Siphonoecetes, Nephtyidae polychaetes and venerid bivalves in circalittoral sand

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

Dr Harvey Tyler-Walters

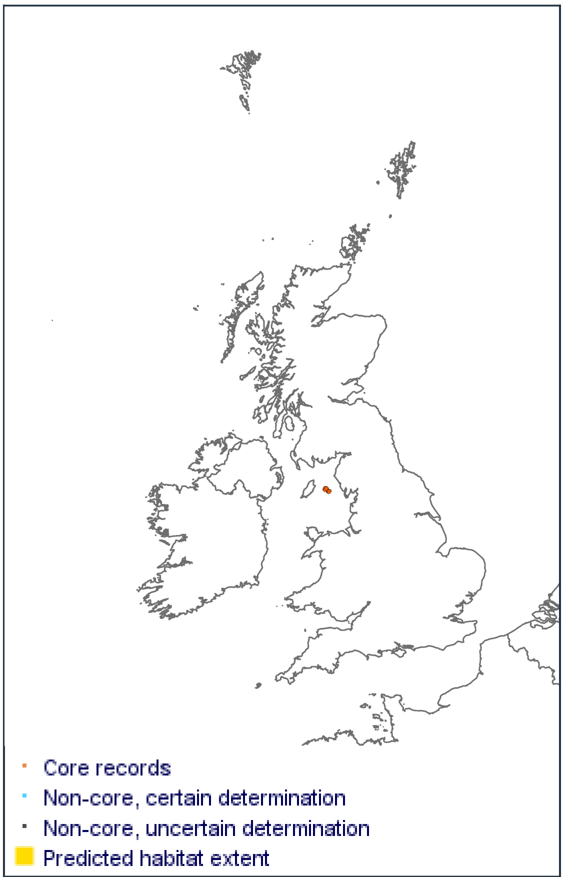
2022-11-01

A report from:
The Marine Life Information Network, Marine Biological Association of the United Kingdom.

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/1261]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

This review can be cited as:
Tyler-Walters, H., 2022. *Siphonoecetes*, Nephtyidae polychaetes and venerid bivalves in circalittoral sand. In Tyler-Walters H. *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom.
DOI https://dx.doi.org/10.17031/marlinhab.1261.2

(page left blank)



Biotope distribution data provided by the JNCC (mhc.jncc.gov.uk)

Researched by Dr Harvey Tyler-Walters **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A5.252TMP	None (TBC)
JNCC 2022	SS.SSa.CFiSa.SiphNephVen	*Siphonoecetes*, Nephtyidae polychaetes and venerid bivalves in circalittoral sand
JNCC 2015	None	None
JNCC 2004	None	None
1997 Biotope	None	None

Description

Circalittoral shallow coarse or medium sands (with shells and gravel) characterized by a community of amphipods, Nephtyidae and bivalves. This biotope has been recorded on sandbanks to the East of the Isle of Man (Irish Sea). The description of this biotope is based on infauna recorded from the above location but could be found in other areas with similar environmental conditions. The infauna was impoverished and characterized by *Siphonoecetes*, *Sthenelais limicola*, clean sand-loving Nephtyidae polychaetes *Aglaphamus agilis*, *Nephthys cirrosa* and venerid bivalves *Asbjornsenia pygmaea* and *Venus casina*. This biotope was described using Day grab infaunal data and the characterising species listed will partly reflect the method used to collect data. (Information from JNCC, 2022).

Depth range

20-30 m

Additional information

Similar *Siphonoectes* (complex) dominated sandy sediment assemblages have been recorded in Dogger Bank in the North Sea (Reiss & Kröncke, 2005), the Iberian Peninsula (Mora, 1991; Guerra-García *et al.*, 2014) and the Spanish, Portuguese and Italian coasts of the Mediterranean (Guerra-García & García-Gómez, 2004; Carvalho *et al.*, 2006; Harriague *et al.*, 2006; Moreira *et al.*, 2008; De-la-Ossa-Carretero *et al.*, 2016b), and the Indian Ocean (Bigot *et al.*, 2006). Little information on the life history or population dynamics of *Siphonoectes* spp. was found so the review draws on the above, mainly Mediterranean studies for information. In addition, the *Siphonoecetes* complex has been revised by Just (2017). The most common Siphonoectini in the UK is probably *Centraloecetes kroyeranus* (syn. *Siphonoecetes (Centraloecetes) kroyeranus*; syn *Siphonoecetes kroyeranus*) (Myers & MacGrath, 1979; Just, 2017). However, *Siphonoecetes* spp. is used in the review for consistency with the biotope description.

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

This biotope (SS.SSa.CFiSa.SiphNephVen) is dominated by amphipods of the genus *Siphonoecetes* (complex) together with clean sand-loving Nephtyidae polychaetes *Aglaphamus agilis*, *Nephthys cirrosa* and venerid bivalves *Asbjornsenia pygmaea* and *Venus casina*. The characteristic polychaete and venerids are typical of other clean fine and coarse sand biotopes. However, *Siphonoectes* spp. are the important characteristic species. A significant reduction in the abundance of *Siphonoecetes* spp. would result in the loss or re-classification of the biotope. Therefore, *Siphonoecetes* spp. are the focus of the sensitivity assessment, although other characteristic species are mentioned where appropriate.

Resilience and recovery rates of habitat

Siphonoecetes spp. are typical of sandy sediments but individual species have different depth preferences (Myers & McGrath, 1979; Mora, 1991; Reiss & Kröncke, 2005; Carvalho *et al.*, 2006; Harriague *et al.*, 2006; Moreira *et al.*, 2008; Navarro-Barranco *et al.*, 2012; Guerra-García *et al.*, 2014; De-la-Ossa-Carretero *et al.*, 2012; 2016b). *Siphonoecetes* spp. are small amphipods of up to five or eight millimetres in length depending on the species (Myers & McGrath, 1979). They burrow into clean fine or coarse sand, where they live in tubes composed of agglutinated sand grains, or tubes anchored by empty bivalve shells or in the empty shells or vacated tubes of *Dentalium* (Myers & McGrath, 1979; Falck & Bowman, 1994).

No information on the life history or population dynamics of *Siphonoecetes* (complex) was found. Therefore, we have assumed that its life cycle is similar to another corophid species, *Corophium voluntator*. *Corophium volutator* lives for a maximum of one year (Hughes, 1988) and females can have 2-4 broods in a lifetime (Conradi & Depledge, 1999). Populations in southerly areas such as the Dovey Estuary, Wales or Starrs Point, Nova Scotia have two reproductive episodes per year. Those populations in colder, more northerly areas such as the Ythan Estuary, Scotland or in the Baltic Sea only have one (Wilson & Parker, 1996). On the west coast of Wales, breeding takes place from April to October and mating takes place in the burrow. Adult males crawl over the surface of the moist sediment as the tide recedes in search of burrows occupied by mature females. The females can produce 20-52 embryos in each reproductive episode (Fish & Mills 1979; Jensen & Kristensen, 1990). Juveniles are released from the brood chamber after about 14 days, and development is synchronized with spring tides, possibly to aid dispersal. Recruitment occurs within a few centimetres of the parent, although they may disperse later by swimming (Hughes, 1988). In the warmer regions where *Corophium volutator* is found, juveniles can mature in 2 months (Fish & Mills, 1979) and add their own broods to the population. The juveniles born in May undergo rapid growth and maturation to reproduce from July to September and generate the next overwintering population (Fish & Mills, 1979). In short, we assume that *Siphonoecetes* spp. probably only live for a year and have one or two small broods per year depending on the local conditions and exhibit rapid local recruitment but slow recruitment from the surrounding area limited to adult swimming and/or bedload transport.

Bigot *et al.* (2006) suggested that amphipods had unstable population dynamics with sharp peaks in abundance dependent on local conditions, sediment and competition with other species. In their study of the effects of sugar cane refinery effluents (in Reunion Island, Indian Ocean) sudden increases in *Siphonoecetes* abundance in 1994 and 1996 were the main contributor to the difference in communities indices observed in their data at the shallow site closest to the outfall, rather than organic enrichment. De-la-Ossa-Carretero *et al.* (2016b) examined the effect of brine discharge on amphipod assemblages near the brine discharge. They noted that *Siphonoecetes* spp. returned at high abundance (ca 13 to 96 ind./m^2) to areas of medium to coarse sand within the vicinity of the brine discharge within about one year after the discharge was mitigated by dilution. Harriague *et al.* (2006) examined the communities of sandy areas within *Posidonia* beds in the Ligurian Sea. They reported significant seasonal variation in the abundance and diversity of the assemblage between April 1990 and 1991. Seasonal variation was mainly due to the high abundance of recruits (juveniles) of *Siphonoecetes dellavallei* in the summer of 1990. However, diversity was reduced in the summer of 1991 due to no recruitment by *Siphonoecetes* (Harriague *et al.*, 2006). Reiss &

Kröncke (2005) examined infaunal communities at several sites in the North Sea. They noted that seasonal changes in the communities present were driven by recruitment in spring and summer. They noted that the highest abundances of *Siphonoecetes kroyeranus* occurred in the 'autumn-winter' community in the amphipod-dominated Dogger Bank. Its abundance increased from ca 15 ind./m^2 in spring to 151 ind./m^2 in autumn. However, significant mortality of juveniles in autumn across all species returned the community to its spring and summer state (Reiss & Kröncke, 2005). Similar seasonal changes were reported by Moreira *et al.* (2008) in the amphipod-dominated sands in the Playa America beach, northwest Spain. The sands were dominated by *Siphonoecetes kroyeranus*, other amphipods and cumaceans, and the abundance increased through summer and reached its highest vlasues in autumn. For example, the abundance of *Siphonoecetes* ranged from 7.1 ind./m^2 in April 1996 to 3,657.1 ind./m^2 in July and 1,514.3 ind./m^2 in January 1997 (Moreira *et al*., 2008).

Nephtys sp. is a relatively long-lived polychaete with a lifespan of six to possibly as much as nine years. It matures at one year and the females release over 10,000 (and up to 80,000 depending on species) eggs of 0.11-0.12 mm from April through to March. These are fertilized externally and develop into an early lecithotrophic larva and a later planktotrophic larva which spends as much as 12 months in the water column before settling from July to September. The genus *Nephtys* has a relatively high reproductive capacity and widespread dispersion during the lengthy larval phase. It is likely to have a high recoverability following disturbance (MES, 2010). Both of the characteristic bivalves are long-lived; *Asbjornsenia* (syn *Moerella*) *pygmaea* at 6-10 years and *Venus* spp at 5-8 years (MES, 2010). Little is known about the life history of *Asbjornsenia* but MES (2010) reported that it produced relatively few large yolky eggs, and was likely to have a low or intermediate recovery period. However, Venus sp., had a high fecundity and planktonic larva so dispersal potential was high but that recoverability was uncertain (MES, 2010).

Resilience assessment. This biotope is dominated by the amphipod *Siphonoecetes* spp. Little information on its life history was found but the above evidence, especially from the North Sea and Spain, suggests that it has a short lifespan but develops relatively stable long-term populations with significant seasonal variation in abundance due to breeding and recruitment in summer. Where natural or man-made disturbance removes a portion of the population (resistance 'Low' or 'Medium') resilience is likely to be **'High'** as long as adults remain. However, in areas of suitable habitat that are isolated, where total extinction of the population occurs (resistance 'None') recovery is likely to depend on favourable hydrodynamic conditions that will allow recruitment from farther away and recruitment to re-colonize the impacted area may take longer. However, once an area has been recolonized, restoration of the biomass/abundance of *Siphonoecetes* spp. is likely to occur quickly. Therefore, resilience is likely to be **'Medium'** (full recovery within 2-10 years) depending on the time taken for adults to recolonize the area. An **exception** is made for permanent or ongoing (long-term) pressures where recovery is not possible as the pressure is irreversible, in which case resilience is assessed as **'Very low'** by default.

Hydrological Pressures

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

No information on the temperature tolerance of *Siphonoecetes* spp. was found. *Centraloecetes kroyeranus* (syn. *Siphonoecetes (Centraloecetes) kroyeranus*; syn *Siphonoecetes kroyeranus*) (Myers & MacGrath, 1979; Just, 2017) is recorded from northern Norway, south, into the Mediterranean but most of the records occur in the North Sea, around the coasts of the British Isles, France and Spain as far east as the Kattegat near the entrance to the Baltic (OBIS, 2022). Therefore, it is probably resistant to the range of temperatures experienced to the north and south of the British Isles. Therefore, resistance is assessed as **'High'**, resilience as **'High'** and sensitivity as '**Not sensitive'**, but with 'Low' confidence.

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

No information on the temperature tolerance of *Siphonoecetes* spp. was found. *Centraloecetes kroyeranus* (syn. *Siphonoecetes (Centraloecetes) kroyeranus*; syn *Siphonoecetes kroyeranus*) (Myers & MacGrath, 1979; Just, 2017) is recorded from northern Norway, south, into the Mediterranean but most of the records occur in the North Sea, around the coasts of the British Isles, France and Spain as far east as the Kattegat near the entrance to the Baltic (OBIS, 2022). Therefore, it is probably resistant to the range of temperatures experienced to the north and south of the British Isles. Therefore, resistance is assessed as **'High'**, resilience as **'High'** and sensitivity as '**Not sensitive'**, but with 'Low' confidence.

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

De-la-Ossa-Carretero *et al.* (2016b) examined the amphipod communities of sand habitats in the vicinity of harbour, sewage, and brine discharges from the Port of Alicante, Spain. While the abundance f amphipods declined near the discharges, some species (i.e. *Gammarella fucicola, Ampelisca spinipes, Siphonoecetes bulborostrum* and *Pseudolirius kroyeri* were abundant in the transect closest to the harbour and sewage discharge). However, amphipods were absent in the vicinity of the brine discharge, whose salinity was in excess of 39 psu in 2004 and 2005. But the abundance of amphipods increased and was dominated by *Siphonoecetes sabatieri* in the station closest to the brine discharge after it was diluted in 2006 (De-la-Ossa-Carretero *et al.*, 2016b).

Sensitivity assessment. The evidence suggests that *Siphonoecetes* spp. and other amphipods are probably very sensitive to hypersaline effluent. Therefore, resistance is assessed as **'None'.** In the example above (Port of Alicante), *Siphonoecetes* sp. was abundant in the surrounding area so recruitment into the site was rapid (probably one year). However, this biotope is only recorded in a few isolated locations, so resilience is assessed as **'Medium'.** Hence, sensitivity is assessed as **'Medium'.**

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

This biotope (SS.SSa.CFiSa.SiphNephVen) is only recorded from full salinity (30-35). *Centraloecetes kroyeranus* (syn. *Siphonoecetes (Centraloecetes) kroyeranus)* was recorded from sites with full salinity(30-35 psu) with only a small number of records from reduced (18-30 psu) conditions. In the absence of other evidence, this species complex is probably limited to marine waters. Therefore, it probably has a **'Low'** resistance to a reduction in salinity at the benchmark level. However, resilience is probably **'High'** so sensitivity is assessed as **'Low'** but with 'Low' confidence due to the lack of direct evidence.

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

This biotope (SS.SSa.CFiSa.SiphNephVen) is only recorded from moderate tidal steams (0.5-1.5 m/sec) and moderately exposed wave conditions. *Siphonoecetes* spp. are recorded from medium and coarse sandy bottoms (Myers & McGrath, 1979; Mora, 1991; Moreira *et al.*, 2008; De-la-Ossa-Carretero *et al.*, 2015), predominately sand with little mud on the Dogger Bank (Reiss & Kröncke, 2005) and fine sands (Bigot *et al.*, 2006). Therefore, the biotope and the dominant characteristic species are dependent on the hydrographic conditions suitable for the deposition and presence of fine to coarse sands. A decrease in water flow by 0.1-0.2 m/s might increase the deposition of fine silts and muds in areas of the biotope with the lowest water flow, although that may be offset by the moderate wave action that characterizes the biotope. Similarly, an increase in flow may remove some fine sands but as it normally occurs between 0.5 and 1.5 m/s, such an increase is probably not significant. Therefore, resistance to changes in water flow is probably

'High' at the benchmark level. Hence, resilience is **'High'** and sensitivity is assessed as **'Not sensitive' at the benchmark level.**

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

This biotope (SS.SSa.CFiSa.SiphNephVen) is only recorded from 20-30 metres. Hence, this pressure is **'Not relevant'.**

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

This biotope (SS.SSa.CFiSa.SiphNephVen) is only recorded from moderate tidal steams (0.5-1.5 m/sec) and moderately exposed wave conditions. *Siphonoecetes* spp. are recorded from medium and coarse sandy bottoms (Myers & McGrath, 1979; Mora, 1991; Moreira *et al.*, 2008; De-la-Ossa-Carretero *et al.*, 2016b), predominately sand with little mud on the Dogger Bank (Reiss & Kröncke, 2005) and fine sands (Bigot *et al.*, 2006). Therefore, the biotope and the dominant characteristic species are dependent on the hydrographic conditions suitable for the deposition and presence of fine to coarse sands. A change in significant wave height of 3-5% (the benchmark) is unlikely to be significant in the wave regime that characterizes this biotope. Hence, resistance to changes in wave action is probably **'High'**, resilience is **'High'**, and sensitivity is assessed as **'Not sensitive' at the benchmark level.**

Chemical Pressures

	Resistance	Resilience	Sensitivity
Transition elements & organo-metal contamination	Low Q: Low A: NR C: NR	Medium Q: High A: Medium C: Medium	Not sensitive Q: Low A: Low C: Low

Little direct evidence of the effects of transitional metals on *Siphonoecetes* spp. was found. Guerra-García & García-Gómez (2004) compared amphipod communities inside the harbour of Ceuta, North Africa, with communities outside the harbour. *Siphonoecetes dellavallei* dominated the amphipod community outside the harbour in sandy sediments with a low concentration of nitrogen, phosphorous and copper, while the internal stations contained less sand, more organic matter and higher concentrations of nitrogen, phosphorous and copper and were dominated by gammarids and *Corophium* sp. (Guerra-García & García-Gómez, 2004). However, the dominance of *Siphonoecetes* in their samples may have been due to the sediment type rather than pollution.

Amphipods are considered to be sensitive to a variety of pollutants (Bellan-Santini, 1980; Dauvin, 2018). For example, the ECOTOX database (Olker *et al.*, 2022) recorded the following lethal concentrations in *Ampelisca* sp.: 24-hour LC_{50} of 2.5 mg/l cadmium (Cd); 96-hour LC_{50} of between 0.2 and 1.32 mg/l Cd; 10-day LC_{50} of 36 µg/l Cd; 96-hour LC_{50} between 4.16 and 8.46 mg/l Arsenic (As); 48-hour LC_{50} of ca 56 µg/l chromium (Cr); 96-hour LC_{50} of ca 33.5 µg/l Copper (Cu), 7-day LC_{50} of 90 µg/l Cu and 10-day LC_{50} of 20.5 µg/l Cu; 96-hour LC_{50} of 0.62 mg/l Lead (Pb) and 10-day LC_{50} of ca 3 mg/l Pb; 10-day LC_{50} of ca 2.4 mg/l Nickel (Ni) and a 10-day LC_{50} of ca 0.34 mg/l Zinc (Zn), depending on the study.

In laboratory investigations, Hong & Reish (1987) observed 96-hour LC_{50} water column concentrations of between 0.19 and 1.83 mg/l of Cd for several species of amphipod. *Corophium volutator* is highly intolerant of metal pollution at levels often found in estuaries from industrial outfalls and contaminated sewage. A concentration of 38 mg Cu/l was needed to kill 50% of *Corophium volutator* in 96-hour exposures (Bat *et al.*, 1998). Other metals are far more toxic to *Corophium volutator*, e.g. Zn was toxic over 1 mg/l and toxicity to metals increases with increasing temperature and salinity (Bryant *et al.*, 1985b). Mortality of 50% was caused by 14 mg/l (Bat *et al*., 1998). Although exposure to zinc may not be lethal, it may affect the perpetuation of a population by reducing growth and reproductive fitness. Mercury was found to be very toxic to *Corophium volutator*, e.g. concentrations as low as 0.1 mg/l caused 50% mortality in 12 days. Other metals are known to be toxic include cadmium, which causes 50% mortality at 12 mg/l (Bat *et al*., 1998); and arsenic, nickel and chromium which are all toxic over 2 mg/l (Bryant *et al*., 1984; Bryant *et al*., 1985; 1985b).

Vogt *et al.* (2018) reviewed the effects of tributyl tin (TBT) on Crustacea. TBT was reported to interfere with carbohydrate and lipid metabolism, growth, sexual maturity, steroid synthesis and reproduction in Crustacea. In *Corophium* sp., a 10-day LC_{50} of ca 329 ng/l TBT chloride was reported while the LOEC (Lowest Observable Effect Concentration) was between 524 and 558 ng/l TBT chloride (ECOTOX; Olker *et al*., 2022).

Sensitivity assessment. The above evidence suggests that organotins may affect reproduction and hence population dynamics in amphipods because they are crustaceans and could provide lethal at high enough concentrations. Similarly, the evidence reports that exposure to heavy metals under laboratory conditions can result in significant mortality in amphipods, depending on the duration and concentration of exposure. Therefore, resistance is assessed as **'Low'**. Recolonization of affected areas will require the polluting heavy metals to be removed or reduced in concentration. Hence, resilience is assessed as **'Medium'** and sensitivity as **'Medium'.** However, confidence in the assessment is 'Low' due to the lack of direct evidence on the characteristic species.

Hydrocarbon & PAH contamination	None Q: High A: High C: High	Medium Q: High A: Medium C: Medium	Medium Q: High A: Medium C: Medium

Amphipods in general and ampeliscid amphipods, in particular, seem particularly sensitive to contamination with oil (Suchanek, 1993). Dauvin (2018) noted that several studies have shown the great sensitivity of the amphipods to hydrocarbons compared to other groups of invertebrates, either in the laboratory or due to environmental to pollution by hydrocarbons. For example, Dauvin (2018) noted that oil spills in the Baltic Sea (*Palva*, *Tsesis* and *Antonio Gramsci*), in the South Atlantic (the *Esso Essen*), the western part of the English Channel (the *Amoco Cadiz*) (Dauvin, 1987, 1998), in Galicia, Spain (the *Aegean Sea*) (Gomez Gesteira and Dauvin, 2000), and in Milford Haven, Wales, UK (the *Sea Empress*) (Nikitik & Robinson, 2003), demonstrated the high sensitivity of amphipods to accidental oil spill pollution. Both the *Amoco Cadiz* and the *Aegean Sea* oil spills resulted in the disappearance of amphipods from polluted stations (Dauvin, 2018). Southward (1982) suggested it took five or more years for amphipod abundance to return after oil spills, presumably due to the persistence of oil in the sediments (Southward, 1982; Suchanek, 1993). Nikitik & Robinson (2003) reported a sharp decline in amphipods (*Ampelisca* sp. and *Harpinia* sp.) in Milford Haven after the *Sea Empress* spill but noted that amphipod populations showed signs of recovery within five years.

Furthermore, light fractions (C10 - C19) of oils are much more toxic to *Corophium volutator* than heavier fractions (C19 - C40). In exposures of up to 14 days, light fraction concentrations of 0.1 g/kg sediment caused high mortality. It took 9 g/kg sediment to achieve similar mortalities with the heavy fraction (Brils *et al*., 2002). Roddie *et al.* (1994) found high levels of mortality of *Corophium* at sites contaminated with crude oil.

Sensitivity assessment. There is considerable evidence that amphipods, as a group, are highly sensitive to the effects of hydrocarbon contamination. Therefore, resistance is assessed as **'None'**. Recolonization is dependent on a reduction of the hydrocarbon concentration in the sediment (presumably by degradation or dilution) and resilience is assessed as **'Medium'**. Hence, sensitivity is assessed as **'Medium'.**

Synthetic compound contamination	Low Q: Medium A: Medium C: Medium	High Q: High A: Medium C: Medium	Low Q: Medium A: Medium C: Medium

Hua & Reylea (2014) examined the effects of multiple insecticides on the amphipod *Crangonyx* *psesudocracilis* and isopod *Asellus aquaticus* in mesocosms. The exposed mesocosms to organophosphates (chlorpyrifos, diazinon, endosulfan, and malathion) at 10ug/l (low concentration) or 40 ug/l (high concentration) individually or in mixtures for up to 18 weeks. They found that the low concentration of diazinon, endosulfan, and malathion had no effect on the amphipods but the low concentration of chlorpyrifos eliminated them. Amphipod abundance was severely reduced by malathion at the high concentration but eliminated by chlorpyrifos, diazinon, and endosulfan (Hua & Reylea, 2014).

LeBlanc (2007) reviewed crustacean endocrine toxicology and list several synthetic compounds that had been demonstrated to have anti-ecdysteroidal effects (EC_{50}), and hence interfere with embryo development, growth (moulting) and reproduction. These included Bisphenol A, Diethylphthalate, 4-Nonylphenol, Fluoranthene, Lindane, 4,4-DDD, 2,4-DDE, 4,4-DDE, 4,4-DDT, Dieldrin, Reseratrol, and Zearalenone (LeBlanc, 2007).

Corophium volutator is paralysed by pyrethrum-based insecticide sprayed onto the surface of the mud (Gerdol & Hughes, 1993) and pyrethrum would probably cause significant mortalities if it found its way into estuaries from agricultural runoff. Nonylphenol is an anthropogenic pollutant that regularly occurs in water bodies, it is an oestrogen mimic that is produced during the sewage treatment of non-ionic surfactants and can affect *Corophium volutator* (Brown *et al*., 1999). Nonylphenol is a hydrophobic molecule and often becomes attached to sediment in water bodies. This will make nonylphenol available for ingestion by *Corophium volutator* in estuaries where much of the riverine water-borne sediment flocculates and precipitates out of suspension to form mudflats. Nonylphenol was not lethal to *Corophium volutator* but does reduce growth and has the effect of causing the secondary antennae of males to become enlarged, which can make the amphipods more vulnerable to predators (Brown *et al*., 1999). However, The ECOTOX database (Olker *et al*., 2022) recorded a 96-hour LC50 of ca 1.67 mg/l and a 10-day LC50 of ca 0.62 mg/l for 4-nonylphenol in *Corophium* sp.. *Corophium volutator* is killed by 1% ethanol if exposed for 24 hours or more but can withstand higher concentrations in short pulses. Such short pulses, however, have the effect of rephasing the diel rhythm and will delay the timing of swimming activity for the duration of the ethanol pulse (Harris & Morgan, 1984b). The ECOTOX database records LC50s for a range of synthetic compounds, for example, fluoranthene, Pentachlorophenol, trichlorobenzene, Sodium methylundecyl benzenesulfonate (a pesticide), and the synthetic pyrethroid (4-Chloro-alpha-(1-methylethyl)benzeneacetic acid cyano(3-phenoxyphenyl)methyl ester).

Sensitivity assessment. The above evidence suggests that amphipods are likely to be affected adversely by a range of synthetic compounds, especially insecticides, depending on exposure duration and concentration. Therefore, resistance is assessed as **'Low',** resilience as **'High'**, and sensitivity as **'Low'.**

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

Corophium volutator was reported to readily absorb radionuclides such as americium and plutonium from water and contaminated sediments (Miramand *et al*., 1982). However, the effect of contamination on the individuals was not known but accumulation through the food chain was assumed (Miramand *et al*., 1982). There was '**No evidence'** on which to base an assessment.

Introduction of other substances	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 relevant evidence was found.

De-oxygenation	Low Q: High A: Low C: Medium	High Q: High A: Medium C: Medium	Low Q: High A: Low C: Medium

Vaquer-Sunyer & Duarte (2008) suggested that crustaceans (as a group) were the most sensitive to deoxygenation after fish, and more sensitive than polychaetes, echinoderms and molluscs. Amphipods appear not to be tolerant of reduced oxygenation. For example, *Ampelisca agassizi* was reported to be sensitive to hypoxia (Diaz & Rosenberg, 1995). *Jassa falcata*, another tube-building amphipod species, was absent from Californian harbours with low oxygen concentrations (0-2.5 mg/l) but recovery was rapid with recolonization taking place within 6-9 months (Barnard, 1958).

In a series of experiments Gamenick *et al.* (1996) suggested that *Corophium volutator* was highly sensitive to hypoxia and suffered 50% mortality after just 4 hours in hypoxic conditions (0.032 mg/l), or in 2 hours if there was a rapid build-up of sulphide (Gamenick *et al.*, 1996; Gray *et al.*, 2002). *Corophium volutator* was the most sensitive to hypoxia when compared to other species tested, e.g. polychaetes. Also, in areas where the sediment was covered to induce anoxia and sulphide build-up, *Corophium volutator* was the last of the species examined to recolonize the sediment; after two months (Gamenick *et al.*, 1996). These results are largely in concordance with other work by Gamble (1970) who found that survival rates were temperature dependent with individuals surviving longer at lower temperatures. Gamble (1970) found that at 5°C most individuals were inactive after 30 minutes of exposure to anaerobic seawater and that mortality occurred later, the inactivity may have allowed the species to survive longer (Gamble, 1070). At 10°C, *Corophium volutator* survived for 22 hours while *Corophium arenarium* survived for 25 hours. Gray *et al.* (2002) also reported that *Gammarus oceanicus* and other crustacea survived for less than 100 hours at <0.15 ml O_2/l (<0.21 mg O_2/l at 10°C, 17 psu) (Dries & Theede, 1974; cited in Gray *et al.*, 2002).

Sensitivity assessment. No evidence of the effects of deoxygenation of the characteristic species *Siphonoecetes* was found. However, the evidence above suggests that amphipods are sensitive to hypoxia. Therefore, resistance is assessed as **'Low'**, resilience as **'High'** and sensitivity as **'Low'** but with 'Low' confidence due to the lack of direct evidence on *Siphonoecetes* spp.

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

Guerra-García & García-Gómez (2004) compared amphipod communities inside the harbour of Ceuta, North Africa, with communities outside the harbour. *Siphonoecetes dellavallei* dominated the amphipod community outside the harbour in sandy sediments with a low concentration of nitrogen, phosphorous and copper, while the internal stations contained less sand, more organic matter and higher concentrations of nitrogen, phosphorous and copper and were dominated by gammarids and *Corophium* sp. (Guerra-García & García-Gómez, 2004). However, the dominance of *Siphonoecetes* in their samples may have been due to the sediment type rather than pollution.

Bigot *et al.* (2006) examined amphipod communities in the vicinity of the power station and sugar cane plant effluents in Reunion Island (Indian Ocean). The sugar mill effluent discharged ca 0.8-1.1 tonnes of particular matter per day, and 0.023 mg/l of total organic matter, and the thermal effluent included 0.33-0.98 tons of particulate matter and 0.021 mg/l total organic matter. *Siphonoecetes* sp. was one of the dominant crustaceans in the community closest to the outfalls, and contributed to the annual variation in species abundance. However, they concluded that its variation in abundance was probably due to natural population fluctuations rather than organic enrichment.

De-la-Ossa-Carretero *et al.* (2012) examined the effect of five different sewage outfalls on amphipod communities on the Castellon coast (NE Spain). They noted that most of the species showed high sensitivity. In particular, *Bathyporeia borgi*, *Perioculodes longimanus* and *Autonoe spiniventris*, were sensitive while other species such as *Ameplisca brevicornis* appeared to be more tolerant to the sewage input. They noted that burrowing (fossorial) species were more sensitive, while the tube-dwelling (domicolous) species were less affected. They suggested that tube-dwelling species were less exposed to contaminated interstitial water and could pump water into their burrows to avoid the effects of deoxygenation due to organic enrichment (De-la-Ossa-Carretero *et al.*, 2012). In a similar study of sewage effluents on the Alicante coast, De-la-Ossa-Carretero *et al.* (2016b) reported the amphipods *Gammarella fucicola*, *Ampelisca spinipes*, *Siphonoecetes bulborostrum* and *Pseudolirius kroyeri* were abundant in the transect closest to the harbour and sewage discharge.

Sensitivity assessment. The above evidence suggests that *Siphonoecetes* spp. are amongst a number of amphipod species that are resistant or organic enrichment and that their tube-dwelling habit may provide protection from the indirect effects of organic or nutrient enrichment. Therefore, resistance is assessed as **'High',** although their response may be mediated by changes in the sediment and/or the moderator energy (wave exposure and tidal flow) conditions typical of this biotope. Hence, resilience is assessed as **'High'** and sensitivity as **'Not sensitive', although the evidence does not allow a direct comparison with the benchmark.**

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

Guerra-García & García-Gómez (2004) compared amphipod communities inside the harbour of Ceuta, North Africa, with communities outside the harbour. *Siphonoecetes dellavallei* dominated the amphipod community outside the harbour in sandy sediments with a low concentration of nitrogen, phosphorous and copper, while the internal stations contained less sand, more organic matter and higher concentrations of nitrogen, phosphorous and copper and were dominated by gammarids and *Corophium* sp. (Guerra-García & García-Gómez, 2004). However, the dominance of *Siphonoecetes* in their samples may have been due to the sediment type rather than pollution.

Bigot *et al.* (2006) examined amphipod communities in the vicinity of the power station and sugar cane plant effluents in Reunion Island (Indian Ocean). The sugar mill effluent discharged ca 0.8-1.1 tonnes of particular matter per day, and 0.023 mg/l of total organic matter, and the thermal effluent included 0.33-0.98 tons of particulate matter and 0.021 mg/l total organic matter. *Siphonoecetes* sp. was one of the dominant crustaceans in the community closest to the outfalls, and contributed to the annual variation in species abundance. However, they concluded that its variation in abundance was probably due to natural population fluctuations rather than organic enrichment.

De-la-Ossa-Carretero *et al.* (2012) examined the effect of five different sewage outfalls on amphipod communities on the Castellon coast (NE Spain). They noted that most of the species showed high sensitivity. In particular, *Bathyporeia borgi*, *Perioculodes longimanus* and *Autonoe spiniventris*, were sensitive while other species such as *Ameplisca brevicornis* appeared to be more tolerant to the sewage input. They noted that burrowing (fossorial) species were more sensitive, while the tube-dwelling (domicolous) species were less affected. They suggested that tube-dwelling species were less exposed to contaminated interstitial water and could pump water into their burrows to avoid the effects of deoxygenation due to organic enrichment (De-la-Ossa-Carretero *et al.*, 2012). In a similar study of sewage effluents on the Alicante coast, De-la-Ossa-Carretero *et al.* (2016b) reported the amphipods *Gammarella fucicola*, *Ampelisca spinipes*, *Siphonoecetes bulborostrum* and *Pseudolirius kroyeri* were abundant in the transect closest to the harbour and sewage discharge.

Sensitivity assessment. The above evidence suggests that *Siphonoecetes* spp. are amongst a number of amphipod species that are resistant or organic enrichment and that their tube-dwelling habit may provide protection from the indirect effects of organic or nutrient enrichment. Therefore, resistance is assessed as **'High',** although their response may be mediated by changes in the sediment and/or the moderator energy (wave exposure and tidal flow) conditions typical of this biotope. Hence, resilience is assessed as **'High'** and sensitivity as **'Not sensitive'.**

Physical Pressures

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

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

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

If sedimentary substrata were replaced with rock substrata the biotope would be lost, as it would no longer be a sedimentary habitat and would no longer support sea pens and burrowing megafauna. Resistance to the pressure is considered '**None**', and resilience '**Very low**' or 'None' (as the pressure represents a permanent change), and the sensitivity of this biotope is assessed as '**High'**.

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

This biotope (SS.SSa.CFiSa.SiphNephVen) is only recorded from moderate tidal steams (0.5-1.5 m/sec) and moderately exposed wave conditions. *Siphonoecetes* spp. are recorded from medium and coarse sandy bottoms (Myers & McGrath, 1979; Mora, 1991; Moreira *et al.*, 2008; De-la-Ossa-Carretero *et al.*, 2015), predominately sand with little mud on the Dogger Bank (Reiss & Kröncke, 2005) and fine sands (Bigot *et al.*, 2006). Therefore, the biotope and the dominant characteristic species are dependent on the presence of fine to coarse sands. A change in sediment type from sand to 'mud and sandy muds' or to mixed or coarse sediments would probably result in the loss of the biotope and its reclassification due to the difference in sediment type and the resultant change in the associated community. Hence, resistance is assessed as **'None'**, resilience as **'Very low'** (permanent change) and sensitivity as **'High'.**

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

Siphonoecetes spp. live in burrows made of agglutinated sand grains and shells in the sediment. The species are small (< 1cm in length) so we can presume that their burrows are fairly shallow (i.e. only a few centimetres deep). Hence, the removal of the sediment to a depth of 30 cm in the affected area (the benchmark) would remove the entire population within the affected area. Therefore, resistance is assessed as **'None'**. Once the sediment returns to its prior state, resilience is probably **'Medium'** so sensitivity is assessed as **'Medium'.**

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

No evidence of the effects of physical abrasion of the sediment surface or penetration or disturbance of the subsurface in a *Siphonoecetes*-dominated habitat was found. However, evidence from other similar amphipod-dominated habitats may be a useful proxy. For example, sediment turnover caused by cockles and lugworms disturbed the burrows of *Corophium volutator* and caused a significant negative effect on *Corophium volutator* density as a result of the increased rate of swimming making the amphipod more vulnerable to predation (Flach & De Bruin, 1993, 1994). *Corophium arenarium* was also sensitive to sediment disturbance from bioturbating species (Flach, 1993). In the Columbia river, no significant difference was found in *Corophium volutator* densities before and after dredging a channel and no difference between the dredged site and a control site (McCabe *et al.*, 1998). Presumably, the dredging did cause mortality of *Corophium volutator* but recolonization was so rapid that no difference was found. The extraction of cockles by sediment raking and mechanical disturbance and digging for lugworms for bait is likely to cause significant mortality of *Corophium volutator*. Bait digging was found to reduce *Corophium volutator* densities by 39%. Juveniles were most affected, suffering a 55% reduction in dug areas (Shepherd & Boates, 1999).

Sensitivity assessment. *Siphonoecetes* spp. are probably adapted to minor hydrodynamic disturbance of the surface of the sediment. However, abrasion by passing fishing gear may disturb the surface of the sediment and either destroy the surface of their tubes or cause them to leave their tubes, increasing their susceptibility to predation. The species is very small and unlikely to be removed in significant numbers. Therefore, abrasion may cause some mortality to the resident population and resistance is assessed as **'Medium'.** However, recovery is likely to be rapid and so resilience is assessed as **'High'** and sensitivity as **'Low'** albeit with 'Low confidence due to the lack of direct evidence.

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

No evidence of the effects of physical abrasion of the sediment surface or penetration or disturbance of the subsurface in a *Siphonoecetes*-dominated habitat was found. However, evidence from other similar amphipod-dominated habitats may be a useful proxy. For example, sediment turnover caused by cockles and lugworms disturbed the burrows of *Corophium volutator* and caused a significant negative effect on *Corophium volutator* density as a result of the increased rate of swimming making the amphipod more vulnerable to predation (Flach & De Bruin, 1993, 1994). *Corophium arenarium* was also sensitive to sediment disturbance from bioturbating species (Flach, 1993). In the Columbia river, no significant difference was found in *Corophium volutator* densities before and after dredging a channel and no difference between the dredged site and a control site (McCabe *et al.*, 1998). Presumably, the dredging did cause mortality of *Corophium volutator* but recolonization was so rapid that no difference was found. The extraction of cockles by sediment raking and mechanical disturbance and digging for lugworms for bait is likely to cause significant mortality of *Corophium volutator*. Bait digging was found to reduce *Corophium volutator* densities by 39%. Juveniles were most affected, suffering a 55% reduction in dug areas (Shepherd & Boates, 1999).

Sensitivity assessment. *Siphonoecetes* spp. are probably adapted to minor hydrodynamic disturbance of the surface of the sediment. However, penetration and disturbance of the sediment by passing fishing gear may destroy their tubes and remove them from the sediment increasing their susceptibility to predation. The species is very small and unlikely to be removed in significant numbers. Therefore, penetration may cause some or significant mortality to the resident population and resistance is assessed as **'Low'.** However, recovery is likely to be rapid and so resilience is assessed as **'High'** and sensitivity as **'Low'** albeit with 'Low confidence due to the lack of direct evidence.

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

Changes in light penetration or attenuation associated with this pressure are not relevant in this circalittoral biotope. The characteristic species are infaunal so unlikely to be directly dependent on light. In addition, the biotope occurs in moderate tidal flow and moderate wave exposure which suggests that the sand-dominated habitat is probably well-sorted and subject to occasional resuspension, especially during winter storms. *Siphonoecetes* spp. is a surface deposit feeder that feeds on non-surface bound organic matter, including microflora and microfauna, but without ingesting sediment particles (Guidi, 1986; Guerra-García *et al.*, 2014). Therefore, an increase in turbidity may reduce the development of microflora on the sediment surface but it can probably ingest other food sources. The greatest risk is a change in sediment type due to an increase in fine sediment in suspension (see above) although the hydrographic conditions should prevent the accumulation of fine sediments. Therefore, resistance is assessed as **'High',** resilience as **'High'**, and sensitivity as **'Not sensitive'**.

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

Siphonoecetes spp. live in burrows made of agglutinated sand grains and shells in the sediment. The species are small (< 1cm in length) so we can presume that their burrows are fairly shallow (i.e. only a few centimetres deep). *Siphonoecetes* spp. are recorded from medium and coarse sandy bottoms (Myers & McGrath, 1979; Mora, 1991; Moreira *et al.*, 2008; De-la-Ossa-Carretero *et al.*, 2015), predominately sand with little mud on the Dogger Bank (Reiss & Kröncke, 2005) and fine sands (Bigot *et al.*, 2006). Therefore, the biotope and the dominant characteristic species are dependent on the presence of fine to coarse sands. The sudden deposition of 5 cm of fine sediment may be detrimental for species that are adapted to living and burrowing in fine to coarse sediment. However, the hydrographic regime would probably remove the deposited sediment with a few tidal cycles. Therefore, resistance is assessed as **'High'**, resilience as **'High'**, and sensitivity as **'Not sensitive'**.

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

Siphonoecetes spp. live in burrows made of agglutinated sand grains and shells in the sediment. The species are small (< 1cm in length) so we can presume that their burrows are fairly shallow (i.e. only a few centimetres deep). *Siphonoecetes* spp. are recorded from medium and coarse sandy bottoms (Myers & McGrath, 1979; Mora, 1991; Moreira *et al.*, 2008; De-la-Ossa-Carretero *et al.*, 2015), predominately sand with little mud on the Dogger Bank (Reiss & Kröncke, 2005) and fine sands (Bigot *et al.*, 2006). Therefore, the biotope and the dominant characteristic species are dependent on the presence of fine to coarse sands.

The sudden deposition of 30 cm of fine sediment may be detrimental for species that are adapted to living and burrowing in fine to coarse sediment. They may struggle to burrow up through the deposited sediment and be suffocated within the affected area. The hydrographic regime would probably remove the deposited sediment over a period of time dependent on the exact location. Therefore, resistance is assessed as **'Low'**, resilience as **'High'**, and sensitivity as **'Low'**, albeit with 'Low' confidence due to the lack of direct evidence.

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'.**

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 was found.

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

Siphonoecetes spp. and other infauna are probably sensitive to localised vibration caused by the approach of predators but are unlikely to respond to noise as defined under this pressure. Therefore, the pressure is assessed as **'Not relevant'.**

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

Changes in light penetration or attenuation associated with this pressure are probably not relevant in this circalittoral biotope. The characteristic species are infaunal so unlikely to be directly dependent on light. In addition, the biotope occurs in moderate tidal flow and moderate wave exposure which suggests that the sand-dominated habitat is probably well-sorted and subject to occasional resuspension, especially during winter storms. *Siphonoecetes* spp. is a surface deposit feeder that feeds on non-surface bound organic matter, including microflora and microfauna, but without ingesting sediment particles (Guidi, 1986; Guerra-García *et al.*, 2014). Therefore, shading might reduce the development of microflora on the sediment surface but it can probably ingest other food sources. Therefore, resistance is assessed as **'High',** resilience as **'High'**, and sensitivity as **'Not sensitive'**.

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 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. Where populations were removed changes in water transport of adults may, however, be reduced by changes in local hydrodynamics preventing recolonization. Conversely, a barrier may enhance local connectivity by reducing the loss of adults from the system. Therefore, resistance is assessed as **'High'**, resilience **'High'** (by default) and the biotope is assessed as **'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

Siphonoecetes spp. and other infauna are probably sensitive to localised shading caused by the approach of predators but are unlikely to respond to visual disturbance as defined under this pressure. Therefore, the pressure is assessed as **'Not relevant'.**

Biological Pressures

	Resistance	Resilience	Sensitivity
Genetic modification & translocation of indigenous species	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

No information on the translocation or genetic modification of this species was found.

Introduction or spread of invasive non-indigenous species	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 information on the potential interaction of *Siphonoecetes* spp. and invasive non-native species was found.

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

No information on the effects of potential diseases or parasites was found. Falck & Bowman (1994) reported that ca 50% of tubes created by *Siphonoecetes* sp. in the northern Red Sea were also occupied by the commensal harpacticoid copepod *Parasunaristes chelicerata*. However, as a commensal, the harpacticoid probably gains benefit from sharing the tube with its host without causing any harm.

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

Siphonoecetes spp. are not targeted by collectors or fisheries. Therefore, this pressure is not relevant.

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

Physical disturbance to the sediment is addressed under the 'physical loss' and 'physical disturbance' pressures above. No biological relationship between *Siphonoecetes* spp. and other species (except its Red Sea commensal) were found in UK waters. It is probably fed on by demersal fish and decapods but as their diet is varied and they are highly mobile its loss is unlikely to be significant. Therefore, bycatch may cause some mortality to the resident population of *Siphonoecetes* sp. and resistance is assessed as **'Medium'.** However, recovery is likely to be rapid and so resilience is assessed as **'High'** and sensitivity as **'Low'** albeit with 'Low confidence due to the lack of direct evidence.

Bibliography

Barnard, J.L. & Thomas, J.D., 1984. 2 new species of the *Siphonoecetes* complex from the Arabian Gulf and Borneo (Crustacea, Amphipoda). *Proceedings of the Biological Society of Washington*, **97** (4), 864-881.

Barnard, J.L., 1958. Amphipod crustaceans as fouling organisms in Los Angeles-Long Beach harbours, with reference to the influence of seawater turbidity. *California Fish and Game*, **44**, 161-170.

Bat, L., Raffaelli, D. & Marr, I.L., 1998. The accumulation of copper, zinc and cadmium by the amphipod *Corophium volutator* (Pallas). *Journal of Experimental Marine Biology and Ecology*, **223**, 167-184.

Bellan-Santini, D., 1980. Relationship between populations of amphipods and pollution. *Marine Pollution Bulletin*, **11**, 224-227. https://doi.org/10.1016/0025-326X(80)90411-7

Bigot, L., Conand, C., Amouroux, J. M., Frouin, P., Bruggemann, H. & Grémare, A., 2006. Effects of industrial outfalls on tropical macrobenthic sediment communities in Reunion Island (Southwest Indian Ocean). *Marine Pollution Bulletin*, **52** (8), 865-880. DOI https://doi.org/10.1016/j.marpolbul.2005.11.021

Brils, J.M., Huwer, S.L., Kater, B.J., Schout, P.G., Harmsen, J., Delvigne, G.A.L. & Scholten, M.C.T., 2002. Oil effect in freshly spiked marine sediment on *Vibrio fischeri*, *Corophium volutator*, and *Echinocardium caudatum. Environmental Toxicology and Chemistry*, **21**, 2242-2251.

Brown, R.J., Conradi, M. & Depledge, M.H., 1999. Long-term exposure to 4-nonylphenol affects sexual differentiation and growth of the amphipod *Corophium volutator* (Pallas, 1766). *Science of the Total Environment*, **233**, 77-88.

Bryant, V., McLusky, D.S., Roddie, K. & Newbery, D.M., 1984. Effect of temperature and salinity on the toxicity of chromium to three estuarine invertebrates (*Corophium volutator*, *Macoma balthica*, *Nereis diversicolor*). *Marine Ecology Progress Series*, **20** (1-2), 137-149. DOI https://doi.org/10.3354/meps020137

Bryant, V., Newbery, D.M., McLusky, D.S. & Campbell, R., 1985b. Effect of temperature and salinity on the toxicity of nickel and zinc to two estuarine invertebrates (*Corophium volutator*, *Macoma balthica*). *Marine Ecology Progress Series*, **24**, 139-153.

Bryant, V., Newbery, D.M., McLusky, D.S. & Campbell, R., 1985. Effect of temperature and salinity on the toxicity of arsenic to three estuarine invertebrates (*Corophium volutator*, *Macoma balthica*, *Tubifex costatus*). *Marine Ecology Progress Series*, **24**, 129-137.

Carvalho, S., Moura, A. & Sprung, M., 2006. Ecological implications of removing seagrass beds (*Zostera noltii*) for bivalve aquaculture in southern Portugal. *Cahiers De Biologie Marine*, **47** (3), 321-329.

Corey, S., 1981. Comparative fecundity and reproductive strategies in seventeen species of the Cumacea (Crustacea: Peracarida). *Marine Biology*, **62** (1), 65-72. DOI https://doi.org/10.1007/BF00396952

Curras, A. & Mora, J., 1991. Benthic communities of the Eo Estuary (Galicia-Austurias, Northwestern Spain). *Cahiers De Biologie Marine*, **32** (1), 57-81.

Dauvin, J. C. & Cabioch, L., 1988. New species of marine fauna from Roscoff - Crustacea, Amphipoda, *Siphonoecetes striatus* Myers and Mcgrath, and Annelida, Polychaeta, Paraonidae, plus new data on *Echinocardium pennatifidum* Norman (Spatangoida) Distribution. *Cahiers De Biologie Marine*, **29** (2), 215-219.

Dauvin, J.-C., 2018. Twenty years of application of Polychaete/Amphipod ratios to assess diverse human pressures in estuarine and coastal marine environments: A review. *Ecological Indicators*, **95**, 427-435. DOI https://doi.org/10.1016/j.ecolind.2018.07.049

Dauvin, J.C., 1987. Evolution a long terme (1978-1986) des populations d'amphipodes des sables fins de la Pierre Noire (Baie de Morlaix, Manche Occidentale) apres la catastophe de l'Amoco Cadiz. *Marine Environmental Research*, **21**, 247-273.

Dauvin, J.C., 1998. The fine sand *Abra alba* community of the Bay of Morlaix twenty years after the *Amoco Cadiz* oil spill. *Marine Pollution Bulletin*, **36**, 669-676.

De-La-Ossa-Carretero, J. A. & Marti, A., 2014. A new species of *Siphonoecetes* Kroyer, 1845 *Siphonoecetes (Centraloecetes) bulborostrum* sp nov (Crustacea, Amphipoda, Ischyroceridae) from the western Mediterranean, coast of Iberian Peninsula. *Zootaxa*, **3765** (1), 69-76. DOI https://doi.org/10.11646/zootaxa.3765.1.4

De-la-Ossa-Carretero, J. A., Del-Pilar-Ruso, Y., Gimenez-Casalduero, F. & Sanchez-Lizaso, J. L., 2016b. Amphipoda assemblages in a disturbed area (Alicante, Spain, Western Mediterranean). *Marine Ecology - an Evolutionary Perspective*, **37** (3), 503-517. DOI https://doi.org/10.1111/maec.12264

De-la-Ossa-Carretero, J.A., Del-Pilar-Ruso, Y., Giménez-Casalduero, F., Sánchez-Lizaso, J.L. & Dauvin, J.C., 2012. Sensitivity of amphipods to sewage pollution. *Estuarine, Coastal and Shelf Science*, **96**, 129-138. DOI https://doi.org/10.1016/j.ecss.2011.10.020

Demorais, A. T. & Guidi, L., 1983. Use of fecal pads of ascidia by an epibenthic amphipod – *Siphonoecetes dellavallei*. *Bulletin De La Societe Zoologique De France-Evolution Et Zoologie*, **108** (4), 696-696.

Diaz, R.J. & Rosenberg, R., 1995. Marine benthic hypoxia: a review of its ecological effects and the behavioural responses of benthic macrofauna. *Oceanography and Marine Biology: an Annual Review*, **33**, 245-303.

Falck, C. L. & Bowman, T. E., 1994. Commensal life, sexual dimorphism, and handedness in the Canuellid Harpacticoid *Parasunaristes chelicerata* (Por And Marcus, 1972). *Hydrobiologia*, **293**, 455-459.

Flach, E.C., 1993. The distribution of the amphipod *Corophium arenarium* in the Dutch Wadden Sea- relationships with sediment composition and the presence of cockles and lugworms. *Netherlands Journal of Sea Research*, **31** (3), 281-290.

Flach, E.C. & De Bruin, W., 1993. Effects of *Arenicola marina* and *Cerastoderma edule* on distribution, abundance and population structure of *Corophium volutator* in Gullmarsfjorden western Sweden. *Sarsia*, **78**, 105-118.

Flach, E.C. & De Bruin, W., 1994. Does the activity of cockles, *Cerastoderma edule* (L.) and lugworms, *Arenicola marina* (L.), make *Corophium volutator* Pallas more vulnerable to epibenthic predators: a case of interaction modification? *Journal of Experimental Marine Biology and Ecology*, **182**, 265-285.

Gamble, J., 1970. Anaerobic survival of the crustaceans *Corophium volutator*, *C. arenarium* and *Tanais chevreuxi*. *Journal of the Marine Biological Association of the United Kingdom*, **50** (03), 657-671.

Gamenick, I., Jahn, A., Vopel, K. & Giere, O., 1996. Hypoxia and sulphide as structuring factors in a macrozoobenthic community on the Baltic Sea shore: Colonization studies and tolerance experiments. *Marine Ecology Progress Series*, **144**, 73-85. DOI https://doi.org/10.3354/meps144073

Gerdol, V. & Hughes, R.G., 1993. Effect of the amphipod *Corophium volutator* on the colonisation of mud by the halophyte *Salicornia europea*. *Marine Ecology Progress Series*, **97**, 61-69.

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

Gray, J.S., Wu R.S.-S. & Or Y.Y., 2002. Effects of hypoxia and organic enrichment on the coastal marine environment. *Marine Ecology Progress Series*, **238**, 249-279. DOI https://doi.org/10.3354/meps238249

Guerra-García, J.M., Tierno de Figueroa, J.M., Navarro-Barranco, C., Ros, M., Sánchez-Moyano, J.E. & Moreira, J., 2014. Dietary analysis of the marine Amphipoda (Crustacea: Peracarida) from the Iberian Peninsula. *Journal of Sea Research*, **85**, 508-517. DOI https://doi.org/10.1016/j.seares.2013.08.006

Guerra-Garcia, J. M. & Garcia-Gomez, J. C., 2004. Crustacean assemblages and sediment pollution in an exceptional case study: A harbour with two opposing entrances. *Crustaceana*, **77**, 353-370. DOI https://doi.org/10.1163/1568540041181538

Guidi, L.D., 1986. The feeding response of the epibenthic amphipod *Siphonoecetes dellavallei* Stebbing to varying food particle sizes and concentrations. *Journal of Experimental Marine Biology and Ecology*, **98** (1-2), 51-63. DOI https://doi.org/10.1016/0022-0981(86)90075-4

Harriague, A. C., Bianchi, C. N. & Albertelli, G., 2006. Soft-bottom macrobenthic community composition and biomass in a *Posidonia oceanica* meadow in the Ligurian Sea (NW Mediterranean). *Estuarine Coastal and Shelf Science*, **70** (1-2), 251-258. DOI https://doi.org/10.1016/j.ecss.2005.10.017

Hong, J. & Reish, D.J., 1987. Acute toxicity of cadmium to eight species of marine amphipod and isopod crustaceans from southern California. *Bulletin of Environmental Contamination and Toxicology*, **39**, 884-888.

Hua, J. & Relyea, R., 2014. Chemical cocktails in aquatic systems: Pesticide effects on the response and recovery of >20 animal taxa. *Environmental Pollution*, **189**, 18-26. DOI https://doi.org/10.1016/j.envpol.2014.02.007

Just, J., 2017. A fresh look at the higher classification of the Siphonoecetini Just, 1983 (Crustacea, Amphipoda, Ischyroceridae) 12: with a key to all taxa. *Zootaxa*, **4320** (2), 321-338. DOI https://doi.org/10.11646/zootaxa.4320.2.7

LeBlanc, G.A., 2007. Crustacean endocrine toxicology: a review. *Ecotoxicology*, **16** (1), 61-81. DOI https://doi.org/10.1007/s10646-006-0115-z

McCabe, G.T. Jr., Hinton, S.A. & Emmett, R.L., 1998. Benthic invertebrates and sediment characteristics in a shallow navigation channel of the lower Columbia River. *Northwest Science*, **72**, 116-126.

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

Miramand, P., Germain, P. & Camus, H., 1982. Uptake of americium and plutonium from contaminated sediments by three benthic species: *Arenicola marina*, *Corophium volutator* and *Scrobicularia plana*. *Marine Ecology Progress Series*, **7**, 59-65.

Mora, A.C.J., 1991. Communidades bentonicas de la ria del Eo (Galicia-Asturias, NW Espana). *Cahiers de Biologie Marine*, **32**, 57-81.

Moreira, J., Gestoso, L. & Troncoso, J. S., 2008. Diversity and temporal variation of peracarid fauna (Crustacea : Peracarida) in the shallow subtidal of a sandy beach: Playa America (Galicia, NW Spain). *Marine Ecology - an Evolutionary Perspective*, **29**, 12-18. DOI https://doi.org/10.1111/j.1439-0485.2007.00195.x

Myers, A.A. & McGrath, D., 1979. The British and Irish species of *Siphonoecetes* Kroyer (Amphipoda-Gammaridea). *Journal of Natural History*, **13** (2), 211-220. DOI https://doi.org/10.1080/00222937900770151

Navarro-Barranco, C., Guerra-Garcia, J. M., Sanchez-Tocino, L. & Garcia-Gomez, J. C., 2012. Soft-bottom crustacean assemblages in Mediterranean marine caves: the cave of Cerro Gordo (Granada, Spain) as case study. *Helgoland Marine Research*, **66** (4), 567-576. DOI https://doi.org/10.1007/s10152-012-0292-5

Navarro-Barranco, C., Guerra-Garcia, J. M., Sanchez-Tocino, L. & Garcia-Gomez, J. C., 2014. Amphipods from marine cave sediments of the southern Iberian Peninsula: diversity and ecological distribution. *Scientia Marina*, **78** (3), 415-424. DOI https://doi.org/10.3989/scimar.04043.28E

Nikitik, C.C.S. & Robinson, A.W., 2003. Patterns in benthic populations in the Milford Haven waterway following the *'Sea Empress'* oil spill with special reference to amphipods. *Marine Pollution Bulletin*, **46** (9), 1125-1141. DOI https://doi.org/10.1016/S0025-326X(03)00236-4

OBIS (Ocean Biodiversity Information System), 2024. Global map of species distribution using gridded data. Available from: Ocean Biogeographic Information System. www.iobis.org. Accessed: 2024-01-04

Olker, J. H., Elonen, C. M., Pilli, A., Anderson, A., Kinziger, B., Erickson, S., Skopinski, M., Pomplun, A., LaLone, C. A., Russom, C. L., & Hoff, D. (2022). The ECOTOXicology Knowledgebase: A Curated Database of Ecologically Relevant Toxicity Tests to Support Environmental Research and Risk Assessment. *Environmental Toxicology and Chemistry*, 41(6):1520-1539. DOI https://doi.org/10.1002/etc.5324

Reiss, H. & Kröncke, I., 2005. Seasonal variability of infaunal community structures in three areas of the North Sea under different environmental conditions. *Estuarine, Coastal and Shelf Science*, **65** (1), 253-274. DOI https://doi.org/10.1016/j.ecss.2005.06.008

Roddie, B., Kedwards, T., Ashby-Crane, R. & Crane, M., 1994. The toxicity to *Corophium volutator* (Pallas) of beach sand contaminated by a spillage of crude oil. *Chemosphere*, **29** (4), 719-727.

Schubert, A. & Reise, K., 1987. Predatory effects of *Nephtys hombergii* on other polychaetes in tidal flat sediments. *Marine Ecology Progress Series*, **34**, 117-124.

Shepherd, P.C.F. & Boates, S.J., 1999. Effects of commercial baitworm harvest on semipalmated sandpipers and their prey in the Bay of Fundy hemispheric shorebird reserve. *Conservation Biology*, **13**, 347-356.

Southward, A.J., 1982. An ecologist's view of the implications of the observed physiological and biochemical effects of petroleum compounds on marine organisms and ecosystems. *Philosophical Transactions of the Royal Society of London. B*, **297**, 241-255.

Suchanek, T.H., 1993. Oil impacts on marine invertebrate populations and communities. *American Zoologist*, **33**, 510-523. DOI https://doi.org/10.1093/icb/33.6.510

Thomas, J. D., 1983. Peraeopod morphology and locomotion in the amphipod genera *Cerapus* and *Siphonoecetes*. *American Zoologist*, **23** (4), 942-942.

Trevor, J.H., 1978. The dynamics and mechanical energy expenditure of the polychaetes *Nephtys cirrosa*, *Nereis diversicolor* and *Arenicola marina* during burrowing. *Estuarine and Coastal Marine Science*, **6** (6), 605-619. DOI https://doi.org/10.1016/0302-3524(78)90034-8

Vaquer-Sunyer, R. & Duarte, C.M., 2008. Thresholds of hypoxia for marine biodiversity. *Proceedings of the National Academy of Sciences*, **105** (40), 15452-15457.DOI https://doi.org/10.1073/pnas.0803833105

Walker, A.J.M. & Rees, E.I.S., 1980. Benthic ecology of Dublin Bay in relation to sludge dumping. *Irish Fisheries Investigations, Series B (Marine)*, **22**, 1-59. Available from http://oar.marine.ie/handle/10793/146