Eurydice pulchra in littoral mobile sand

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

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View along sandy shore with lighthouse in background.
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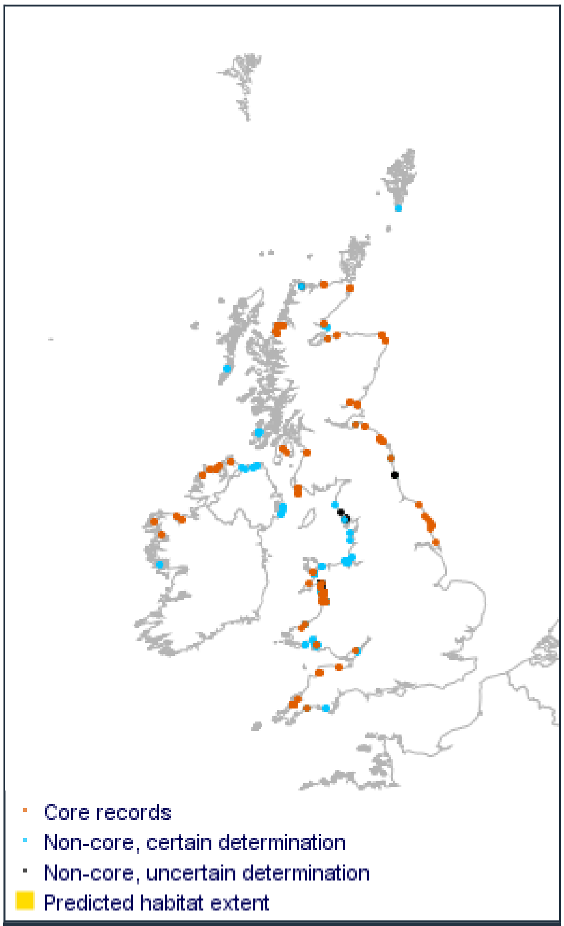

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Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Dr Heidi Tillin & Georgina Budd **Refereed by** Dr John Fish

Summary

UK and Ireland classification

EUNIS 2008	A2.2232	*Eurydice pulchra* in littoral mobile sand
JNCC 2015	LS.LSa.MoSa.AmSco.Eur	*Eurydice pulchra* in littoral mobile sand
JNCC 2004	LS.LSa.MoSa.AmSco.Eur	*Eurydice pulchra* in littoral mobile sand
1997 Biotope		

Description

Found on well-draining beaches of medium to fine-grained mobile sand, often (but not always) well sorted. Occasionally, a small fraction of coarse sand may be present. The biotope generally occurs on exposed open coasts but sometimes in estuarine conditions, supporting populations of the isopod *Eurydice pulchra* and burrowing amphipods which frequently include *Bathyporeia pilosa* and *Haustorius arenarius*. The degree of drainage appears to be a critical factor in determining the presence of polychaetes, with only Scolelepis squamata capable of tolerating the well-drained sediments of this biotope. This biotope has two facies: drying upper and mid shore sands, and highly mobile lower shore and shallow sublittoral sand bars. Where this biotope occurs in estuarine conditions, *Haustorius arenarius* is often highly abundant.

AmSco.Eur may occur on the mid and upper shore together with AmSco.Sco, below Ol, or above Amsco.Pon and the polychaete dominated Po communities. Under more exposed, open conditions, AmSco.Eur may be restricted to the lower part of the shore, with Ol, barren sand (BarSa) or barren shingle (BarSh) on the upper shore. Tal may occur where driftlines of wracks or other debris accumulate on the upper shore. Winter storms may reduce the number of or temporarily remove macroinvertebrates from exposed sandy beaches, with the sediment becoming re-colonized during the summer months. (Information from Connor *et al*., 2004; JNCC, 2015).

Depth range

Strandline, Upper shore, Mid shore, Lower shore

Additional information

The information on the ecology of mobile sand communities dominated by amphipods present in this review is also applicable to the other mobile sand communities, e.g. AmSco, AmSco.Sco, and AmSco.Pon. Please note the section on ecology has not been updated since 2004.

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Habitat review

Ecology

Ecological and functional relationships

Patterns of distribution and abundance in exposed sandy beaches have been assumed to be primarily controlled by specific species responses to the hydrodynamic climate and sediment characteristics which are intimately linked, a scenario where biological interactions do not appear to play a critical role (McLachlan, 1983). There is a conspicuous lack of information concerning the effects of biotic factors e.g. competition, on the structure and distribution of sandy beach populations, as it is likely that detection of intra- and interspecific competition in such a dynamic environment is very complex (Branch, 1984). Consequently the ecology of exposed sandy beaches remains relatively poorly understood in comparison to rocky shores (Schoeman *et al.*, 2000).

- The macrofauna of sandy beaches and the meiofauna (and microfauna) of the interstices between sand grains, comprise two entirely separate faunal components with limited overlap or exchanges of energy (McLachlan, 1983). This is because the meiofauna are extremely small interstitial forms while the macrofauna are several orders of magnitude larger.
- The meiofauna are likely to be important consumers of the microphytobenthic productivity. The dominant components of sandy beach meiofauna are nematodes and harpacticoid copepods with several other taxa of variable importance (McLachlan, 1983). There is a well established relationship between the relative proportions of nematodes and harpaticoids and grain size. Nematodes tend to dominate in finer sediments, harpaticoids in coarser sediments and in sediments with a median grain size of 0.3-0.35 mm they are both equally important (Gray, 1971; McLachlan *et al.*, 1981).
- The macrofauna of sandy beaches are often abundant. A common feature is the high degree of mobility displayed by all species with shifting distributions in the intertidal. The crustaceans, polychaetes and molluscs are the most conspicuous taxa on sandy beaches, the Crustacea e.g. *Eurydice pulchra*and *Bathyporeia pelagica* being most abundant on exposed sandy shores.
- The sandy beach comprises an unusual ecosystem in that the customary food chain of plants-herbivores-carnivores is not clearly discernible (Eltringham, 1971). The absence of macroalgae means that herbivorous macrofauna either feed on the biogenic film, on and in the deposit, or on phytoplankton from the overlying seawater during high tide, or on plant debris carried by currents to the area from elsewhere.
- The isopod *Eurydice pulchra* is a carnivore feeding on a wide range of invertebrates found on sandy shores.
- The sandy intertidal zone is utilized by juvenile flatfish as a feeding ground. Sole, *Solea solea*, dab, *Limanda limanda*, flounder, *Platichythys flesus* and plaice, *Pleuronectes platessa* migrate inshore on the flood tide to feed upon tidally active crustaceans, such as *Bathyporeia* and *Eurydice* spp., polychaetes and young bivalves and their siphons (Elliott *et al.*, 1998).
- The biotope complexes represented by this key information review are used by important wintering and passage birds for feeding and roosting and consequently are important visiting predators. Particularly dependent species are brent geese, shelduck, pintail, oystercatcher, ringed and grey plovers, bar-tailed and black-tailed godwits, curlew, redshank, knot, dunlin and sanderling (Jones & Key, 1989; Davidson *et al.*, 1991).

Seasonal and longer term change

- Vertical migrations from the substratum into the overlying sea water are made by the dominant crustaceans e.g. *Eurydice pulchra* and *Bathyporeia pelagica*. Such behaviour is endogenously controlled and has a circatidal rhythm that is coupled to a circasemilunar pattern of emergence (Alheit & Naylor, 1976; Fish & Fish, 1972; Preece, 1971; Fincham, 1970a & 1970b; Jones & Naylor, 1970; Watkin, 1939b).
- Fish & Preece (1970) observed the disappearance of *Bathyporeia pelagica* from their sampling site in west Wales in March 1967 and specimens were not recorded again until October. In subsequent years the disappearance of *Bathyporeia pelagica* was sudden and characterized by the movement of a large proportion of the population to the lowest levels of the shore. The seasonal change was believed to be influenced by salinity-temperature fluctuations to which the species is intolerant.
- Seasonal storm events can change sediment distribution and composition significantly e.g. the removal of the top 20 cm of sand has been reported (Dolphin *et al*., 1995).
- Seasonal change has been documented for the meiofauna of sandy shores in temperate regions, with the meiofauna occurring in lower abundance and moving deeper into the sediment in winter (citations in McLachlan, 1983). Vertical migrations other than seasonal have been reported in response to heavy rain, wave disturbance, tidal factors and changes in moisture and oxygen over the tidal cycle.

Habitat structure and complexity

The hydrodynamic regime (tides, waves and residual currents) together with the underlying physiography and geology create the conditions for a given substratum to develop. In terms of ecological relationships the interstices of the sand are significant owing to influences on the physical and chemical properties of the substratum to which the infauna are sensitive. Most physical properties of the interstitial system are directly determined by the sediment properties which in turn are related to the wave and current regime. Grain size, shape and degree of sorting are most important in determining porosity and permeability which influence drainage. Drainage is critical in determining the moisture content, oxygen saturation, organic content and the depth of the reducing layer (if present). Permeability increases with coarse substrate and better sorting, and drainage also increases on steeper beaches. The macrophyte community is poor owing to the lack of stable substrata, consequently the presence of occasional stones or an artificial substratum (e.g. coastal defences) would allow the establishment of some species of macrophyte e.g. *Chorda filum*.

Productivity

The primary production of sandy shores is very low if the sand is particularly clean, i.e. low in organic matter. Steele & Baird (1968) gave a figure of 5 g of carbon per m^2 per year for the productivity of a moderately exposed sandy beach. In most situations, diatoms are the primary producers of the depositing shore, and are confined to the illuminated sediment surface layers. The role of sulphur reducing bacteria is limited in clean sandy shore environments owing to the lack of an anoxic black sub-surface layer (under normal conditions). The phytoplankton of the sea becomes a temporary part of the sandy shore ecosystem when the tide is in and primary producers from other environments appear on the shore. These are invariably macroalgae that have become detached from rocky substrata and have been washed up, eventually they decompose on the beach and contribute to the energy budget of the shore system. Consequently most productivity on the depositing sandy shore may be categorised as secondary, derived from detritus and allochthonous organic matter, which is utilized by the fauna.

Recruitment processes

- *Eurydice pulchra* breeds between April and August once sea temperatures rise above 10°C, and the highest number of juveniles occur around the periods of maximum summer temperatures. Males and females pair during their nightly swimming on falling spring tides and mating occurs in the sand once the female has completed her moult. Incubation of the embryo in the brood pouch takes some 7-8 weeks and after release of the young, the female returns to the non-breeding condition (J. Fish, pers. comm.). Juvenile *Eurydice pulchra* first appear in July, the minimum length being 1.7 mm (J. Fish, pers. comm.). Although the first juveniles may reach sexual maturity before the onset of winter, they begin breeding in the following spring and die during their second autumn after a total lifespan of approximately 15 months. Mid-summer juveniles also mature to breed the following summer and only reached 12 months of age before dying. In contrast, the last broods appearing as late as October, do not mature until late the following summer. They breed in their second October and then overwinter for a second time, producing a second brood in the spring before dying of at 18-20 months old (Hayward, 1994; Jones, 1970; Fish, 1970).
- *Bathyporeia pelagica* may breed throughout the year, but the greatest reproductive activity occurs during spring and late summer/autumn. Males and females pair whilst swimming and mate on the night-time ebb tides following each new and full moon. Development of an egg to the stage when it is released as a juvenile takes about 15 days to complete. The overwintering population of *Bathyporeia pelagica* consists largely of juvenile animals. These mature in spring to form the majority of the next breeding population and eventually die in June and July, after a lifespan of about one year (Fish & Preece, 1970). *Bathyporeia pilosa* has a similar recruitment cycle.
- In *Pontocrates arenarius* from Irish Sea coasts breeding has been recorded throughout the year (Fish & Fish, 1996).
- Little is known of the breeding patterns of *Haustorius arenarius* populations in Britain, but females with eggs are found during the summer months and longevity is believed to be two, possibly three years (Fish & Fish, 1996).
- *Scolelepis squamata* from the south coast of England bred from March to at least July. The sexually mature worms are not pelagic. Fertilization is external and the larva is free swimming for about five weeks before settlement (Fish & Fish, 1996).
- Important meiofaunal nematodes and harpacticoid copepods of the sandy shore are reported to have year round reproduction with generation times ranging from 1-3 months (McIntyre, 1969).

Time for community to reach maturity

Little evidence concerning community development was found and consequently information on the key species recruitment processes and longevity has been used to infer a time period of 1 to 2 years. One of the important characterizing species, *Bathyporeia pelagica*, produces a sequence of broods throughout the spring and summer which reach maturity within a year to produce subsequent generations. The meiofaunal community produces several generations within a year.

Additional information

No text entered

Preferences & Distribution

Habitat preferences

Depth Range	Strandline, Upper shore, Mid shore, Lower shore
Water clarity preferences	No information found
Limiting Nutrients	No information found
Salinity preferences	Full (30-40 psu), Variable (18-40 psu)
Physiographic preferences	Enclosed coast / Embayment, Estuary, Open coast
Biological zone preferences	Eulittoral
Substratum/habitat preferences	Fine clean sand, Medium clean sand
Tidal strength preferences	No information
Wave exposure preferences	Exposed, Extremely sheltered, Moderately exposed, Sheltered, Very sheltered
Other preferences	No text

Additional Information

No text entered

Species composition

Species found especially in this biotope

- *Bathyporeia pelagica*
- *Eurydice pulchra*
- *Haustorius arenarius*
- *Pontocrates arenarius*

Rare or scarce species associated with this biotope

-

Additional information

No text

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

This sandy beach biotope LS.LSa.MoSa.AmSco.Eur is characterized by mobile clean sand sediments on wave exposed or sheltered shores on the open coast or in estuaries, with sediment grain sizes ranging from medium to fine, although a small fraction of coarser sediment may be present. The mobility of the sediment leads to a species-poor community, dominated by polychaetes (*Scolelepis squamata*), isopods (*Eurydice pulchra*) and burrowing amphipods (*Bathyporeia pilosa* and *Haustorius arenarius*). The biotope is found in two principal conditions: drying upper and mid-shore sands and highly mobile lower shore or shallow sublittoral sand bars. Hence, AmSco.Eur may occur on the mid and upper shore together with AmSco.Sco, below Ol, or above Amsco.Pon and the polychaete dominated Po communities. Under more exposed, open conditions, AmSco.Eur may be restricted to the lower part of the shore, with Ol, barren sand (BarSa) or barren shingle (BarSh) on the upper shore. The sediments and wave exposure are key factors maintaining the biotope and are considered in the sensitivity assessments where the pressure may alter these.

Resilience and recovery rates of habitat

The species inhabiting this biotope are characteristic of sandy beaches and are adapted to the high levels of disturbance in mobile sediments. Exposed beaches where this biotope typically occurs may change seasonally where winter storms remove large amounts of material that are then re-deposited over the following weeks and months as the material is shifted from the subtidal (Quartel *et al*., 2008; Douglas *et al*., 1998). For instance, at Village Bay on St Kilda (an island group far out into the Atlantic west of Britain), an expanse of sandy beach was removed offshore as a result of winter storms to reveal an underlying rocky shore (Scott, 1960). Yet in the following summer, the beach was gradually replaced when wave action was less severe. In view of such observations, that many sandy beaches disappear in winter and reappear in spring, it is likely that physical recovery of sediments would occur in less than a year, although longer time periods may be required for unusually severe erosion events (Douglas *et al*., 1998).

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

The polychaete *Scolelepis squamata* is a widespread species typical of sandy beaches but occurring in a range of sediment types. Populations are likely to be interconnected, supporting recolonization, as this species produces pelagic larvae. *Scolelepis squamata* exhibits an extended reproductive period allowing it to produce larvae over an extended period. In a Belgian population, *Scololepis squamata* were semelparous (breeding once and then dying) and lived for 24 months (Speybroeck *et al*., 2007). Fertilization is external and the larva is free swimming for about five weeks before settlement (Fish & Fish, 1996). Recruitment in Belgium was observed from July until October (Speybroek *et al*., 2007). *Scolelepis squamata* has been observed to swim and significant seasonal changes in its distribution within the swash and surf zones have been reported, indicating that the species is able to re-establish itself within the substratum following displacement

The amphipods characterizing this biotope are found in sediments subject to physical disturbance, as a result of wave action or in wave sheltered biotopes, strong tidal streams. This group is therefore tolerant of disturbed environments and can recover quickly. *Bathyporeia* spp. are short-lived, reaching sexual maturity within six months with 6-15 eggs per brood, depending on species. Reproduction may be continuous (Speybroeck *et al*., 2008) with one set of embryos developing in the brood pouch whilst the next set of eggs is developing in the ovaries. However, specific reproductive periods vary between species and between locations (Mettam, 1989) and bivoltine patterns (twice yearly peaks in reproduction) have been observed (Mettam, 1989; Speybroeck *et al*., 2008). In *Pontocrates arenarius* from Irish Sea coasts, breeding was recorded throughout the year (Fish & Fish, 1996). Little is known of the breeding patterns of *Haustorius arenarius* populations in Britain, but females with eggs are found during the summer months and longevity is believed to be two, possibly three years (Fish & Fish, 1996). Adult amphipods are highly mobile in the water column and recolonization by the adults is likely to be a significant recovery pathway. The life history traits of rapid sexual maturation and production of multiple broods annually support rapid local recolonization of disturbed sediments where some of the adult population remains. The isopod *Eurydice pulchra* also produces brooded young, but only produces a single brood a year, reproducing twice in its two-year lifespan (Fish, 1970; Jones, 1970).

Leewis *et al*. (2012) investigated the recovery of the characterizing species, *Scolelepis squamata*, *Eurydice pulchra*, *Haustorius arenarius* and *Bathyporeia sarsi*, after beach nourishment by comparing beaches that had been exposed at different times. The lengths of beach nourished varied from 0.5 kn to >7 km and nourishment is likely to kill all animals present, so the results are applicable to broad-scale disturbance and defaunation. Recovery to original abundances appeared to occur within one year for the characterizing species, which was in agreement with other studies (Leewis *et al*., 2012 and references therein).

Resilience assessment. As a consequence of the dynamic nature of the habitat, the faunal component of the biotope is very sparse and low in species richness. Therefore, the community might be considered 'mature' only a few days or weeks after the last storm event, as the mobile species displaced from the biotope and those from adjacent area colonize the substratum via the surf plankton. Even following severe disturbances recovery would be expected to occur within a year, supported by the study by Leewis *et al*. (2012) and life-history traits. Resilience is, therefore, assessed as **'High'** (< 2 years) for any level of impact (i.e resistance is 'None', 'Low' or 'Medium').

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

Hydrological Pressures

Resistance Resilience Sensitivity

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

Intertidal species are exposed to extremes of high and low air temperatures during periods of emersion. They must also be able to cope with sharp temperature fluctuations over a short period of time during the tidal cycle. In winter air temperatures are colder than the sea, conversely in summer air temperatures are much warmer than the sea. Species that occur in the intertidal are therefore generally adapted to tolerate a range of temperatures, with the width of the thermal niche positively correlated with the height of the shore that the animal usually occurs at (Davenport & Davenport, 2005). The species present in this biotope are present in the mid and/or upper shore and therefore are likely to have broad temperature tolerances and to be tolerant of temperature fluctuations.

Many intertidal species can alter metabolic activity, burrow deeper in sediment or move to deeper water to tolerate or escape unfavourable conditions. At low tide, air temperature becomes critically important to intertidal animals: on sandy beaches, the substratum, from the surface to a depth of several centimetres, can experience large variations in temperature during a single tidal cycle and throughout the year (Hayward, 1994). For instance, Khayrallah & Jones (1980b) reported the temperature range of sand at a depth of 1 cm during neap tides to be from -2°C in February 1973, to a maximum of 25°C in July 1977. Although adapted to temperature change, severe acute change may result in seasonal reduction in species richness and abundance, but the effects of an acute temperature increase are not necessarily direct and may be more related to the resultant changes in other factors, especially reductions in oxygen resulting from enhanced microbial activity (Hayward, 1994; Eltringham, 1971).

The amphipods and isopods that occur within this habitat are mobile and can avoid unfavourable conditions to some extent. The isopod *Eurydice pulchra* was observed to migrate seasonally off-shore in the Dovey Estuary (Wales). *Bathyporeia* life cycles vary between locations and this is related to temperature (Mettam, 1989). Preece (1971) tested temperature tolerances of *Bathyporeia pelagica* and *Bathyporeia pilosa* in the laboratory. Individuals acclimated to 15°C for 24 hours were exposed to temperature increases (water temperature raised by 0.2 °C/minute). As test temperatures were reached individuals were removed, placed in seawater at 4°C and allowed to recover for 24 hours at which point mortalities were tested. Amphipods were also allowed to bury into sediments and held at test temperatures for 24 hours of 32.5°C, 31.8°C and 29.5°C before being allowed to recover in fresh seawater at 15°C for a further 24 hours, before mortalities were assessed. Upper lethal temperatures (the temperature at which 50% of individuals died for adult males and gravid females of *Bathyporeia pilosa* were 37.5°C and 39.4°C, respectively. *Bathyporeia pelagica* exhibited lower tolerances and adult males and gravid females had an upper lethal temperature tolerance of 33.4 and 34.2°C respectively. These tests measures short-term exposure only and species had a lower tolerance for longer-term (24 hour exposure). No mortality occurred for *Bathyporeia pilosa* individuals held at 29.5°C and 30.8°C. However, 15% of individuals exposed to water temperatures of 31.8°C and 96% at 32.5°C died. *Bathyporeia pelagica* exhibited lower tolerances, 11% of individuals died after 24 hr exposure to 29.5°C and 100% mortality occurred at 30.8°C and above (Preece, 1971).

Tolerances for temperature changes may, therefore, vary between even closely related characterizing species and some shifts between the variant sub-biotopes may occur although the biotope LS.LSa.MoSa.AmSco would still be recognisable. The amphipod *Bathyporeia pilosa*, for example, tends to occur higher on the shore than *Bathyporeia sarsi* (Degraer *et al*., 2003) and *Bathyporeia pelagica* (Preece, 1971) and this may be linked to a greater physiological tolerance for temperature extremes. Other species of the community, such as *Scolelepis squamata* are infaunal and their environmental position and ability to bury deeper into the sand is likely to protect them from desiccation.

Scolelepis squamata appears to be capable of tolerating the well-drained sediments of this biotope and generally demonstrates a high tolerance to different environmental conditions (Souza & Borzone, 2000). *Scolelepis squamata* is a widespread species occurring on sandy beaches in the North and South Atlantic, North Pacific, Indian Ocean, and the Mediterranean (Souza & Borzone, 2000), with the latitudinal range from 58°N to 35°S (Bayed *et al*., 2006). Over its range it is exposed to both higher and lower temperatures than experienced in the UK, suggesting a broad thermal tolerance. Widely separated populations may be genetically distinct and acclimated to local conditions so that the distribution may not necessarily represent temperature tolerance.

Sensitivity assessment. Typical surface water temperatures around the UK coast vary seasonally from 4-19°C (Huthnance, 2010). A chronic increase in temperature throughout the year of 2°C may fall within the normal temperature variation and an acute increase in water temperatures from 19 to 24°C for a month may be tolerated by the characterizing species supported by deeper burrowing and/or migration. For *Bathyporeia* spp. temperature increases above 30°C appear to be critical based on Preece (1971). For intertidal biotopes, air temperature may be more critical in the hottest parts of the year although the nocturnal emergence of *Bathyporeia* spp. and isopods or the burrowing life habit may also enhance survival. Biotope resistance is therefore assessed as '**High'** and resilience as **'High'** so that the biotope is assessed as **'Not sensitive'**. Increased water and air temperatures and desiccation may lead to greater synergistic effects and the loss of characterizing amphipods and isopods may result in shifts between the variant sub-biotopes.

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

Intertidal species are exposed to extremes of high and low air temperatures during periods of emersion. They must also be able to cope with sharp temperature fluctuations over a short period of time during the tidal cycle. In winter air temperatures are colder than the sea; conversely in summer air temperatures are much warmer than the sea. Species that occur in the intertidal are therefore generally adapted to tolerate a range of temperatures, with the width of the thermal niche positively correlated with the height of the shore that the animal usually occurs at (Davenport & Davenport, 2005).

Crisp (1964) reported that species of amphipod and isopods seemed to be unharmed by the severe winter of 1962-1963. This may be due to burial in sediments buffering temperature or seasonal migration to deeper waters to avoid freezing. In the winter, *Eurydice pulchra*, for example, migrates into the sublittoral zone, thus escaping extreme temperatures (Jones, 1970b) and winter migrations have also been observed for Bathyporeia spp. (Fish & Fish, 1978; Fish & Preece, 1970).

Preece (1971) tested the temperature tolerances of *Bathyporeia pelagica* and *Bathyporeia pilosa* in the laboratory. Individuals acclimated to 15°C for 24 hours were placed in a freezer in wet sediment. As test temperatures were reached individuals were removed and allowed to recover for 24 hours at which point mortalities were tested. Amphipods were also allowed to bury into sediments and held at test temperatures of -1°C, -3°C and -5°C for 24 hours before being allowed to recover in fresh seawater at 15°C for a further 24 hours before mortalities were assessed. Lower lethal short-term tolerances *of Bathyporeia pilosa* and *Bathyporeia pelagica* were -13.6°C and

-6.4°C respectively. Sensitivity to longer-term exposure is greater, especially for *Bathyporeia pelagica*. *Bathyporeia pilosa* individuals could withstand temperatures as low as -1°C for 24 hours, while 42% of *Bathyporeia pelagica* died. At -3°C 5% of *Bathyporeia pilosa* died (100% of *Bathyporeia pelagica*) but this rose to 82% at -5°C.

Sensitivity assessment. Typical surface water temperatures around the UK coast vary seasonally from 4-19°C (Huthnance, 2010). A chronic decrease in temperature throughout the year of 2°C may fall within the normal temperature variation but an acute decrease in water temperatures from 4°C to -1°C at the coldest part of the year may lead to freezing and lethal effects on for a month may be tolerated by the characterizing species supported by deeper burrowing and/or migration. For *Bathyporeia* spp. seawater temperature decreases below -1°C appear to be critical based on Preece (1971). For intertidal biotopes, air temperature may be more important than seawater temperatures in the coldest parts of the year and nocturnal emergence of *Bathyporeia* spp. and isopods or burrowing life habit may reduce survival, although these species are more likely to be quiescent during cold periods or to have migrated to the subtidal. Biotope resistance is therefore assessed as **'High'** and resilience as **'High'** so that the biotope is assessed as **'Not sensitive'.**

Salinity increase (local)	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

This biotope is found in full salinity (30-35 ppt) habitats (JNCC, 2015), a change at the pressure benchmark is therefore assessed as a change to hypersaline conditions. However, monitoring at a Spanish desalination facility where discharges close to the outfall reached a salinity of 53, found that amphipods were sensitive to the increased salinity and that species free-living in the sediment were most sensitive. The study area did not host any of the species characterizing this biotope but the results indicate the general sensitivity of amphipods to hypersaline conditions (De-la-Ossa-Carretero, *et al*., 2016). Nevertheless, no evidence was found to assess the response of the relevant characteristic species to hypersalinity.

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

The biotope is found in full salinity habitats (JNCC, 2015). A change at the pressure benchmark refers to a decrease from full to variable (18-35 ppt), or to reduced salinity (18-30 ppt). Intertidal species tend to be euryhaline as they experience periods of higher salinities where freshwater evaporates from interstitial spaces and decreased salinities when rainfall is high. Short-term tolerance is likely to be high but changes in salinity over the longer time may affect the biological assemblage. *Eurydice pulchra* was found to be relatively euryhaline (Jones, 1970b), whilst *Bathyporeia pelagica* migrates seaward in response to reduced salinities, the effect of which is enhanced by higher temperature (Preece, 1970). *Bathyporeia pilosa* is, however, more tolerant of low salinities and is capable of reproducing at salinities as low as 2 (Khayrallah, 1977). Populations of *Bathyporeia pilosa* within the upper reaches of the Severn Estuary experience wide fluctuations in salinity ranging from 1-22 depending on the season and tidal cycle (Mettam, 1989). The physiological stress for this environment affects size and reproduction (Mettam, 1989). Speybroeck *et al*. (2008) noted that *Bathyporeia pilosa* tends to occur subtidally in estuarine and brackish conditions. Local populations may be acclimated to the prevailing salinity regime and may exhibit different tolerances to other populations subject to different salinity conditions and, therefore, caution should be used when inferring tolerances from populations in different regions.

Sensitivity assessment. A decrease in salinity may lead to some changes in species abundance and this may lead to some changes in classification between the sub-biotope variants. *Bathyporeia pilosa* has high salinity tolerances and may replace more sensitive species, however, the biotope would still be recognisable as a LS.LSa.MoSa habitat and may retain its identity as LS.LSa.MoSa.AmSco.Eur. As some changes in species richness and abundance may occur, resistance is assessed as **‘Medium’** and resilience as **‘High’** (following restoration of typical habitat conditions). Sensitivity is, therefore, assessed as **‘Low’**. Prolonged decreases in salinity (longer than the benchmark) may result in the replacement of amphipods and polychaetes by an oligochaete dominated community and lead to the reclassification to the biotope as LS.LSa.MoSa.Ol.VS.

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

Water movement is a key factor physically structuring this biotope, with sediment sorting and mobilisation by tidal streams and wave action modifying the sediments present and the level of disturbance. Where this biotope occurs in more wave sheltered areas the biological structure alters in response to the decrease in sediment mobility and the presence of finer sand fractions and the habitat may become classified as another LS.LSa.MoSa.AmSco sub-biotope depending on the species present and abundance. In areas sheltered from wave action, water flow may become a more important factor but the threshold for changes is less clear. Some changes between biotope types may also be cyclical and/or vary naturally depending on seasonal patterns.

A change in water flow at the pressure benchmark may, however, be significant as sand fractions are not cohesive (particularly where these occur higher on the shore and are coarser and drier) and are eroded at lower current velocities that muds and silts. Sand particles are most likely to be eroded at about 0.20 m/s (based on the Hjulström-Sundborg diagram; Sundborg, 1956). Of the species present, *Scolelepis squamata* occurs in the broadest range of sediment types (see physical change pressures) and may have the greatest tolerance for changes in flow speeds, based on its habitat distribution. This species may respond to decreased water flows by switching from suspension feeding to deposit feeding (Dauer,1983).

Sensitivity assessment. The sediments that characterize this biotope and sub-biotopes are mobile sands that range from coarse to fine, a change at the pressure benchmark (increase or decrease) may lead to some changes in sediment sorting and the biotope classification may revert to different sub-biotopes within the biotope LS.LSa.MoSa.AmSco based on sediment changes. However, it is unlikely that a change would lead to a sandy mud or mud sediment developing as fine silts require lower velocities to deposit than erode. The wave action typically experienced by the exposed habitats this biotope occurs in will maintain a recognisable species-poor sand biotope. Biotope resistance is, therefore, assessed as **‘High’** and resilience as **‘High’** (by default), so that the biotope is assessed as **‘Not sensitive’ in wave exposed conditions**. In the more sheltered estuarine conditions, where water flow is more important for the physical sorting of sediment, a change at the benchmark level may result in changes in the sub-biotope present. Therefore, resistance is assessed as **'Medium',** resilience as **'High'** and sensitivity is assessed as **'Low' in wave sheltered conditions.**

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

This biotope is found on the mid and lower shore (JNCC, 2015). On sandy shores (as in rocky shores), zonation of species occurs in relation to tidal height. The degree of wave exposure and sediment characteristics (notably drainage) influences the zonation patterns observed (McLachlan *et al*., 1995). Under more exposed conditions this biotope may occur below BarSa, or BarSh (JNCC, 2015). Under more sheltered conditions, it may occur above the LS.LSa.FiSa communities. The biotope LS.LSa.St.Tal may be present on the same shores where drift lines of decomposing seaweed and other debris occur on the upper shore.

Established beach fauna, exhibit physiological and behavioural adaptations to the drying out of sediments that accompanies the tidal cycle (Eltringham, 1971). The characterizing amphipod species are mobile, with an endogenous swimming rhythm that is coupled to circa semilunar pattern of emergence, which serves to reduce the risk of animals being stranded high on the shore (Jones & Naylor, 1970; Fish & Fish, 1972; Alheit & Naylor, 1976). Tolerances for emergence may vary between species and some shifts may occur although the biotope would still be recognisable. The amphipod *Bathyporeia pilosa*, for example, tends to occur higher on the shore than *Bathyporeia sarsi* (Degraer *et al*., 2003) and *Bathyporeia pelagica* (Fish & Preece, 1970). Other characterizing species, including *Scolelepis squamata*, are also infaunal and their environmental position and ability to bury deeper into the sand is likely to protect them from desiccation. *Scolelepis squamata* appears to be capable of tolerating the well-drained sediments of this biotope and generally demonstrates a high tolerance to different environmental conditions (Souza & Borzone, 2000).

Changes in emergence are likely to alter suspension feeding by *Scolelepis squamata* which will be restricted to periods when immersed in water. Drying of sediments may prevent feeding by *Bathyporeia* spp. (Fish & Preece, 1970). An increase in emergence could, therefore, affect both these species but may not directly inhibit the predator *Eurydice pulchra*.

Changes in emergence may result in shifts between the LS.LSa.MosSa.AmSco sub-biotopes as the characterizing species for the biotopes exhibit some zonation (Degraer *et al*., 2003), influenced also by wave exposure and sediment sorting and degree of water retention (Defeo & McLachlan, 2005). The sub-biotope LS.LSa.MoSa.AmSco.Eur may occur on the mid and upper shore together with LS.LSa.MoSa.AmSco.Sco, or above LS.LSa.MoSa.AmSco.Pon and the Po communities. Under more exposed, open conditions, LS.LSa.MoSa.AmSco.Eur may be restricted to the lower part of the shore. Where LS.LSa.MoSa.AmSco.Pon occurs on the mid-shore in relatively sheltered conditions, finer sand biotopes (LS.LSa.FiSa.Po) may be present on the lower shore. Talitrid dominated biotopes may occur above this biotope group where drift lines of fucoids and other debris occur on the upper shore.

In summary, changes in emergence are likely to result in some shifts in the shoreward or landward extent of the biotope complex due to changes in the length of time the biotope is uncovered and covered. Where the changes are relatively small the changes may simply be shifts between sub-biotopes. However, more significant changes could lead to biotopes at the lower shore becoming sub-littoral or colonized by bivalves and more species rich assemblages. Similarly, upper shore biotopes that are at the limit of the ebbing tide could revert to strandline biotopes LS.LSa.St.Tal or tend to revert to the species poor biotope LS.LSa.MoSa or the *Scolelepis squamata* dominated variant (LS.LSa.MoSa.AmSco.Sco) due to the species tolerance for well-drained habitats

Sensitivity assessment. Sandy beaches exhibit vertical zonation of biotopes due to species differing tolerances for emergence. Species within the biotope exhibit physiological and behavioural adaptations to changes and the biotope as a complex is unlikely to be very sensitive to changes in emergence that do not alter the shore zone (from mid-eulittoral to supralittoral, for example). Changes in emergence may result in some changes in upper and lower extents of the biotope and the sub-biotopes and biotope resistance is, therefore, assessed as **'Medium'**, resilience as **'High'** and the biotope sensitivity as **'Low'**.

Wave exposure changes (local)	Medium Q: High A: Medium C: High	High Q: High A: High C: High	Low Q: High A: Medium C: High

Water movement is a key factor physically structuring this biotope, with sediment sorting and mobilisation by tidal streams and wave action modifying the sediments present and the level of disturbance. The LS.LSa.MoSa.BarSa biotope group tends to be found on exposed shores (very exposed to moderately exposed; JNCC, 2015). In sandy habitats that are more sheltered from wave action, finer sands are deposited that are less mobile, more cohesive and hold more water. This allows more species rich and diverse assemblages to develop, such as the sub-biotope LS.LSa.MoSa.AmSco.Eur in more wave sheltered areas the barren sand biotope may be present on the upper shore only.

Sensitivity assessment. Wave action is a key factor structuring this biotope and moderately exposed to sheltered examples may contain the more species rich sub-biotopes. As the biotope occurs from wave exposed to extremely wave sheltered shores (JNCC, 2015) it is possible that a change in wave exposure at the benchmark level may change the distribution or position of this sub-biotope (AmSco.Eur) on the shore, especially in estuarine examples. Biotope resistance to this pressure is, therefore, assessed as **'Medium'** and resilience as **'High'** (by default) so that the biotope is considered to be **'Low' at the pressure benchmark.**

Chemical Pressures

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

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

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

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

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

Similar biotopes have been shown to recover rapidly from exposure to oil pollution from single events. The exposed sandy beach of Ladeira (Corrubedo Bay, NW Spain) was sampled during seven years (2003-2009) after the Prestige oil spill (winter 2002-03), to determine interannual variations in the macroinfaunal community in two ways: (i) through ecological indices (species richness and abundances, Shannon's diversity and Pielou's evenness) and (ii) through the density of the most representative species (Junoy *et al*., 2013). A clear zonation pattern was found, consisting of two zones: (i) the supralittoral, occupied by talitrid amphipods, isopods and insects, and (ii) the intertidal, where marine crustaceans and polychaetes prevailed. The amphipods *Talitrus saltator* and *Talorchestia deshayesii* dominated from the drift line upwards, and isopods (*Eurydice* spp.), polychaetes (*Scolelepis* spp.) and the amphipod *Pontocrates arenarius* dominated the intertidal. Univariate indices remained constant throughout the study period in the supralittoral, but they varied widely in the intertidal zone. Multivariate analysis showed that the Prestige oil spill scarcely affected the macroinfaunal community structure during the study period (2003-2009) and its effect was limited just to the first campaign (2003), six months after the Prestige accident (Junoy *et al*., 2013).

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.

Bioaccumulation of conservative contaminants may occur within the infauna, but in coarse sand beaches, contaminants are unlikely to accumulate owing to a relative absence of organic matter. Direct toxic effects would, therefore, be expected. In general, crustaceans are widely reported to be intolerant of synthetic chemicals (Cole *et al*., 1999) and intolerance to some specific chemicals has been observed in amphipods. Powell (1979) inferred from the known susceptibility of Crustacea to synthetic chemicals and other non-lethal effects, that there would probably also be a deleterious effect on isopod fauna as a direct result of the chemical application. Toxicity tests conducted by Smith (1968), indicated that survival of *Eurydice pulchra* after oil detergent treatment was above average for crustaceans. All were killed at about 10 ppm BP 1002 after 24 hours exposure, whilst at 5 ppm four out of five individuals survived when transferred to clean seawater. However, in the field, a proportion of the *Eurydice pulchra* population survived exposure to lethal concentrations of BP 1002, both in the sand and water.

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

No evidence.

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

This pressure is **Not assessed**.

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

The mobile sands that characterize this biotope may have relatively high oxygen concentration and a lack a black reducing layer (JNCC, 2015). Brafield (1964) concluded that the most significant factor influencing the oxygenation is the drainage of the beach which, in turn, is determined by the slope and particle size.

On exposed shores, the sand sediments are coarser and more porous and therefore have a higher oxygen content. Oxygen depletion becomes a severe problem at all states of the tide on only the very finest grained beaches, and as a general rule, if the percentage of particles of less than 0.25 mm median diameter exceeds 10% of a sediment, then the oxygen concentration of its interstitial water will be less than 20% of the air saturation level, and will drop rapidly during low tide periods (Brafield, 1964). Fine sands tend to have lower oxygen levels because their lower permeability leads to the trapping of detritus which, together with the large surface area for microbial colonization, leads to higher oxygen uptake (Eagle, 1983). Laboratory studies by Khayrallah (1977) on *Bathyporeia pilosa*, indicated that it has a relatively poor resistance to conditions of hypoxia in comparison to other interstitial animals. However, Mettam (1989) and Sandberg (1997) suggest that *Bathyporeia pilosa* can survive short-term hypoxia.

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

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

In-situ primary production is limited to microphytobenthos within and on sediments and the high levels of sediment mobility may limit the level of primary production as abrasion would be likely to damage diatoms (Delgado *et al*., 1991). The characterizing polychaete *Scolelpis squamata* is a suspension and deposit feeding polychaete (Dauer, 1983) while the amphipods feed on epipsammic diatoms attached to the sand grains (Nicolaisen & Kanneworff, 1969). Both these groups may benefit from slight nutrient enrichment if this enhanced primary production.

Sensitivity assessment. The nutrient level is not a key factor structuring the biotope at the pressure benchmark. In general, primary production is low and this biotope is species poor and characterizing species may be present at low abundances (depending on wave exposure). Biotope resistance is therefore assessed as **'High'**, resilience as **'High'** (by default) and the biotope is considered to be **'Not sensitive'**. Changes in nutrient status may indirectly affect this biotope where these result in changes in diatom production and inputs of macroalgal debris.

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

The biotope occurs in mobile sand sediments where wave action leads to particle sorting, in-situ primary production is restricted to microphytobenthos although sediment mobility may restrict production levels (Delgado *et al*., 1991). An input of organic matter would provide a food subsidy to the suspension/deposit feeding *Scolelepis squamata* and may be utilised by amphipods also. In organically enriched areas, *Scolelepis squamata* switch from suspension to deposit feeders (Weston, 1990). In Loch Eil, where sediments were enriched with organic matter from pulp mill effluent, the congener *Scolelepis fuliginosus* was a co-dominant with *Capitella capitata* (Gray, 1979). The congener, *Scolelepis fuliginosa*, has also been reported to colonize the anoxic and surrounding enriched sediments beneath fish pens in the Aegean and in Scottish Waters (Klaoudatos *et al*., 2006; Brown *et al*., 1987).

The biotope description (JNCC, 2015) notes that inputs of organic matter seeping from the drift line can result in high abundances of *Bathyporeia pilosa*. Organic matter is unlikely to accumulate as sediment mobility and re-suspension by wave action will result in the removal of fine organic matter deposits. The isopod *Eurydice pulchra* is an aggressive and very mobile predator, feeding on polychaetes and amphipods, including *Bathyporiea pilosa*, *Bathyporeia sarsi* and *Scolelepis squamata* (Jones, 1968). An increase in secondary production of prey species would, therefore, be of benefit to this species.

An increase in organic enrichment that exceeded the pressure benchmark may impact the habitat and biological assemblage, particularly in more sheltered areas where deposits can accumulate. For instance, prior to the introduction of a sewage treatment scheme in the Firth of Forth (Scotland), the communities of several sandy beaches were considerably modified by gross sewage pollution (Read *et al*., 1983). The west end of Seafield beach exhibited extremely reduced diversity with a community dominated by *Scolelepis fuliginosa* and *Capitella capitata*, to the almost exclusion of all other species of macrofauna. However, at Portobello beach, a reduction in the number of species was recorded and the presence of a 'dominant' replacement community was less obvious. Furthermore, in 1977, before the introduction of the sewage scheme, meiofauna population counts at Seafield and Portobello were also conspicuously lower than for other Scottish beaches (McIntyre, 1977). Many of the major taxa commonly associated with marine intertidal meiobenthos were scarce or absent. Only nematodes, gastrotrichs, harpacticoids and turbellarians were commonly identified from samples, nematodes being the most abundant taxon. Following sewage pollution abatement in 1977, dramatic changes in the macrofauna occurred. The *Scolelepis / Capitella* community declined steadily throughout 1978-1979 so that by spring 1980 species normally associated with 'cleaner' sandy beaches were recorded e.g. *Microthalmus* sp., *Ophiodromus flexuosus*, *Eulalia viridis*, *Eurydice pulchra Monoculodes* sp., but not at pre-impact abundances. There was also an increase in meiofaunal diversity and reduction in dominance by certain taxa.

Sensitivity assessment. At the pressure benchmark organic inputs are likely to represent a food subsidy for the characterizing species and are unlikely to significantly affect the structure of the biological assemblage or impact the physical habitat. Biotope sensitivity is therefore assessed as **'High'** and resilience as **'High'** (by default) and the biotope is therefore considered to be **'Not sensitive'**.

Physical Pressures

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

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

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

The biotope is characterized by the sedimentary habitat (JNCC, 2015), a change to an artificial or rock substratum would alter the character of the biotope leading to reclassification and the loss of the sedimentary community including the characterizing amphipods and *Scolelepis squamata* that live buried within the sediment (Van Tomme *et al*., 2013).

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

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

The pressure benchmark refers to the simplified Folk classification developed by Long (2006) and the UK Marine Habitat Classification Littoral and Sublittoral Sediment Matrices (Connor *et al*., 2004). The biotope occurs on mobile sands. A change at the pressure benchmark refers to a change to sandy muds or muddy sands or to coarser gravel sediments. Experiments by Van Tomme *et al*. (2013) have shown that the optimal sedimentary habitats for the species that characterize this biotope vary slightly. *Bathyporeia pilosa* and *Eurydice pulchra* prefer the finest sediments, although at a subtidal dredge disposal site the change to a finer sediment led to a reduction in the abundance of *Bathyporeia pilosa* (Witt *et al*., 2004). *Bathyporeia sarsi* has a broader preference and also occurred in medium-coarse sediments (Van Tomme *et al*., 2013). The polychaete *Scolelepis squamata* exhibits the broadest preferences and occurs in muddy sands, sands and coarse sediments (Speybroek *et al*. 2007; Van Tomme *et al*., 2013).

Sensitivity assessment. Although *Scolelepis squamata* has broad sediment preferences a change to either a finer muddy sediment or a coarser sediment, would lead to loss of the biotope and the characterizing species. Based on the loss of the biotope, resistance is assessed as **'None',** recovery is assessed as **'Very low**' (as the change at the pressure benchmark is permanent and sensitivity is assessed as **'High**'.

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

Bathyporeia pelagica lives infaunally in the uppermost 3 cm of sandy substrata as does the isopod *Eurydice pulchra* (Fish, 1970). The burrowing polychaete *Scolelepis squamata* may burrow more deeply. A depth of 40 cm was quoted but a citation for this depth was not found. Extraction of the sediment to 30 cm is likely to remove all amphipods and isopods within the footprint (although if disturbed some may be able to escape). Most *Scolelepis squamata* are also likely to be removed. Removal of some beaches by storm action is normal and recovery is likely to occur within one-two years depending on local sediment supply and water transport.

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

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

This biotope is present in mobile sands. The associated species are generally present in low abundances and adapted to frequent disturbance suggesting that resistance to surface abrasion would be high. The amphipod and isopod species present are agile swimmers and are characterized by their ability to withstand sediment disturbance (Elliott *et al.* 1998). Similarly, the polychaete *Scolelepis squamata* is adapted to life in unstable sediments and survives through rapid burrowing (McDermott, 1983, cited from Elliott *et al.*, 1998). This characteristic is likely to protect the characteristic species from surface abrasion.

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

Sensitivity assessment. The trampling experiment (Ugolini *et al.*, 2008) represents a high intensity of abrasion with multiple steps on the sediment within a short time period. The experiment, does, however, demonstrate that amphipods are sensitive to abrasion and compaction of the sediment and these results are observed by comparisons between heavily and lightly used areas (Reyes-Martínez *et al.*, 2015; Bessa *et al.*, 2014). Therefore, resistance to a single abrasion event is assessed as **'Low'** based on the characterizing species. Resilience is assessed as **'High'**, based on migration from adjacent populations and in-situ reproduction by surviving amphipods. Sensitivity is therefore assessed as **'Low'**. This assessment may underestimate sensitivity to high levels of abrasion (repeated events within a short period). The trampling evidence and the evidence for penetration from mobile gears (see below) differ in the severity (resistance) of impact. This may be due to different levels of intensity (multiple trampling/abrasion events vs single penetration/towed gear impacts) or the nature of the pressure. Abrasion from trampling also involves a level of compaction that could collapse burrows and damage species through compression. Penetration may, however, break sediments open allowing mobile species to escape or species may be pushed forwards from towed gear by a pressure wave where this is deployed subtidally (Gilkinson *et al.*, 1998). This suggests that exposure at different states of tide will mediate impacts. Both assessments are considered applicable to single events based on the evidence and the sensitivity assessment for both pressures is the same although resistance differs.

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

This biotope is present in mobile sands, the associated species are generally present in low abundances and adapted to frequent disturbance suggesting that resistance to abrasion and penetration and disturbance of the sediment would be high. The amphipod and isopod species present are agile swimmers and are characterized by their ability to withstand sediment disturbance (Elliott *et al*. 1998). Similarly, the polychaete *Scolelepis squamata* is adapted to life in unstable sediments and survives through rapid burrowing (McDermott, 1983, cited from Elliott *et al*., 1998). This characteristic is likely to protect this species from surface abrasion.

Bergman & Santbrink (2000) found that direct mortality of gammarid amphipods, following a single passage of a beam trawl (in silty sediments where penetration is greater) was 28%. Similar results were reported from experiments in shallow, wave disturbed areas, using a toothed, clam dredge. *Bathyporeia* spp. experienced a reduction of 25% abundance in samples immediately after intense clam dredging, abundance recovered after 1 day (Constantino *et al*. 2009). Experimental hydraulic dredging for razor clams resulted in no statistically significant differences in *Bathyporeia elegans* abundances between treatments after 1 or 40 days (Hall *et al*., 1990), suggesting that recovery from effects was very rapid. Ferns *et al*. (2000) examined the effects of a tractor-towed cockle harvester on benthic invertebrates and predators in intertidal plots of muddy and clean sand. Harvesting resulted in the loss of a significant proportion of the most common invertebrates from both areas. In the muddy sand, the population of *Bathyporeia pilosa* remained significantly depleted for more than 50 days, whilst the population in clean sand recovered more quickly. These results agree with other experimental studies that clean sands tend to recover more quickly that other habitat types with higher proportions of fine sediment (Dernie *et al*., 2003).

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

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

The characterizing species live within the sand and are unlikely to be directly affected by an increased concentration of suspended matter in the water column. Within the mobile sands habitat storm events or spring tides may re-suspend or transport large amounts of material and therefore species are considered to be adapted to varying levels of suspended solids.

Scolelepis squamata is a suspension feeder (Dauer, 1983) and may also deposit feed so may benefit from increased organic particles in suspension or deposited on the surface. *Bathyporeia* spp. feed on diatoms within the sand grains (Nicolaisen & Kanneworff, 1969) and an increase in suspended solids that reduced light penetration could alter food supply. However, diatoms are able to photosynthesise while the tide is out and therefore a reduction in light during tidal inundation may not affect this food source, depending on the timing of the tidal cycle. The isopod *Eurydice pulchra* feeds on the amphipod and polychaete characterizing species and, it may therefore be indirectly affected by changes in food supply if other species are impacted by changes in suspended solids.

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

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

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

Evidence for the effects of siltation by thick layers of added sediment from beach nourishment is described for the heavy deposition pressure below. The pressure benchmark for light deposition refers to the addition of a relatively thin layer of deposits in a single event. Species adapted to coarse sediments may not be able to burrow through fine sediments, or experienced reduced burrowing ability. For example, Bijkerk (1988, results cited from Essink 1999) found that the maximal overburden through which *Bathyporeia* could migrate was approximately 20 cm in mud and 40 cm in sand. No further information was available on the rates of survivorship or the time taken to reach the surface.

To allow respiration, *Scolelepis squamata* requires permeable sediments (Dauer, 1985). Increased siltation that leads to surficial layers of fine sediment will inhibit permeability of surface sediments and reduce habitat suitability for this species. In a review that developed new sensitivity indices, *Scolelepis squamata* was characterized as AMBI Sedimentation Group II-Species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation (Gittenberger & van Loon, 2011). However, *Scolelepis squamata* has been found to rapidly recover following disturbance, with some increase from original population size (Peterson *et al*., 2006; Leewis *et al*., 2012, Manning *et al*., 2014), recovering within nine months following nourishment (Menn *et al*., 2003, Leewis *et al*., 2012).

Sensitivity assessment. Where the biotope is associated with wave exposed beaches, some sediment removal will occur, mitigating the effect of deposition. The mobile amphipods and the isopod *Eurydice pulchra* are likely to be able to burrow through a 5 cm layer of fine sediments. *Scolelepis squamata* is also likely to be able to survive some burial and to reposition. Biotope resistance is therefore assessed as **'High'** and resilience as **'High'** (by default). Hence, the biotope is considered to be **'Not sensitive'** to this pressure. Repeated deposits or deposits over a large area or in sheltered systems that were shifted by wave and tidal action may result in sediment change (see physical change pressure).

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

Studies have found that beach 'replenishment' or 'nourishment' that involves the addition of sediments on beaches can have a number of impacts on the infauna (Peterson *et al*., 2000, Peterson *et al*., 2006). Impacts are more severe when the sediment added differs significantly in grain size or organic content (Nelson *et al*., 1989, Peterson *et al*., 2000). For example, Maurer *et al*. (1981) found that the amphipod *Parahaustorius longimerus*, which occurs intertidally in clean, well-sorted sands and is an active, effective burrower, was able to regain the surface after being buried by sand far more easily than when buried under silt/clay mixtures. A thick layer of sediment has a smothering effect and in most instances buried species will die although some polychaetes can escape up to 90 cm of burial in response to nourishment (Speybroek *et al*., 2007). Peterson *et al*. (2000) found that the dominant macrofauna were reduced by 86-99% 5-10 weeks after the addition of sediment that was finer than the original sediments but with a high shell content.

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

Leewis *et al*. (2012) investigated the recovery of the characterizing species, *Scolelepis squamata*, *Eurydice pulchra*, *Haustorius arenarius* and *Bathyporeia sarsi*, following beach nourishment by comparing beaches that had been exposed at different times. The lengths of beach nourished varied from 0.5 km to >7 km. Recovery to original abundances appeared to occur within one year for the characterizing species, which was in agreement with other studies (Leewis *et al*., 2013). *Scolelepis squamata* has been found to rapidly recover following disturbance, with some increase from original population size (Peterson *et al*., 2006; Leewis *et al*., 2012, Manning *et al*., 2014), recovering within nine months following nourishment (Menn *et al*., 2003, Leewis *et al*., 2012).

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

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

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

This pressure is not assessed. Amphipods may consume microplastics although no negative effects have been documented. Ugolini *et al.* (2013) found that *Talitrus saltator* could consume polyethylene microspheres (diameter 10-45 µm). Most microspheres were expelled in 24 hr. and were totally expelled in one week after microsphere ingestion on the survival capacity in the laboratory. Analyses carried out on faeces of freshly collected individuals revealed the presence of polyethylene and polypropylene, confirming that microplastic debris could be swallowed by *Talitrus saltator* in natural conditions. The talitrid *Orchestia gammarellus* has also been reported to ingest microplastics in the size range 20-200 µm (Thompson *et al*., 2004).

Electromagnetic changes	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence for the characterizing species was found to assess this pressure. For some amphipods, there is evidence for geomagnetic orientation being inhibited or disrupted by the presence of electromagnetic fields or by changing magnetic fields. Arendse & Barendregt (1981) manipulated magnetic fields to alter the orientation of the talitrid amphipod *Orchestia cavimana*. Deep-water amphipods *Gondogenia arctica* have been shown to be sensitive to even weak electromagnetic fields which cancel magnetic orientation (Tomanova & Vacha, 2016). Loss of orientation was observed at a radiofrequency electromagnetic field of 2 nT (0.002 µT) (Tomanova & Vacha, 2016).

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

Not relevant.

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

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

Orientation by light has been well studied for intertidal amphipods (particularly *Talitrus saltator)*. Intertidal amphipods orientate themselves by a range of factors that include (but are not limited to) visual cues based on solar or astronomic cues such as the moon and the geomagnetic field (Scapini, 2014). Activity patterns are also linked to internal biological clocks that respond to diel, tidal, lunar and seasonal cycles so that animals are active during the most suitable time of day or night (Scapini, 2014). The introduction of light or an increase in shading could, therefore, alter behavioural patterns and navigation. As responses may be species-specific or vary according to local factors or individual needs such as feeding, mating, it is not possible to provide a simple assessment for this species. Some sensitivity is however likely if incident light levels were altered. This will depend, however, on the footprint and intensity of impact. Fanini *et al.* (2014) found no difference in abundance of *Talitrus saltator* between Greek beaches that frequently hosts small-scale beach-parties with lights at night and those that were not used in this way.

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

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

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

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

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

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

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

Visual disturbance	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 evidence was found to assess visual perception for *Scolelepis squamata*. The characterizing species are likely to be able to detect light and some movement but are unlikely to have any visual acuity. Therefore, the pressure is considered to be **'Not relevant'** in this biotope.

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

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

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

The sediments characterizing this biotope are coarse, mobile and free-draining, which limits the establishment of marine and coastal invasive non-indigenous species as the habitat conditions are unsuitable for most species, as exemplified by the low species richness characterizing this biotope. This biotope is, therefore, considered to have **'High'** resistance to this pressure and **'High'** resilience (by default) so that it is assessed as **'Not sensitive'** to this pressure.

Introduction of microbial pathogens	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

The polychaete *Scolelepis squamata* may be parasitized externally by a nematode *Theristus polychaetophilus* (Hopper, 1966). Amphipods may also be infected by a number of parasites or pathogens that alter population numbers through changes in host condition, growth, behaviour and reproduction (Green Extabe & Ford, 2014). Infection by acanthocephalan larvae, for example, may alter the behaviour and responses of gammarid amphipods (Bethel & Holmes, 1977). However, **'No evidence'** was found for pathogen/parasite outbreaks that may result in mass-mortalities in the characterizing species.

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

No species characterizing the biotope are targeted by commercial or recreational fishing or harvesting. This pressure is therefore considered **'Not relevant'.**

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

The loss of the key characterizing species through unintentional removal would alter the character of the biotope and, depending on prey selection, could mean temporary reversion to another biotope within the LS.LSa.MoSa (depending on the identities and abundance of species remaining). The ecosystem services such as secondary production and food for higher trophic levels would be lost. The polychaete *Scolelepis squamata* and the amphipods are predated on by wading birds, flat-fish and other invertebrate predators during tidal inundation (Speybroeck *et al*., 2007; Van Tomme *et al*., 2014).

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

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