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

Sublittoral sand in variable salinity (estuaries)

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

Matthew Ashley

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Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/habitats/detail/1014]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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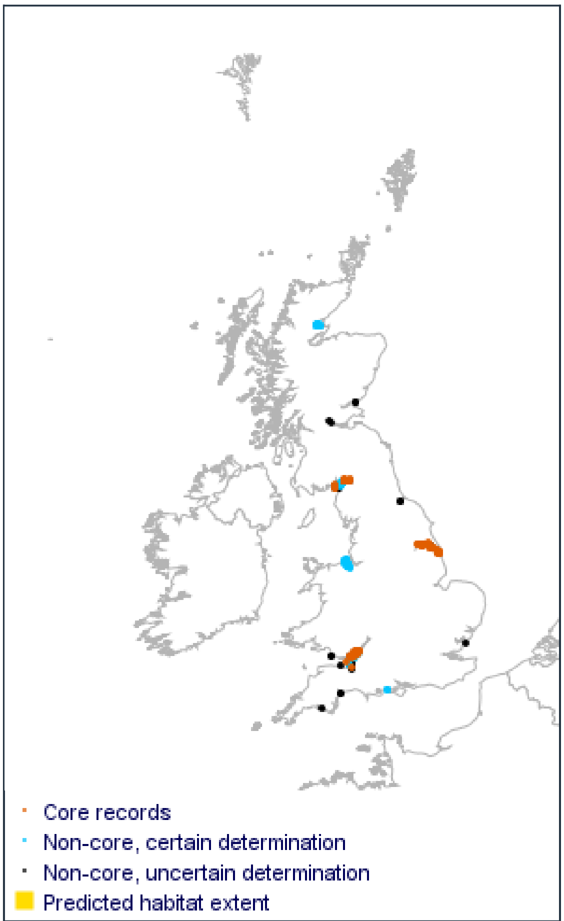

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Matthew Ashley **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A5.22	Sublittoral sand in variable salinity (estuaries)
JNCC 2015	SS.SSa.SSaVS	Sublittoral sand in variable salinity (estuaries)
JNCC 2004	SS.SSa.SSaVS	Sublittoral sand in variable salinity (estuaries)
1997 Biotope	SS.IGS.EstGS	Estuarine sublittoral gravels and sands

Description

Clean gravels and sands which occur in the upper reaches of marine inlets, especially estuaries, where water movement is sufficiently strong to remove the silt content of the sediment. The habitat typically lacks a significant seaweed component and is characterized by robust brackish-water tolerant fauna, particularly amphipods, robust polychaetes and mysid shrimps (JNCC, 2015).

Depth range

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

Additional information

-

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

There are three sub-biotopes within the SS.SSa.SSaVS (Sublittoral sand in variable salinity estuaries) biotope, these are: i) SS.SSa.SSaVS.NcirLim (*Nephtys cirrosa* and *Macoma balthica* in variable salinity infralittoral mobile sand), ii) SS.SSa.SSaVS.NintGam (*Neomysis integer* and *Gammarus* spp. in fluctuating low salinity infralittoral mobile sand), and iii) SS.SSa.SSaVS.MoSaVS (Infralittoral mobile sand in variable salinity (estuaries). The sensitivity characteristics of the biotope and sub-biotopes are summarised below and are based on the on-line descriptions (Connor *et al*., 2004; JNCC, 2015). The sensitivity assessments presented in the review are made at the biotope level and are considered applicable to the sub-biotopes, if the sensitivity of a sub-biotope is considered to be different this is discussed.

SS.SSa.SSaVS: Clean sands that occur in the upper reaches of marine inlets, especially estuaries, where water movement is moderately strong, allowing the sedimentation of sand but not the finer silt fraction. The habitat typically lacks a significant seaweed component and is characterized by brackish-water tolerant fauna, particularly amphipods, polychaetes and mysid shrimps. Characterizing species include the polychaetes *Nephtys cirrosa* and *Capitella capitata*, and mysid *Neomysis integer* and the amphipod *Gammarus salinus* and the sensitivity assessments are based on these species. The sea louse *Eurydice pulchra* is more mobile and may occur in the biotope in high abundance seasonally. Three variant sub-biotopes are described for this biotope, based principally on differences in infaunal species composition, response to salinity conditions and tidal flow strengths. The sensitivity assessments are applicable to all three variant biotopes where additional information and sub-biotope assessments are not provided.

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

SS.SSa.SSaVS.NintGam: Upper estuary mobile fine muddy sands with very low fluctuating salinity characterized by the mysid shrimp *Neomysis integer* (see Arndt 1991) and amphipods of the genus *Gammarus spp*. This habitat has a rather sparse infauna and species such as *Neomysis integer* will most likely be found on the sediment surface or just above it whilst *Gammarus* may be under loose weed, stones or other detritus on the sediment surface. The harsh physicochemical regime imposed by such environmental conditions in the upper estuary leads to a relatively impoverished community but high densities of the mobile, salinity-tolerant, crustaceans can occur. The biotope is found in the transitional zone between freshwater and brackish environments, relying on the decreased freshwater input during the summer for penetration of the brackish species up-stream. As such this biotope may also contain elements of freshwater communities. *Neomysis integer* and *Gammarus salinus* are the only two species with significant populations regularly recorded from this biotope. The characterizing species considered in this sensitivity review are *Neomysis integer* and *Gammarus salinus*. Due to the impoverished community, no other species are reviewed in association with SS.SSa.SSaVS.NintGam, although it is acknowledged where appropriate that freshwater species may occur, as this biotope occurs in the transition zone between freshwater and brackish environments.

SS.SSa.SSaVS.MoSaVS: Very mobile sand in areas of strong tidal currents and variable salinity. No stable community is able to develop within this extremely mobile and abrasive habitat. The fauna encountered in this habitat consists of epifaunal crustaceans or relatively low numbers of robust species, such as the isopod *Eurydice pulchra*. The polychaete *Capitella capitata* may occur frequently in some areas. Other taxa such as the polychaetes *Eteone* spp. and *Arenicola marina*, the mysid *Neomysis integer* and the amphipods *Bathyporeia* spp. and *Haustorius arenarius* may also be washed in from adjacent communities. This biotope is found in tidal channels of estuaries and areas where water movement keeps silt and mud in suspension, and excludes even the more robust infauna.

Resilience and recovery rates of habitat

Biotopes in the upper reaches of estuaries are characterized by strong tidal streams and mobile sediments that create inhospitable conditions for the development of stable communities. They are home to impoverished animal communities with high abundances of opportunistic species that can tolerate low and variable salinities and which typically mature rapidly and have short lifespans.

The polychaete *Nephtys cirrosa* is relatively long-lived with a lifespan of six to possibly as much as nine years (MES, 2010). It matures at one year and the females release over 10,000 (and up to 80,000 depending on species) eggs of 0.11-0.12mm from April through to March. These are fertilized externally and develop into an early lecithotrophic larva and a later planktotrophic larva which spend as much as 12 months in the water column before settling from July-September. The genus has a relatively high reproductive capacity and widespread dispersion due to the lengthy larval phase. this species is likely to have a high recoverability potential following disturbance (MES, 2010). *Nephtys cirrosa* is an active worm which can swim short distances with an undulatory movement and, therefore, seek preferred conditions and populations can recover through active migration.

Capitella capitata is a classic opportunist species possessing life history traits of rapid development, many reproductions per year, high recruitment and high mortality rates (Grassle & Grassle, 1974; McCall, 1977). In favorable conditions maturity can be reached in <3 months and growth rate is estimated to be 30 mm per year. Adult potential dispersal is up to 1 km. The species complex displays reproductive variability, planktonic larvae are able to colonize newly disturbed patches but after settlement the species can produce benthic larvae brooded within the adult tube to rapidly increase the population before displacement by more competitive species (Gray, 1979). Shull (1997) demonstrated that recolonization occurs by larval settlement, bedload transport and by burrowing. Thus, when conditions are suitable, the time for the community to reach maturity is likely to be less than six months. Bolam & Fernandes (2002) and Shull (1997) noted that *Capitella capitata* can colonize azoic sediments rapidly in relatively high numbers. Experimental studies using defaunated sediments, have shown that on small scales *Capitella* can recolonize to background densities within 12 days (Grassle & Grassle, 1974; McCall, 1977). In Burry Inlet, Wales, tractor towed cockle harvesting led to a reduction in density of some species but *Capitella capitata* had almost trebled its abundance within the 56 days in a clean sandy area (Ferns *et al*., 2000).

The amphipod *Gammarus salinus* produce multiple broods per year (a maximum of 5 was observed in Norway by Skadsheim (1984)) . Mature females have been found from late November through to late July and the main reproduction period occurred during the winter (Leineweber, 1985). Juveniles were most numerous from April through to July, and in the warmer months between July and October a relatively stable population was attained. *Gammarus salinus* also has a lifespan of less than a year. Fertilization is external with sperm being deposited in a brood chamber formed of brood plates that arise from the base of thoracic appendages (Fish & Fish, 1996).

The mysid *Neomysis integer* reaches maturity within 2 - 3 months of release form the females brood pouch (marsupium). It breeds between spring and autumn and typically produces three generations per year, two during the summer and one in the autumn which overwinters. In most populations of *Neomysis integer* breeding ceases in winter, with the exception of a population from Loch Etive, Scotland, which bred continuously throughout the year, although at low intensity (Mauchline, 1971). *Neomysis integer* has a lifespan of less than a year.

Resilience assessment. As the characterizing species reach maturity within a year, and proceed to produce more than one generation, recovery is likely to be rapid. In terms of the species present the biotope may be recognizable within 1-2 years following defaunation. Resilience is therefore assessed as 'High' for all levels of impact.

Hydrological Pressures

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

The geographic distributions of species characteristic of the sub-biotopes in this group extends south of the British Isles, so species are considered likely to be resistant to an increase in temperature. Infaunal species are likely to be protected to some extent from the direct effects of short-term increases in temperature by sediment buffering, although increased temperatures may affect infauna indirectly by stimulating increased bacterial activity and increased oxygen consumption. Evidence for the tolerances of characterizing species to temperature changes is outlined below.

Emery & Stevensen (1957) reported that *Nephtys spp.* could withstand summer temperatures of 30-35°C so the characterizing species, *Nephtys cirrosa*, is likely to withstand acute and chronic temperature increases at the pressure benchmarks. An acute increase in temperature at the benchmark level may result in physiological stress but this is considered unlikely to lead to mortality.

Capitella capitata is a cosmopolitan species in coastal marine and estuarine soft sediment systems. Grassle and Grassle (1976) used electrophoretic enzyme analysis to determine that the global population is actually made up of several genetically distinct (and apparently genetically isolated) sibling species whose distributions overlap such that local *Capitella capitata* populations actually consist of a number of co-occurring sibling species. Within the complex tolerances may vary and local acclimation is possible. *Capitella capitata* has also been recorded in extreme environments around hydrothermal vents (Gamenick & Giere, 1997) which suggests that the species complex would be relatively tolerant to an increase in temperature. Experimental evaluation of the effects of combinations of varying salinities and temperature on *Capitella capitata* were carried out by Redman (1985) and Warren (1977). Redman (1985) found that, length of life decreased as follows: 59 weeks at mid-temperature and salinity (15°C, 25ppt); 43 weeks at high temperature & high salinity (18°C, 30ppt); 33 weeks at lower temperature & high salinity (12°C, 30ppt); 17 weeks at high temperature & low salinity (18°C, 20ppt). Redman (1985) also found that net reproduction (Ro: the mean number of offspring produced per female at the end of the cohort) decreased as follows: 41.75 control; 36.69 under high salinity, high temperature; 2.19 high temperature, low salinity; 2.16 low temperature, high salinity. Therefore, a combination of changes in temperature and salinity may decrease the viability of the population. Warren (1977) used individual worms collected from Warren Point (south-west England) to test response to high and low temperatures. Worms were acclimated to 10°C for 10 days and subsequently heated in a water bath to experienced a rise in temperature of 1 °C per 5 min. When the temperature had reached 28 °C worms were removed at 0.5 °C intervals and returned to a constant temperature of 10 °C. The percentage mortality after 24 h was calculated. Larvae were removed from the maternal tube and tested using the same method. The experiments indicated that temperatures above 30 °C were most critical; the upper lethal temperature was 31.5 °C for adult worms and a little higher for the larvae.

The amphipod *Gammarus salinus* has been demonstrated to tolerate a variety of temperature and salinity changes. Furch (1972) exposed *Gammarus salinus* to both constant (8 °C, 14 °C & 20 °C) and fluctuating (daily fluctuations between 8 °C to 20 °C) temperatures. The species revealed significant differences in heat resistance, which became apparent within 12 hours. *Gammarus salinus* was able to endure long-term exposure (2 to 4 weeks) to fluctuating temperatures, although rapid temperature changes (every hour) were less tolerated than lower temperature fluctuations (2 hours). Acute temperature changes may cause additional stress but are unlikely to result in mortality. Recovery from rapid fluctuations is apparent within a matter of hours (Furch, 1972).

Environmental temperature exerts an influence on many of the physiological processes of mysid shrimps (Mauchline, 1980). However, the tolerance of mysid shrimps to changes in environmental temperatures varies between species and, to a lesser extent, between populations of the same species in different environments (Mauchline, 1980). The distribution of *Neomysis integer* extends to the south of the UK, along the Atlantic coast of Spain so the species may be able to tolerate a change of 2 °C. However, Kinne (1955) found that juveniles of *Neomysis integer* had a different tolerance to temperature changes than adults. Kuhlman (1984) also found that overwintering and summer generations of *Neomysis integer* demonstrated distinct differences to increasing temperature, the upper tolerance of the winter generation being 10-12 °C in comparison to 20-25 °C for the summer generation. Consequently, an acute increase in temperature may be particularly damaging to the population during the spring when the overwintering population commences breeding than at other times of the year. Survival and growth of *Neomysis integer* continued within a temperature range of 8°C to 25°C , but sexual maturation was only possible in the narrower range of 15–25 °C (Fockeday *et al*., 2005, 2006). *Neomysis integer* is likely to recover within a few weeks or at most six months following summer recruitment and probable migration between suitable habitats.

Sensitivity assessment. Typical surface water temperatures around the UK coast vary, seasonally from 4-19 °C (Huthnance, 2010) although in estuaries and other shallow waters the temperature range may exceed this due to summer warming and winter cooling. The biotope, based on the characterizing species is considered to tolerate a 2 °C increase in temperature for a year. *Nephtys cirrosa* is likely to be resistant to changes at the pressure benchmark level. The experimental studies by Redman (1985) suggest that changes in temperature may reduce the life-span of *Capitella capitata*, however this effect is not considered to alter the character of the biotope as the short life cycle of this species should lead to rapid replenishment of the population. The experiments by Warren (1977) suggest that both the chronic and acute increases in temperature would not exceed the thermal tolerance of *Capitella capitata*.

Gammarus salinus and *Neomysis integer* are likely to be resistant to a chronic change of 2°C for one year but a 5°C increase for one month may impact the *Neomysis integer* population during the spring when the overwintering population commences breeding. Survival and growth of *Neomysis integer* were detected within the whole range tested, but sexual maturation was only possible in the narrower range of 15–25 °C and 5–15 psu.

Although it is possible there may be effects on timing of reproductive cycles, biotope resistance to temperature increases at the benchmark level is '**High**' and Resilience '**High**'. The biotope SS.SSa.SSaVS is therefore assessed as '**Not sensitive**'. The biotope SS.SSa.SSaVS.NintGam is characterized by *Gammarus salinus* and *Neomysis integer*, reductions in the abundanceof Neomysis integer may lead to a shift in classification to the variant sub-biotope SS.SSa.SSaVS.MoSaVS.

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

No evidence was found to assess the sensitivity of the characterizing polychaete *Nephtys cirrosa* to this pressure and the assessment is based on geographic distribution. *Nephtys cirrosa* reaches its northern limit in Scotland, and German Bight of the North Sea. A decrease in temperature may result in loss of the species from the SS.SSa.SSaVS biotope in these areas.

Wu *et al*. (1988) collected *Capitella capitata* individuals at seawater temperatures of -2°C that harboured mature oocytes indicating reproductive activity even under low temperatures.Warren (1977) used individual worms collected from Warren Point (south-west England) to test response to high and low temperatures. Worms were acclimated to 10°C for 10 days prior to testing. The worms were cooled in a water bath to experience a decrease in temperature of 1 °C per 5 min. When the final temperature was reached, worms were removed at 0.5 °C intervals and returned to a constant temperature of 10 °C. The percentage mortality after 24 h was calculated. Each experiment was repeated once. Larval *Capitella capitata* were removed from the maternal tube and tested using the same method. Both adults and larvae of *Capitella capitata* were tolerant of low temperatures, 50 % of the adults and 65 % of the larvae surviving at - 1°C.

The distribution of both *Neomysis integer* and *Gammarus salinus* extends to the north of the UK, so the fauna of the biotope would probably be resistant to a long-term decrease in temperature of 2°C. Acute decreases in temperature may cause death of vulnerable proportions of the population owing to additional stress, e.g. those that are parasitized but resistance of healthy individuals is probably high at the benchmark pressure. Survival and growth of *Neomysis integer* continued within a temperature range of 8 °C to 25 °C, but sexual maturation was only possible in the narrower range of 15 –25 °C (Fockeday *et al*. 2005, 2006). Reproduction and longer-term abundance of the population may be impacted at the pressure benchmark, particularly in higher latitudes where winter water temperatures would fall below the lower limits of growth and sexual maturation.

Sensitivity assessment. Typical surface water temperatures around the UK coast vary, seasonally from 4-19 °C (Huthnance, 2010). Based on the characterizing species, the assessed biotopes are considered to be tolerant of a 2°C decrease in temperature for a year, except in the most Northerly areas of Scotland where the northerly range of *Nephtys cirrosa* is likely to be reduced under the benchmark pressure. A 5°C decrease for a one month period is likely to cause some mortality to vulnerable portions of the *Neomysis integer* and *Gammarus salinus* populations. Records of the biotope SS.SSa.SSaVS are reported as far north as the Firth of Forth, Scotland. Within the current temperature range, resistance to an acute decrease in temperature at the pressure benchmark level is assessed as '**Low**', Resilience is '**High**' and therefore, sensitivity is assessed as '**Low**'.

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

Salinity is a key factor structuring the biotope. The three variant sub-biotopes are present within different salinity ranges, therefore, an increase in salinity at the pressure benchmark could lead to changes in habitat suitability for the variant biotopes resulting in changes in distribution and extent. Some seasonal changes in salinity occur within estuaries and such shifts may be part of the natural temporal variability. For example, the location of the biotope SS.SSa.SSaVS.NintGam within the estuary may also shift upstream or downstream on a seasonal or yearly basis related in part to the freshwater flow into the estuary (JNCC, 2015) as has been noted in the Humber (Allen *et al*. 2003).

Nephtys cirrosa were most abundant in salinities >30 psu in the German Bight (south eastern North Sea) (Meißner *et al*., 2008), suggesting the species would be resistant to an increase to full salinity (30-35 ppt).

Capitella capitata and other associated species occur intertidally and in areas with limited water exchange such as lagoons: these habitats may experience short-term increases in salinity due to evaporation and some resistance is therefore expected with local acclimation possible.

Neomysis integer and *Gammarus salinus* are euryhaline species. However, whilst *Gammarus salinus* may tolerate salinities of 30 psu, *Neomysis integer* was found to have an upper salinity tolerance between 20-25 psu, with death occurring at 30 psu (Kuhlman, 1984) and in the Severn estuary, UK were shown to occur in low salinities (Bamber & Henderson 1994). Resistance of these species especially *Neomysis integer* is low to none, to an increase to 'full' salinity. Increased salinity would cause physiological stress and favour the establishment of fully marine species and biotopes such as the SS.SSa.SSaVS.NintGam biotope would temporarily not be recognised. On return to a brackish water salinity regime, recovery of the important characterizing species has been assessed to be very high owing to immigration and rapid reproduction.

Sensitivity assessment. Salinity is a key factor structuring the biotope and changes at the pressure benchmark are likely to lead to changes in species distribution and abundance within estuarine systems. The characterizing species of SS.SSa.SSaVS.NcirLim*Nephtys cirrosa* and *Capitella capitata* display high resistance to a change to full salinity. The amphipods *Neomysis integer* and *Gammarus salinus* display less resistance and *Neomysis integer* in particular will be absent from 'full' salinity conditions. Changes in salinity are likely to result in shifts between the variant SS.SSa.SSaVS biotopes. Resistance to this pressure is assessed as ''**Medium**' and Resilience as '**High**' (following restoration of typical conditions) so that biotope sensitivity is considered to be '**Low**'.

The biotope SS.SSa.SSaVS.NintGam, characterized by presence of *Neomysis integer* and *Gammarus salinus* would likely show a Resistance of '**None**', Resilience of '**High**' and a Sensitvity of '**Medium**'.

A change to full salinity may lead to replacement of the SS.SSa.SSaVS.MoSaVS by the biotope

SS.SSa.IFiSa.IMoSa as this biotope occurs in similar conditions in full salinities (JNCC, 2015).

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

Salinity is a key factor structuring the biotope. The three variant sub-biotopes are present within different salinity ranges and hence a decrease in salinity at the pressure benchmark will lead to changes in habitat suitability for the variant biotopes leading to shift in distribution. Some seasonal changes in salinity occur within estuaries and such shifts may be part of the natural temporal variability. For example, the location of the biotope SS.SSa.SSaVS.NintGam within the estuary may also shift upstream or downstream on a seasonal or yearly basis related in part to the freshwater flow into the estuary (JNCC, 2015) as has been noted in the Humber (Allen *et al*., 2003).

Nephtys species, characteristic of SS.SSa.SSaVS and SS.SSa.SSaVS.NcirLim biotopes are tolerant of brackish waters and penetrate into the mouths of estuaries and estuarine lagoons where salinity may fall below 20 psu (Barnes, 1994), so are unlikely to be especially affected by a reduction in salinity.

The characterizing species in SS.SSa.SSaVS.NcirLim; *Bathyporeia pelagica*, is found in the intertidal but is restricted to the lower half of the tidal range by its intolerance to reduced salinity (Preece, 1970). Salvat (1967), Fish & Preece (1970), Ladle (1975) and Fish & Fish (1978) have reported both the re-distribution of *Bathyporeia pelagica* populations down the shore during spring and summer on open coasts, and the migration of *Bathyporeia pelagica* from sandy estuarine beaches to sites on the open coast. Thus it is probable that where reduced salinity is most likely to occur, the species would migrate offshore. Other species of amphipod crustaceans appear more tolerant of reduced salinity than *Bathyporeia pelagica*, e.g. *Haustorius arenarius* will tolerate salinities <10 psu and *Bathyporeia pilosa* tolerates salinities as low as 4 psu (Barnes, 1994).

Locations close to the freshwater source in an estuary in southern, Portugal had higher abundances of the abundant polychaete in the SS.SSa.SSaVS biotope, *Capitella capitata* than locations in more saline conditions (Silva *et al*., 2012). Opportunistic, deposit feeding polychaetes, such as *Capitella capitata* tolerate stressful conditions, and often out-compete more sensitive species due to tolerance of decreased salinity (or other pressures such as organic enrichment) (Newell, 1998). These species may increase in abundance following a decrease salinity of one MNCR category.

The biotope SS.SSa.SSaVS.NintGam occurs in upper estuaries with very low fluctuating salinity. *Neomysis integer* is tolerant of salinities as low as 0.5 psu (Koepke & Kausch, 1996) and occurs in upper estuary low salinity areas in the Severn estuary UK (Bamber & Henderson, 1994). *Gammarus salinus* can also tolerate a low salinity of 2 psu. A further reduction in salinity at the extreme of their salinity tolerance range would expose them to freshwater. *Neomysis integer* successfully made the transition to freshwater environments but presumably over an extended period of time. An intolerance assessment of high has been made as freshwater species may successfully penetrate the biotope and the SS.SSa.SSaVS.NintGam biotope would temporarily not be recognised. On return to a brackish water salinity regime, recovery of the important characterizing species has been assessed to be very high owing to migration and rapid reproduction.

Gammarus salinus is a euryhaline species relatively tolerant of salinities as low as 2 psu and as high as 30 psu, but it is most abundant at 10 psu. Bulnheim (1984) recorded the respiratory response of *Gammarus salinus* in response to an acute salinity change, from 30 psu to 10 psu, respiration rate moderately increased after an initial shock like response and initially specimens were quiescent as they acclimated to the decreased salinity but recovered within 24 hours. Resistance is likely to be high and recovery immediate.

Some of the 'abundant' species identified in the biotopes, however, may be unaffected, or increase in abundance. For instance, locations close to the freshwater source in an estuary in southern, Portugal had higher abundances of the abundant polychaete in the SS.SSa.SSaVS biotope, *Capitella capitata* than locations in more saline conditions (Silva *et al.*, 2012). Opportunistic, deposit feeding polychaetes, such as *Capitella capitata* and *Manayunkia aestuarina* tolerate stressful conditions, and often out-compete more sensitive species due to tolerance of decreased salinity (or other pressures such as organic enrichment). These species may increase in abundance following a decrease salinity of one MNCR category.

Sensitivity assessment. Characterizing species of the biotope SS.SSa.SSaVS, show **'High'** Resistance and so '**High'** resilience to lower salinities, Sensitivity is assessed as '**Not Sensitive'** as the furthest reduction to the transition zone with freshwater would result in dominance of the biotope variation SS.SSa.SSaVS.NintGam.

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

The biotopes occur in sheltered locations where tidal flow is normally more important than wave action as a structuring factor. Tidal flow ranges from weak to strong occur in the biotope SS.SSa.SSaVS suggesting changes in flow velocity are unlikely to impact the biotope. Stronger currents lead to constant change in the size shape and position of sand banks and in some areas e.g. in the Solway Firth where tidal streams are particularly strong, sandbanks may move considerably over one tidal cycle (Perkins, 1974).

Tidal flow is strong in the biotope SS.SSa.SSaVS.NintGam. *Neomysis integer* actively seeks regions where water flow rate is not in excess of 0.2 knots (10 cm/sec) such as at the waters edge or boundary layer. Normally the biotope experiences strong to moderately strong water flow rates and the benchmark increase would expose the community to currents in excess of 6 knots (> 3 m/sec). Species present in the biotope would probably experience difficulty in maintaining a position and be washed from the biotope. Sand is also likely to be swept away by increased tidal flow. In the absence of the important characterizing species the biotope would not be recognised. On resumption of a normal flow regime the species that may have been lost will probably recolonize from adjacent areas and recovery has been assessed to be very high assuming suitable substrate is deposited.

Spooner (1947) stated that species of *Gammarus* are relatively indifferent to the nature of the substratum to a remarkable degree, provided that there is some kind of object to provide them with shelter/cover. However, an increase in the water flow rate would increase scour which, over a longer period may create the problem of retaining a position in the estuarine environment, against conditions of net seaward transport.

Sensitivity assessment. Resistance of SS.SSa.SSaVS is likely to be '**High**', Resilience is '**High**' by default and Sensitivity assessed as '**Not Sensitive'** as the biotope occurs across a range of flow velocities.

Resistance of SS.SSa.SSaVS.NintGam is lower, due to the biotope occurring in weaker tidal streams and inability of characterizing species to occupy areas with stronger tidal flow (in excess of 0.2 knots (10 cm/sec)). Resistance is assessed as '**Medium**' as abundance may be reduced by loss of individuals that cannot sustain position under increased flow rates. Resilience is assessed as '**High**' and Sensitivity is assessed as **'Low'.** This higher sensitivity is shown in the assessment table.

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

Not relevant as the biotope occurs in depths of 0-5 m or deeper.

Owing to the infaunal habit and/or mobility, the characterizing species are likely to be offered considerable protection or would move away to seek more favourable conditions if the limit of the biotope became intertidal.

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

Increased wave action causes stress to the infauna by disrupting feeding and burrowing. Wave action is also important subtidally in shallower areas as it can disturb the sediment, particularly during storms. Disturbances of this nature may affect shallow and deep sand banks (Perkins, 1974) and may result in large scale sediment transport.

Storm activities reduce species richness, abundance and biomass. Tube dwelling polychaetes are likely to be severely affected by storm events and very large waves, as a large reduction in species richness and abundance may occur. This may lead to the development of a transitional community dominated by opportunist species and more mobile infauna. However biotopes occur in sheltered locations in upper estuaries, between 0-5m and deeper depths.

An increase in wave height at the benchmark level is unlikely to create a noticeable impact, where initial conditions are sheltered. Where conditions are moderately exposed, infauna such as *Nepthys cirrosa* are likely to be washed from the sediment by the largest waves. Wave conditions at benchmark levels are unlikely to be strong enough to result in complete loss of the community. Resistance and Resilience are assessed as '**High**', and Sensitivity is therefore, '**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.

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*.

The sediment grade and the hydrographic conditions within the biotope are responsible for a high dispersion, so that instances of severe pollution are less in comparison to regions with weaker tidal flow. Bryan & Gibbs (1983) reported lower sediment-metal concentrations in sandy areas than mud near the mouth of Restronguet Creek, a branch of the Fal Estuary system which is heavily contaminated with metals.

Although heavy metals may not accumulate in the substratum to the extent that they would in muddy substrata, characterizing infauna are likely to be susceptible. Bryan & Gibbs (1983) suggested that in populations of polychaetes exposed to heavy metal contamination for a long period, metal resistance could be acquired. For example *Nephtys hombergii* from Restronguet Creek seemed able to regulate copper. The head end of the worm became blackened and x-ray microanalysis by Bryan & Gibbs (1983) indicated that this was caused by the deposition of copper sulphide in the body wall. In the same study, Bryan & Gibbs (1983) presented evidence that *Nephtys hombergii* from Restronguet Creek possessed increased tolerance to copper contamination. Specimens from the Tamar Estuary had a 96 h LC50 of 250 µg/l, whilst those from Restronguet Creek had a 96 h LC50 of 700 µg/l (35 psu; 13°C).

For most metals, toxicity to crustaceans increases with decreased salinity and elevated temperature. Consequently amphipod 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). Amphipod species characterizing the variations of the biotope in transition zones between freshwater and brackish environments are thereby, likely to suffer greater impacts from contamination.

Infaunal population of polychaetes may be intolerant of pulses of heavy metals in solution entering the biotope, as in the absence of mud and silts in combination with the highly dispersive hydrographic regime, concentrations in the substratum are likely to be low and populations do not develop resistance. Whilst many individuals may survive by escaping from the vicinity, some mortality would be expected and defaunation of the sediment may occur.

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 influence the biotope. Suchanek (1993) reviewed the effects of oil spills on marine invertebrates and concluded that, in general, on soft sediment habitats, infaunal polychaetes, bivalves and amphipods were particularly affected.

Oil spills resulting from tanker accidents have caused deterioration of sandy communities in the intertidal and shallow sublittoral. Subtidal sediments, however, may be at less risk from oil spills unless oil dispersants are used, or if wave action causes dispersion of oil into the water column and sediment mobility drives oil in to the sediment (Elliott *et al.*, 1998). Microbial degradation of the oil within the sediment would increase the biological oxygen demand and oxygen within the sediment may become significantly reduced.

Species within the biotope have been reported to be intolerant of oil pollution, e.g. amphipods (Suchanek, 1993). After the *Amoco Cadiz* oil spill there was a reduction in both the number of amphipod species and the number of individuals (Cabioch *et al.*, 1978). Initially, significant mortality would be expected, attributable to toxicity. Amphipod populations have been reported not return to pre-spill abundances for five or more years, which is most likely related to the persistence of oil within sediments (Southward, 1982). *Nephtys* species were amongst the fauna that was eradicated from sediments following the 1969 West Falmouth spill of Grade 2 diesel fuel documented by Sanders (1978).

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). Opportunistic species such *Capitella capitata* have been shown to increase in abundance close to sources of contamination. High numbers of *Capitella capitata* have been recorded in hydrocarbon contaminated sediments (Ward & Young, 1982; Olsgard, 1999; Petrich & Reish, 1979) and colonization of areas defaunated by high hydrocarbon levels may be rapid (Le Moal, 1980). After a major spill of fuel oil in West Virginia *Capitella capitata* increased dramatically alongside large increases in *Polydora ligni* and *Prionospio* sp. (Sanders *et al*. 1972, cited in Gray 1979). Experimental studies adding oil to sediments have found that *Capitella capitata* increased in abundance initially although it was rarely found in samples prior to the experiment (Hyland, 1985).

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

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

No evidence concerning the specific effects of chemical contaminants on *Nephtys* species was found. Boon *et al.* (1985) reported that *Nephtys* species in the North Sea accumulated organochlorines but, based on total sediment analyses, organochlorine concentrations in *Nephtys* species were not correlated with the concentrations in the (type of) sediment which they inhabited.

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 low resistance to some specific chemicals has been observed in amphipods. Powell (1979) inferred from the known susceptibility of Crustacea to synthetic chemicals and other non-lethal effects, that there would probably also be a deleterious effect on isopod fauna as a direct result of chemical application. 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	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

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

Introduction of other substances	Not Assessed (NA) 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: Medium A: Low C: Low	High Q: Medium A: Medium C: Medium	Not sensitive Q: Medium A: Low C: Low

The mobile sands that characterize this biotope may have relatively high oxygen concentration and a lack a black reducing layer (JNCC, 2015).

Information concerning the reduced oxygen tolerance of *Nephtys cirrosa* was not found but evidence (Alheit, 1978; Arndt & Schiedek, 1997; Fallesen & Jørgensen, 1991) indicated a similar species, *Nephtys hombergii*, to be very tolerant of episodic oxygen deficiency and at the benchmark duration of one week.

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

Sensitivity assessment. The species characterizing the biotope are mobile and able to migrate vertically 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: High A: Medium C: Medium	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

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).

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

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

Organic enrichment	High	High	Not sensitive
	Q: High A: High C: High	Q: High A: High C: High	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 driftline 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 removal of fine organic matter deposits. The isopod *Eurydice pulchra* is an aggressive and very mobile predator, feeding on polychaetes and amhipods, including *Bathyporiea pilosa*, *Bathyporeia sarsi* and *Scolelepuis 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, gastrotriches, 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 and estuarine 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

This biotope is only found in upper reaches of marine inlets, especially estuaries, where water movement is moderately strong, allowing the sedimentation of sand but not the finer silt fraction. If the substratum type was changed to either a soft rock or hard artificial type. Consequently the biotope would be lost altogether if such a change occurred.

Sensitivity assessment. The resistance to this change is '**None**', and the resilience is assessed as '**Very low'** due to the long-term nature of a change in substratum. The biotope is assessed to have a '**High**' sensitivity to this pressure at the benchmark.

Physical change (to another sediment type)	High Q: Medium A: Medium C: Medium	High Q: Medium A: Medium C: Medium	Not sensitive Q: Medium A: Medium C: Medium

The SS.SSa.SSaVS biotope is characterized by sand that does dot contain finer silt fraction. A change in 1 Folk class would result in a change to either i) muddy sand or ii) gravelly sand.

Nepthys cirrosa occurs in fine to coarser sands, with greatest abundance in the Belgium part of the North Sea recorded in medium grain sizes (Degraer *et al.*, 2006). A change to gravelly sand is unlikely to impact the species, however a change to muddy sand may limit the species abundance as the species displays a slight preference for low mud content levels (< 10%) (Degraer *et al.*, 2006).

Capitella capitata was found in fine and medium grain size sediments and was almost completely absent in sediments without mud in the Belgium part of the North Sea (Degraer *et al.*, 2006). This suggests that a change to muddy sand is likely to result in increased abundance but a change to gravelly sand is likely to lead to reduced abundance.

Bathyporeia spp. favour medium to coarse grained sediments with lower mud content (< 10%) (Degraer *et al.*, 2006). *Gammarus spp.* are present on a wide range of substratum, independent of sediment size and composition, provided the environment is sheltered and there is organic detritus upon which to feed (MES, 2010). Increases in mud content are likely to impact *Bathyporeia spp* populations but not *Gammarus spp.*. Increases in gravel content are unlikely to affect the abundance of either species and potentially lead to increases in abundance of *Bathyporeia spp.*

Sensitivity assessment. *Capitella capitella* is the only species that displays a preference for greater mud content. An increase to gravelly sand is unlikely to have significant impacts on abundance of characterizing species. As the biotopes in estuaries, occupying stronger tidal streams are likely to experience dynamic sediment conditions. Resistance is assessed as **'High'** Resilience as **'High'** and Sensitivity to changes at the benchmark level is **'Nor Sensitive'.**

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

The process of extraction is considered to remove all biological components of the biotope group. If extraction occurred across the entire biotope, loss of the biotope would occur. Recovery would require substratum to return to sand and with a finer silt fraction. *Capitella capitella* are opportunistic species and are likely to recolonize the area rapidly. *Gammarus spp.* are present on a wide range of substratum, independent of sediment size and composition, provided the environment is sheltered and there is organic detritus upon which to feed (MES, 2010). Recovery is likely to be rapid, although the population present at the time of extraction will be removed. *Nephtys cirrosa* is a larger, longer lived species and recovery is likely to be slower.

Sensitivity assessment. Resistance of the biotope to extraction **is 'None'** , Resilience differs between species but in mobile sands recovery is likely to be rapid, *r*esilience is assessed as '**High**' and biotope sensitivity is assessed as '**Medium**'.

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

Mean response of infauna and epifauna communities to fishing activities is shown to be much more negative in mud and sand communities than other habitats Collie *et al*. (2000). *Nephtys cirrosa* was found to be sensitive to experimental trawling disturbance over 18 months (Tuck *et al*., 1998). *Nephtys cirrosa* is also likely to be vulnerable to dredging but can probably accommodate limited sediment deposition from the dredging process (MES 2010).

Capitella capitata, are soft bodied relatively fragile species inhabiting mucus tubes close to the sediment surface. Abrasion and compaction of the surficial layer may damage individuals. *Capitella capitata* and *Pygospio elegans* have been categorised through literature and expert review, as AMBI fisheries Group IV- a second-order opportunistic species, which are sensitive to fisheries in which the bottom is disturbed. Their populations recover relatively quickly however and benefit from the disturbance, causing their population sizes to increase significantly in areas with intense fisheries (Gittenberger & Van Loon 2011). Chandrasekara and Frid (1996) found that in intertidal muds, along a pathway heavily used for five summer months (ca 50 individuals a day), some species including *Capitella capitata* and *Scoloplos armiger* reduced in abundance. Bonsdorff & Pearson (1997) found that sediment disturbance forced *Capitella capitata* deeper into the sediment, although the species was able to burrow back through the sediment to the surface again.

Sensitivity assessment. This biotope group is present in mobile sands, the associated species are generally present in low abundances and adapted to frequent disturbance suggesting that resistance to surface abrasion would be high. The amphipod and isopod species present are agile swimmers and are characterized by their ability to withstand sediment disturbance (Elliott *et al*. 1998). Similarly, the polychaete *Nephtys cirrosa* is adapted to life in unstable sediments and survives through rapid burrowing (McDermott, 1983, cited from Elliott *et al*., 1998). This characteristic is likely to protect this species from surface abrasion. Resistance is assessed as 'Medium', as abrasion is unlikely to affect high numbers of the key characterizing species, resilience is assessed as 'High' and biotope sensitivity is assessed as 'Low'.

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

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

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

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

Estuaries where this biotope is often found form can be naturally turbid systems due to sediment resuspension by wave and tide action and inputs of high levels of suspended solids, transported by rivers. The level of suspended solids depends on a variety of factors including: substrate type, river flow, tidal height, water velocity, wind reach/speed and depth of water mixing (Parr *et al*. 1998). Transported sediment including silt and organic detritus can become trapped in the system where the river water meets seawater. Dissolved material in the river water flocculates when it comes into contact with the salt wedge pushing its way upriver. These processes result in elevated levels of suspended particulate material with peak levels confined to a discrete region (the turbidity maximum), usually in the upper-middle reaches, which moves up and down the estuary with the tidal ebb and flow. Intertidal mudflats depend on the supply of particulate matter to maintain mudflats and the associated biological community is exposed naturally to relatively high levels of turbidity/particulate matter.

For instance, *Neomysis integer* collected from the of the Schelde, Gironde and Elbe estuaries in spring occurred in the maximum turbidity zone (Fockedey *et al*., 2005).

Sensitivity assessment. The biological assemblage characterizing this biotope includes infaunal species *Nephtys cirrosa* and *Capitella capitata* and the mobile mysids and amphipods *Neomysis integer* and *Gammarus salinus*. Increased suspended solids are unlikely to have an impact and resistance is assessed as 'High' and resilience as 'High', so that the biotope is considered to be 'not sensitive'. A reduction in suspended solids may reduce deposition and supply of organic matter, resistance to a decrease is therefore assessed as 'Medium' as a shift between deposition and erosion could result in the net loss of surficial sediments. A reduction in organic matter as suspended solids could also reduce production within this biotope. Resistance is assessed as '**Medium'** as over a year the impact may be relatively small and resistance is assessed as '**High**', following restoration of usual conditions. Biotope sensitivity is therefore assessed as '**Low**'.

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

Nepthys cirrosa occurs in fine to coarser sands, with greatest abundance in the Belgium part of the North Sea recorded in medium grain sizes (Degraer *et al.*, 2006). A light deposition of fine sediment may lead to small but insignificant changes in abundance as it will reduce the available preferred habitat with medium grain size. As the tidal flow is strong in this biotope, a light deposition of finer sediment is likely to be resuspended. Resistance is likely to be high for *Nepthys cirrosa* at the benchmark level. Powilleit *et al.*, (2009) studied the response of the polychaete *Nephtys hombergii* to smothering. This species successfully migrated to the surface of 32-41 cm deposited sediment layer of till or sand/till mixture and restored contact with the overlying water. The high escape potential could partly be explained by the heterogeneous texture of the till and sand/till mixture with 'voids'. While crawling upward to the new sediment surfaces burrowing velocities of up to 20 cm/day were recorded for *Nephtys hombergii*. Similarly, Bijkerk (1988, results cited from Essink 1999) indicated that the maximal overburden through which species could migrate was 60 cm through mud for *Nephtys* and 90 cm through sand. No further information was available on the rates of survivorship or the time taken to reach the surface.

Capitella capitata was found in fine and medium grain size sediments and was almost completely absent in sediments without mud in the Belgium part of the North Sea (Degraer *et al.*, 2006). This suggests that an increase in fine material will have limited impact on abundance. *Capitella capitata* has also been categorised through expert and literature review, as AMBI sedimentation Group IV – a second-order opportunistic species, insensitive to higher amounts of sedimentation. Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong fluctuation in sedimentation (Gittenberger & van Loon 2011).

Bathyporeia spp. favour medium to coarse grained sediments with lower mud content (< 10%) (Degraer *et al.*, 2006). *Gammarus spp.* are present on a wide range of substratum, independent of sediment size and composition, provided the environment is sheltered and there is organic detritus upon which to feed (MES, 2010). Presence of fine material is likely to impact *Bathyporeia spp* populations but not *Gammarus spp.*. Smothering may cause some mortality to individuals resting on the surface, for instance, *Gammarus salinus* lives in a variety of locations within the estuarine environment: amongst algae and other vegetation, as well as generally over the sediment surface and beneath stones. It is a mobile species capable of a rapid escape response (back flip) if disturbed, however in the event of suddenly being smothered by up to 5 cm of sediment individuals resting on the surface may be killed. *Neomysis integer* is a free-swimming mysid shrimp, which may rest on the surface of the substratum, but does not live within it and although sufficiently mobile to avoid the deposition of smothering materials, it is possible some individuals will be killed in the event of smothering.

Sensitivity assessment. None of the characterizing species are likely to be significantly impacted by deposition of up to 5 cm of fine material, although a limited percentage of the characterizing amphipod population may suffer mortality from smothering. Resistance is assessed as '**High'**. Resilience as '**High'** and Sensitivity as '**Not sensitive'**.

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

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

Nephtys cirrosa is a larger infaunal species, with adult size between 6 cm and 10 cm and capable of moving through the sediment, suggesting some resilience to smothering. Deposition of up to 30 cm of fine material is likely to bury some individuals beyond the typical 5 to 15 cm depth of tunnels. It is likely *Nephtys cirrosa* close to the surface may be capable of relocating in the sediment although feeding and reproduction activities are likely to be interrupted.

Powilleit *et al*., (2009) studied the response of the polychaete *Nephtys hombergii* to smothering. This species successfully migrated to the surface of 32-41 cm deposited sediment layer of till or sand/till mixture and restored contact with the overlying water. The high escape potential could partly be explained by the heterogeneous texture of the till and sand/till mixture with 'voids'. While crawling upward to the new sediment surfaces burrowing velocities of up to 20 cm/day were recorded for *Nephtys hombergii*. Similarly, Bijkerk (1988, results cited from Essink 1999) indicated that the maximal overburden through which species could migrate was 60 cm through mud for *Nephtys* and 90 cm through sand. No further information was available on the rates of survivorship or the time taken to reach the surface. *Nepthys cirrosa* occurs in fine to coarser sands, with greatest abundance in the Belgium part of the North Sea recorded in medium grain sizes (Degraer *et al*., 2006). The presence of fine material may lead to small but insignificant changes in abundance as it will reduce the available preferred habitat with medium grain size. As the tidal flow is strong in this biotope, a light deposition of finer sediment is likely to be resuspended. Resistance is likely to be high to the presence of finer material for *Nepthys cirrosa* but initial smothering is likely to cause some mortality and interrupt feeding and reproduction activity at the benchmark level.

Capitella capitata has been categorised through expert and literature review, as AMBI sedimentation Group IV – a second-order opportunistic species, insensitive to higher amounts of sedimentation. Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong fluctuation in sedimentation (Gittenberger & van Loon 2011).

Presence of fine material is likely to impact *Bathyporeia spp* populations but not *Gammarus spp*.. Smothering may cause some mortality to individuals resting on the surface, for instance, *Gammarus salinus* lives in a variety of locations within the estuarine environment: amongst algae and other vegetation, as well as generally over the sediment surface and beneath stones. It is a mobile species capable of a rapid escape response (back flip) if disturbed, however in the event of suddenly being smothered by up to 5 cm of sediment individuals resting on the surface may be killed, particularly so if the materials are viscous or impermeable. *Neomysis integer* is a free-swimming mysid shrimp, which may rest on the surface of the substratum, but does not live within it and although sufficiently mobile to avoid the deposition of smothering materials, it is possible some individuals will be killed in the event of smothering.

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

Leewis *et al*. (2012) investigated the recovery of the characterizing species, *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 kn to > 7 km. Recovery to original abundances appeared to occur within one year for the characterizing species which were in agreement with other studies (Leewis *et al*., 2012 and references therein). Sediment removal by wave action could mitigate the level of effect but the biotope SS.SSa.SSaVS and variants are sheltered and wave action is limited.

Sensitivity assessment. Overall smothering by fine sediments is likely to result in some mortality of characterizing polychaetes, amphipods and isopods, although most are likely to reposition. Biotope resistance is therefore assessed as **'Low'** and Resilience as '**High,'** biotope sensitivity is therefore assessed as '**Medium**'.

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

A study of microparticle transfer via planktonic organisms was shown to lead to microplastic intake by *Neomysis integer*. Food web transfer experiments were done by offering zooplankton labelled with ingested microspheres to mysid shrimps. Microscopy observations of mysid intestine showed the presence of zooplankton prey and microspheres after 3 h incubation. *Neomysis integer* showed egestion of microspheres within 12 h (Setälä *et al*., 2014). Although this study did not examine impacts on health and survivability other studies have shown negative impacts from microplastic ingestion that are likely to impact the food web within this and other biotopes.

The effect of microplastic exposure of the copepod *Centropages typicus* showed that 7.3 m microplastics (>4000 mL−1) significantly decreased algal feeding from experimental studies of exposure to natural assemblages of algae with and without microplastics (Cole *et al*., 2013). These findings imply that marine microplastic debris can negatively impact upon zooplankton function and would potentially limit prey availability to species feeding on *Centropages typicus* such as *Neomysis integer*.

Sensitivity assessment. Overall evidence is very limited and assessments cannot be made with confidence and this pressure is **'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 was found on effects of electric and magnetic fields on the characterizing species.

Electric and magnetic fields generated by sources such as marine renewable energy device/array cables may alter behaviour of predators and affect infauna populations. Evidence is limited and occurs for electric and magnetic fields below the benchmark levels, confidence in evidence of these effects is very low.

Field measurements of electric fields at North Hoyle wind farm, North Wales recorded 110μ V/m (Gill *et al.* 2009). Modelled results of magnetic fields from typical subsea electrical cables, such as those used in the renewable energy industry produced magnetic fields of between 7.85 and 20 μT (Gill *et al.* 2009; Normandeau *et al.* 2011). Electric and magnetic fields smaller than those recorded by in field measurements or modelled results were shown to create increased movement in thornback ray *Raja clavata* and attraction to the source in catshark *Scyliorhinus canicular* (Gill *et al.* 2009).

Flatfish species which are predators of many polychaete species including dab *Limanda limanda* and sole *Solea solea* have been shown to decrease in abundance in a wind farm array or remain at distance from wind farm towers (Vandendriessche *et al.*, 2015; Winter *et al.* 2010). However, larger plaice increased in abundance (Vandendriessche *et al.*, 2015). There have been no direct causal links identified to explain these results.

Sensitivity assessment. 'No evidence' was available to complete a sensitivity assessment, however, responses by flatfish and elasmobranchs suggest changes in predator behaviour are possible. There is currently no evidence but effects may occur on predator prey dynamics as further marine renewable energy devices are deployed, these are likely to be over small spatial scales and not impact the biotope.

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

Species within the biotope can probably detect vibrations caused by noise. However, at the benchmark level the community is unlikely to be sensitive to noise and this pressure is '**Not relevant'**.

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

As this feature is not characterized by the presence of primary producers it is not considered that shading would alter the character of the habitat. No specific evidence was found to assess 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).

Changes in light and level of shade may indirectly affect *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 characterizing species could result. Resistance is assessed as '**High'** and Resilience is assessed as '**High**'. Biotope sensitivity ids therefore assessed as '**Not sensitive**'.

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

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

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

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

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

Visual disturbance	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

characterizing species may have some, limited, visual perception. As they live in the sediment the species will most probably not be impacted at the pressure benchmark and this pressure is **'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

Key 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	Medium Q: Medium A: Medium C: Medium	Medium Q: Medium A: Medium C: Medium	Medium Q: Medium A: Medium C: Medium

Limited evidence was available to assess the sensitivity of this biotope. Any invasive species would have to tolerate variable salinity and sediments or mobile sediments that characterizes this biotope group and this will exclude species only able to survive in fully marine conditions and/or that require hard substratum. The North American amphipod *Gammarus tigrinus* was detected in the north-eastern Baltic Sea in 2003 and has rapidly expanded into European waters since (Jänes *et al*., 2015.). Native gammarids, such as *Gammarus salinus* have almost disappeared from some habitats of the northeastern Baltic Sea and the competition for space between the invasive *Gammarus tigrinus* the native *Gammarus salinus* has been a contributing factor in certain habitats (Kotta *et al*. 2011). Competition for space alone did not explain the mass disappearance of *Gammarus salinus* as *Gammarus tigrinus* did not out-compete *Gammarus salinus* in all Baltic Sea habitats, limiting confidence in the evidence. However, *Gammarus tigrinus* has been identified in many UK estuaries and coasts and appears likely to influence species composition in the biotope (NBN, 2016).

Sensitivity assessment. Limited evidence was available for all characterizing species in relation to this pressure. *Gammarus tigrinus* displays faster reproduction and is a voracious predator that is abundant in dilute, and more turbid sites. *Gammarus tigrinus* appears to be competitively superior to native gammarids and is likely to alter the species composition of the biotope. In particular the biotope variant SS.SSa.SSaVS.NintGam. The function of the biotope is likely to remain similar however as one gammarid species is likely to be replaced by another but predation rates may change. As the biotope classification is unlikely to change, the resistance of the assessed biotopes is **'Medium'**, resilience is **'Very low' a**s the invasive species is unlikely to be removed and its impact is permanent and sensitivity is assessed as **'Low'**.

Introduction of microbial pathogens	High Q: High A: High C: Medium	High Q: High A: High C: High	Not sensitive Q: High A: High C: Medium

Limited evidence was available on effect of microbial populations, particularly on *Nephtys cirrosa*.

Gammarus salinus, *Gammarus zaddachi* and *Gammarus oceanicus* were found to be important host species for the transmission of parasites (Voigt, 1991). Larval stages of 4 fish parasites (1 Nematoda, 2 Acanthocephala and 1 Digena) as well as larval stages of 4 bird parasites (1 Nematoda, 1 Acanthocephala, 1 Digena and 1 Cestoda) were found. However, there was insufficient information concerning the effect that such parasitization may have on the species viability.

Astthorsson (1980) found specimens of *Neomysis integer* collected from the Ythan Estuary, Scotland, to be parasitized by the third larval stage of the nematode *Thynnascaria adunca*. The nematodes were found in both the thorax and the abdomen, usually coiled. In some instances, the total length of the *Thynnascaria adunca* larvae was almost the same length as the *Neomysis integer* hosting it. Astthorsson (1980) suspected that the larvae would probably have an influence on the internal physiology of the host, but there is insufficient information concerning any effect upon the population that such parasitization may have.

Sensitivity assessment. Based on the lack of evidence for mass mortalities in characterizing species in relation to pathogens, and amphipods hosting parasites, resistance is assessed as '**High**' and resilience as '**High**', by default, so that the biotope is assessed as '**Not sensitive'**. Confidence however is low due to the lack of evidence of effects on populations of microbial pathogens

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

Nephtys cirrosa is targeted by bait digging. There is limited information on effect of digging directly on *Nephtys cirrosa* populations, however there is evidence on effects on another *Nephtys* species: *Nephtys hombergii*. *Nephtys hombergii* is directly removed through commercial bait digging and by recreational anglers and abundance significantly decreased in areas of the Solent, UK, where bait digging (primarily for *Nereis virens*) had occurred (Watson *et al.* 2007).

Recovery of *Nephtys hombergii* has been assessed to be very high as re-population would occur initially relatively rapidly via adult migration and later by larval recruitment. Dittman *et al.* (1999) observed that *Nephtys hombergii* was amongst the macrofauna that colonized experimentally disturbed tidal flats within two weeks of the disturbance that caused defaunation of the sediment. However, if sediment is damaged recovery is likely to be slower, for instance *Nephtys hombergii* abundance was reduced by 50% in areas where tractor towed cockle harvesting was undertaken on experimental plots in Burry inlet, south Wales, and had not recovered after 86 days (Ferns *et al.*, 2000).

Sensitivity assessment. Confidence in this assessment in relation to the removal of *Nephtys cirrosa* is low as it is based on evidence of removal of *Nephtys hombergii*. Biotope resistance is assessed as **'Medium'** as removal of this species is unlikely to affect biotope classifications and resilience is assessed as **'High'**. Sensitivity is assessed as **'Low'**. The sensitivity of the species where targeted is greater and it is important to consider that the spatial extent and duration of harvesting is important to consider when assessing this pressure as smaller scale extraction may not impact the entire extent of the biotope but greater scale extraction over a long period would cause longer term impacts.

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

Direct, physical impacts are assessed through the abrasion and penetration of the seabed pressures, while this pressure considers the ecological or biological effects of by-catch. Species in this biotope, including the characterizing species, may be damaged or directly removed by static or mobile gears that are targeting other species (see abrasion and penetration pressures).

Collie *et al.* (2000) found that abundance of a Nephtys species; *Nephtys hombergii* was negatively affected by fishing activities. Mean response of infauna and epifauna communities to fishing activities was also much more negative in mud and sand communities (such as this biotope) than other habitats. *Nephtys hombergii* abundance also significantly decreased in areas of the Solent, UK, where bait digging (primarily for *Nereis virens*) had occurred (Watson *et al.* 2007). Similarly, *Nephtys hombergii* abundance was reduced by 50% in areas where tractor towed cockle harvesting was undertaken on experimental plots in Burry inlet, south Wales, and had not recovered after 86 days (Ferns *et al.*, 2000).

Sensitivity assessment. Resistance is '**Low**' as removal or damage of characterizing species, on commercial scales can remove a large proportion of the population and lead to an impacted community. Resilience is assessed as **'High'** as the characteristic fauna are likely to recover rapidly. Biotope sensitivity is therefore assessed as **'Low'.**

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