Maldanid polychaetes and *Eudorellopsis deformis* in offshore circalittoral sand or muddy sand

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

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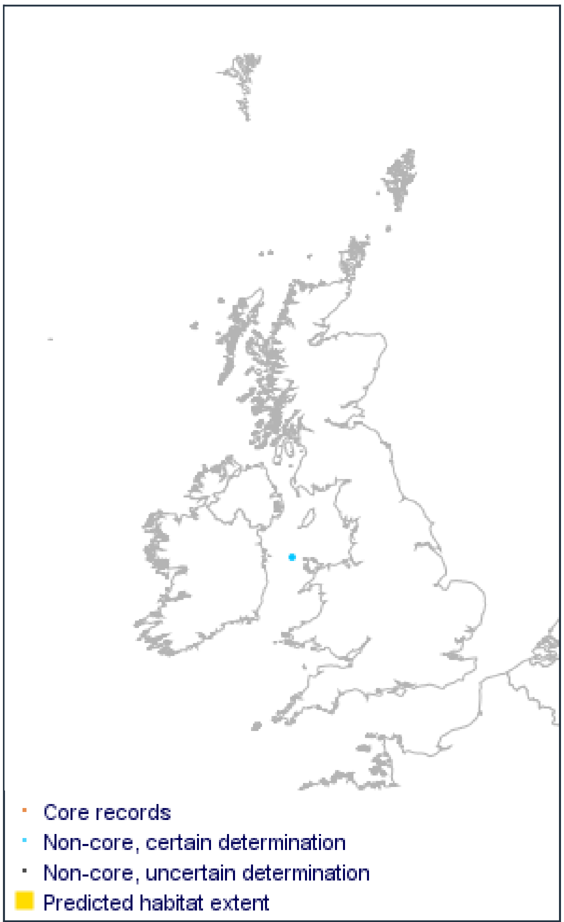

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Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Matthew Ashley **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A5.271	Maldanid polychaetes and *Eudorellopsis deformis* in deep circalittoral sand or muddy sand
JNCC 2015	SS.SSa.OSa.MalEdef	*Maldanid polychaetes* and *Eudorellopsis deformis* in offshore circalittoral sand or muddy sand
JNCC 2004	SS.SSa.OSa.MalEdef	*Maldanid polychaetes* and *Eudorellopsis deformis* in offshore circalittoral sand or muddy sand
1997 Biotope		

Description

In deep offshore sand or non-cohesive muddy sand dense populations of maldanid polychaetes such as *Maldane sarsi* and the cumacean *Eudorellopsis deformis* may be found. Accompanying these species are abundant ophiuroids including *Amphiura filiformis*, polychaetes such as Terebellidae sp., *Chaetozone setosa*, *Levinsenia gracilis*, *Scoloplos armiger*, the amphipod *Harpinia antennaria* and the bivalves *Ennucula tenuis* and *Parvicardium minimum*. This biotope is similar to the *Maldane sarsi*-*Ophiura sarsi* community defined by Glemarec (1973). (Information from Connor *et al*., 2004).

Depth range

-

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

This biotope as occurs in deep offshore sand or non-cohesive muddy sand and is characterized by dense populations of maldanid polychaetes such as *Maldane sarsi*, the cumacean *Eudorellopsis deformis* may also be found. Ofen accompanying these species are abundant ophiuroids including *Amphiura filiformis*, polychaetes such as *Terebellidae sp.*, *Chaetozone setosa*, *Levinsenia gracilis*, *Scoloplos armiger*, the amphipod *Harpinia antennaria* and the bivalves *Ennucula tenuis* and *Parvicardium minimum*. This biotope is similar to the *Maldane sarsi-Ophiura sarsi* community defined by Glemarec (1973) (Connor *et al.*, 2004).

Connor *et al.* (2004) do not identify specific characterizing species. In this sensitivity review, maldanid polychaetes such as *Maldane sarsi*, the cumacean *Eudorellopsis deformis* are considered to define the biotope as these are referred to in the biotope title. The brittle star *Amphiura filiformis* is also reviewed.

Resilience and recovery rates of habitat

The characteristic species require sand or muddy sand substratum, due to feeding or substratum preferences. For instance, the cumacean *Eudorellopsis deformis* is commonly referred to as a sand sucker as the species feeds on diatoms and organic material on the surface of sand grains. If a pressure causes removal of sand or muddy sand, or replacement with other sediment types (such as an increase in gravel content) sediment characteristics will have to return to sand or muddy sand before characteristic species return in high densities.

No direct evidence was found to assess the likely recovery of maldanid polychaetes. *Maldane sarsi* is a deposit feeding, tube-building polychaete that can reach lengths of 11-20 cm. Populations can reach high densities but are likely to be susceptible to burial from pressures such as deposition of suspended sediment or removal of substratum, due to the limited mobility of the species. The species has been identified as a negative indicator species to pollution (hydrocarbons) and deoxygenation, as it decreases in abundance or disappears under these conditions (Rosenberg *et al.* 2002; Belan, 2003). As a larger polychaete species with low mobility recovery may take longer than two years if the population is entirely removed.

No directly relevant information on cumacean life-history characteristics was found to support this assessment. *Eudorellopsis deformis* is a small cumacean species, growing to 5mm that feeds on small diatoms and other organic matter present on sand grains (Ghiold, 1982). Information on recovery rates from various pressures is limited. Gilkinson *et al.* (2005) found *Eudorellopsis deformis* occurred in high abundance amongst opportunistic species communities colonizing areas of coastal east Canada, 1 year after experimental hydraulic clam dredging, suggesting recovery was rapid from abrasion pressures. Benthic primary production is an important factor relating to *Eudorellopsis deformis* food sources and so population density. *Eudorellopsis deformis* will occur in higher densities where pelagic and epipelic diatoms occur and so recovery of populations is likely to be linked to primary productivity and in turn the drivers of primary productivity such as nutrient availability and light levels (Schukel *et al.* 2010).

Amphiura filiformis is a small brittlestar, disc up to 10 mm in diameter, with very long arms (10x disc diameter) which lives buried in muddy sand. Muus (1981) showed the mortality of new settling *Amphiura filiformis* to be extremely high with less than 5% contributing to the adult population in any given year. Sköld *et al.* (1994) also commented on the high mortality and low rates of recruitment in this species. In Galway Bay populations (O'Connor *et al.*, 1983), small individuals make up approximately 5% of the population in any given month, which also suggests the actual level of input into the adult population is extremely low. Muus (1981) estimated the lifespan of *Amphiura filiformis* to be 25 years based on oral width (which does not change with gonadal growth) with recruitment taking place at the 0.3 mm disc size. In very long-term studies of *Amphiura filiformis* populations in Galway Bay, a lifespan of some 20 years is possible (O'Connor *et al.*, 1983).

Amphiura filiformis reaches sexual maturity after 2 years, breeds annually and, in the UK, one period of recruitment occurs in the autumn (Pedrotti, 1993). The species is thought to have a long pelagic life. Sköld *et al.* (1994) estimated the time lag between full gonads and settlement to be 88 days. This duration is comparable to the time period when pelagic larvae have been recorded in the plankton from July to November in one prior study, and August to December in another prior study (Fosshagen, 1965; Thorson, 1946, respectively, cited in Sköld *et al.*, 1994). A long planktonic life stage means this species is predicted to disperse over considerable distances. However, the growth rate is relatively slow so recovery of the biomass is likely to take as much as 10 years after initial re-colonization of the seabed has taken place (MES, 2010). Gilkinson *et al.* (2005) found that brittle star species increased 100% 1 year after experimental hydraulic clam dredging, suggesting resilience is high. However, brittle star species show large fluctuations in populations over time and this increase may be related to high recruitment or migration in this period.

Resilience assessment. Little evidence was found on the life history and potential recovery rates of the important characterizng maldanid polychaetes and cumaceans. The *Amphiura* component of the community may recover within a few years (2-10 years) after significant disturbance ('Low' or 'None' resistance). However, due to limited evidence a resilience of **Medium** is assumed, where the biotope suffers a significant loss in the population of the important characteristic species. Due to limited evidence on recovery rates of characterizing species, low confidence is associated with this assessment.

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

Hydrological Pressures

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

Maldane sarsi has a global distribution including the Red Sea and Mexico where temperatures are above the range experienced in UK and Irish Seas (4-19°C, Huthnance, 2010) Therefore, it would be expected to be resistant to the pressure at the benchmark levels.

Eudorellopsis deformis is recorded as occurring in maximum temperatures of 12.8°C in non-peer reviewed literature (OBIS, 2016) and is recorded from the Arctic Sea, the Bering Sea and Greenland south to Washington on the west Atlantic but only from Shetland to the Celtic Sea in the North East Atlantic. Information on the response of *Eudorellopsis deformis* to changes in temperature is limited. In shallow waters, where light penetration supports photosynthesis, the abundance of *Eudorellopsis deformis* is linked to benthic primary productivity (Schukel *et al*., 2010). Shukel *et al.* (2010) found that the highest abundance occurred where an increased abundance of pelagic and epipelic diatoms occurred.

Amphiura filiformis is distributed in waters to the north and south of Britain and Ireland, a distribution that suggests it may be resistant of a long-term change in temperature of 2 °C. In Galway Bay, long-term recordings of water temperature at a site of high-density aggregations of *Amphiura filiformis* showed the species is subject to annual variations in temperature of about 10°C (O'Connor *et al*., 1983). Increases in temperature may affect growth and fecundity. Muus (1981) showed that juvenile *Amphiura filiformis* are capable of much higher growth rates in experiments with temperatures between 12 and 17°C. Juvenile disk diameter increased from 0.5 to 3.0mm in 28 weeks under these conditions compared to over 2 years in the North Sea (Duineveld & Van Noort, 1986). Recovery of normal growth rates and fecundity are likely to be rapid on return to pre-impact temperatures and so resilience is likely to be high.

Sensitivity assessment. The characterizing species of the biotopes are widely distributed and likely to occur both north and south of the British Isles, where typical surface water temperatures vary seasonally from 4-19°C (Huthnance, 2010). No information was found on the maximum temperature tolerated by the characterizing species. Resistance and Resilience are assessed as '**High**' (based on distribution) and the biotope is assessed as '**Not sensitive**'.

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

The characterizing species all occupy temperature ranges that extend below the minimum for UK seas (4°C (Huthnance, 2010). This suggests they would have high resistance to a decrease in temperature at the pressure benchmark levels. A decrease in temperature may, however, reduce food availability and affect the timing of reproduction and so affect abundance in both the short and long-term.

The abundance of *Eudorellopsis deformis* is linked to benthic primary productivity (Schukel, 2010). Schukel *et al.* (2010) found that the highest abundance occurred where an increased abundance of pelagic and epipelic diatoms occurred. Diatom abundance is linked to increases in sea surface temperature, combined with increased nutrient levels (Schukel, 2010). A decrease in temperature may, therefore, limit the abundance of food sources and this, in turn, may lead to a decrease in *Eudorellopsis deformis* abundance.

Echinoderms, including *Amphiura filiformis*, of the North Sea, seem periodically affected by winter cold. A population at 27 m depth off the Danish coast was killed by the winter of 1962-63 (Muus, 1981) and a population at 35-50 m depth in the inner German Bight was killed in the winter of 1969-1970 and a new population not re-established until 1974 (Gerdes, 1977). Ursin (1960, cited in Gerdes, 1977) suggested that *Amphiura filiformis* does not occur in areas with winter temperatures below 4 °C although in Helgoland waters could tolerate temperatures as low as 3.5 °C. Low temperatures are a limiting factor for breeding which takes place during the warmest months in the UK. Recovery of normal growth rates and fecundity will be rapid on return to pre-impact temperatures.

Sensitivity assessment. Limited evidence was available on *Eudorellopsis deformis* and *Maldane sarsi* limiting confidence in assessment for these species. However, their distribution suggests that they would be resistant to this pressure at the benchmark level. But resistance is assessed as **'Medium'** due to potential mortality of *Amphiura filiformis* and limits to the abundance of *Eudorellopsis deformis.* Resilience is assessed as **'High'** and sensitivity is assessed as '**Low'.**

Salinity increase (local)	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

This biotope occurs in full salinity, a change at the pressure benchmark refers to a change to hypersalinity (>40ppt). No directly relevant evidence was found to assess this pressure. A study from the Canary Islands indicates that exposure to high salinity effluents (47- 50 psu) from desalination plants alter the structure of biological assemblages, reducing species richness and abundance (Riera *et al*., 2012). Bivalves and amphipods appear to be less tolerant of increased salinity than polychaetes and were largely absent at the point of discharge.

Sensitivity assessment. High saline effluents alter the structure of biological assemblages. Polychaete species may be more tolerant than other species but an increase in salinity is likely to result in declines in species richness and abundance based on Riera *et al.* (2012). Biotope resistance is assessed as **'Low'** and resilience as **'Medium'** (following restoration of typical salinity regime). Biotope sensitivity is assessed as **'Medium'**.

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

The sensitivity assessment pressure benchmark considers a decrease in one MNCR category from fully marine 30-40‰ to variable 18-40‰. No evidence was found for salinity tolerances of *Eudorellopsis deformis* and *Maldane sarsi*, but as subtidal species, inhabiting fully marine conditions a decrease in one MNCR salinity category is likely to have a negative impact on populations. *Amphiura filiformis* is a subtidal species generally occurring in areas of full salinity although the species has been recorded from the Sado estuary in Portugal (Monteiro Marques, 1982; cited in Stickle & Diehl, 1987) where the salinity is 26 psu. However, echinoderms are generally regarded to be stenohaline organisms and a salinity change to the lower variable range is likely to reduce the abundance of *Amphiura filiformis.*

Sensitivity assessment. Resistance is assessed as **'Low'** due to the likely large reductions in abundance of populations of characterizing species. If conditions return to fully marine recoverability is **'Medium'** and Sensitivity is assessed as **'Medium'.**

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

The sediments that characterize this biotope are muddy sands. A change at the pressure benchmark (increase or decrease) may lead to some changes in sediment sorting. However, it is unlikely that a decrease at the pressure benchmark would lead to the development of a mud sediment as fine silts require lower velocities to deposit than erode. An increase at the pressure benchmark may lead to increased erosion of fine silts but the biotope is likely to persist. *Maldane sarsi* favour sand or non-cohesive muddy sand and therefore populations may persist following some removal of fine sediments.

As a suspension feeder *Amphiura filiformis* utilizes currents to feed, water flow rate will be of primary importance. Individuals respond rapidly to currents by extending their arms vertically to feed. Under laboratory conditions, individuals would be unlikely to maintain this position if water movement were to increase to 3-6 knots (1.5 to 3.1 m/s) and so would retract their arms (Buchanan, 1964). A long-term increase in water flow rate is also likely to change the nature of the sediment removing finer particles. High density aggregations of *Amphiura filiformis* seem to be characteristic of fine sediments with silt/clay values of 10 to 20% (O'Conner *et al.*, 1983) so removal of the finer matter is likely to reduce abundance. At the highest benchmark level feeding would be significantly impaired and viability of the population reduced. Over the period of a year, many individuals would be likely to die if an increase of water flow rate to 1.5 – 3.1 m/s occurred.

Amphiura filiformis are less sensitive than some species to reductions in flow velocity as the species will change to deposit feeding in stagnant water or areas of very low water flow (Ockelmann & Muus, 1978). Under laboratory conditions *Amphiura filiformis* was shown to maintain arms in a vertical feeding position at currents of 30 cm/s (approx. 0.6 knots or 0.3 m/s) (Buchanan, 1964), suggesting only weak flow is required to initiate this feeding method.

Sensitivity assessment. Although there are no core biotope records for this biotope to provide evidence of the strength of tidal streams the biotope occurs within, other deep offshore sand biotopes occur in weaker tidal streams. At the benchmark level, an increase may increase food supply but cause some re-suspension of finer sediment. Resistance at the benchmark pressure is assessed as '**High**', Resilience is assessed as '**High**' and Sensitivity is, therefore, **'Not sensitive'.**

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

The biotope occurs sub-tidally, sensitivity to this pressure has not been assessed as this pressure is considered **'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

Amphiura filiformis is found in sheltered habitats characterized by fine muddy sandy sediments and low wave exposure. The species is likely to be intolerant of increases in wave exposure because strong wave action can resuspend the sediment and break up and scatter *Amphiura filiformis*. However, the species is able to burrow further into the sediment and if displaced is able to reburrow. Re-suspension of sediment would also impact infauna such as maldanid polychaetes including *Maldane sarsi* and the cumacean *Eudorellopsis deformis*. However, deeper biotopes are only likely to be impacted by the largest storms and at the pressure benchmark level, the biotope is likely to be unaffected.

Sensitivity assessment. The biotope occurs subtidally at depths that would be outside the influence of all but the largest increases in wave height. Therefore, the biotope is probably **Not sensitive** (Resistance and Resilience are High) to changes in wave action at the benchmark level.

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

The biotope is considered This pressure is **Not assessed** but evidence is presented where available, although contamination at levels greater than the pressure benchmark may adversely affect the biotope.

No evidence was found for maldanid and cumacean sensitivity to this pressure.

Echinoderms tend to be very sensitive to various types of marine pollution (Newton & McKenzie, 1995). A study of the influence of TBT on arm regeneration in another brittle star *Ophioderma brevispina*, revealed some evidence of inhibition at 10ng/l and significant inhibition at 100 ng/l. It is suggested that TBT acts via the nervous system, although direct action on the tissues at the point of breakage could not be excluded. Adult echinoderms are known to be efficient concentrators of heavy metals including those that are biologically active and toxic (Ag, Zn, Cd and Co) (Hutchins *et al*., 1996). This suggests species such as *Amphiura filiformis* would be affected by contamination. There is no information available regarding the effects of this bioaccumulation. Gounin *et al*. (1995) studied the transfer of heavy metals (Fe, Mn, Pb, Cu, Cd) through *Ophiothrix* beds. They concluded that heavy metals ingested or absorbed by the animals transited rapidly through the body and were expelled in the faeces and did not appear to accumulate the metals in their tissues. More recent studies by Deheyn & Latz (2006), at the Bay of San Diego found that heavy metal accumulation in brittlestars occurs both through dissolved metals as well as through the diet, to the arms and disc, respectively. Similarly, Sbaihat *et al*. (2013) measured concentrations of heavy metals (Cu, Ni, Cd, Co, Cr and Pb) in the body of *Ophiocoma scolopendrina* collected from the Gulf of Aqaba and found that most concentration was found in the central disc rather than arms and no simple correlations could be found between contaminant and body length. It is logical to suppose that brittlestars would be adversely affected by major pollution incidents such as oil spills, or by continuous exposure to toxic metals, pesticides, or the antiparasite chemicals used in cage aquaculture. The water-accumulated fraction of diesel oil has been found to be acutely toxic to *Ophiothrix fragilis* and *Ophiocomina nigra* (Newton & McKenzie, 1995). So far, however, there are no field observations of epifaunal brittlestars being damaged by any of these forms of pollution, and there seems to be no evidence of the toxicity effects of heavy metal accumulation on brittlestars.

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. Although contamination at levels greater than the pressure benchmark may adversely affect the biotope.

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, in soft sediment habitats, infaunal polychaetes, bivalves and amphipods were particularly affected. Untreated oil (e.g. from oil spills) is not a risk, since it is concentrated mainly at the surface, and deeper subtidal biotopes are protected by their depth. If oil is treated by dispersant the resulting emulsion will penetrate down the water column, especially under the influence of turbulence.

Spies & Davis (1979) found a maldanid polychaete *Praxillella affinis pacifica* at sample stations at a natural oil seep, this suggested some advantages for deposit feeders at the seep station. However, Rygg (1985) cited by Dean (2008) analysed pollution gradients in Norwegian fjords, and results showed that the absence of species including the characterizing maldanid *Maldane sarsi* were indicative of poor environmental conditions. This suggests loss of a key characterizing species is likely under hydrocarbon and PAH contamination.

In a study of the effects of oil exploration and production on benthic communities, Olsgard & Gray (1995) found *Amphiura filiformis* to be very intolerant of oil pollution. During monitoring of sediments in the Ekofisk oilfield Addy *et al*. (1978) suggest that reduced abundance of *Amphiura filiformis* within 2-3 km of the site was related to discharges of oil from the platforms and to physical disturbance of the sediment. Although acute toxicity test showed that drill cuttings containing oil based muds had a very low toxicity (LC50 52,800 ppm total hydrocarbons in test sediment) Newton & McKenzie (1998) suggest these toxicity tests are a poor predictor of chronic response. Chronic sub-lethal effects were detected around the Beryl oil platform in the North Sea where the levels of oil in the sediment were very low (3ppm) and *Amphiura filiformis* was excluded from areas nearer the platform with higher sediment oil content. However, the authors do suggest that effects may also be related to the non-hydrocarbon element of the cuttings such as metals, physical disturbance or organic enrichment. *Amphiura filiformis* is a host for symbiotic sub-cuticular bacteria. After exposure to hydrocarbons loadings of this bacteria were reduced indicating a possible sub-lethal stress to the host (Newton & McKenzie, 1995).

The 1969 West Falmouth Spill of Grade 2 diesel fuel, documented by Sanders (1978), illustrates the effects of hydrocarbons in a sheltered habitat with a soft mud/sand substrata (Suchanek, 1993). The entire benthic fauna was eradicated immediately following the spill and remobilization of oil that continued for a period >1 year after the spill contributed to much greater impact upon the habitat than that caused by the initial spill. Effects are likely to be prolonged as hydrocarbons incorporated within the sediment by bioturbation will remain for a long time owing to slow degradation under anoxic conditions. Oil covering the surface and within the sediment would prevent oxygen transport to the infauna and promote anoxia as the infauna utilise oxygen during respiration. Although this study investigates impacts on an estuarine biotope the impact on benthic infauna communities is likely to be similar in shallow sandbank biotopes.

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. Although contamination at levels greater than the pressure benchmark may adversely affect the biotope.

No evidence was found for the response of the characterizing maldanid polychaetes and cumaceans to synthetic compound contamination. Although at benchmark levels impacts are likely to be minimal it is important to consider that contamination at levels greater than the pressure benchmark may adversely influence the biotope.

Echinoderms tend to be very sensitive to various types of marine pollution (Newton & McKenzie, 1995) and so an intolerance assessment of high is reported. A study of the influence of TBT on arm regeneration in another brittle star *Ophioderma brevispina*, revealed some evidence of inhibition at 10ng/l and significant inhibition at 100 ng/l. It is suggested that TBT acts via the nervous system, although direct action on the tissues at the point of breakage could not be excluded.

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

Insufficient information was available in relation to characterizing species to assess this pressure. There is insufficient information on the intolerance of *Amphiura filiformis* to radionuclides, although adult echinoderms, such as *Ophiothrix fragilis*, are known to be efficient concentrators of radionuclides (Hutchins *et al.*, 1996).

Limited evidence is available on other infauna species Beasley & Fowler (1976) and Germain *et al.*, (1984) examined the accumulation and transfers of radionuclides in *Hediste diversicolor* from sediments contaminated with americium and plutonium derived from nuclear weapons testing and the release of liquid effluent from a nuclear processing plant. Both concluded that the uptake of radionuclides by *Hediste diversicolor* was small. Beasley & Fowler (1976) found *that Hediste diversicolor* accumulated only 0.05% of the concentration of radionuclides found in the sediment. Both also considered that the predominant contamination pathway for *Hediste diversicolor* was from the interstitial water.

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

The biotope is considered This pressure is **Not assessed**. Although contamination at levels greater than the pressure benchmark may adversely affect the biotope.

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

Limited evidence was found for the effects of decreased dissolved oxygen concentrations on the characterizing species.

After winter storms, Dean (2008) found that communities were dominated by Maldanidae and Spionidae, indicative of low organic content sediments, which may indicate higher oxygen content in these locations (Dean, 2008). *Maldane sarsi* was an important characterizing species at 75m depth samples from the Swedish west coast but abundance decreased in deeper samples, where oxygen levels decreased (Nilsson & Rosenberg, 2000). *Maldane sarsi* were present in equilibrium communities but not earlier stages in succession communities. A critical lower oxygen level of ~10% of air saturation (0.75mg/l) was identified to lead to a decrease in species richness and abundance, which limited succession to the equilibrium communities (containing *Maldane sarsi*). Although evidence is limited and inferred from broader community studies it is likely *Maldane sarsi* abundance would be limited by A decrease in dissolved oxygen concentrations.

In experiments exposing benthic invertebrates to decreasing oxygen levels *Amphiura filiformis* only left its protected position in the sediment when oxygen levels fell below 0.85mg/l (Rosenberg *et al.*, 1991). This escape response increases predation risk. Mass mortality of *Amphiura filiformis* has been observed during severely low oxygen events (<0.7 mg/l) (Nilsson, 1999). Mass mortality has also been observed following large increases in eutrophication and subsequent reductions in oxygen (Vistisen & Vismann, 1997). Also associated with eutrophic related oxygen depletion is an increase in sulphide concentration in the sediment, which is very toxic to most aerobic organisms. Decreases in sub-cuticular bacteria have also been recorded following nutrient limitation. Reductions in these bacteria are probably indicative of levels of stress and may lead to mortality (Newton & McKenzie, 1995). However, at oxygen concentrations between 0.85mg/l and 1.0mg/l, the species was able to survive for several weeks (Rosenberg *et al*., 1991).

The regeneration rate of arms is significantly decreased at low oxygen concentrations (1.8-2.2 mg/l) (Nilsson, 1999), growth rate is decreased in oxygen concentrations of <2.7 mg/l and spawning is restricted (Nilsson & Sköld, 1996). Therefore at the benchmark level growth rate and regeneration rate are decreased reducing the viability of the population. On return to normal oxygenation levels recovery will be very rapid.

Sensitivity assessment. At the benchmark level the species characterizing the community are likely to show some resistance although feeding, health (indicated by rate of regrowth of arms in *Amphiura* filiformis) and reproduction are likely to be affected, affecting long-term population levels. Resistance is therefore **'Medium',** Resilience is **'High'** and sensitivity is assessed as **'Low'.** A decrease in oxygen levels below 0.75 mg/l is likely to lead to the loss of the maldanid polychaetes, based on Nilsson & Rosenberg, 2000) and resistance, in that instance, would be **'Low'.**

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

Primary production is influenced by light levels and sea surface temperature and levels of nutrient enrichment. The proportion of surface and subsurface deposit feeders has been linked to changes in the magnitude and pattern of primary production reaching the sea floor (Desrosiers *et al*., 2000). Increased nutrients are most likely to affect abundance of phytoplankton which may include toxic algae. This primary effect resulting from elevated nutrients will affect other biological elements or features (e.g. toxins produced by phytoplankton blooms or de-oxygenation of sediments) and may lead to 'undesirable disturbance' to the structure and functioning of the ecosystem. With enhanced primary productivity in the water column, organic detritus that falls to the seabed may also be enhanced.

Interface feeders such as *Amphiura filiformis* have been reported to respond rapidly to increased primary production that may result from increased nutrient availability (Pearson & Mannvik, 1998, cited in Schückel *et al*., 2010). The *Amphiura filiformis* populations increased between 1972 and 1988 within the Danish Kagerrak-Kattegat area. The data indicated that fish populations had not decreased, so predation was assumed to not be the main cause of the population increase. Instead, increased organic enrichment, linked to increased primary and secondary productivity levels, and so available food sources, were concluded to be the main factor supporting the increase (Josefson & Jensen, 1992).

Sensitivity assessment. The overall species diversity in these biotopes is likely to decline given the varying responses of the species occurring here to nutrient enrichment (Hiscock *et al*., 2005). The community, and hence the biotopes, may change to one dominated by nutrient enrichment resistant species, in particular polychaete worms. However, these changes generally refer to gross nutrient enrichment. A decrease in nutrient availability may result in impaired growth and fecundity although species diversity is not likely to be affected significantly. Nevertheless, the biotope is **Not sensitive** at the pressure benchmark that assumes compliance with good status as defined by the WFD. Although contamination at levels greater than the pressure benchmark may adversely affect the biotope.

	Resistance	Resilience	Sensitivity
Organic enrichment	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

The tube-building polychaete *Maldane sarsi* was not found at inshore stations within the benthic fauna in Adventfjorden, Svalbard. It was suggested that its lack of abundance were due to high sedimentation rates, increased organic effluent and grain size (coarser) (Dahl, 2007). A decrease in oxygen levels may occur in relation to increased organic enrichment. *Maldane sarsi* was an important characterizing species at 75 m depth samples from the Swedish west coast but abundance decreased in deeper samples, where oxygen levels decreased (Nilsson & Rosenberg, 2000). *Maldane sarsi* were present in equilibrium communities but not earlier stages in succession communities. A critical lower oxygen level of ~10% of air saturation was identified to lead to a decrease in species richness and abundance, which limited succession to the equilibrium communities (containing *Maldane sarsi*). Although evidence is limited and inferred from broader studies of oxygen levels it is likely *Maldane sarsi* abundance may be limited by increased organic enrichment.

Amphiura filiformis populations increased between 1972 and 1988 within the Danish kagerrak-Kattegat area. As data indicated fish populations have not decreased, predation was assumed to not be the main cause of the population increase, increased organic enrichment, linked to increases in primary and secondary productivity levels, and so available food sources were concluded to be the main factor supporting the increase (Josefson & Jensen, 1992). *Amphiura filiformis* was shown to respond positively to increased organic enrichment in further studies (Nilsson, 1999). In the Skagerrak in the North Sea, a massive increase in abundance and biomass of the species between 1972 and 1988 was attributed to organic enrichment (Josefson, 1990). Rosenberg *et al*. (1997) also reported that *Amphiura filiformis* appeared to be more densely packed in the sediment when food occurred superabundantly compared to when food was less common. Sköld & Gunnarsson (1996) reported enhanced growth and gonad development in response to short-term enrichment of sediment cores containing *Amphiura filiformis* maintained in laboratory mesocosms. Individuals from the more densely populated offshore sediment did not experience enhanced somatic growth (unlike those from the less populated coastal site) indicating a negatively density-dependent relationship.

Sensitivity assessment. Evidence was limited and so confidence low for assessment based on *Maldane sarsi*, and the cumacean *Eudorellopsis deformis.* There was more evidence of response of *Amphiura filiformis*, which responds positively to organic enrichment. At the benchmark pressure, resistance is assessed as '**Low**' due to the impact on *Maldane sarsi* population. Resilience '**Medium** and sensitivity as '**Medium**. The potential for positive effects for increased food resources may be offset if depletion of oxygen levels occurs, as this depletion oxygen is likely to negatively affect *Maldane sarsi.*

Physical Pressures

Resistance	Resilience	Sensitivity

Physical loss (to land or freshwater habitat)

Resistance	Resilience	Sensitivity
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)

Resistance	Resilience	Sensitivity
None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

A change from sedimentary to rock substrata would result in loss of the biotope.

Sensitivity assessment. The resistance to this change is '**None**', and the resilience is assessed as '**Very low'** as the assessed change at the pressure benchmark is permanent. The biotope is assessed to have a '**High**' sensitivity to this pressure at the benchmark.

Physical change (to another sediment type)

Resistance	Resilience	Sensitivity
None Q: High A: Medium C: Medium	Very Low Q: High A: High C: High	Medium Q: High A: Medium C: Medium

This biotope occurs in deep offshore sand or non-cohesive muddy sand (JNCC, 2015). *Maldane sarsi* buries its head down in the substratum and favours finer sediment with mud content. Although increased gravel content may be easier to bury into the available studies record the species as a characterizing species of communities in sand and sandy mud habitats (Dahle *et al.*, 1998).

Eudorellopsis deformis feeds on diatoms and organic material on the surface of sand grains. If a pressure causes removal of sand or muddy sand, or replacement with other sediment types (such as an increase in gravel content), this species is likely to be lost and sediment characteristics will have to return to sand or muddy sand before the species is likely to occur in high densities.

Amphiura filiformis requires muddy sand or sandy mud in which to bury and although is likely to be resilient over short periods to increased coarse sediment, individuals are likely to relocate if sediment grain size increases.

Sensitivity assessment. Based on species habitat preferences a change in sediment type to mud or coarse sediments would result in loss of the biotope and characterizing species. Resistance is **'None'**, resilience is **Very low** (the pressure benchmark is a permanent change) and sensitivity is assessed as **High**. It is important to consider that further increases in sediment grain size and increase in gravel content would have a greater impact on the biotope and lead to a change in species community (as characterizing species show a preference for smaller grain size sediments with some mud content).

Habitat structure changes - removal of substratum (extraction)

Resistance	Resilience	Sensitivity
None Q: Low A: Low C: Low	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

Newell *et al.* (1998) stated that removal of 0.5 m depth of sediment is likely to eliminate benthos from the affected area. Recovery of the sediment structure by infilling will depend on local factors including the mobility of sediments, sediment supply, hydrodynamics and the spatial scale of the area affected. Removal of 30 cm of sediment at the benchmark level will remove species that occur on the surface and within the upper layers of sediment.

As a tube building polychaete *Maldane sarsi* has limited mobility, populations will be removed in areas that experience extraction of substratum to 30 cm. Maldanid polychaetes typically develop inside a protective mucous cocoon, until the initiation of segmentation demarcates the onset of larval life (Brinkmann & Wanninger, 2010). Removal of these cocoons as well as adults in the biotope will hinder recovery in impacted areas.

Gilkinson *et al.* (2005) found *Eudorellopsis deformis* occurred in high abundance amongst opportunistic species communities colonizing areas of coastal east Canada, 1 year after experimental hydraulic clam dredging. Initially after dredging all fauna had decreased in abundance with greatest declines in the dredge furrows. The increase in opportunistic species, including *Eudorellopsis deformis* and brittle star species by over 100% compared to pre-dredging levels suggests *Eudorellopsis deformis* and *Amphiura filiformis* will increase in abundance within the first year following extraction of substratum. However, this would be dependent upon sediment supply providing deposition of sand and non-cohesive muddy sand.

Sensitivity assessment. Resistance is assessed as **'None'** as populations of characterizing species would be removed from the sediment. Resilience is assessed as **'Medium'** as full recovery of maldanid populations may require more than 2 years. Sensitivity is therefore assessed as '**Medium**'.

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

Surface compaction can collapse infauna burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content. The tops of burrows may be damaged and repaired subsequently at energetic costs to their inhabitants.

The characterizing species and associated infaunal community are relatively protected from temporary surface disturbance e.g. potting/netting, by burrowing life habit. An assessment at an expert workshop convened to assess sensitivity to fishing activities for the Beaumaris approach (Hall *et al.*, 2008), suggested that intertidal muddy sand habitats had low to no sensitivity to surface abrasion from correctly deployed nets, weights and anchors (Hall *et al.*, 2008) at all levels of activity. Subtidal muddy sand sediments are likely to have similar resistance to this pressure.

Brittlestars have fragile arms which are likely to be damaged by abrasion or physical disturbance. *Amphiura filiformis* burrows in the sediment and extends only its arms when feeding. Ramsay *et al.* (1998) suggest that *Amphiura spp.* may be less susceptible to beam trawl damage than other species like echinoids or tube dwelling amphipods and polychaetes. For example, Bergman & Hup (1992) found that beam trawling in the North Sea had no significant direct effect on small brittle stars. Brittlestars can tolerate considerable damage to arms and even the disk without suffering mortality and are capable of arm and even some disk regeneration.

Abrasion may cause sediment scouring. Depending on the intensity sediment composition is likely to change. Russell (1938) concluded that a change in sediment composition is a slow process requiring >1 abrading event. Abrasion by natural events is unlikely to have a significant effect on the biodiversity of the habitat. However, Kaiser *et al*. (2001) demonstrated that polychaetes in intertidal muddy sands are susceptible to damage by abrasion from fishing activity at the sediment surface. Hinz *et al.* (2009) also showed that otter trawling from a Nephrops fishery in muddy sediments had a significant, negative effect on benthic macrofauna communities. Benthic infauna displayed consistent negative responses to trawling and *Amphiura filiformis* abundance display a negative correlation with increased trawling activity.

Coates *et al.* (2014) found that scour and re-deposition of scored material influenced macrobenthic communities around the base of a wind farm tower in the Belgium part of the North Sea. Deposition of fine particle sediment, disturbed by scour around the base of a wind farm tower led to higher macrobenthic densities and created a shift in macrobenthic communities around the wind farm tower (in the direction fine material had settled) (Coates *et al*., 2014).

Resilience of characterizing species will depend on reproductive traits. The egg cocoons of *Maldane sarsi* are likely to be sensitive to the effects of abrasive sediment transportation.

Sensitivity assessment. Resistance is assessed as **'Medium'** as some mortality of characterizing species may occur although due to burrowing nature of species such as *Maldane sarsi* and *Amphiura filiformis* entire populations will not be removed. Resilience is assessed as **'Medium'** as sediment would be required to return to sand or non-cohesive muddy sand and full recovery may take as much as 10 years. Sensitivity is,therefore, assessed as '**Medium**'.

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

Penetration and or disturbance of the substratum would result in similar effects as 'abrasion' or 'extraction' of this biotope. As the characterizing species are burrowing species the impact from damage to the sub-surface sediments would be greater than damage to the sea bed surface alone. Consequently the pressure has been given the same sensitivity assessment as removal.

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 '**Medium**', and sensitivity is assessed as '**Medium**'.

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 to Maldanid polychaetes and *Amphiura filiformis.* As the species live in the sediment they are also likely to be adapted to increased suspended sediment (and turbidity). However, alterations in the availability of food or the energetic costs in obtaining food or changes in scour could either increase or decrease habitat suitability for characterizing species.

Amphiura filiformis is a passive suspension feeder. Increases in siltation of inorganic particles may interfere with the feeding of this species. However, the species live in burrows maintained by mucus so *Amphiura filiformis* can tolerate slight increases in siltation by removing an excess of particles with mucus production. On the Northumberland coast *Amphiura filiformis* is abundant in an area close to a rich supply of fine sediment from coastal erosion and run-off (Buchanan, 1964).

Sensitivity assessment. Resistance is assessed as **'High',** Resilience is assessed as '**High'** and Sensitivity is assessed as **'Not Sensitive'.** It is important to consider that larger increases in suspended solids are likely to have a negative impact on characterizing species, as smaller or limited mobility species such as Maldanid polychaetes and *Eudorellopsis deformis* may suffer mortality or have feeding interrupted and encounter greater energetic costs.

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

Maldane sarsi favour sand or non-cohesive muddy sand but are susceptible to burial, due to limited mobility. Fine sediment is likely to be a more difficult barrier to upward burrowing than coarse sediment (Turk & Risk 1981), however, fine sand or muddy sand is preferred by *Maldane sarsi* so it is likely that smaller levels of deposited fine sediment will have limited impact on the species abundance.

High density aggregations of *Amphiura filiformis* seem to be characteristic of fine sediments with silt/clay values of 10 to 20% (O'Conner *et al*., 1983) so additional finer matter is likely to support abundance. Feeding may be impaired at the time material is deposited as the animal adjusts its position in the sediment.

Sensitivity assessment. 'Light' deposition of up to 5 cm of fine material in a single event is likely to cause some reduction of feeding and energetic costs to characterizing species but recovery is likely to be rapid and food resources may be provided by deposited material. Resistance is assessed as '**High',** Resilience is assessed as '**High**' and sensitivity as '**Not Sensitive**'.

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

Heavier deposition of up to 30 cm of fine material is likely to negatively impact characterizing species. In a study in Svalbard, Norway, Dahl (2007) found that *Maldane sarsi* was not found in the innermost sample stations. Environmental factors contributing to community structure at these sites included high sedimentation rates, increased organic effluent and the presence of coarser sediment (Dahl, 2007).

Maldane sarsi has limited mobility and is at risk of burial and high mortality following heavy deposition of fine material. *Amphiura filiformis* is an infaunal species which can burrow and lives up to a depth of 4 cm within the sediment.Hill (2001) states that dense beds of brittlestars do not persist in areas of excessive sedimentation, because high levels of sediment foul the brittlestars feeding apparatus (tube feet and arm spines), and ultimately suffocates them (Schäfer, 1962, cited in Aronson, 1992). Aronson (1989, cited in Hill, 2001) referred to the demise of Warner's (1971) *Ophiothrix* bed in Torbay, and tentatively suggested it was due to increased sedimentation caused by the localised dumping of construction materials (Aronson, 1989, cited in Hill, 2001).

Eudorellopsis deformis is a smaller cumacean species, growing to 5mm and smothering by up to 30cm of fine material would be likely to cause high mortality. Access to food resources such as diatoms is likely to be limited. As an opportunistic species resilience is likely to be rapid through resettlement of juveniles.

Sensitivity assessment. Resistance is assessed as **'Low'** as there is likely to be high mortality of less mobile characterizing species , Resilience is assessed as '**Medium**' as egg laying species such as the maldanid polychaetes are likely to recover slowly and recovery is dependent upon the deposited sediment being fine sand or muddy sand. Sensitivity is therefore assessed as '**Medium**'. Confidence is low as there was limited peer reviewed evidence on the species themselves and expert judgement using evidence from case studies of similar pressures.

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

No evidence was found for the impact of litter on characterizing species for this biotope, although studies show impacts from ingestion of micro plastics by sub surface deposit feeding worms (*Arenicola marina)* and toxicants present in cigarette butts have been shown to impact the burrowing times and cause DNA damage in ragworms *Hediste diversicolor*.

Litter, in the form of cigarette butts has been shown to have an impact on ragworms. *Hediste diversicolor* showed increased burrowing times, 30% weight loss and a >2 fold increase in DNA damage when exposed to water with toxicants (present in cigarette butts) in quantities 60 fold lower than reported from urban run-off (Wright *et al*., 2015). Studies are limited on impacts of litter on infauna and this UK study suggests health of infauna populations are negatively impacted by this pressure.

Studies of sediment dwelling, sub surface deposit feeding worms, a trait shared by species abundant in this biotope, showed negative impacts from ingestion of microplastics. For instance, *Arenicola marina* ingests micro-plastics that are present within the sediment it feeds within. Wright *et al*. (2013) carried out a lab study that displayed presence of micro-plastics (5% UPVC) significantly reduced feeding activity when compared to concentrations of 1% UPVC and controls. As a result, *Arenicola marina* showed significantly decreased energy reserves (by 50%), took longer to digest food, and decreased bioturbation levels, which would be likely to impact colonisation of sediment by other species and reducing diversity.

Sensitivity assessment. 'Not assesed' as this presure lacks a benchmark, however, both microplastics and the toxicants present in cigarette butts are likely to have negative impacts on the characterizing species.

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 for the impact of electromagnetic changes on characterizing species for this biotope.

Sensitivtiy assessment. 'No evidence' was returned to complete a sensitivity assessment. Sources of artificial electric and magnetic fields, such as renewable energy array power cables have been shown to alter the behaviour and movement patterns of shark and ray species which may affect predation of species feeding on infauna such as flatfish (Gill *et al*. 2009; Winter *et al*. 2010)

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 and in response may retreat in to the sediment for protection, this possible behaviour is likely to reduce time feeding but longer term impacts are unlikely. For example, brittlestar beds have been recorded from Kinsale Harbour (Hughes, 1998b) on the south coast of Ireland where there is likely to be noise disturbance from passing boat traffic.

Sensitivity assessment. At the benchmark level the community is unlikely to be sensitive to noise and this pressue is considered to be '**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

All characterizing species live in the sediment and do not rely on light levels directly to feed or find prey so limited direct impact is expected. The biotope also occurs in the deeper offshore regions and will not be influenced directly by light levels. Most species will respond to the shading caused by the approach of a predator, however, their visual acuity is probably very low. Even then, additional disturbance, such as an electronic flash, caused the retraction of palps and cirri and cessation of all activity for some minutes. Visual disturbance, in the form of direct illumination during the species' active period at night, may therefore result in loss of feeding opportunities, which may compromise growth and reproduction.

Increased light levels along with increased nutrients lead to increased levels of primary production and plankton blooms. Diatoms are a principal food source of *Eudorellopsis deformis* and decreased abundance of this food source reaching the sea bed from the water column above is likely if light levels are decreased. Other changes to the productivity of the water column adjacent to the biotope may, also, occur. Shading will prevent photosynthesis leading to death or migration of sediment microalgae altering sediment cohesion and food supply to higher trophic levels. The impact of these indirect effects is difficult to quantify.

Sensitivity assessment. Based on the direct impact, biotope resistance is assessed as '**High**' and resilience is assessed as '**High**' (by default) and the biotope is considered to be '**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

Barriers that reduce the degree of tidal excursion may alter larval supply to suitable habitats from source populations. Barriers may also act as stepping stones for larval supply over greater distances (Adams *et al*., 2014). Conversely, barriers may enhance local population supply by preventing the loss of larvae from enclosed habitats to environments, which are unfavourable, reducing settlement outside of the population. Barriers such as renewable energy developments such as a tidal barrier are unlikely in deeper offshore biotopes. However, other renewable energy devices such as tidal energy turbines, or the bases of wind turbines or wave energy devices, may affect hydrodynamics and so migration pathways for larvae into and out of the biotope (Adams *et al*., 2014; Coates *et al.* 2014). Evidence on this pressure is limited. Adams *et al. (*2014) modelled the effects of renewable energy devices placed Scottish waters to assess the impact of novel habitat on the spread of organisms and the effect of physical barriers to dispersal. The results suggest this pressure has implications for existing species' distributions and genetic population structure. They also suggest there are likely effects on the spread of non-native species, and "climate migrants" (Adams *et al.* 2014).

Sensitivity assessment. Deeper, offshore biotopes are less likely to experience barriers that alter tidal excursion, although offshore renewable energy developments may provide stepping stones for species movement and also alter local hydrodynamic conditions, and so larvae dispersal pathways. Due to deeper, offshore position of the biotope, Resistance to this pressure is assessed as '**High**' and resilience as '**High**' by default. This biotope is, therefore, 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 interaction with bottom towed fishing gears and moorings are 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

The 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, so this pressure is assessed as **'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

The important characterizing and denominated species in this biotope are not cultivated or likely to be translocated. This pressure is therefore considered '**Not relevant**'.

Introduction or spread of invasive non-indigenous species	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence was found that non-indigenous species were present at, or had an adverse impact on this biotope and the associated defining species.

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

Insufficient evidence is currently available to support an assessment and '**No evidence'** is recorded.

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

The sensitivity assessment for this pressure considers any biological effects resulting from the removal of target species characterizing this biotope. The characterizing species, including brittlestars, are not targeted by commercial fisheries and hence not directly affected by this pressure, although they may be directly removed or damaged by static or mobile gears that are targeting other species (see removal of non-target species and physical damage pressures).

Sensitivity assessment. As species within the biotope are not directly targeted this pressure is considered **'Not relevant'.**

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

Gilkinson *et al.* (2005) found that *Eudorellopsis deformis* occurred in high abundance amongst opportunistic species communities colonizing areas of coastal east Canada 1 year after experimental hydraulic clam dredging. Initially after dredging, all fauna had decreased in abundance with greatest declines in the dredge furrows. The increase in opportunistic species, including *Eudorellopsis deformis* compared to pre-dredging levels suggests *Eudorellopsis deformis* are likely to increase in abundance within the first year following dredge or bottom towed fishing activities. *Maldane sarsi* is likely to be disturbed or physically damaged by bottom towed fishing gears penetrating the substratum to depths of up to 10cm, such as dredge or trawl gears. Re-suspension of finer sediment as a result of dredge or bottom towed fishing gears such as beam trawls may also increase risk of burial *Maldane sarsi.*

Incidental removal of the characterizing species would alter the character of the biotope and the delivery of ecosystem services such as secondary production and habitat provision. *Maldane sarsi has been* identified as a key food source for fish species in a food web model for Kongsfjorden, Norway (Hop *et al.* 2002). The loss of the *Maldane sarsi* population could, therefore, impact other trophic levels.

Sensitivity assessment. Evidence from existing studies suggests initial impact to the characterizing species is likely but recovery will be rapid, as species are either mobile or recolonize disturbed areas rapidly. Opportunistic species are likely to benefit from disturbance but populations of tube building species such as *Maldane sarsi* are likely to be impacted. This impact over limited spatial scales is unlikely to impact the biotope but will cause an alteration in the abundant species contributing to benthic species communities, which may alter the food available to higher trophic levels. Resistance is assessed as '**Medium',** resilience is assessed as '**High'** and biotope sensitivity is assessed as '**Low'.**

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