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Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand

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

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Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand.
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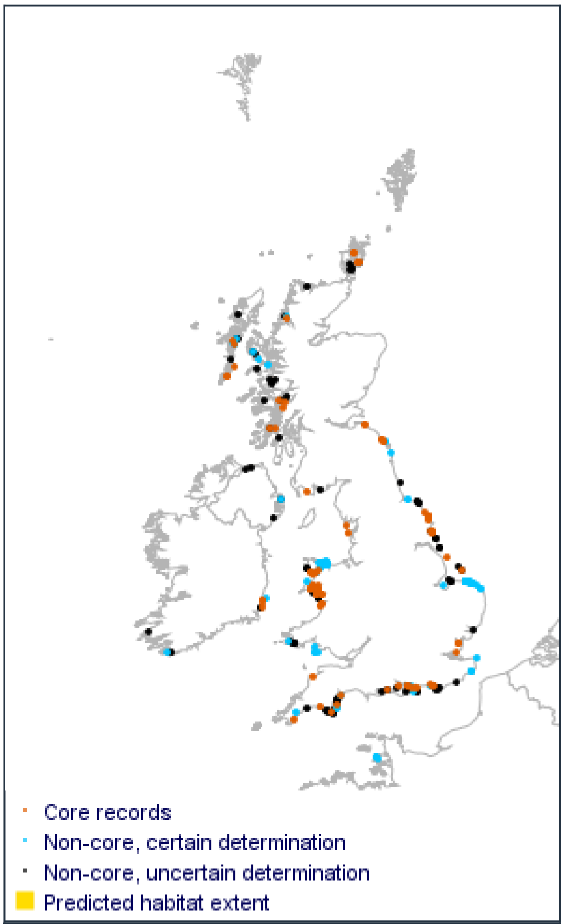

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

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

Summary

UK and Ireland classification

EUNIS 2008	A5.137	Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand
JNCC 2015	SS.SCS.ICS.SLan	Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand
JNCC 2004	SS.SCS.ICS.SLan	Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand
1997 Biotope	SS.IGS.FaS.Lcon	Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand

Description

Dense beds of *Lanice conchilega* occur in coarse to medium fine gravelly sand in the shallow sublittoral, where there are strong tidal streams or wave action. Several other species of polychaete also occur as infauna e.g. *Spiophanes bombyx*,*Scoloplos armiger*, *Chaetozone setosa* and *Magelona mirabilis*. *Lanice* beds are found in a wide range of habitats including muddier mixed sediment. The dense *Lanice* biotope (LGS.Lan) on certain lower shores may be a littoral extension of the current biotope. The presence of *L. conchilega* in high numbersmay, over time, stabilise the sediment to the extent where a more diverse community may develop (Wood, 1987). Possibly as a result of this, there is a high level of variation with regard the infauna found in SCS.SLan. It is likely that a number of sub-biotopes may subsequently be identified for this biotope. Offshore from the Wash and the North Norfolk coast *Lanice* beds are often found intermixed with *Sabellaria spinulosa* beds in muddier mixed sediment, particularly in the channels between the shallow sandbanks, which are so prevalent in this area (IECS, 1995; NRA, 1995). It is possible that the presence of *Lanice* has stabilised the habitat sufficiently to allow the deposition of finer material, which has subsequently assisted the development of *S. spinulosa*. It may be more accurate to define SLan as an epibiotic biotope which overlays a variety of infaunal biotopes (e.g. NcirBat in finer sands and AalbNuc or FfabMag in slightly muddier areas) (JNCC, 2015).

Depth range

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

Additional information

No text entered

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Habitat review

Ecology

Ecological and functional relationships

- The hydrodynamic regime and sediment composition and interaction between the two are probably the most significant factors structuring the community rather than biological interactions (Tyler, 1977a; Warwick & Uncles, 1980; Elliott *et al.*, 1998).
- Species in the biotope are predominantly suspension and deposit feeders, and probably little direct interaction occurs between them other than competition for space.
- Some species feed on both suspended particulates and surface deposits (e.g. the bivalves *Fabulina fabula* and *Abra alba* and the tube building polychaete *Lanice conchilega*). Following laboratory experiments, Buhr (1976) concluded that *Lanice conchilega* was capable of completely replacing deposit feeding by suspension feeding. The absolute amounts of food retained from suspension feeding and the assimilation efficiencies calculated were in the range typical for obligatory suspension-feeding organisms.
- Studies of *Lanice conchilega* aggregations in the Wadden Sea (Zühlke *et al.*, 1998; Dittmann, 1999; Zühlke, 2001) have shown that tubes built by *Lanice conchilega* can have 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. 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. In particular, abundances of predatory polychaetes (*Eteone longa*, *Nephtys hombergii*, *Hediste diversicolor*) were higher (Dittmann, 1999). The increased species diversity and abundance recorded in patches of *Lanice conchilega* are also known to occur around the tubes of other species of polychaetes (Woodin, 1978).
- In sand, the primitive sea slug *Faction 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).
- *Lanice conchilega* constitutes an important prey item for curlew *Numenius arquata*, bar-tailed godwit *Limosa lapponica* and grey plover *Pluvialis squatarola*.
- The amphipods e.g. *Ampelisca* and *Atylus* species are probably epistatic grazers, grazing benthic microalgae from sand grains.
- Amphipods and the infaunal annelid species in the biotope probably interfere strongly with each other. Adult worms probably reduce amphipod numbers by disturbing their burrows and tubes, while high densities of amphipods can prevent establishment of worms by consuming larvae and juveniles (Olafsson & Persson, 1986).
- Spatial competition probably occurs between the infaunal suspension feeders and deposit feeders. Reworking of sediment by deposit feeders makes the substratum less stable, increases the suspended sediment and makes the environment less suitable for suspension feeders (Rhoads & Young, 1970). Tube building by amphipods and polychaetes stabilizes the sediment and arrests the shift towards a community consisting entirely of deposit feeders. In the coarse sediments in this biotope the suspension feeding species dominate.
- Amphipods are preyed upon chiefly by nemertean worms (see McDermott, 1984) and

demersal fish (Costa & Elliott, 1991).

- The abundant infauna are preyed upon by carnivorous polychaetes, e.g. phyllodocids species of *Anaitides* and *Eumida*, scale worms (e.g. *Harmothoe* sp.) and *Nephtys hombergii*.
- *Asterias rubens*, predates the bivalves (Aberkali & Trueman, 1985; Elliott *et al*., 1998).
- Crabs, particularly *Liocarcinus depurator* and *Carcinus maenas*, are scavengers and predators of molluscs and annelids (Thrush, 1986; Elliott *et al*., 1998).
- The hermit crab *Pagurus bernhardus*, brittlestars (e.g. *Ophiura albida*) *and nemerteans are probably scavengers on detritus and carrion.*
- *Gobies (e.g. Pomatoschistus species) and flatfish frequent the biotope to feed upon polychaetes, small crustaceans such as amphipods, cumaceans, small crabs, such predators also nip the siphons of bivalves and tails of polychaetes.*

Seasonal and longer term change

- Temporal changes are likely to occur in the community due to seasonal recruitment processes. For instance, in the German Bight, peak abundance of *Fabulina fabula* (ca 2000 individuals/m▯) occurred in September following the main period of spatfall and then decreased to a minimum in February (ca 500 individuals/m▯), at which point settlement began to occur again (Salzwedel, 1979). Similarly, temporal evolution of *Fabulina fabula* in NW Spain showed well marked annual peaks in autumn (Lopez-Jamar *et al*., 1995). In the German Bight, spatfall for *Magelona mirabilis* was heaviest in August/September, and for *Echinocardium cordatum* spatfall was heaviest in August (Bosselmann, 1989).
- Temporal variations in species richness and abundance are likely to occur due to seasonal patterns of disturbance, such as storms, harsh winters and oxygen deficiencies (Bosselmann, 1989; Lopez-Jamar *et al*., 1995). The biotope may also be liable to severe substratum disturbance, such as one in 25 year or one in 50 year storms, which can turn over sediment and completely disrupt the community (Elliott *et al*., 1998).
- There may be a spring-neap and winter-summer cycle of erosion and deposition of sediment, altering the biotope extent and reflecting changes in hydrodynamic energy (Dyer, 1998).
- The water temperature in subtidal sandy habitats may vary over 5-10°C through the year in British coastal waters depending on depth. The variation may have short-term but significant effects on species diversity (Buchanan & Moore, 1986).
- There is a seasonal variation in planktonic production in surface waters. Increased production by phytoplankton in spring and summer enhanced by increasing temperature and irradiance is followed by phytoplankton sedimenting events which correlate with seasonal variations in the organic content of benthic sediments (Thouzeau *et al*., 1996). Such variations directly influence the food supply of the deposit feeders and suspension feeders in the biotope.

Habitat structure and complexity

- Tidal streams in particular are a predominant factor influencing the structure of infralittoral sands, causing constant change in the shape, size and position and owing to the mobile nature of the sandy substratum and scour macrophyte communities do not become established.
- 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 ephemeral green algae in the summer months. The aerobic upper layer of sediment supports shallow burrowing species such as amphipods and small crustacea, whilst the

reducing layer and deeper anoxic layer support chemoautotrophic bacteria, burrowing polychaetes (e.g. *Chaetopterus variopedatus* and *Arenicola marina*) that can irrigate their burrows, and burrowing bivalves (e.g. *Abra alba*).
- 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 hydrodynamincs (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. The burrow of *Arenicola marina* is irrigated (and therefore aerated) by intermittent cycles of peristaltic contractions of the body from the tail to the head end. *Lanice conchilega* is not known to purposely irrigate its tube since food acquisition occurs through surface deposit and suspension feeding, and respiration takes place via gills positioned outside the tube when the animal is feeding. However, the sand mason periodically withdraws from the surface into its tube for a few seconds, therefore acting as a 'piston pump', exchanging interstitial sediment water with overlying water (Forster & Graf, 1995).

Productivity

Production in the biotope is mostly secondary, dependant upon detritus and organic material. Some primary production comes from benthic microalgae and water column phytoplankton. The microphytobenthos consists 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 sea bed, 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

The dominant species in the biotope are polychaetes and bivalves which tend to have relatively long-lived planktonic larvae. More detailed information concerning recruitment of important characterizing species is given below:

- *Lanice conchilega* is a polychaete species with separate sexes. During its life of 1-2 years (Beukema *et al*., 1978), the species initially passes through two larval stages, of which the last one, when it is known as an aulophora larva, lives about 4-6 weeks in the plankton (Kessler, 1963). Kuhl (1972) reported that the larvae of *Lanice conchilega* are released between April and October. Experimental data and field studies from the Wadden Sea revealed that the existence of 'hard substrate', preferentially tubes of conspecific adults, was a requirement for initial settlement of *Lanice conchilega* larvae, although single juveniles were also observed to settle on eroded shells of cockles (*Cerastoderma edule*) and soft-shelled clams (*Mya arenaria*) (Heuers, 1998; Heuers *et al*., 1998). Presumably this was the case following the ice winter of 1995/96 which decimated populations of *Lanice conchilega* on intertidal sand flats of the Dutch Wadden Sea, as settlement of larvae occurred in the absence of adults in the intertidal and shallow sublittoral (Strasser & Pielouth, 2001). Near bottom water velocity and turbulence are thought to be essential factors determining the spatial and temporal distribution of *Lanice conchilega*. According to Harvey & Bourget (1995) current velocity over a dense *Lanice conchilega* tube 'lawn' has to reach a value that causes turbulence and facilitates larval settlement. Lower current speeds reduce turbulence and thus the probability of larval settlement is reduced. The current speed at which turbulence developed depended on the density of the tube 'lawn', tube diameter and surface roughness in combination with currents. Grimm (1999) modelled the spatial and temporal distribution of *Lanice conchilega* with the intention of exploring mechanisms responsible for the large differences in density of the species on a tidal flat of the Dutch Wadden Sea. Field data collected by Brandt *et al.* (1995) seemed to tentatively confirm the model assumption made by Grimm (1999) that 'the local density of *Lanice conchilega* is strongly influenced by the overall velocity of the near bottom flow: low density occurs in areas where low velocities prevail, whereas high densities occur where high velocities prevail'. Brandt *et al.* (1995) recorded a mean flow velocity of 10 cm/s in low density stands of the species, and 20 cm/s near populations of high density.
- Hayward (1994) summarized recruitment of *Arenicola marina*. The species breeds late in the year and has a protracted spawning period between September and November, consisting of two peaks, in late September and late November, with a five week period between during which no spawning occurs. Production of eggs starts in February and March, so that by July the entire population consists of sexually mature adults, usually equal in number. Spawning is synchronous, induced by falling seawater temperature at a threshold of 13°C, or by an abrupt downward temperature shock (Farke & Berghuis, 1979). Males are the first to spawn into their burrows, from which it is ejected to form pools on the sand. Females draw sperm into their burrows as they ventilate their burrows and eggs are fertilized. Development and hatching occurs within the female burrow. After spawning males fast for 2 days while females fast for 3-4 weeks, presumably to avoid ingesting eggs and larvae (Farke & Berghuis, 1979). The larvae leave the burrow when they have grown three chaete-bearing body segments. Post larvae are capable of active migration by crawling, swimming in the water column and passive transport by currents e.g. Günther (1992) suggested that post-larvae of *Arenicola marina* were transported distances in the range of 1 km. The species may live between 5 and 10 years.
- Reproductive data concerning *Magelona mirabilis* is scarce (Fiege *et al*., 2000). It is generally agreed that *Magelona mirabilis* displays characteristics typical of an r-selected species, i.e. high reproductive rate, short lifespan and high dispersal potential (Krönke, 1990; Niermann *et al*., 1990), and typically occurs in the early successional stages of

variable, unstable habitats (Bosselmann, 1989; Niermann *et al*., 1990). *Magelona mirabilis* seems to have a protracted reproductive period. Fiege *et al.* (2000) recorded males with sperm masses and females with eggs in Scotland in March and egg bearing females in France in May. Probert (1981) reported *Magelona* sp. larvae in Plymouth Sound between April and November with greatest abundances from July to October, and Bosselmann (1989) reported that *Magelona* sp. larvae were captured in plankton trawls on most dates of sampling in the German Bight but were most abundant in August and September. Bosselmann (1989) also noted large interannual variability in numbers of *Magelona* sp. larvae in the plankton.

- The bivalves in the biotope are gonochoristic broadcast spawners with pelagic larval dispersal. They therefore have the potential to recruit both locally and remotely. However, 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). *Abra alba* is generally considered to be an 'r-strategist'; capable of rapidly exploiting any new or disturbed substratum suitable for colonization through larval recruitment, secondary settlement of post metamorphosis juveniles or redistribution of adults following storms (Rees & Dare, 1993). Normally, there two distinct spawning periods, in July and September and according to the season of settlement, individuals differ in terms of growth and potential lifespan (Dauvin & Gentil, 1989). Autumn settled individuals from the Bay of Morlaix, France, initially showed no significant growth; they were not collected on a 1 mm mesh sieve until April, 5 to 7 months after settlement. Such individuals were expected to have a maximum lifespan of 21 months and could produce two spawnings. In contrast, veliger larvae that settled during the summer grew very rapidly and were collected on a 1 mm mesh sieve just one month after settlement. They lived about one year and spawned only once (Dauvin & Gentil, 1989).

Time for community to reach maturity

The life history characteristics of the species, particularly the polychaetes, which characterize the biotope suggest that the community would probably reach maturity within 3 years. For instance, settlement of *Lanice conchilega* has been reported to be more successful in areas with existent adults than areas without (Heuers & Jaklin, 1999), however, Strasser & Pielouth (2001) reported settlement in location without adults, but that establishment of a mature population took three years. Adults of *Arenicola marina* reach sexual maturity by their second year (Newell, 1948; Wilde & Berghuis, 1979) but may mature by the end of their first year in favourable conditions depending on temperature, body size, and hence food availability (Wilde & Berghuis, 1979). The life history characteristics of *Abra alba* and its widespread distribution contribute to its powers of recoverability. Diaz-Castaneda *et al.* (1989) experimentally investigated recolonization sequences of benthic areas over a period of one year following defaunation of the sediment. Recovery of the *Abra alba* population was rapid, recruitment occurred from surrounding populations via the plankton. The abundance, total biomass and diversity of the community all increased until a maximum was reached after 20 to 24 weeks, according to the season. The community within the experimental containers matched that of the surrounding areas qualitatively but quantitatively within 4 to 8 months depending on the seasonal availability of recruits, food supply and faunal interactions. The experimental data suggests that *Abra alba* would colonize available sediments within the year following environmental perturbation. Summer settled recruits may grow very rapidly and spawn in the autumn, whilst autumn recruits experience delayed growth and may not reach maturity until the following spring/summer.

Additional information

No text entered.

Preferences & Distribution

Habitat preferences

Depth Range	0-5 m, 5-10 m, 10-20 m
Water clarity preferences	Field Unresearched
Limiting Nutrients	Data deficient
Salinity preferences	Full (30-40 psu)
Physiographic preferences	
Biological zone preferences	Infralittoral
Substratum/habitat preferences	Fine clean sand, Gravelly sand, Medium clean sand
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 Weak (negligible), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Exposed, Moderately exposed, Sheltered
Other preferences	Tidal streams

Additional Information

The dense *Lanice* biotope (LGS.Lan) on certain lower shores may be a littoral extension of this biotope.

Species composition

Species found especially in this biotope

- *Lanice conchilega*

Rare or scarce species associated with this biotope

-

Additional information

The MNCR recorded ca 613 species within this biotope, although not all species occur in all examples of the biotope (JNCC, 1999). Connor *et al* (1997b) noted that this biotope may consist of a number of separate communities. Although the density of *Lanice conchilega* is the characteristic feature of the biotope, community composition probably varies with location, the degree of detritus and nutrient input and the local hydrographic regime, resulting in the high number of species recorded in this biotope.

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and characterizing species are based on JNCC (2015). The biotope is characterized by dense beds of *Lanice conchilega* occuring in coarse to medium fine gravelly sand in the shallow sublittoral, where there are strong tidal streams or wave action. 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. Several other species of polychaete also occur as infauna e.g. *Spiophanes bombyx*, *Scoloplos armiger*, *Chaetozone setosa* and *Magelona mirabilis* and the sensitivities of these species are assessed generally.

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 some of the associated species may be more rapid than the recovery of dense patches of *Lanice conchilega*. Species with opportunistic life strategies (small size, rapid maturation and short lifespan of 1-2 years), include the characterizing polychaetes *Chaetozone setosa* and *Spiophanes bombyx*.The resilience of *Chaetozone* spp. Were reviewed by MES (2010). has a lifespan of 1-2 years and reaches sexual maturity in <1 year. There is little information on the fecundity but the eggs are fertilized externally and may have a significant larval dispersal potential. It shows all the characteristics of an opportunistic species with a short lifespan and rapid growth rate. Where the environmental conditions are suitable, *Chaetozone setosa* is likely to recover to be one of the first genera to recover following disturbance (MES, 2010). *Scoloplos armiger* and *Magelona mirabilis* are larger and longer-lived and recovery may be longer but occur within the time same scales as *Lanice conchilega*.

Scoloplos armiger has a lifespan of about four years and reaches maturity at two years. The sexes are separate and as many as 100-5000 eggs of about 0.25 mm are fertilized externally between February-April. The eggs are attached to the seabed in a gelatinous mass and emerge after three weeks and burrow near the site of release. There may be a very short lecithotrophic pelagic phase in subtidal populations but dispersal is very limited. This genus has a low dispersal potential (MES, 2010). *Scoloplos armiger* is considered to be a species that characterize the end of the transitional phase and the development of final equilibrium communities following impact or disturbance, rather than an opportunistic species that initially colonizes (Newell *et al*., 1998).

Magelona spp. Are small-medium sized polychaete worms up to 5-20 cm length free-living within sediments. *Magelona* lives for about 3 years and reaches maturity at 2 years. There is only one reproductive period, which occurs between May-October. The eggs released by the female are fertilized externally and develop into planktotrophic larvae that settle from June-November. The genus has a high dispersal potential and forms dense communities with a relatively rapid growth rate (MES, 2010).

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.

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

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.

Magelona mirabilis are widespread on the coasts of Britain and Northern Ireland (Richards, 2007) and their distribution extends to north-west Europe and the Mediterranean (Hayward & Ryland, 1995b). *Scoloplos armiger* is a species complex as is *Chaetozone setosa*. Both are widely distributed but populations may be sibling species and exhibit different tolerances. Until recently, *Chaetozone setosa* was considered cosmopolitan with records world-wide, from the intertidal zone to the deep sea. It is now known that there are several species of eyeless *Chaetozone* spp. in the north-east Atlantic but the worldwide distribution is unclear. Chambers *et al*. (2007) assessed numerous records of *Chaetozone setosa* in the north-east Atlantic, and identified habitat preferences *Chatezone setosa* was frequently found in habitats where the mean minimum winter bottom temperature is 5-10°C and the summer maximum is >10°C (Chambers *et al*., 2007).

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* and the other characterizing polychaetes have a wide geographic range. The lack of evidence for mass mortalities of intertidal populations in very hot summers (compared with reports for low winter temperatures), suggest that the characterizing and associated species are likely to tolerate a chronic or acute increase at the pressure benchmark).

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

Infaunal species such *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.

Scoloplos armiger is a species complex as is *Chaetozone setosa*. Both are widely distributed but populations may be sibling species and exhibit different tolerances. Until recently, *Chaetozone setosa* was considered cosmopolitan with records world-wide, from the intertidal zone to the deep sea. It is now known that there are several species of eyeless *Chaetozone* in the north-east Atlantic and the worldwide distribution is unclear. Chambers *et al*. (2007) assessed numerous records of *Chaetozone setosa* in the north-east Atlantic. The species is frequently found in habitats where the mean minimum winter bottom temperature is 5-10°C and the summer maximum is >10°C.

Sensitivity assessment. Biotope resistance has been assessed to be ‘Low’ as evidence suggests that populations of the key characterizing species *Lanice conchilega* 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) salinity (JNCC, 2015). At the pressure benchmark, an increase from full to hypersaline (>40 ppt) was considered but no direct evidence was found to assess the sensitivity of this biotope to a long-term increase.

Salinities within tide swept habitats vary due to weather conditions such as rainfall 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). *Lanice conchilega* as a tube dwelling polychaete may retract deeper into the sediment to avoid unfavourable conditions but some physiological tolerance for short-term increases in salinity is suggested by its presence in the intertidal.

No direct evidence was found to assess sensitivities of the other characterizing polychaete species. *Scoloplos armiger* was found at low abundances at the discharge point the discharge point of brine effluents at 47-50 psu in the Canary Islands (Riera *et al*., 2012). However, in the western Baltic Sea *Scoloplos armiger* abundance was greatest between 12 psu and 17 psu and reduced abundance with increasing salinity was observed (Gogina *et al*., 2010). As *Scoloplos armiger* is a species complex and is not a cosmopolitan species there may be differences in tolerances between populations.

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), but the intertidal biotope LS.LSa.MuSa.Lan is found in both 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 *Lanice conchilega* as this falls within the natural habitat distribution.

Scoloplos armiger shows a lower salinity limit of 10.5 psu (Gogina *et al*., 2010), suggesting the species is tolerant of a decrease from full to reduced salinity and even the low salinity category in the MNCR scale. *Magelona mirabilis* occurs in the Baltic Sea (Fiege *et al*., 2000) where salinity is typically lower than in the open ocean. It is likely that some populations of *Magelona mirabilis* are adapted to reduced salinity habitats, however, no information on the effects of an overall decrease in salinity were found.

Sensitivity assessment. Little empirical evidence was found to assess sensitivity of *Lanice conchilega* and other characterizing polychaetes to this pressure at the benchmark level and therefore the assessment was made based on the intertidal biotope. 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 strong (1.5-3 m/s) to negligible (JNCC, 2015).

There is limited evidence to assess changes in water flow rates for >1 year at the benchmark level. 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.

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

The biotope occurs from the shallow sublittoral (0-5 m) down to a depth of 20 m, therefore it does not normally experience periods of emergence. An increase in emergence may affect the uppermost part of it. However, on certain shores the LS.LSa.MuSa.Lan biotope may be a littoral extension of this biotope. An increase in emergence may lead to an increase in predation (of the relatively small proportion of the biotope affected) by wading sea birds. However, on balance the major extent of the biotope would be unaffected and biotope resistance is assessed as ‘High’, resilience as ‘High’ and the biotope is considered ‘Not sensitive’.

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 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. By default 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. 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.

Boilly & Richard (1978) stated that the presence of *Magelona mirabilis* is indicative of sediments which have been contaminated with iron. Studies on a dredge spoil disposal site in the harbours of Boulogne and Dunkerque in France (Bourgain *et al*., 1988) found higher densities of *Magleona mirabilis* three months after the dumping of dredge spoil than after five months, when the metal contamination of the sediments was higher. No information regarding the effect of other metals on this species was found.

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 *et al.* (1980) and Kingston *et al.* (1995) as a result of the *Florida* oil spill and the *Braer* oil spill (Gómez Gesteira & Dauvin, 2000).

Gray *et al.* (1990) found that *Scoloplos armiger* were a dominant species in uncontaminated soft sediments at a case study site adjacent to the Ekofisk oil field but were not present at contaminated sites.

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* was found.

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 was found

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	Low Q: High A: Low C: NR	High Q: High A: Low C: High	Low Q: High A: Low C: Low

Niermann *et al.* (1990) reported changes in a fine sand community for the German Bight in an area with regular seasonal hypoxia. In 1983, oxygen levels were exceptionally low (<3 mg O_2/l) in large areas and <1 mg O_2/l in some areas. Species richness decreased by 30-50% and overall biomass fell. The abundance of *Lanice conchilega* was significantly reduced during the period of hypoxia (1-3 mg/O_2/dm▯). However, the period of hypoxia lasted for about a month and, therefore, exceeds the pressure benchmark. *Magelona* sp. remained abundant during the hypoxic period and decreased slightly in abundance on resumption of normoxia. *Spiophanes bombyx* was found in small numbers at some, but not all areas, during the period of hypoxia. Once oxygen levels returned to normal *Spiophanes bombyx* increased in abundance; the evidence suggests that at least some individuals would survive hypoxic conditions (Niermann *et al*., 1990)

In laboratory conditions, *Scoloplos armiger* survived low oxygen conditions for 40 hours (Schöttler & Grieshaber, 1988). No evidence was returned by searches on extended exposure to low levels of dissolved oxygen.

Sensitivity assessment. Based on the available evidence biotope resistance is assessed as ‘Low’ (based on *Lanice conchilega*) and resilience is assessed as 'High' (following restoration of typical habitat conditions). Biotope resistance is therefore assessed as ‘Low’. Due to the lack of evidence for *Lanice conchilega*, at the pressure benchmark confidence in applicability 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).

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

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

The polychaete species characterizing this biotope are all deposit feeders that may benefit from an input of organic material and are likely to be resistant to this pressure at the benchmark. *Chaetezone setosa* were typical of enriched sites off the coast of Barcelona that were subject to effluents and sludge disposal from treatment plants (Corbera & Cardell, 1995) and other studies suggest the characterizing polychaetes are unlikely to be affected by organic enrichment at the pressure benchmark. Borja *et al.* (2000) assessed relative sensitivity of *Scoloplos armiger* as an ABMI Ecological Group II species (indifferent/tolerant to enrichment). Field studies have also identified *Scoloplos armiger* as a ‘progressive’ species, i.e. one that shows increased abundance under slight organic enrichment (Leppakoski, 1975 cited in Gray, 1979).

Lanice conchilega was 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)'.

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. Biotope resistance is assessed as ‘High’ and resilience as ‘High’ (by default), and the biotope is categorized as ‘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 very fine gravelly sands (Connor *et al*., 2004). The biotope would not be considered sensitive to a change to mixed sediments for muddy sands, as the sediment would still be likely to support the biotope without a fine sand fraction could, however, lead to a reduction in habitat suitability for both *Lanice conchilega* and the associated burrowing polychaetes.

An assessment of distribution records of *Chaetozone setosa* in the North Sea concluded that the species is usually associated with fine sediments (Chambers *et al*., 2007). *Magelona* spp. occur in coarse clean sand and fine clean sand (Rayment, 2007b). The polychaete *Scoloplos armiger* has relatively broad sediment preferences. Changes in sediment composition that alter the grade of sediment this species must move through can affect the suitability of the habitat. An increase in coarse composition to gravels would be expected to negatively impact this burrowing species.

Sensitivity assessment. Changes in sediment that lead 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 (Sch□ttler, 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 key 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).

The characterizing polychaetes *Magelona mirabilis*, *Chaetozone setosa* and *Spiophanes bombyx* are soft bodied organism which will be exposed to abrasion while feeding at the sediment surface while feeding. Abrasion would be likely to cause physical damage to these species.

Juveniles and adults of *Scoloplos armiger* stay permanently below the sediment surface, and freely move without establishing burrows. While juveniles are only found a few millimetres below the sediment surface, adults may retreat to 10 cm depth or more (Reise, 1979; Kruse *et al*., 2004). The egg cocoons are laid on the surface and hatching time is 2-3 weeks during which these are vulnerable to surface 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 but species may be able to repair and recover from damage. 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 *Lanice conchilega* tubes and some reduction in abundances of the associated polychaete species but this unlikely to significantly alter the character of the biotope. 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.

Sparks-McConkey & Watling (2001) identified *Chaetozone setosa* as a common species that declined in abundance in response to experimental trawling. Tuck *et al.* (1998) found that following trawl disturbance, abundances of *Chaetozone setosa* had recovered and became greater at treatment sites than undisturbed sites 10 months after disturbance. *Scoloplos armiger*, however, had declined at disturbed sites.

Direct mortality (percentage of initial density) of *Scoloplos armiger* from a single pass of a beam trawl was estimated from experimental studies on sandy and silty grounds as 22% and 28% respectively. Mortality of *Magelona* sp. was estimated as 30% (Bergman & Van Santbrink, 2000a).

Experimental intertidal dredging for cockles reduced the abundance of *Scoloplos armiger* in disturbed plots compared to control sites. These differences persisted for 56 days (Hall & Harding, 1997). Ferns *et al.* (2000) reported a decline of 31% in intertidal populations of *Scoloplos armiger* in muddy sands when a mechanical tractor towed harvester was used (in a cockle fishery) (surpassing the study monitoring timeline). *Scoloplos armiger* demonstrated recovery >50 days after harvesting in muddy sands.

Sensitivity assessment. The experiments by Rabaut *et al.* (2008, 2009) suggest that *Lanice conchilega* has ‘High’ resistance to single abrasion and penetration events. Other polychaetes within the biotope may be more impacted. Biotope resistance to a single event is assessed as ‘Medium’ based on the key characterizing species *Lanice conchilega* and associated characterizing species. 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 metabolizing 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 and muddy sand intertidal flats wher epopulations of this species occur. *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).

Chaetezone setosa occurs in areas subject to high natural rates of sedimentation where other benthic macrofauna were excluded (Wlodarska-Kowalczuk *et al*., 2007) although this is likely to be due to rapid recolonization rather than survival. In general, the surface deposit feeders, *Chaetozone setosa*, *Magelona mirabilis* and *Spiophanes bombyx* will be smothered by a deposit at the benchmark and prevented from feeding while this remains in place. No evidence was found on the ability of these species to reposition within fine sediment deposits or survive burial.

Bijkerk (1988, results cited from Essink, 1999) indicated that the maximal overburden through which *Scoloplos* could migrate was 50 cm in sand and mud. No further information was available on the rates of survivorship or the time taken to reach the surface. Warner (1971) simulated the effects of dredge disposal of different thicknesses on animals in aquaria or plastic cores for 2 weeks. In core experiments at temperatures ranging from 14 to 18°C and 20 to 21°C, there was a relationship between vertical migration distance and sediment depth for the congener *Scoloplos fragilis*. This species could vertically migrate through 30 cm of sand. In other core experiments in silt-clay at temperatures of 17°C to 18°C, there was a suggestion of reduced efficiency of burrowing in finer grained sediment where even the smallest amount of silt-clay proportion tested (20%) affected the burrowing ability of this species.

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 *Scoloplos armiger* is considered to be able to migrate vertically, this may be limited where the overburden consists of fine sediments (based on Maurer *et al*., 1978). 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, biotope resistance is assessed as ‘High’ based on *Lanice conchilega* 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.

Bijkerk (1988, results cited from Essink, 1999) indicated that the maximal overburden through which *Scoloplos* could migrate was 50 cm in sand and mud. No further information was available on the rates of survivorship or the time taken to reach the surface. Warner (1971) simulated the effects of dredge disposal of different thicknesses on animals in aquaria or plastic cores for 2 weeks. In core experiments at temperatures ranging from 14 to 18°C and 20 to 21°C, there was a relationship between vertical migration distance and sediment depth for the congener *Scoloplos fragilis*. This species could vertically migrate through 30 cm of sand. In other core experiments in silt-clay at temperatures of 17°C to 18°C, there was a suggestion of reduced efficiency of burrowing in finer grained sediment where even the smallest amount of silt-clay proportion tested

(20%) affected the burrowing ability of this species.

Sensitivity assessment. Although *Scoloplos armiger* is considered to be able to migrate vertically, this may be limited where the overburden consists of fine sediments (based on Maurer *et al*., 1978). The addition of 30 cm of sediment would prevent the surface deposit feeders from extending palps to the surface. It is unlikely that these species could emerge from a 30 cm thick deposit of fine materials., 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 characterizing species, including *Lanice conchilega*. Resistance is assessed as 'Low' and resilience as 'High'. Sensitivity is therefore assessed as 'Low'.

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

Not assessed.

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

No evidence.

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

No information was found concerning the intolerance of the biotope or the characterizing species to noise. The 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.

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

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

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

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. No characterizing or associated benthic species are targeted by recreational or commercial fishers and this pressure is considered to be 'Not relevant'.

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 stabilizes 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).

Bibliography

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

Ager, O.E.D. 2008. *Lanice conchilega* Sand mason. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/species/detail/1642

Austen, M.C. & McEvoy, A.J., 1997. Experimental effects of tributyltin (TBT) contaminated sediment on a range of meiobenthic communities. *Environmental Pollution*, **96** (3), 435-444.

Bandeira, S.O., 1995. Marine botanical communities in southern Mozambique: Sea grass and seaweed diversity and conservation. *Ambio*, **24**, 506-509.

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

Bergman, M.J.N. & Van Santbrink, J.W., 2000a. Mortality in megafaunal benthic populations caused by trawl fisheries on the Dutch continental shelf in the North Sea in 1994. *ICES Journal of Marine Science*, **57** (5), 1321-1331.

Beukema, J.J., 1990. Expected effects of changes in winter temperatures on benthic animals living in soft sediments in coastal North Sea areas. In *Expected effects of climatic change on marine coastal ecosystems* (ed. J.J. Beukema, W.J. Wolff & J.J.W.M. Brouns), pp. 83-92. Dordrecht: Kluwer Academic Publ.

Beukema, J.J., De Bruin, W. & Jansen, J.J.M., 1978. Biomass and species richness of the macrobenthic animals living on the tidal flats of the Dutch Wadden Sea: Long-term changes during a period of mild winters. *Netherlands Journal of Sea Research*, **12**, 58-77.

Bijkerk, R., 1988. Ontsnappen of begraven blijven: de effecten op bodemdieren van een verhoogde sedimentatie als gevolg van baggerwerkzaamheden: literatuuronderzoek: RDD, Aquatic ecosystems.

Boilly, B. & Richard, A., 1978. Accumulation de fer chez une annelide polychete: *Magelona papillicornis* F. Müller. *Compte Rendu Hebdomadaire Acadamie Sciences de Paris*, **286**, 1005-1008.

Borja, A., Franco, J. & Perez, V., 2000. A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. *Marine Pollution Bulletin*, **40** (12), 1100-1114.

Bosselmann, A., 1989. Larval plankton and recruitment of macrofauna in a subtidal area in the German Bight. In *Reproduction, Genetics and Distributions of Marine Organisms* (ed. J.S. Ryland & P.A. Tyler), pp. 43-54.

Bourgain, J-L., Dewez, S., Dewarumez, J-M., Richard, A. & Beck, C., 1988. Les rejets de vases portuaires: impacts sedimentologiques et biologiques sur le peuplement des sables a *Ophelia borealis* de la manche orientale et de la mer du nord. *Journal de Recherche Oc&#233anographique*, **13**, 25-27.

Brandt, G., Fleßner, J., Glaser, D. *et al.*, 1995. Dokumentation zur hydrographischen Frühjahrs-Meßkampagne 1994 der ökosystemforschung Niedersächsisches Wattenmeer im Einzugsgebeit der otzmer Balje. Hyrographie Nr. 8, Nieders. Landesamt für ökologie - Forschungstelle Küste, Norderney.

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

Buchanan, J.B. & Moore, J.B., 1986. A broad review of variability and persistence in the Northumberland benthic fauna - 1971-85. *Journal of the Marine Biological Association of the United Kingdom*, **66**, 641-657.

Buhr, K-J., 1976. Suspension-feeding and assimilation efficiency in *Lanice conchilega*. *Marine Biology*, **38**, 373-383.

Buhr, K.J., 1981. Effects of the cold winter 1978/79 on the macrobenthos of the Lanice-association in the Weser Estuary. *Veroffentlichungen des Instituts fur Meeresforschung in Bremerhaven*, **19**, 115–131.

Buhr, K.J. & Winter, J.E., 1977. Distribution and maintenance of a *Lanice conchilega* association in the Weser estuary (FRG), with special reference to the suspension-feeding behaviour of *Lanice conchilega*. In *Proceedings of the Eleventh European Symposium of Marine Biology, University College, Galway, 5-11 October 1976. Biology of Benthic Organisms* (ed. B.F. Keegan, P.O. Ceidigh & P.J.S. Boaden), pp. 101-113. Oxford: Pergamon Press.

Callaway, R., Desroy, N., Dubois, S.F., Fournier, J., Frost, M., Godet, L., Hendrick, V.J. & Rabaut, M., 2010. Ephemeral Bio-engineers or Reef-building Polychaetes: How Stable are Aggregations of the Tube Worm *Lanice conchilega* (Pallas, 1766)? *Integrative and Comparative Biology*, **50** (2), 237-250.

Chambers, S.J., Dominguez-Tejo, E.L., Mair, J.M., Mitchell, L.A. & Woodham, A., 2007. The distribution of three eyeless *Chaetozone* species (Cirratulidae: Polychaeta) in the north-east Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, **87** (05), 1111-1114.

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. & Reker, J.B., 2004. The Marine Habitat Classification for Britain and Ireland. Version 04.05. ISBN 1 861 07561 8. In JNCC (2015), *The Marine Habitat Classification for Britain and Ireland Version 15.03.* [2019-07-24]. Joint Nature Conservation Committee, Peterborough. Available from https://mhc.jncc.gov.uk/

Connor, D.W., Brazier, D.P., Hill, T.O., & Northen, K.O., 1997b. Marine biotope classification for Britain and Ireland. Vol. 1. Littoral biotopes. *Joint Nature Conservation Committee, Peterborough, JNCC Report* no. 229, Version 97.06., *Joint Nature Conservation*

Committee, Peterborough, JNCC Report No. 230, Version 97.06.

Corbera, J. & Cardell, M.J., 1995. Cumaceans as indicators of eutrophication on soft bottoms. *Scientia Marina*, **59**, 63-69.

Costa, M.J. & Elliot, M., 1991. Fish usage and feeding in two industrialised estuaries - the Tagus, Portugal and the Forth, Scotland. In *Estuaries and Coasts: Spatial and Temporal Intercomparisons* (ed. B. Knights & A.J. Phillips), pp. 289-297. Denmark: Olsen & Olsen.

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

Cromey, C., Black, K., Edwards, A. & Jack, I., 1998. Modelling the deposition and biological effects of organic carbon from marine sewage discharges. *Estuarine, Coastal and Shelf Science*, **47** (3), 295-308.

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

Dauvin, J.C., 1985. Dynamics and production of a population of *Venus ovata* (Pennant) (Mollusca-Bivalvia) of Morlaix Bay (western English Channel). *Journal of Experimental Marine Biology and Ecology*, **91**, 109-123.

Dauvin, J.C., 2000. The muddy fine sand *Abra alba - Melinna palmata* community of the Bay of Morlaix twenty years after the *Amoco Cadiz* oil spill. *Marine Pollution Bulletin*, **40**, 528-536.

De Smet, B., Godet, L., Fournier, J., Desroy, N., Jaffré, M., Vincx, M. & Rabaut, M., 2013. Feeding grounds for waders in the Bay of the Mont Saint-Michel (France): the *Lanice conchilega* reef serves as an oasis in the tidal flats. *Marine Biology*, **160** (4), 751-761.

Degraer, S., Verfaillie, E., Willems, W., Adriaens, E., Vincx, M. & Van Lancker, V., 2008. Habitat suitability modelling as a mapping tool for macrobenthic communities: An example from the Belgian part of the North Sea. *Continental Shelf Research*, **28** (3), 369-379.

Denis, L., Desroy, N. & Ropert, M., 2007. Ambient flow velocity and resulting clearance rates of the terebellid polychaete *Lanice conchilega* (Pallas, 1766). *Journal of Sea Research*, **58** (3), 209-219.

Dernie, K.M., Kaiser, M.J., Richardson, E.A. & Warwick, R.M., 2003. Recovery of soft sediment communities and habitats following physical disturbance. *Journal of Experimental Marine Biology and Ecology*, **285-286**, 415-434.

Diaz-Castaneda, V., Richard, A. & Frontier, S., 1989. Preliminary results on colonization, recovery and succession in a polluted areas of the southern North Sea (Dunkerque's Harbour, France). *Scientia Marina*, **53**, 705-716.

Dittmann, S., 1999. Biotic interactions in a *Lanice conchilega* dominated tidal flat. In *The Wadden Sea ecosystem*, (ed. S. Dittmann), pp.153-162. Germany: Springer-Verlag.

Dyer, K.R., 1998. *Estuaries - a Physical Introduction.* John Wiley & Son, Chichester.

Eckman, J.E., Nowell, A.R.M. & Jumars, P.A., 1981. Sediment destabilization of animal tubes. *Journal of Marine Research*, **39**, 361-374.

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

Essink, K., 1999. Ecological effects of dumping of dredged sediments; options for management. *Journal of Coastal Conservation*, **5**, 69-80.

Everett, R.A., 1991. Intertidal distribution of infauna in a central California lagoon: the role of seasonal blooms of macroalgae. *Journal of Experimental Marine Biology and Ecology*, **150**, 223-247.

Farke, H. & Berghuis, E.M., 1979. Spawning, larval development and migration behaviour of *Arenicola marina* in the laboratory. *Netherlands Journal of Sea Research*, **13**, 512-528.

Faubel, A., Hartig, E. & Thiel, H., 1983. On the ecology of the benthos of sublittoral sediments, Fladen Ground, North Sea. 1. Meiofauna standing stock and estimation of production. *Meteor Forschungsergebnisse*, **36**, 35-48.

Ferns, P.N., Rostron, D.M. & Siman, H.Y., 2000. Effects of mechanical cockle harvesting on intertidal communities. *Journal of Applied Ecology*, **37**, 464-474.

Fiege, D., Licher, F. & Mackie, A.S.Y., 2000. A partial review of the European Magelonidae (Annelida : Polychaeta) *Magelona mirabilis* redefined and *M. johnstoni sp. nov*. distinguished. *Journal of the Marine Biological Association of the United Kingdom*, **80**, 215-234.

Forster, S. & Graf, G., 1995. Impact of irrigation on oxygen flux into the sediment: intermittent pumping by *Callianassa subterranea* and "piston pumping" by *Lanice conchilega*. *Marine Biology*, **123**, 335-346.

Gittenberger, A. & Van Loon, W.M.G.M., 2011. Common Marine Macrozoobenthos Species in the Netherlands, their Characterisitics and Sensitivities to Environmental Pressures. GiMaRIS report no 2011.08. DOI: 10.13140/RG.2.1.3135.7521

Godet, L., Toupoint, N., Olivier, F., Fournier, J. & Retière, C., 2008. Considering the Functional Value of Common Marine Species as a Conservation Stake: The Case of Sandmason Worm *Lanice conchilega* (Pallas 1766) (Annelida, Polychaeta) Beds. *AMBIO: A Journal of the Human Environment*, **37** (5), 347-355.

Gogina, M., Glockzin. M. & Zettler, M.L., 2010. Distribution of benthic macrofaunal communities in the western Baltic Sea with regard to near-bottom environmental parameters. 2. Modelling and prediction. *Journal of Marine Systems*, **80**, 57-70.

Gomez Gesteira, J.L. & Dauvin, J.C., 2000. Amphipods are good bioindicators of the impact of oil spills on soft-bottom macrobenthic communities. *Marine Pollution Bulletin*, **40** (11), 1017-1027.

Gray, J.S., 1979. Pollution-induced changes in populations. *Philosophical Transactions of the Royal Society of London*, Series B, **286**, 545-561.

Gray, J.S., Clarke, K.R., Warwick, R.M. & Hobbs, G., 1990. Detection of initial effects of pollution on marine benthos - an example from the Ekofisk and Eldfisk oilfields, North Sea. *Marine Ecology Progress Series*, **66** (3), 285-299.

Grimm, V., 1999. Modelling the spatial and temporal distribution of *Lanice conchilega.* In *The Wadden Sea: stability, properties and mechanisms*, (ed. S. Dittmann), pp.147-152. Germany: Springer-Verlag.

Günther, C-P., 1992. Dispersal of intertidal invertebrates: a strategy to react to disturbances of different scales? *Netherlands Journal of Sea Research*, **30**, 45-56.

Hall, S.J. & Harding, M.J.C., 1997. Physical disturbance and marine benthic communities: the effects of mechanical harvesting of cockles on non-target benthic infauna. *Journal of Applied Ecology*, **34**, 497-517.

Harvey, M. & Bourget, E.,1997. Recruitment of marine invertebrates onto arborescent epibenthic structures: active and passive processes acting at different spatial scales. *Marine Ecology Progress Series*, **153**, 203-215.

Harvey, M. & Bourget, E., 1995. Experimental evidence of passive accumulation of marine bivalve larvae on filamentous epibenthic structures. *Limnology and Oceanography*, **40**, 94-104.

Hayward, P.J. 1994. *Animals of sandy shores.* Slough, England: The Richmond Publishing Co. Ltd. [Naturalists' Handbook 21.]

Hayward, P.J. & Ryland, J.S. (ed.) 1995b. *Handbook of the marine fauna of North-West Europe.* Oxford: Oxford University Press.

Herlyn, M., Millat, G. & Petersen, B., 2008. Documentation of sites of intertidal blue mussel (*Mytilus edulis L.*) beds of the Lower Saxonian Wadden Sea, southern North Sea (as of 2003) and the role of their structure for spatfall settlement. *Helgoland Marine Research*, **62** (2), 177-188.

Heuers, J. & Jaklin, S., 1999. Initial settlement of *Lanice conchilega*. *Senckenbergiana Maritima*, **29** (suppl.), 67-69.

Heuers, J., 1998. Ansiedlung, Dispersion, Rekrutierung und Störungen als strukturierende Faktoren benthischer Gemeinschaften im Eulitoral. Dissertation, Universität Bonn.

Heuers, J., Jaklin, S., Zülkhe, R., Dittmann, S., Günther, C-P., Hildenbrandt, H. & Grimm, V., 1998. A model on the distribution and abundance of the tube-building polychaete *Lanice conchilega* (Pallas, 1766) in the intertidal of the Wadden Sea. *Verhandlungen Ges Ökologie*, **28**, 207-215.

Hjulström, F., 1939. Transportation of detritus by moving water: Part 1. Transportation. Recent Marine Sediments, a Symposium (ed. P.D. Trask), pp. 5-31. Dover Publications, Inc.

Huntington, T., Roberts, H., Cousins, N., Pitta, V., Marchesi, N., Sanmamed, A. & Brockie, N., 2006. Some Aspects of the Environmental Impact of Aquaculture in Sensitive Areas. *Report to the DG Fish and Maritime Affairs of the European Commission. Poseidon Aquatic Resource Management Ltd.*

Huthnance, J., 2010. Ocean Processes Feeder Report. London, *DEFRA on behalf of the United Kingdom Marine Monitoring and Assessment Strategy (UKMMAS) Community*.

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

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

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

Jones, C.G., Lawton, J.H. & Shackak, M., 1994. Organisms as ecosystem engineers. *Oikos*, **69**, 373-386.

Jones, C.G., Lawton, J.H. & Shackak, M., 1997. Positive and negative effects of organisms as ecosystem engineers. *Ecology*, **78**, 1946-1957.

Jones, S.E. & Jago, C.F., 1993. In situ assessment of modification of sediment properties by burrowing invertebrates. *Marine Biology*, **115**, 133-142.

Juneau, P., Barnett, A., Méléder, V., Dupuy, C. & Lavaud, J., 2015. Combined effect of high light and high salinity on the regulation of photosynthesis in three diatom species belonging to the main growth forms of intertidal flat inhabiting microphytobenthos. *Journal of Experimental Marine Biology and Ecology*, **463**, 95-104.

Kessler, M., 1963. Die Entwicklung von *Lanice conchilega* (Pallas) mit besonderer Berücksichtigung der Lebensweise. *Helgolander Wissenschaftliche Meeresuntersuchungen*, **8**, 425-476.

Kingston, P.F., Dixon, I.M.T., Hamilton, S. & Moore, D.C., 1995. The impact of the Braer oil spill on the macrobenthic infauna of the sediments off the Shetland Islands. *Marine Pollution Bulletin*, **30** (7), 445-459.

Kochmann, J., Buschbaum, C., Volkenborn, N. & Reise, K., 2008. Shift from native mussels to alien oysters: differential effects of ecosystem engineers. *Journal of Experimental Marine Biology and Ecology*, **364** (1), 1-10.

Kröncke, I., 1990. Macrofauna standing stock of the Dogger Bank. A comparison: II. 1951 - 1952 versus 1985 - 1987. Are changes in the community of the northeastern part of the Dogger Bank due to environmental changes? *Netherlands Journal of Sea Research*, **25**, 189-198.

Kruse, I., Strasser, M. & Thiermann, F., 2004. The role of ecological divergence in speciation between intertidal and subtidal *Scoloplos armiger* (Polychaeta, Orbiniidae). *Journal of Sea Research*, **51**, 53-62.

Kuhl, H., 1972. Hydrography and biology of the Elbe Estuary. *Oceanography and Marine Biology: an Annual Review*, **10**, 225-309.

Leppäkoski, E., 1975. Assessment of degree of pollution on the basis of macrozoobenthos in marine and brackish water environments. *Acta Academiae Åboensis*, Series B, **35**, 1-90.

Lopez-Jamar, E., Francesch, O., Dorrio, A.V. & Parra, S., 1995. Long term variation of the infaunal benthos of La Coruna Bay (NW Spain): results from a 12-year study (1982-1993). *Scientia Marina*, **59**(suppl. 1), 49-61.

Maurer, D.L., Keck, R., Tinsman, J., Leathem, W. & Wethe, C., 1978. Vertical migration of benthos in simulated dredged material overburdens. *Volume I. Marine Benthos. DTIC Document.*

McDermott, J.J., 1984. The feeding biology of *Nipponnemertes pulcher* (Johnston) (Hoplonemertea), with some ecological implications. *Ophelia*, **23**, 1-21.

MES, 2010. *Marine Macrofauna Genus Trait Handbook*. Marine Ecological Surveys Limited. http://www.genustraithandbook.org.uk/

Newell, G.E., 1948. A contribution to our knowledge of the life history of *Arenicola marina* L. *Journal of the Marine Biological Association of the United Kingdom*, **28**, 554-580.

Newell, R.C., Seiderer, L.J. & Hitchcock, D.R., 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent biological recovery of biological resources on the sea bed. *Oceanography and Marine Biology: an Annual Review*, **36**, 127-178.

Nicolaidou, A., 2003. Observations on the re-establishment and tube construction by adults of the polychaete *Lanice conchilega*. *Journal of the Marine Biological Association of the United Kingdom*, **83** (06), 1223-1224.

Niermann, U., Bauerfeind, E., Hickel, W. & Westernhagen, H.V., 1990. The recovery of benthos following the impact of low oxygen content in the German Bight. *Netherlands Journal of Sea Research*, **25**, 215-226.

Olafsson, E.B. & Persson, L.E., 1986. The interaction between *Nereis diversicolor* (Muller) and *Corophium volutator* (Pallas) as a structuring force in a shallow brackish sediment. *Journal of Experimental Marine Biology and Ecology*, **103**, 103-117.

Pedersen, T.F., 1991. Metabolic adaptations to hypoxia of two species of Polychaeta, *Nephtys ciliata* and *Nephtys hombergii*. *Journal of Comparative Physiology B*, **161** (2), 213-215.

Probert, P.K., 1981. Changes in the benthic community of china clay waste deposits is Mevagissey Bay following a reduction of discharges. *Journal of the Marine Biological Association of the United Kingdom*, **61**, 789-804.

Rabaut, M., Braeckman, U., Hendrickx, F., Vincx, M. & Degraer, S., 2008. Experimental beam-trawling in Lanice conchilega reefs: Impact on the associated fauna. *Fisheries Research*, **90** (1), 209-216.

Rabaut, M., Guilini, K., Van Hoey, G., Vincx, M. & Degraer, S., 2007. A bio-engineered soft-bottom environment: The impact of *Lanice conchilega* on the benthic species-specific densities and community structure. *Estuarine, Coastal and Shelf Science*, **75** (4), 525-536.

Rabaut, M., Van de Moortel, L., Vincx, M. & Degraer, S., 2010. Biogenic reefs as structuring factor in *Pleuronectes platessa* (Plaice) nursery. *Journal of Sea Research*, **64** (1), 102-106.

Rabaut, M., Vincx, M. & Degraer, S., 2009. Do *Lanice conchilega* (sandmason) aggregations classify as reefs? Quantifying habitat modifying effects. *Helgoland Marine Research*, **63** (1), 37-46.

Rayment, W.J. 2007b. *Magelona mirabilis* A polychaete. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/species/detail/1630

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

Reise, K., 1979. Spatial configurations generated by motile benthic polychaetes. *Helgoländer Wissenschaftliche Meeresuntersuchungen*, **32**, 55-72.

Richards, S. 2007. *Magelona filiformis* A bristleworm. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/species/detail/21

Richardson, C.A., Ibarrola, I. & Ingham, R.J., 1993b. Emergence pattern and spatial distribution of the common cockle *Cerastoderma edule*. *Marine Ecology Progress Series*, **99**, 71-81.

Riera, R., Tuya, F., Ramos, E., Rodríguez, M. & Monterroso, Ó., 2012. Variability of macrofaunal assemblages on the surroundings of a brine disposal. *Desalination*, **291**, 94-100.

Ropert, M. & Dauvin, J-C., 2000. Renewal and accumulation of a *Lanice conchilega* (Pallas) population in the baie des Veys, western Bay of seine. *Oceanologica Acta*, **23**, 529-546.

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

Sanders, H.L., Grassle, J.F., Hampson, G.R., Morse, L.S., Garner-Price, S. & Jones, C.C., 1980. Anatomy of an oil spill: long-term effects from the grounding of the barge Florida off West Falmouth, Massachusetts. *Journal of Marine Research*, **38** (2), 265-380.

Schöttler, U., 1982. An investigation on the anaerobic metabolism of *Nephtys hombergii* (Annelida: Polychaeta). *Marine Biology*, **71** (3), 265-269.

Schories, D. & Reise, K., 1993. Germination and anchorage of *Enteromorpha* spp. In sediments of the Wadden Sea. *Helgolander Meeresuntersuchungen*, **47**, 275-285.

Schottler, U. & Grieshaber, M., 1988. Adaptation of the polychaete worm *Scoloplos armiger* to hypoxic conditions. *Marine Biology*, **99** (2), 215-222.

Sebens, K.P., 1991. Habitat structure and community dynamics in marine benthic systems. In *Habitat structure*, (ed. S.S. Bell), pp. 211-234. Chapman & Hall.

Sparks-McConkey, P.J. & Watling, L., 2001. Effects on the ecological integrity of a soft-bottom habitat from a trawling disturbance. *Hydrobiologia*, **456**, 73-85.

Spencer, B.E., Kaiser, M.J. & Edwards, D.B., 1998. Intertidal clam harvesting: benthic community change and recovery. *Aquaculture Research*, **29** (6), 429-437.

Strasser, M. & Pielouth, U., 2001. Recolonization pattern of the polychaete *Lanice conchilega* on an intertidal sandflat following the severe winter of 1995/96. *Helgoland Marine Research*, **55**, 176-181.

Stubbles, S., 1993. Recent benthic Foraminiferida as indicators of pollution in Restronguet Creek, Cornwall. *Proceedings-USSHER* Society, **8**, 200-200.

Suchanek, T.H., 1993. Oil impacts on marine invertebrate populations and communities. *American Zoologist*, **33**, 510-523.

Sylvand B., 1995. *La baie des Veys(Littoral occidental de la baie de Seine, Manche), 1972-1993: structure et évolution à long terme d'un écosystème benthique intertidal de substrat meuble sous influence estuarienne.* Thèse de Doct. d'Etat.: Université de Caen, 409 pp.

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

Thouzeau, G., Jean, F. & Del Amo, Y., 1996. Sedimenting phytoplankton as a major food source for suspension-feeding queen scallops (*Aequipecten opercularis* L.) off Roscoff (western English Channel) ? *Journal of Shellfish Research*, **15**, 504-505.

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

Tuck, I.D., Hall, S.J., Robertson, M.R., Armstrong, E. & Basford, D.J., 1998. Effects of physical trawling disturbance in a previously unfished sheltered Scottish sea loch. *Marine Ecology Progress Series*, **162**, 227-242.

Tyler, P.A., 1977a. Seasonal variation and ecology of gametogenesis in the genus *Ophiura* (Ophiuroidea: Echinodermata) from the Bristol Channel. *Journal of Experimental Marine Biology and Ecology*, **30**, 185-197.

UKTAG, 2014. UK Technical Advisory Group on the Water Framework Directive [online]. Available from: http://www.wfduk.org

Van Hoey, G., Guilini, K., Rabaut, M., Vincx, M. & Degraer, S., 2008. Ecological implications of the presence of the tube-building polychaete *Lanice conchilega* on soft-bottom benthic ecosystems. *Marine Biology*, **154** (6), 1009-1019.

Villalba, A., Iglesias, D., Ramilo, A., Darriba, S., Parada, J.M., No, E., Abollo, E., Molares, J. & Carballal, M.J., 2014. Cockle *Cerastoderma edule* fishery collapse in the Ria de Arousa (Galicia, NW Spain) associated with the protistan parasite Marteilia cochillia. *Diseases of Aquatic Organisms*, **109** (1), 55-80.

Warner, G.F., 1971. On the ecology of a dense bed of the brittle star *Ophiothrix fragilis*. *Journal of the Marine Biological Association of the United Kingdom*, **51**, 267-282.

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

Wood, E.M., 1987. *Subtidal Ecology*. London: Edward Arnold.

Woodin, S.A., 1978. Refuges, disturbance and community structure: a marine soft bottom example. *Ecology*, **59**, 274-284.

Włodarska-Kowalczuk, M., Szymelfenig, M. & Zajiczkowski, M., 2007. Dynamic sedimentary environments of an Arctic glacier-fed river estuary (Adventfjorden, Svalbard). II: Meio-and macrobenthic fauna. *Estuarine, Coastal and Shelf Science*, **74** (1), 274-284.

Yonow, N., 1989. Feeding observations on *Acteon tornatilis* (Linnaeus) (Opisthobranchia: Acteonidae). *Journal of Molluscan Studies*, **55**, 97-102.

Zühlke, R., 2001. Polychaete tubes create ephemeral community patterns: *Lanice conchilega* (Pallas, 1766) associations studied over six years. *Journal of Sea Research*, **46**, 261-272.

Zühlke, R., Blome, D., van Bernem, K.H. & Dittmann, S., 1998. Effects of the tube-building polychaete *Lanice conchilega* (Pallas) on benthic macrofauna and nematodes in an intertidal sandflat. *Senckenbergiana Maritima*, **29**, 131-138.

Zebe, E. & Schiedek, D., 1996. The lugworm *Arenicola marina*: a model of physiological adaptation to life in intertidal sediments. *Helgoländer Meeresuntersuchungen*, **50**, 37-68.

Ziegelmeier, E., 1952. Beobachtungen über den Röhrenbauvon *Lanice conchilega* (Pallas) im Experiment und am natürlichen Standort. *Helgolander Wissenschaftliche Meeresuntersuchungen*, **IV**. 107-129.