause displacement of the polychaete (Ropert & Dauvin, 2000) and in the intertidal the polychaete is known to be susceptible to severe winters (Strasser &

Pielouth 2001). Populations of the cockle *Cerastoderma edule* are also periodically decimated by severe winter weather, and a high winter mortality is often followed by an exceptionally heavy spring spatfall (Hayward, 1994).

Habitat structure and complexity

- The habitat can be divided into several niches. The illuminated sediment surface supports a flora of microalgae such as diatoms and euglenoids, together with aerobic microbes and possibly ephemeral green algae in the summer months. The aerobic upper layer of sediment supports shallow burrowing species such as amphipods (*Ampelisca* spp., *Bathyporeia* spp. & *Gammarus* spp.) and small Crustacea, whilst the reducing layer and deeper anoxic layer support chemoautotrophic bacteria, burrowing polychaetes (e.g. *Nephtys cirrosa*, *Nephtys hombergii*, *Arenicola marina* and *Magelona mirabilis*), and burrowing bivalves (e.g. *Cerastoderma edule*).
- In fairly homogeneous soft sediments, biotic features play an important role in enhancing species diversity and distribution patterns (Bandeira, 1995; Everett, 1991; Sebens, 1991). Polychaete dwelling tubes, such as those constructed by *Lanice conchilega*, provide one of the main habitat structures in the intertidal and subtidal zones. The tubes modify benthic boundary layer hydrodynamics (Eckman *et al.*, 1981), can provide an attachment surface for filamentous algae (Schories & Reise, 1993) and serve as a refuge from predation (Woodin, 1978; Zühlke *et al.*, 1998). Other biota probably help to stabilize the substratum. For example, the microphytobenthos in the interstices of the sand grains produce mucilaginous secretions which stabilize fine substrata (Tait & Dipper, 1998). The presence of infaunal polychaetes affects the depth of the oxic sediment layer. Tubes of *Lanice conchilega* and *Arenicola marina* can penetrate several tens of centimetres into the sediment. Such burrows and tubes allow oxygenated water to penetrate into the sediment indicated by 'halos' of oxidized sediment along burrow and tube walls.

Productivity

Biological production within intertidal sandbanks is highly variable being reliant on the quantity of nutrients being delivered or internally generated (Elliott *et al.*, 1998). Some primary production comes from benthic microalgae and water column phytoplankton. The microphytobenthos in the interstices of the sand grains consist of unicellular eukaryotic algae and cyanobacteria that grow in the upper several millimetres of illuminated sediments, typically appearing only as a subtle brown or green shading (Elliott *et al.*, 1998). The benthos is supported predominantly by pelagic production and by detrital materials emanating from the coastal fringe (Barnes & Hughes, 1992). According to Barnes & Hughes (1992) the amount of planktonic food reaching the benthos is related to:

- depth of water through which the material must travel;
- magnitude of pelagic production;
- proximity of additional sources of detritus;
- extent of water movement near the seabed, bringing about the renewal of suspended supplies;

In the relatively shallow waters around the British Isles secondary production in the benthos is generally high, but shows seasonal variation (Wood, 1987). Generally, secondary production is highest during summer months, when temperatures rise and primary productivity is at its peak. Spring phytoplankton blooms are known to trigger, after a short delay, a corresponding increase in productivity in benthic communities (Faubel *et al.*, 1983). Some of this production is in the form of reproductive products.

Recruitment processes

Characterizing macrofauna of the biotope are iteroparous, meaning that they breed several times per lifetime. Whilst some of the infauna have a benthic and brooding mode of reproduction (e.g. amphipods and oligochaetes), most are broadcast spawners (Rasmussen, 1973). For instance, polychaete worms including *Lanice conchilega*, *Nephtys* spp. and spionid worms release their eggs and sperm into the water where, after fertilization and a relatively prolonged planktonic phase of development, metamorphose and commence a benthic habit. Recruitment of *Nephtys* species seems related to environmental conditions in central parts of the species range, marginal populations exhibit occasional reproductive failures, e.g. *Nephtys cirrosa*, which is a temperate species and reaches the northern limit of its range in the north of the British Isles. Populations of *Nephtys cirrosa* on the east and west coasts of northern Britain exhibit different reproductive patterns. In south west Scotland gravid adults breed every year in early autumn, whilst those on the east coast experience periods (e.g. over three years) of reproductive failure (Olive & Morgan, 1991). Bivalve populations typically show considerable pluriannual variations in recruitment, suggesting that recruitment is patchy and/or post settlement processes are highly variable (e.g. Dauvin, 1985). For instance, adults of *Cerastoderma edule* spawn in a short peak period over summer with remaining adults spawning over a protracted period, resulting in a short (ca. 3 month) period of peak settlement followed by generally declining numbers of recruits (Hancock, 1967; Seed & Brown, 1977). For further information refer to full *MarLIN* species reviews.

Time for community to reach maturity

The time required for the community to reach maturity will be in part determined by the proximity of other source populations and the season during which a disturbance occurs. Recolonization by some groups is likely to be more rapid than others. For instance, diatoms may be transported by resuspension in the water column and by lateral sediment transport. The rapid colonization (within days) by diatoms establishes food resources for other species, usually nematodes, that subsequently colonize. Dittmann *et al.* (1999) observed that the number of nematode species returned to pre-impact levels within seven days following a month long disturbance. Polychaetes tend to rapid colonizers, and species recorded by Dittmann *et al.* (1999) within two weeks included the polychaetes *Pygospio elegans*, *Polydora* sp., *Nephtys hombergii*, *Capitella capitata*, *Heteromastus filiformis*, *Eteone longa*, *Hediste diversicolor* (as *Nereis diversicolor*) and *Scoloplos armiger*, and the molluscs *Limecola balthica* and *Mytilus edulis*. Next to polychaetes, amphipods e.g. *Urothoe poseidonis*, are also rapid colonizers owing to their mobility. However, species that did not recolonize within the period of subsequent monitoring (14 months) included *Arenicola marina*, *Lanice conchilega* and its commensal *Malmgreniella lunulata*. Although it is likely that these species would recolonize suitable substrata, settlement of *Lanice conchilega*, for instance, has been reported to be more successful in areas with existent adults than areas without (see full *MarLIN* review; Heuers & Jaklin, 1999). Strasser & Pielouth (2001) reported that establishment of a mature population took three years in the absence of an established population. Thus the time taken for the community to reach maturity is likely to be in the order of several years.

Additional information

No text entered.

Preferences & Distribution

Habitat preferences

Depth Range	Mid shore, Lower shore
Water clarity preferences	Field Unresearched
Limiting Nutrients	Field unresearched
Salinity preferences	Full (30-40 psu), Variable (18-40 psu)
Physiographic preferences	Open coast, Strait / sound
Biological zone preferences	Eulittoral, Lower eulittoral, Mid eulittoral
Substratum/habitat preferences	Fine clean sand, Medium clean sand, Mixed
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Strong 3 to 6 knots (1.5-3 m/sec.), Very Strong > 6 knots (>3 m/sec.), Very Weak (negligible), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered, Moderately exposed, Sheltered, Very sheltered
Other preferences	Tidal streams

Additional Information

No text

Species composition

Species found especially in this biotope

- *Lanice conchilega*
- *Nephtys cirrosa*

Rare or scarce species associated with this biotope

-

Additional information

No text entered.

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and characterizing species are based on JNCC (2015). This biotope usually occurs on flats of medium fine sand and muddy sand and is characterized by dense populations of the tube building polychaete *Lanice conchilega*. The sensitivity assessments are based on *Lanice conchilega* as the loss or reduction of the *Lanice conchilega* population would result in a significant change to the character of the biotope and lead to biotope reclassification. The tubes of this species create physical structure in this biotope and modify habitat conditions, this species is therefore considered to be a key structuring/functional species. A range of other species typically found on sandy shores are typically present, including the polychaetes *Nephtys hombergii*, *Scoloplos armiger*, and *Pygospio elegans*, the common cockle *Cerastoderma edule* and the amphipod *Corophium arenarium* may be abundant. The sensitivities of these species are assessed generally. More detailed information is available for these species on this website from biotopes where these are key characterizing species.

Resilience and recovery rates of habitat

Recovery characteristics of *Lanice conchilega* were assessed previously by Ager (2008) and Callaway *et al.* (2010). *Lanice conchilega* is sessile and larval recolonization is therefore the most important recovery mechanism. Water transport of adults, intact in tubes, has been observed after storms and this represents a potential colonization mechanism. The tube itself can be rapidly repaired or rebuilt following damage under variable conditions (Nicolaidou, 2003). Yonow (1989) observed *Lanice conchilega* re-establishing tubes immediately after removal from the sediment into a suitable sediment in the laboratory.

The larvae of *Lanice conchilega* spend up to 60 days as plankton and therefore have a wide dispersal potential. Larvae preferentially settle on the tubes of *Lanice conchilega* but other suitable settlement surfaces might be selected, including artificial tubes (Heuers & Jaklin 1999) or bivalve shells (Herlyn *et al*., 2008). Given the preference for settlement on the tubes of adults, recovery of *Lanice conchilega* populations will be enhanced by the presence of adults that survive impacts.

Population recovery times appear to range between one and four years (Beukema, 1990; Heuers, 1998; Zühlke, 2001; Callaway *et al*., 2010). Strasser & Pielouth (2001) reported that larvae were observed to settle in areas where there were no adults and the population was subsequently re-established in three years. The length of recovery time was attributed to a decline in the wider meta-population that reduced larval supply (Strasser & Pieloth, 2001). In areas where there are dense reefs with suitable water currents recovery may therefore be more rapid due to the greater larval supply, perhaps taking 1-2 years.

Beukema (1990) reported that following removal of entire intertidal populations (following a cold winter), *Lanice conchilega* populations recovered rapidly (within 1 and 2 years) and total-biomass value increased faster as a consequence of generally high successful recruitment in the Wadden Sea. However, Heuers *et al.* (1998) observed *Lanice conchilega* re-established abundance within 3 to 4 years in the Spiekeroog area of the Wadden Sea following severe freezing. In two of three areas disturbed by cultivation of Manila clams, measurable re-colonization took place after one or two years (Callaway *et al*., 2010 and references therein). The results tally with other descriptions of *Lanice conchilega*'s re-colonization strategy, Recovery of the associated species may be more rapid than the recovery of dense patches of *Lanice conchilega*. Patches of cockles are naturally more variable over space and time (Smaal *et al*., 2005) and beds are subject to either gradual declines as the population aged but inhibits recruitment or occasional mass mortalities that have been attributed to a number of causes (Burdon *et al*., 2014). Small disturbed patches may be rapidly infilled by movement of adult cockles by tidal currents and wave action or active migration of adults. *Nephtys hombergii* are also mobile and may migrate to disturbed patches. Associated species with opportunistic life strategies (small size, rapid maturation and short-lifespan of 1-2 years) include *Chaetozone setosa*, *Pygospio elegans* and *Corophium arenarium*. These are likely to recolonize disturbed areas first, however, the actual pattern will depend on recovery of habitat, season of occurrence and other factors.

Resilience assessment. Where the biotope is severely impacted and the entire assemblage is removed, recovery is assessed as ‘Medium’ as re-establishment of a reef may require up to 3 years, based on the observations of Strasser & Pielouth (2001). Where resistance is assessed as ‘Low’ or ‘Medium’, the presence of adults is considered likely to enhance settlement of juveniles and recovery is assessed as ‘High’ (within 2 years). These assessments are considered to equally apply to the associated macrofauna. Recovery of typical biomass and age-structured populations of longer-lived species such as *Ceratoderma edule* and *Nepthys hombergii* is likely to be ‘Medium’ where populations are removed or there is an element of habitat change.

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

Hydrological Pressures

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

Species found high on the shore are generally able to tolerate a greater range of temperatures than those confined to lower shore levels (Davenport & Davenport, 2005), however, the timing of site-specific factors such as low tides will influence local acclimation. For intertidal species increased temperatures may also result in desiccation when exposed (see changes in emergence pressure).

Limited information on the thermal tolerance *of Lanice conchilega* was found. *Lanice conchilega* occurs in temperate regions all around UK and Irish shores in the intertidal and shallow subtidal, populations also occur in the Mediterranean, in the Arabian Gulf and the Pacific and along the south east of the North Sea, but the species is absent from Arctic waters (Ropert & Dauvin, 2000; Connor *et al*., 2004; Degraer *et al*., 2008). The geographical range suggests that the species is adapted to variable temperature conditions but local populations are likely to be acclimated to prevailing temperatures.

Cerastoderma edule is found from Norway to Mauritania (Honkoop *et al*., 2008) and through the Baltic, Mediterranean and Black Sea (Longshaw & Malham, 2013). The eastern border of distribution is the Murmansk coast of the Barents sea (Genelt-Yanovskiy *et al*., 2010). The species is therefore likely to be exposed to warmer and colder water and air temperatures than experienced in the UK over its geographic range. Kristensen (1958) reported that *Cerastoderma edule* from the Dutch Wadden Sea have an upper temperature tolerance of 31°C for 24 hrs while Wilson (1981) reported an upper lethal temperature of 42.5°C. These temperatures are likely to exceed the pressure benchmark. Wilson (1993) concluded that *Cerastoderma edule* was probably tolerant of a long-term temperature rise of 2°C associated with climate change. Warmer temperatures during winter result in increased metabolic rate, hence depletion of energy reserves in a time of low food availability and may contribute to post winter mortality of adult cockles (Wilson & Elkaim, 1991). Therefore, the tolerance of *Cerastoderma edule* to temperature change will be dependent on season, so an acute, short-term temperature rise in summer or decrease in winter may be detrimental.

Nephtys hombergii has been reported from as far south as South Africa, suggesting the species can tolerate temperatures above a 5°C increase on UK and Irish coasts. Records are limited, but Emery & Stevensen (1957) found that *Nephtys hombergii* could withstand summer temperatures of 30-35°C. *Pygospio elegans* are summer visitors to an effluent exposed habitat in the UK where effluents are typically 8-12°C warmer than the receiving waters (Bamber & Spencer, 1984), and this species is considered tolerant of acute and chronic increases in temperature.

Sensitivity assessment. Typical surface water temperatures around the UK coast vary seasonally from 4-19 °C (Huthnance, 2010). The associated species are considered likely to be tolerant of acute and chronic increases in temperature at the pressure benchmark. *Lanice conchilega*, *Nephtys hombergii* and *Cerastoderma edule* have a wide geographic range. As species inhabiting the intertidal, they are likely to experiences rapid fluctuations in temperature over the tidal cycle. The lack of evidence for mass mortalities in very hot summers (compared with reports for low winter temperatures) suggest that the characterizing and associated species are likely to tolerate a chronic increase at the pressure benchmark (2°C for one year). An acute increase in temperature for one month may lead to changes in reproductive success and predation, particularly on spat and juveniles. Adults may, however, survive. Biotope resistance is therefore assessed as 'High' and residence is 'High' (by default), the biotope is therefore considered to be 'Not sensitive'.

Temperature decrease (local)	Low Q: High A: High C: High	High Q: High A: High C: High	Low Q: High A: High C: High

Many intertidal species are resistant of freezing conditions as they are exposed to extremes of low air temperatures during periods of emersion. They must also be able to cope with sharp temperature fluctuations over a short period of time during the tidal cycle. Species that occur in the intertidal are generally adapted to periods of freezing conditions during winter months and have evolved mechanisms of survival to withstand rapid cooling (Loomis, 1995; Davenport & Davenport, 2005).

Infaunal species such as *Pygospio elegans and Nephtys hombergii* and including *Lanice conchilega* may be protected to some extent for short periods by the ability to burrow deeper within the sediment. Prolonged freezing temperatures may, however, result in mortalities. In the German coastal area during 1978-79 winter, water temperature remained below 0 °C on 45 successive days and resulted in the eradication of *Lanice conchilega*. Up to July 1980 no recolonization of the area had taken place (Buhr, 1981). An intertidal population of *Lanice conchilega*, in the northern Wadden Sea, was wiped out during the severe winter of 1995/96 (Strasser & Pielouth, 2001), and Crisp (1964) described mortality of *Lanice conchilega* between the tidemarks but not at lower levels during the severe winter of 1962/63. These severe winters probably exceed the pressure benchmark. Beukema (1990) had noted that the recovery of most species including *Lanice conchilega*, was rapid (within 1 and 2 years) and total-biomass value increased faster as a consequence of generally high successful recruitment in the Wadden Sea. Whilst Heuers *et al.* (1998) observed *Lanice conchilega* re-established abundance within 3 to 4 years in the Spiekeroog area of the Wadden Sea following severe freezing.

High mortalities of *Cerastoderma edule* populations attributed to severe winters have been reported by many authors (Kristensen, 1958; Hancock & Urquhart, 1964; Beukema, 1990; Ducrotoy *et al.*, 1991) and high shore populations are likely to be more vulnerable to extremes of temperature owing to their longer emergence time. Strasser *et al.* (2001) noted mortalities ranging on average between 80% and 100% in the high tidal zone. Mortalities that occurred during spring and summer may have constituted a time-lag effect of the preceding winter. Beukema (1990) suggested that *Cerastoderma edule* was more sensitive to low winter temperatures than other bivalves (e.g. *Mya arenaria*, and *Mytilus edulis*) which make up 50% of the of the macrobenthic biomass (Reise & Lackschewitz, 1998).

Nephtys hombergii are found as far north as the Barents Sea, and would be expected to be resistant to a 5°C decrease in temperature for one month period, or 2°C for one year. However, during the winter of 1978- 79, *Nephtys hombergii* in the River Tyne estuary (north-east England) did not spawn but instead reabsorbed the gametes, reducing the *Nephtys hombergii* population for subsequent years. In previous years, recruitment had been good and it was considered probable that this was a result of the extremely cold conditions experienced in 1978-1979 (Olive *et al.*, 1981).

Sensitivity assessment. Resistance has been assessed to be 'Low' as evidence suggests that intertidal populations of *Lanice conchilega* and *Cerastoderma edule* and other polychaetes are likely to be vulnerable to acute decreases in temperature during winter, resilience is assessed as 'High' where some adults remain and sensitivity is assessed as 'Low'.

Salinity increase (local)	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

This biotope occurs in full (30-35 ppt) and variable salinity biotopes (18-35 ppt). Biotopes occurring in variable salinity are not considered to be sensitivie to an increase to full salinity as this falls within the natural range. At the pressure benchmark, an increase from full to hypersaline (>40 ppt) is considered. Local populations may be acclimated to the prevailing salinity regime and may exhibit different tolerances, therefore caution should be used when inferring tolerances from populations in different regions.

No direct evidence was found to assess the sensitivity of this biotope. Salinities within tide swept habitats vary due to weather conditions such as rain fall at low tide and evaporation causing hypersaline conditions on hot days. Intertidal shores within estuarine environments can also experience considerable short-term changes in salinities. During summer, the Atlantic French coast rapidly increased in salinity and reached hypersaline conditions (48 ppt) in the upper sediment layer within 1.5 hrs (Juneau *et al.*, 2015). However, increased salinity is not restricted to hot summer conditions. This can occur at moderate optimal temperatures (16-20°C), due to wind-driven desiccation in spring in the first 0.5 cm of the sediment where *Lanice conchilega*, *Nephtys hombergii*, *Pygospio elegans* and *Scoloplos armiger* and the cockle *Cerastoderma edule* occur. This may interfere with the sediment cohesion and composition and possibly the ability to retain pore-water at the surface to modulate the species activity (Paterson & Hagerthey, 2001). *Lanice conchilega* as a tube dwelling polychaete has the ability to retract deeper into the sediment to avoid unfavourable conditions.

Verdelhos *et al.* (2015) assessed the saline optimal ranges of *Cerastoderma edule* (a euryhaline species) from 0-35 ppt. High activity was initially observed in conditions above the optimal range (15, 30 and 35 ppt) for *Cerastoderma edule*, but activity decreased after 72 hrs. Results suggest that high saline conditions over short periods is tolerated. Responses involved reduced activity through osmo-regulations and behaviours such as valve closure to prevent exposure.

Sensitivity assessment. Species within the biotope may tolerate short periods of high salinity, however, prolonged exposure to hypersalinity may lead to changes in species richness, abundance and biomass and loss of characterizing and associated species. Sensitivity to this pressure is not assessed due to lack of evidence.

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

The subtidal biotope is found in full salinity (JNCC, 2015), and the intertidal biotope and associated species are found in full and variable salinity. It is therefore considered that a decrease in salinity at the pressure benchmark, from full to variable (18-35 ppt), would not result in loss of the biotope. Since the intertidal biotope is found in full and variable salinity (18-35 ppt), the biotope is not considered sensitive to a change from full to variable salinity, as this falls within the natural habitat distribution. However, the biotope may be sensitive to a change from variable to low salinity (<18 ppt).

There is limited information on the effects of decreased salinity on *Lanice conchilega*. Salinities within tide swept habitats vary due to weather conditions such as rain fall at low tide and evaporation causing hypersaline conditions on hot days. Intertidal shores within estuarine environments can also experience considerable short-term changes in salinities.

Substantial salinity fluctuations due to heavy rains leading to scouring are common in intertidal areas and shallow coastal areas inhabited by adult *Cerastoderma edule*. Kristensen (1958) reported death of young cockle spat (1-2 mm) in the Dutch Wadden Sea due to heavy rain, although adults were able to dig deeper to avoid the freshwater influx (reduced salinities).

Boyden & Russell (1972) stated that *Cerastoderma edule* prefers salinities between 15 and 35 psu, whilst Russell & Peterson (1973) reported lower median salinity limits of 12.5 psu and upper median salinity limits of 38.5 psu. Rygg (1970) noted that *Cerastoderma edule* did not survive 23 days exposure to <10 psu. Rygg (1970) also demonstrated that salinity tolerance was temperature dependant (after 3 days, 100% survival at 33 psu and 35-38°C, but 50% mortality occurred at 20 psu and 37°C and 100% mortality at 13 psu and 37°C). Wilson (1984) noted that *Cerastoderma edule* remained open during 1 hour exposure to salinities between 13.3 and 59.3 psu. It should be noted that the tolerances reported above depended on the duration of the experiment.

Gogina *et al.* (2010) reported the lower limit of *Scoloplos armiger* was resistant of salinities of 8 psu, yet mortalities have been observed in the Baltic region, suggesting a lower limit of 10.5 psu. However, it was noted that *Pygospio elegans* can survive in salinities as low as 2 psu.

Nephtys hombergii has been shown to be highly resistant of a wide range of salinities (as low as 16 psu) (Clarke & Haderile, 1960; Davey & George, 1986), extending from the Mediterranean to the western Baltic Sea (Hartmann-Schroéder, 1996). *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 (1971b) observed that species with pelagic larvae or a free-swimming phase, including *Nephtys hombergii*, 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. *Nephtys hombergii* may still be found in fully marine locations 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*.

Pygospio elegans has been found in brackish water in high abundances, with salinities as low as 2 psu (Bolam & Fernandes, 2003).

Sensitivity assessment. Little empirical evidence was found to assess sensitivity of *Lanice conchilega* to this pressure at the benchmark level and therefore the assessment was made based on the biotopes associated species. The available evidence suggests that adult *Cerastoderma edule* may survive a reduction in salinity to just below 18 psu and populations may become locally acclimated to reduced salinities. Other species such as *Pygospio elegans* and *Nephtys hombergii* are also likely to be tolerant of a reduction at the pressure benchmark. As a reduction may lead to some mortalities and a reduction in growth and reproductive success of the key characterizing species, biotope resistance is assessed as ‘Medium’, recovery is assessed as ‘High’ (following restoration of typical conditions) and resilience is ‘High’. Biotope sensitivity is therefore assessed as ‘Low’.

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

This biotope is found in areas exposed to tidal streams varying from very strong (>3 m/s) to negligible (JNCC, 2015). There is limited evidence to assess changes in water flow rates for >1 year at the benchmark level. It should be noted that *Lanice conchilega* occupies shores with variable exposed flow speeds ranging from sheltered (<0.5 m/sec) to very strong (>3 m/sec) (Connor *et al*., 2004). Laboratory flume studies have showed that *Lanice conchilega* feeding rates on diatoms alter according to flow (Denis *et al*., 2007). Feeding rates were optimal at 0.15 m/s and lower at flow speeds of 0.04 m/s and 0.27 m/s (Denis *et al*., 2007). Changes in current velocity at the pressure benchmark are relevant to feeding rates, however, impacts are likely to depend on food supply, population density and proportion of inorganic particles.

The motion of the water is the dominant factor in the transportation of sediment, facilitating erosion and redistribution of materials (Hjulström, 1939). This may change the sediment structure and have associated effects on the intertidal community. *Lanice conchilega* alter between passive and active feeding depending on the tidal regimes, i.e. in still water, they move their tentacles or in high velocities the fringed tentacles are supported. A switch from active to passive feeding behaviour was observed during the experiments between 4 and 8 cm/s (Denis *et al.*, 2007). Moderate to high velocities of water flow have been reported to enhance settlement of *Lanice conchilega* larvae (Harvey & Bourget, 1997), increasing average particle size in favour of gravels and pebbles.

Increase particle movement is likely to increase sediment scour (see abrasion and sedimentation), re-suspension of material (see organic enrichment, and suspended sediment), and potentially a decrease in clearance in filter feeders. Populations of *Lanice conchilega* and *Pygospio elegans* may decline in part due to a lack of suitable substrata to build its tubes. The biotope would probably become dominated by water flow resistant species that prefer coarse substratum.

Reduced water flow is a factor that has been identified as affecting the density of *Lanice conchilega*, as recruitment to the benthos is reduced (Harvey & Bourget, 1995). The average grain size of the sediment would also be reduced and probably favour deposit feeders and detritivores, to the detriment of the suspension feeders.

Sensitivity assessment. A change in water flow rate at the pressure benchmark level of 0.1-0.2 m/s is considered to fall within the range of flow speeds experienced by the biotope. Resistance and resilience are assessed as 'High' and the biotope considered 'Not sensitive' to a change in water flow at the pressure benchmark level.

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

The biotope and characterizing species occur in the mid to low intertidal. All characterizing species would probably survive an increase in emergence. However, *Lanice conchilega* can only feed when immersed and therefore likely to experience reduced feeding opportunities. Over the course of a year, the resultant energetic cost is likely to cause some mortality. In addition, increased emergence is likely to increase the vulnerability to predation from shore birds. A decrease in emergence is likely to allow the biotope to extend its upper limit, where suitable substrata exist.

The dense *Lanice* biotope LS.LSa.MuSa.Lan on certain lower shores may be a littoral extension of the biotope SS.SCS.ICS.SLan. A decrease in emergence may lead to some shifts in species present but a *Lanice conchilega* dominated biotope is likely to persist.

Sensitivity assessment. Emergence is a key factor structuring intertidal biotopes (JNCC, 2015). The *Lanice conchilega* biotope is likely to shift distribution during periods of altered sea levels. Some changes in the structure of the biological assemblage would be predicted. Resistance is assessed as 'Low' and resilience is 'High', following habitat recovery and sensitivity is assessed as 'Low'.

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

The biotope is recorded from locations that have variable wave exposures (moderately exposed to extremely sheltered) (Connor *et al.*, 2004). The degree of wave exposure influences wave height, as in more exposed areas with a longer fetch waves would be predicted to be higher.

Sensitivity assessment. As this biotope is found across a range of wave exposed shores, resistance is assessed as 'High' and resilience as 'High' to a 3 to 5% change in wave height at the pressure benchmark. Therefore, the biotope is considered 'Not sensitive'.

Chemical Pressures

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

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

Contamination at levels greater than the pressure benchmark may adversely affect the biotope. There is a lack of evidence to identify the tolerance of *Lanice conchilega* and other polychaetes (*Scoloplos armiger*, *Pygospio elegans* and *Nephtys hombergii*) and including the common cockle, *Cerastoderma edule* to transition metals. Bryan (1984) reported that short-term toxicity in polychaetes was highest to Hg, Cu and Ag, declined with Al, Cr, Zn and Pb with Cd, Ni, Co and Se being the least toxic. It was recorded that polychaetes have a range of tolerances to heavy metal levels of Cu, Zn, As and Sn being in the order of 1500-3500 µg/g. An analysis of organisms from Restronguet Creek revealed that *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*. There was evidence to suggest that some metals were regulated and suggests that some species (*Nephtys hombergii*) had developed metal resistant populations as a functional genetic trait to Cu homeostasis (McQuillan *et al*., 2014). However, Alve (1991) and Ellison *et al*. (1986) concluded that there is a shift in the abundance of biodiversity away from the source of contamination, which is indicative of metal contamination (Stubbles, 1993).

Bryan (1984) stated that Hg is the most toxic metal to bivalves. Studies of *Cerastoderma edule* transplanted populations from polluted and uncontaminated sites resulted in 10-15% mortality within 63 days but 100% within 4 months at the Restronguet Creek (Bryan & Gibbs, 1983). Additionally, Cu and Zn are believed to inhibit the settlement of juvenile *Cerastoderma edule*, leading to patchy distributions (Langston *et al*., 2003).

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

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

Contamination at levels greater than the pressure benchmark may adversely influences the biotope. Suchanek (1993) reviewed the effects of oil spills and concluded that soft sediment polychaetes, bivalves and amphipods were particularly sensitive. Dauvin (2000) noted that 20 years after the *Amoco Cadiz* oil spill in 1978, *Lanice conchilega* was re-established between 1978 and 1984 but disappeared after 1985. A similar delayed response was observed by Sanders (1980) and Kingston *et al*. (1995) as a result of the *Florida* oil spill and the *Braer* oil spill (Gómez Gesteira & Dauvin, 2000).

The *Amoco Cadiz* oil spill resulted in reductions in abundance, biomass and production of the invertebrate communities, however, *Nephtys hombergii* and other polychaetes (cirratulids and capitellids) were largely unaffected by the *Amoco Cadiz* oil spill (Conan, 1982). The sediment rapidly recovered and in 1981, benthic recruitment occurred under normal conditions (Dauvin, 1998).

Savari *et al*. (1991a) observed the density and growth of *Cerastoderma edule* decreased with increasing hydrocarbon concentration. McLusky (1982) examined the intertidal mudflat fauna at Kinneil in the Forth Estuary that received petroleum, chemical and domestic effluents. Evidence suggests that soft sediment communities are highly susceptible of hydrocarbon contamination. In the littoral zone especially, oil spills resulting from tanker accidents are likely to be deposited directly on the sediment of the biotope, preventing oxygen transport to the substratum and oil pushed in to the substratum by tidal-pulsing will destabilize the sediment (Elliott *et al*., 1998). Samples obtained from mussel tissue, 11 months after the *Aegean Sea* spill (1992), showed evidence of contamination. Yet 2 years later (October 1995), there was no evidence of oil pollution in that area affected by the *Aegean Sea* spill (Gómez Gesteira & Dauvin, 2005), suggesting recovery.

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 specific effects of synthetic chemical contaminants on *Lanice conchilega* or *Nephtys hombergii* was found. Boon *et al*. (1985) reported that *Nephtys* spp. in the North Sea accumulated organochlorines. However, based on total sediment analyses, organochlorine concentrations in *Nephtys* spp. did not correlate with the concentrations in the sediment which they inhabited. Specific deleterious effects of synthetic chemicals (Ivermecten, tri-butyl-tin (TBT)) have been reported for other polychaetes, e.g. *Hediste diversicolor*, *Arenicola marina*, *Scoloplos armiger* and *Cirratulus cirratus* (Collier & Pinn, 1998; Beaumont *et al*., 1989; Bryan & Gibbs, 1991). Beaumont *et al*. (1989) concluded that bivalves are particularly sensitive to TBT. For example, when exposed to 1-3 µg TBT/l, *Cerastoderma edule* suffered 100% mortality after two weeks. Bryan & Gibbs (1991) presented evidence that TBT caused recruitment failure in bivalves, due to either reproductive failure or larval mortality. Waldock *et al*. (1999) examined recovery of benthic infauna of the Crouch Estuary after a ban on the use of TBT on small boats. They observed marked increases in species diversity, especially of Ampeliscid amphipods and polychaetes (*Tubificoides* spp. and *Aphelochaeta marioni*) which mirrored the decline in sediment TBT concentration. Whilst a causal link could not be shown, the study by Waldock *et al*. (1999) suggested that crustacean and polychaete diversity may be inhibited by TBT contamination.

Polychaetes vary greatly in their tolerance of chemical contamination. The persistence of these chemical residues is highly dependent on the matrix and ambient environmental conditions. Generally, residues in water are less likely to be a long-term concern because of photodegendation and dilution to below biological significant concentrations. However, TBT has a high binding affinity to sediments and residues incorporated into the sediment tend to persist for longer periods (Austen & McEvoy, 1997; Huntington *et al*., 2006).

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

No evidence.

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

This pressure is **Not assessed**.

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

Niermann *et al.* (1990) reported that the abundance of *Lanice conchilega* in a subtidal fine sand community in the German Bight area, was significantly reduced during a period of hypoxia (1-3 mg/O_2/dm^3). However, the period of hypoxia lasted for about a month and, therefore, exceeds the pressure benchmark. The activities of *Lanice conchilega* oxygenate sediments (Forster & Graf, 1995) and this species may not, therefore, be adapted to anoxic/hypoxic conditions unlike burrowing infauna such as *Nephtys* spp. and oligochaetes.

Nilsson & Rosenberg (1994) summarized that *Nephtys hombergii* have the potential to be tolerant of severe hypoxia and hydrogen sulphide (Alheit, 1978; Arndt & Schiedek, 1997). *Nephtys hombergii* survived 5 days in pure artificial anoxic seawater, not shifting from the aerobic to anaerobic metabolic pathways before oxygen saturation decreases to 112% (Schottler, 1982). Other experiments demonstrated that 50% of *Nephtys hombergii* survived 23 days in almost anaerobic conditions (10.2 mg/l), whereas *Nephtys ciliata* survived 11 days in the same tests (Fallesen & Jorgensen, 1991).

Rosenberg *et al.* (1991) observed that *Cerastoderma edule* migrated to the sediment surface in response to reduced oxygen concentrations in the upper sediment layers and reported 100% mortality of *Cerastoderma edule* exposed to 0.5-1.0 ml/l oxygen for 43 days. Theede *et al.* (1969) reported 50% mortality after 4.25 days at 1.5 ml/l oxygen. Theede *et al.* (1969) added that *Cerastoderma edule* only survived 4 days' exposure of <6.1 cm^3/l of hydrogen sulphide, which is associated with anoxic conditions. *Cerastoderma edule* fatalities are likely to occur at the benchmark.

Sensitivity assessment. Although some species associated with the biotope, such as *Nephtys hombergii*, are tolerant of hypoxia and anoxia, while other species that occur in oxygenated sediments or at the surface may be more sensitive. As the biotope occurs in the intertidal, oxygen recharge during immersion may almeliorate the effects of hypoxia and anoxia. Biotope resistance is therefore assessed as 'Medium' and resilience as 'High' (following restoration of typical habitat conditions). Biotope resistance is therefore assessed as 'Low'. Due to the lack of evidence for *Lanice conchilega*, confidence is assessed as 'Low'.

Nutrient enrichment	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not sensitive Q: NR A: NR C: NR

This pressure relates to increased levels of nitrogen, phosphorus and silicon in the marine environment compared to background concentrations. The benchmark is set at compliance with WFD criteria for good status, based on nitrogen concentration (UKTAG, 2014).

Moderate enrichment increases food supply, enhancing productivity and abundance. Mudflats can be sensitive to nutrient enrichment which can result in blooms of opportunistic ephemeral seaweeds such as *Enteromorpha* spp. *Macoma balthica* has been shown experimentally to be able to resist time periods of 9 weeks under algal clover as their long siphon allows them to reach oxygenated water, although other bivalves decreased in abundance (Thiel *et al*., 1998). Organic enrichment beneath oyster cultivation trestles and mussel cultivation sites and fish cages has led to community replacement/dominance by Cirratulid, Capitellid and Spionid polychaetes, particularly *Manayunkia aesturina* in mudflats, which characterize disturbed areas enriched in organic matter (Pearson & Rosenberg, 1978; Samuelson, 2001, see Bouchet & Saurier, 2008 for references for activities). Local hydrodynamics and topographic features will mediate or strengthen biodeposition effects. Gross effects will lead to anoxic, defaunated sediments which may be covered by sulphur reducing bacteria such as *Beggiatoa* spp. (Elliott *et al*., 1998). Diatom density may be reduced by organic enrichment potentially reducing the stability of mudflats (Elliott *et al*., 1998).

Sensitivity assessment. 'Not sensitive' at the pressure benchmark that assumes compliance with good status as defined by the WFD.

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

There is limited evidence to assess the effects of organic enrichment directly on *Lanice conchilega*, other polychaetes (*Pygospio elegans*, *Scoloplos armiger* and *Nephtys hombergii)* and *Cerastoderma edule*. The response of benthic communities and of the sediment to increased organic carbon can be determined by the physical composition of the substrata and the availability of dissolved oxygen.

Cromey *et al.* (1998) found that organic loading rates <36 g C/m^2/year had little effect on the macrobenthic communities; the sediment became enriched up to inputs of 365 g C/m^2/year and organic loading >500 g C/m^2/year led to degraded conditions probably due to lower oxygen concentrations.

Lanice conchilega has been categorised by Borja *et al.* (2000) as AMBI Group II - 'Species indifferent to enrichment, always present in low densities with non-significant variations with time (from initial state, to slight unbalance)'. This assessment was reviewed by Gittenberger & Van Loon (2011) and changed to AMBI Group III - 'Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations)'. From the AMBI index group, *Cerastoderma edule* and *Pygospio elegans* are identified in the Ecological Group III reflecting feeding type and other traits: 'Tolerant of excessive organic matter enrichment and populations are stimulated by organic enrichment' (Borja *et al*., 2000).

Sensitivity assessment. There is little empirical evidence to quantify the effect of organic enrichment deposits of 100 g C/m^2/yr on *Lanice conchilega*. Based on the ranges presented by Cromey *et al.* (1998), this benchmark pressure is unlikely to have an influence upon *Lanice conchilega* and associated species. The resistance of ‘High’ and a resilience of ‘High’ may also be assigned and by default the biotope is ‘Not sensitive’.

Physical Pressures

Resistance Resilience Sensitivity

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

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

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

The species characterizing this biotope occur within the upper layers of the soft sediment (JNCC, 2015). This biotope does not occur on artificial substrata or rock habitats, although patches of sediment may support some of the species associated with this biotope. Any substratum other than the sediments on which this biotope is found would therefore lead to a loss of this biotope. Consequently, biotope resistance is assessed as 'None', resilience is assessed as 'Very Low' (as the change, at the benchmark is permanent), and biotope sensitivity is assessed as 'High'.

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

This biotope is found in medium to fine muddy sand and mixed sediments (Connor *et al.*, 2004). The biotope would not be considered sensitive to a change to mixed sediments from muddy sands or vice versa, as the sediment would still be likely to support the biotope. A change to coarse sediments or clean sands could, however, lead to loss of habitat suitability for the associated species that are restricted to sediments with a high proportion of fine factions, such as the burrowing polychaetes.

The characterizing species *Lanice conchilega* occurs in a range of sediments, including clean sands and coarser, clean sediments and pockets of sediment within otherwise unsuitable habitats. It is therefore likely to still occur in habitats where there has been a change in Folk class at the pressure benchmark. However, abundances of *Lanice conchilega* and the species richness and abundances of other species present are likely to alter. Degraer *et al.* (2006) report that *Lanice conchilega* displays a preference for fine to medium-grained sediments (100 to 500 µm) with relatively high mud content (10 to 40%), and other sediment types are therefore likely to be sub-optimal.

Dense aggregations of *Lanice conchilega* facilitate the deposition of fine materials as the tubes reduce the velocity of flow. Some increase in fine sediment fraction to muds is likely to be tolerated. Sylvand (1995) highlighted the dominant presence of *Lanice conchilega* in areas of oyster cultivation where fine particles were deposited.

High densities of *Nephtys hombergii* were found in substrata of 0.3% particles >0.25 mm and 5.8% <0.125 mm in diameter, but tolerated up to 3.8% 0.25 mm and 2.2-15.9% <0.125 mm (Clark *et al.*, 1962). *Nephtys hombergii* may be found in higher densities in muddy environments. 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) summarized that the higher the medium grain size of the sediment the lower the relative occurrence of *Nephtys* *hombergii* and in grain sizes over 0.5 mm the species was absent in the Belgium part of the North Sea.

Habitat partitioning has been observed between *Corophium volutator* and *Corophium arenarium* on the basis of sediments, although modified by disturbance from other species (see removal of target species). *Corophium arenarium* is associated with areas of sandy sediment whilst *Corophium volutator* prefers muddier sediments (Watkins, 1941; Meadows, 1964; Flach, 1993), changes in sediment type may, therefore, lead to shifts in the species present.

Sensitivity assessment. Changes to increased finer sediments are likely to be tolerated, however, a change in the sediment Folk class classification at the pressure benchmark to gravel is likely to alter the abundance of *Lanice conchilega* and the composition of the species assemblage, resulting in loss of this biotope. Resistance is therefore assessed as 'None' and resilience as 'Very Low' (as the change at the pressure benchmark is permanent). The biotope is considered to have 'High' sensitivity to this pressure.

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

Sedimentary communities are likely to be highly intolerant of substratum removal, which will lead to partial or complete defaunation, exposure of underlying sediment which may be anoxic and/or of a different character or bedrock and lead to changes in the topography of the area (Dernie *et al*., 2003). Any remaining species, given their new position at the sediment/water interface, may be exposed to conditions to which they are not suited, i.e. unfavourable conditions. Newell *et al*. (1998) state that removal of 0.5 m depth of sediment is likely to eliminate benthos from the affected area.

Removal of 30 cm of sediment will remove species that occur at the surface and within the upper layers of sediment. The extraction of sediment would remove the characterizing species *Lanice conchilega*, and the associated species present, including *Cerastoderma edule*, which is found to a depth of 5 cm and Nephtyid species and other polychaetes, such as *Scoloplos armiger* and *Pygospio elegans* that burrow between 5 and 20 cm into the sediment (Schöttler, 1982; Pedersen, 1991; Kruse *et al*., 2004).

Hydrodynamics and sedimentology (mobility and supply) influence the recovery of soft sediment habitats (Van Hoey *et al*., 2008). Recovery of the sedimentary habitat would occur via infilling, some recovery of the biological assemblage may take place before the original topography is restored, if the exposed, underlying sediments are similar to those that were removed.

Sensitivity assessment. Extraction of 30 cm of sediment will remove the characterizing biological component of the biotope. Resistance is assessed as ‘None’ and biotope resilience is assessed as ‘Medium’ as some sediment recovery may be required before recovery processes begin. Biotope sensitivity is therefore assessed as ‘Medium’.

Abrasion/disturbance of the surface of the substratum or seabed	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

The characterizing species of this biotope (*Lanice conchilega*) has robust, flexible tubes and may retract below the surface. They are also able to rapidly rebuild or repair tubes (Nickolaidou, 2003). These characteristics reduce exposure to this pressure and enhance recovery. Rabaut *et al.* (2008) studied fisheries impacts at the species level in temperate sandy bottom areas. A controlled field manipulation experiment was designed focusing on areas with high densities of *Lanice conchilega* (i.e. *Lanice conchilega* reefs). A treatment zone was exposed to a one-off experimental trawling and the impact on, and recovery of, the associated fauna was investigated for a period of 9 days post-impact. Community analysis showed a clear impact on associated species such as *Eumida sanguinea*, followed by a relatively quick recovery. The passage of a single beam trawl did not significantly alter the density of *Lanice conchilega* (Rabaut *et al*., 2008).

Muddy sand sediments, in general, tend to be cohesive, although high levels of water content will reduce this and destabilise sediments. Sediment cohesion provides some sediment stabilisation to resist erosion following surface disturbance. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content (Sheehan, 2007). The tops of burrows may be damaged and repaired subsequently at energetic cost to their inhabitants. Experiments have shown that areas subject to compaction from trampling tend to have reduced species abundance and diversity (Sheehan, 2007; Rossi *et al*., 2007). Sheehan (2007) proposed that following compaction, organisms avoid or emigrate from affected areas.

Rossi *et al.* (2007) investigated the effects of continuous trampling (a source of abrasion) on intertidal soft sediments, with on average of 5 people for 3-5 hrs, twice a month between March and September (2005). The abundance of *Cerastoderma edule* was reduced presumably by sediment compression, leading to asphyxia in adults. Rossi *et al.* (2007) conducted the investigation during spawning periods, when juveniles where present in the water column. There was therefore little observable effect on juvenile *Cerastoderma edule* abundances due to continuous recruitment. Rossi *et al.* (2007) noted that during the growing season, recovery can be fast but in the long-term trampling increased the recruitment of *Limecola balthica* at the expense of *Cerastoderma edule.*

Abrasion is likely to reduce the density of *Corophium* spp. by emigration and increased mortality, as this species is sensitive to sediment disturbance from bioturbating species (Flach, 1993).

Exposure to abrasion may vary according to life stage. For example, the egg cocoons of *Scoloplos armiger* and *Nephtys hombergii* are laid on the sediment surface before hatching and entering into their planktonic stages of development. The juveniles found a few millimetres below the surface (Reise, 1979; Kruse *et al*., 2004) are sensitive to the effects of abrasion.

Sensitivity assessment. The experiments by Rabaut *et al.* (2008) suggest that *Lanice conchilega* has ‘High’ resistance to abrasion, however, other associated species may be more impacted. Biotope resistance to a single abrasion event is assessed as ‘High’ based on the key characterizing species *Lanice conchilega*. There may be some damage to tubes but this is expected to be sub-lethal and tubes are likely to be rapidly repaired. Recovery from impacts of associated species is predicted to be ‘High’ and the biotope is assessed as ‘Not sensitive’.

Penetration or disturbance of the substratum subsurface	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

The characterizing species of this biotope (*Lanice conchilega*) has robust, flexible tubes and may retract below the surface. They are also able to rapidly rebuild or repair tubes (Nickolaidou, 2003). These characteristics reduce exposure to this pressure and enhance recovery.

Rabaut *et al*. (2008) studied fisheries impacts at the species level in temperate sandy bottom areas. A controlled field manipulation experiment was designed focusing on areas with high densities of *Lanice conchilega* (i.e. *Lanice conchilega* reefs). A treatment zone was exposed to a one-off experimental trawling, and the impact on and recovery of the associated fauna was investigated for a period of 9 days post-impact. Community analysis showed a clear impact followed by a relatively quick recovery. The passage of a single beam trawl did not significantly alter the density of *Lanice conchilega*. Rabaut *et al*. (2009) also studied the direct mortality of *Lanice conchilega* as a consequence of sustained physical disturbance at varying frequencies to reflect the effect of beam trawl fisheries. Research was based on a laboratory experiment in which four different disturbance regimes were applied (disturbance every other 12, 24 and 48 h and no fishing disturbance as a control). Survival dropped significantly after 10 and 18 days (with a disturbance frequency of every 12 and 24 h, respectively). The results indicate that *Lanice conchilega* is relatively resistant to physical disturbance but that reef systems can potentially collapse under continuous high frequency disturbance.

Ferns *et al*. (2000) investigated the effect of tractor dredging for cockles on an intertidal muddy sand at Burry Inlet, South Wales mechanical cockle harvesting. The tubes of *Lanice conchilega* were damaged but this damage was rapidly repaired. Associated species were more vulnerable and a decline of 31% in populations of *Scoloplos armiger* (initial density 120/m^2) was recorded in muddy sands and an 83% decline in *Pygospio elegans* (initial density 1850/m^2). *Pygospio elegans* were significantly depleted for >100 days after harvesting (surpassing the study monitoring timeline). Whilst *Nephtys hombergii* and *Scoloplos armiger* demonstrated recovery >50 days after harvesting in muddy sands. *Cerastoderma edule* recovered more quickly than those in muddy sand with a more structured community, which included *Pygospio elegans* and *Lanice conchilega* in clean sands (Ferns *et al*., 2000).

Hand raking for cockles on intertidal silty sandflats, using rakes that penetrated the surface by 5-10 cm, resulted in a three-fold increase in the damage rate of cockles compared to control plots and, in the short-term, led to a relative decrease in the overall abundance of fauna (Kaiser *et al*., 2001). After 56 days, the small (9 m^2) plots had recovered but the larger (36 m^2) plots remained in an altered state. Results collected over a year after the disturbance suggested that while effects of hand-raking may be significant within a year, they are unlikely to persist beyond this time-scale unless there are larger long-lived species present within the community (Kaiser *et al*., 2001). Effects may be longer lasting where sediment damage occurs without recovery. A study in the Dutch Wadden Sea showed that suction-dredging for cockles (*Cerastoderma edule*) led to a significant long-term reduction in settlement and stocks of the target bivalve species (Piersma *et al*., 2001). Analysis of sediment characteristics before and after dredging showed an increase in median grain size and a reduction of silt content, and that these changes were most pronounced in the area dredged for cockles. Sediment characteristics only returned to pre-impact conditions 8-11 years after the suction dredging.

Sensitivity assessment. The experiments by Rabaut *et al*. (2008, 2009) suggest that *Lanice conchilega* has 'High' resistance to abrasion and penetration, however, other associated species may be more impacted. Biotope resistance to a single abrasion event is assessed as 'High' based on the key characterizing species *Lanice conchilega*. There may be some damage to tubes but this is expected to be sub-lethal and tubes are likely to be rapidly repaired. Recovery from impacts of associated species is predicted to be 'High' and the biotope is assessed as 'Not sensitive'.

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

Production within the biotope is predominantly secondary, derived from detritus and to some extent phytoplanktonic production. Characteristic infauna do not require light and therefore the effects of increased turbidity on light attenuation are not directly relevant. However, an increase in turbidity may affect primary production in the water column and therefore reduce the availability of phytoplankton as food but phytoplankton would also be transported in to the biotope from distant areas, so the effect of increased turbidity may be mitigated. As soon as light levels return to normal, phytoplanktonic primary production would increase, the species would resume optimal feeding, so recoverability has been assessed to be very high. A decrease in suspended organic particles may reduce food supply to *Lanice conchilega*, however, this species can switch from suspension to deposit feeding and vice versa (Buhr & Winter, 1977). Supply of materials needed to build the tubes may be affected with a decrease in suspended solids but wave action would be likely to continue to re-suspend and transport sediments.

Sensitivity assessment. A decrease in turbidity and hence increased light penetration may result in increased phytoplankton production and hence increased food availability for suspension feeders, including *Lanice conchilega* and *Cerastoderma edule*. Therefore, reduced turbidity may be beneficial. In areas of high suspended sediment, a decrease may result in improved condition and recruitment due to a reduction in the clogging of filtration apparatus of suspension feeders and an increase in the relative proportion of organic particulates. However, a decrease in suspended organic particles in some areas may reduce food availability for deposit feeders resulting in lower growth or reduced energy for reproduction.

Where increased turbidity results from organic particles then subsequent deposition may enhance food supply for suspension and deposit feeders within the biotope. Alternatively, if turbidity results from an increase in suspended inorganic particles then energetic costs may be imposed on these species as sorting and feeding becomes less efficient, reducing growth rates and reproductive success. Lethal effects are considered unlikely given the occurrence of *Lanice conchilega* and *Cerastoderma edule* and other associated species in estuaries where turbidity is frequently high from suspended organic and inorganic matter. Resistance and resilience are therefore assessed as 'High' and the biotope is considered to be 'Not sensitive'.

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

The tube of *Lanice conchilega* protrudes above the sediment by 1–4 cm, an adaptation to trap suspended particles (Zühlke, 2001). Furthermore, Ziegelmeier (1952) showed that the tubes of *Lanice conchilega* increased the height with increasing sedimentation so that it could continue feeding and metabolising aerobically. This enables *Lanice conchilega* to switch between deposit and suspension feeding (Buhr, 1976). Therefore, *Lanice conchilega* is suitably adapted to discrete events of sedimentation, characteristic of sandy, muddy sand intertidal flats. *Lanice conchilega* has dominated areas of Manila clam cultivation where protective netting had led to an increase in sedimentation (Spencer *et al*.,1998) and in areas where oysters were cultivated and sedimentation increased (Sylvand, 1995).

Cerastoderma edule has short siphons and needs to keep in contact with the surface of the sediment. It will quickly burrow to the surface if covered by as little as 2 cm of sediment (Richardson *et al*., 1993b; Cotter *et al*., 1997). When buried to 5 cm depth in a series of siltation experiments most cockles returned to the surface but few were able to reposition to the surface if buried at 10 cm depth (Jackson & James, 1979). None had died after 72 hours. Additional burial experiments under 10 cm of sediment assessed movement and survival after 3, 6 and 9 days in two sediment types (a mix of surface mud and sand in two ratios 9:1 and 1:9). The movement towards the surface was slower in the predominantly muddy sediment and all cockles died between 3 and 6 days. Substantial mortality resulted in the predominantly sandy mixture, although some cockles were able to move towards the surface and survive for 9 days (Jackson & James, 1979).

The associated species *Pygospio elegans* is limited by high sedimentation rates (Nugues *et al*., 1996) and the species does not appear to be well adapted to oyster culture areas where there are high rates of accumulation of faeces and pseudofaeces (Sornin *et al*., 1983; Deslous-Paoli *et al*., 1992; Mitchell, 2006; Bouchet & Sauriau, 2008). *Pygospio elegans* is known to decline in areas following re-deposition of very fine particulate matter (Rhoads & Young, 1970; Brenchley, 1981). Experimental relaying of mussels on intertidal fine sands led to the absence of *Pygospio elegans* compared to adjacent control plots. The increase in fine sediment fraction from increased sediment deposition and biodeposition alongside possible organic enrichment and decline in sediment oxygen levels was thought to account for this (Ragnarsson & Rafaelli, 1999). *Nephtys* species are highly mobile within the sediment. Vader (1964) observed that *Nephtys hombergii* relocated throughout the tidal cycle and is unlikely to be affected by smothering with sediment consistent with that of the habitat.

Sensitivity assessment. Based upon the ability of *Lanice conchilega* to increase tube elevation above the sediment surface when deposition has increased, it is likely that *Lanice conchilega* is resistant to the effects of a single discrete event of deposition of 5 cm. Although *Cerastoderma edule* and *Pygospio elegans* may be impacted, the *Lanice conchilega* biotope is unlikely to be altered from a single event. Sensitivity to continuous events will depend on tidal hydrodynamics, and spawning and recruitment, prior to the event (see recover/resilience rates). As the benchmark refers to a single discrete event, resistance is 'High' and resilience is 'High', therefore this biotope is 'Not sensitive'.

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

No evidence was found to assess sensitivity of *Lanice conchilega* to heavy sedimentation. It is likely that intertidal flats may sometimes be subject to sedimentation following storm events but no species-specific examples were found. Ziegelmeier (1952) showed that *Lanice conchilega* increased the height of its tube top with increasing sedimentation so that it could continue feeding and respire. However, heavy sedimentation of 30 cm during a single event may have a severe effect on *Lanice conchilega* and the associated species.

Cerastoderma edule has short siphons and needs to keep in contact with the surface of the sediment. Bait digging (for large polychaete worms) disturbs the sediment down to a depth of 30 cm (Jackson & James, 1979) and leads to repositioning within sediment or burial from piled sediments. Intensification of bait digging on intertidal flats on the north Norfolk coast for lugworm (*Arenicola marina*) and ragworm (*Hediste diversicolor*) was associated with declines in the *Cerastoderma edule* populations (Jackson & James, 1979). Experimental simulation of bait digging (sediment dug over to a depth of 30 cm with a garden fork) led to high mortalities of cockles in dug areas rather than undug areas (48% mortality in 9 days to a maximum of 85% after 11 days), probably due to smothering (Jackson & James, 1979). The observation was tested experimentally in the laboratory by burying 3 size-classes of cockles at 0, 5 or 10 cm depth in a mix of oxidated and deeper anoxic sands (mixed as a ratio of 3:1). Movements were recorded after 24, 48 and 72 hours. When buried to 5 cm depth, most cockles returned to the surface but few were able to reposition to the surface if buried at 10 cm depth. None had died after 72 hours. Additional burial experiments under 10 cm of sediment assessed movement and survival after 3, 6 and 9 days in two sediment types (a mix of surface mud and sand in two ratios 9:1 and 1:9). The movement towards the surface was slower in the predominantly muddy sediment and all cockles died between 3 and 6 days. Substantial mortality resulted in the predominantly sandy mixture, although some cockles were able to move towards the surface and survive for 9 days.

Sensitivity assessment. The addition of 30 cm of sediment would prevent *Cerastoderma edule* from extending siphons to the surface. It is unlikely that this species could emerge from this depth of sediment, although some individuals may survive and sediment may be rapidly removed by tide and wave action. It is likely, however, that there would be considerable mortality of *Cerastoderma edule* and other species, including *Lanice conchilega*. Resistance is assessed as ‘Low’ and resilience as ‘High’. Sensitivity is therefore assessed as ‘Low’. Although some polychaetes may be able to reposition following sedimentation at the pressure benchmark, this will depend on the characteristics of the overburden, and sedentary species such as *Pygospio elegans* are likely to suffer high levels of mortality.

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

Not assessed.

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

No evidence.

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

No information was found concerning the intolerance of the biotope or the characterizing species to noise. The siphons of bivalves and palps of polychaetes are likely to detect vibrations and would probably be withdrawn as a predator avoidance mechanism. However, it is unlikely that the biotope and characterizing species will be affected by noise or vibrations caused by noise at the level of the benchmark and this pressure is assessed as ‘Not relevant’.

Introduction of light or shading	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. As this feature is not characterized by the presence of primary producers, it is not considered that shading would alter the character of the habitat directly. However, 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). The biomass of the benthic microalgae often exceeds that of the phytoplankton in the overlying waters (MacIntyre *et al*., 1996) such that benthic microalgae play a significant role in system productivity and trophic dynamics, as well as habitat characteristics such as sediment stability. Shading will prevent photosynthesis leading to death or migration of sediment microalgae, altering sediment cohesion and food supply to higher trophic levels.

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

Barriers that reduce the degree of tidal excursion may alter larval supply to suitable habitats from source populations. 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. 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) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

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

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

'Not relevant'.

Biological Pressures

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

Characterizing and associated species are not cultivated or transplanted and this pressures is considered 'Not relevant'.

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

Intertidal flats may be colonized by the invasive non-indigenous species *Crepidula fornicata* and the pacific oyster *Crassostrea gigas*. 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).

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*., 2004). Densities of *Cerastoderma edule* and *Abra tenuis* have increased since the introduction of the Manila clam, but the abundance of *Scrobicularia plana* and *Limecola balthica* has declined (Caldow *et al*., 2005). However, 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 predatory veined whelk (*Rapana venosa*) and *Hemigrapsus takinei* are not established in the UK (although *Hemigrapsus takinei* has been recorded at two locations) and could become significant predators of *Cerastoderma edule* and other species associated with the biotope in the future.

Sensitivity assessment. Intertidal muddy sands 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	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

No evidence was found for microbial pathogens, parasites or diseases of *Lanice conchilega* or other characterizing polychaetes.

A review of parasites, pathogens and commensals identified a range of agents impacting European cockles, including 50 conditions affecting *Cerastoderma edule* (Longshaw & Malham, 2013). Cockles are hosts to viruses, bacteria, fungi, Apicomplexa , Amoeba, Ciliophora, Perkinsozoa, Haplosporidia, Cercozoa, Turbellaria, Digenea, Nematoda, Crustacea and Nemertea. Mortalities are associated particularly with digeneans and some protistan infections; parasites may limit growth, reduce fecundity and alter burrowing behaviour (Longshaw & Malham, 2013). A number of examples of conditions associated with mass mortalities of *Cerastoderma edule* are presented below. Parasites and disease are more likely to cause mortalities in populations that are subject to suboptimal conditions or other stressors such as hot summers or cold winters (Longshaw & Malham, 2013).

The *Cerastoderma edule* catchment in Galicia (NW Spain) was previously a productive cockle fishery, however, cockle mortality rate increased sharply in this bed in April 2012, reaching 100%

in May 2012. Marteiliosis, which was first detected in February 2012 and reached 100% prevalence in April 2012, was identified as the most probable cause. Marteiliosis had never been detected in Galician cockles. Extensive surveillance of the Galician coast in May to July 2012 detected Marteiliosis in most cockle beds of the Ría de Arousa, whereas it was not found in other rías; 2 months later, the cockle catch in the Ría de Arousa became negligible as a result of a *Martelia cochillia* protozoan infection (Villalba *et al*., 2014).

Sensitivity assessment. Based on the evidence for *Cerastoderma edule*, it is likely that parasitic infection may indirectly alter the species composition of the biotope, however, there is no evidence of pathogens influencing *Lanice conchilega* and the other characterizing polychaetes. Resistance is assessed as ‘High’ as the biotope classification would be unlikely to change and removal of *Cerastoderma edule* may increase the extent of *Lanice conchilega* patches and the abundance of species that are sensitive to its sediment disturbing activities, such as *Pygospio elegans* and *Corophium arenarium*. Resilience is therefore assessed as ‘High’ and the biotope is considered to be ‘Not sensitive’.

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

The direct, physical impacts of removal are assessed through the abrasion and penetration of the seabed pressures. The sensitivity assessment for this pressure considers any biological/ecological effects resulting from the removal of target species on this biotope. The cockle *Cerastoderma edule* may be targeted by recreational and commercial fishers and the polychaete *Nephtys hombergii* may be targeted by bait collectors. The removal of target species (*Cerastoderma edule*) may result in changes to the sediment structure (see physical disturbances pressures).

Dense populations of *Cerastoderma edule* on intertidal flats support commercial fisheries in several areas of the UK and the species is also harvested throughout Europe. Harvesting may use mechanical methods (e.g. tractor dredges or hydraulic suction dredging) or hand collection using rakes or other methods. The method of harvesting cockles will influence the proportions that are removed and damaged. Pickett (1973) found that intense dredging for a short period on a bed of cockle spat had little effect on survival and growth, although Cook (1991) found that impacts on small cockles from dredging were variable, with little reduction one year but a reduction in density observed the following year. Cotter *et al*. (1997) assessed the catch rates and damage and mortality of *Cerastoderma edule* resulting from experimental tractor dredging at the Burry Inlet (Wales). Stocks of adult cockles were reduced by 31 and 49% in low and high density areas respectively. Similarly, mechanical cockle harvesting in muddy sand reduced the abundance of *Cerastoderma edule* by ca 34%. Populations had not recovered to their original abundance after 174 days (Ferns *et al*., 2000).

Removal of adult cockles by harvesting or other factors allows other species to establish. Following experimental removal of large adult *Cerastoderma edule* by Cesar & Frid (2012), sediments showed increased biodiversity and assemblages dominated by traits common to opportunist taxa at a species-poor shore at Warton Sands, Morecambe Bay, and a more diverse shore at Thurstaston, Dee Estuary. The movements of cockles disturb and exclude the amphipod *Corophium volutator* and other species (Flach, 1996; Flach & De Bruin, 1994). The removal of cockles may, therefore, allow this species to colonize intertidal flats. During periods of low cockle density, Desprez *et al*. (1992) observed that *Pygospio elegans* established dense populations, when cockles returned these were lost within one year.

Sensitivity assessment. This biotope is characterized by *Lanice conchilega*, the removal of *Cerastoderma edule* and *Nephthys hobergii* may affect the biotope through physical damage (see abrasion and penetration pressures) but their loss would not lead to biotope reclassification. Resistance is therefore assessed as 'Medium' as removal would lead to some alteration of the biological assemblage through changes in abundance and biomass and through changes in competition for space and sediment disturbance (*Cerastoderma edule*) and predation (*Nephtys hombergii*). The densities of prey species and species sensitive to sediment disturbance such as *Corophium arenarium* may increase. Removal of competitors and predators may enhance recruitment of *Lanice conchilega*. Where sediments remain suitable cockles are likely to recolonize via adult migration, survival of small, discarded cockles or via larval recruitment. Resilience is assessed as 'High' so that biotope sensitivity is assessed as 'Low'.

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

Species within this biotope may be removed or damaged by static or mobile gears that are targeting other species. These direct, physical impacts are assessed through the abrasion and penetration of the seabed pressures. The sensitivity assessment for this pressure considers any biological/ecological effects resulting from the removal of non-target species on this biotope.

Lanice conchilega (sand mason worm) is the dominant polychaete in this biotope. It qualifies as an 'ecosystem engineer' in that it changes and/or creates a habitat, which affects the abundance of other species (Jones *et al*., 1994, 1997). The tube which *Lanice conchilega* builds provides structure and stabilises the sediment (Jones & Jago, 1993). The tubes also obstruct the activities of predatory burrowers enabling other sedentary animals to establish themselves (Wood, 1987). The burrows and tubes allow oxygenated water to penetrate into the sediment, the oxic upper layer of sediment to support shallow burrowing species such as amphipods (*Ampelisca* spp., *Bathyporeia* spp. & *Gammarus* spp.) and small Crustacea. *Lanice conchilega* may therefore increase species richness and abundance through habitat modification (Rabaut *et al*., 2007; Zuhlke, 2001). Dense aggregates of *Lanice conchilega* have the potential to enhance food supply to birds and fish due to increased biodiversity (Rabaut *et al*., 2010; Godet *et al*., 2008; Van Hoey *et al*., 2008; Callaway *et al*., 2010; De Smet *et al*., 2013).

Sensitivity assessment. The removal of non-target species may result in changes to the biological community and hence the classification of the assemblage type as assessed in the biotope. Incidental removal of *Lanice conchilega* would alter the biotope classification and most likely result in changes to the habitat and associated species. As *Lanice conchilega* is sedentary and present at the surface, resistance is 'Low' and resilience is 'High'. Biotope sensitivity is therefore assessed as 'Low'. This assessment considers the ecological effect of removal, the abrasion pressure assessment provides evidence for the robustness of tubes and the species may be resistant to removal by bottom trawls deployed at low intensity (e.g. single passes).

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