# Foraminiferans and *Thyasira* sp. in deep circalittoral fine mud

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

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2016-06-01

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/215]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

This review can be cited as:
Tillin, H.M. & Riley, K., 2016. Foraminiferans and [Thyasira] sp. in deep circalittoral fine mud. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom.
DOI https://dx.doi.org/10.17031/marlinhab.215.1

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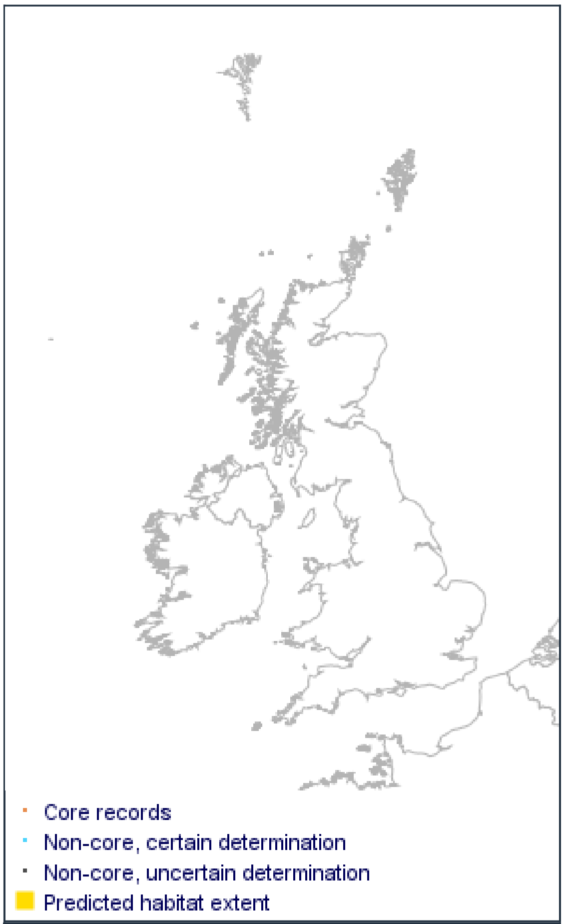

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

**Researched by** Dr Heidi Tillin & Karen Riley **Refereed by** This information is not refereed.

# Summary

## UK and Ireland classification

| | | |
|---|---|---|
| **EUNIS 2008** | A5.372 | Foraminiferans and *Thyasira* spp. in deep circalittoral soft mud |
| **JNCC 2015** | SS.SMu.OMu.ForThy | Foraminiferans and *Thyasira* sp. in deep circalittoral fine mud |
| **JNCC 2004** | SS.SMu.OMu.ForThy | Foraminiferans and *Thyasira sp.* in deep circalittoral fine mud |
| **1997 Biotope** | COS.COS.ForThy | Foramaniferans and *Thyasira sp.* in deep circalittoral soft mud |

## Description

In deep water and soft muds of Boreal and Arctic areas, a community dominated by foraminiferans and the bivalve Thyasira sp. (e.g. *Thyasira croulinensis* and *Thyasira pygmaea*) may occur (Thorson, 1957; Künitzer *et al.*, 1992). Foraminiferans such as *Saccammina*, *Psammosphaera*, *Haplophragmoides*, *Crithionina* and *Astorhiza* are important components of this community with dead tests numbering thousands per m2 (see Stephen 1923; McIntyre 1961) and sometimes visible from benthic photography (Mackie *et al*., 1995). It is likely that a community dominated by *Astorhiza* in fine sands in the Irish Sea may be another distinct biotope (E.I.S. Rees pers. comm. 2002). Polychaetes, e.g. *Paraonis gracilis*, *Myriochele heeri*, *Spiophanes kroyeri*, *Tharyx* sp., *Lumbrineris tetraura*, are also important components of this biotope. These communities appear to have no equivalent on the continental plateau further south (Glemarec, 1973) but are known from the edge of the Celtic Deep in the Irish Sea (Mackie *et al*., 1995). The benthos in these offshore areas has been shown to be principally Foraminifera and similar, rich communities may exist in Scottish sealochs (McIntyre 1961). Communities from yet deeper (northern) waters at the extremes of the North Sea may be reminiscent, although dissimilar to ForThy (see Pearson *et al*., 1996) reflecting a higher proportion of silt/clay. A fully Arctic version of this biotope has also been described (Thorson 1934, 1957) although it should be noted that Jones (1950) considered this Boreal foraminiferan community to be part of a 'Boreal Deep Mud Association' (JNCC, 2015).

## Depth range

50-100 m

## Additional information

None entered

## Listed By

- none -

## Further information sources

Search on:

G G G JNCC

# Habitat review

## Ecology

### Ecological and functional relationships

**Community structure**
The presence of the characterizing and other species in this biotope is primarily determined by the occurrence of a suitable substratum rather than by interspecific interactions. However, the component species modify the habitat and, in that way, affect each other. The following points may be relevant to this biotope.

- Deposit feeders sort and process sediment particles and may result in destabilization of the sediment, which inhibits survival of suspension feeders. This can result in a change in the vertical distribution of particles in the sediment that may facilitate vertical stratification of some species with particle size preferences. Vertical stratification of species according to sediment particle size has been observed in some soft-sediment habitats (Peterson, 1977). Polychaetes also significantly influence nutrient fluxes of nitrogen and phosphorus at the sediment-water interface, owing to their burrowing activity promoting oxygenation of the substrata. The burrowing and feeding activities of the macrofauna are likely to modify the fabric and increase the mean particle size of the upper layers of the substrata by aggregation of fine particles into faecal pellets. Such actions create a more open sediment fabric with a higher water content which affects the rigidity of the seabed (Rowden *et al.*, 1998b). Such alteration of the substratum surface can affect rates of particle resuspension.
- Bioturbation is particularly important in controlling chemical, physical and biological processes in marine sediments, especially when the influences of physical disturbances such as wave action or strong currents are minimized (Widdicombe & Austen, 1999).

Another factor determining the distribution of assemblages is the annual variation of temperature in bottom layers, influenced by the amount of stratification in the water column. COS.ForThy occurs in water depth greater than 100 m in the North Sea and Celtic Sea, i.e. deeper than the seasonally stratified water.

- Differences in stratification north and south of the Dogger Bank might explain why cold water species do not go further south than the Dogger Bank (Künitzer *et al.*, 1992).
- In Loch Nevis there is greater vertical mixing and primary production, therefore a higher rate of deposition of organic material would be present and able to support greater populations of benthic animals (McIntyre, 1961).

**Predator-prey relationships**
Most of the species living in deep mud biotopes are generally cryptic so are protected to some extent from visual surface predators. However, some species of foraminifera, such as *Astrorhiza* sp. usually live on the substratum surface. The arm tips of *Amphiura chiajei*, which is often present in this biotope, are also an important food source for demersal species.

- Foraminifera are able to move along the sediment surface. Feeding takes place when the animal is stationary, by developing a network of numerous thin extensions of cytoplasm called reticulopodia or pseudopodia (Buchanan & Hedley, 1960; Wetmore,1995). Buchanan & Hedley (1960) noted that the pseudopodia of *Astrorhiza lamicola* ramify over

the sediment surface and through the interstitial spaces to a depth of 2-3mm, extending to a distance of ~7cm from the animal.
- Depending on size and available food, foraminifera, prey on dissolved organic molecules; bacteria, diatoms and other single-celled phytoplankton; small crustacea and recently metamorphosed *Echinocardium flavesens* (Buchanan & Hedley, 1960; Wetmore, 1995; Rivkin & DeLaca, 1990).
- Buzas (1978) suggested that foraminiferans probably also represent an important food source for benthic macrofauna. Predation was thought mainly to be by demersal fish species (McIntyre, 1961).
- Dando & Southward (1986), Southward (1986), and Spiro *et al*. (1986) found that different species of *Thyasira* species show a range of nutritional dependence on bacteria in their gills; from none (heterotrophs) to complete dependence (chemoautotrophs).

## Seasonal and longer term change

Large areas of the southern North Sea are not stratified during most of the year and the summer temperature of bottom waters is high (>10°C) (Tomczak & Goedecke, 1964), while in the stratified areas north of the Dogger Bank summer temperatures are <7°C. In winter the southern North Sea is colder (4°C) than the rest of the North Sea (5-7°C). Phytoplankton productivity increases during the summer, which may lead to more available food for macrofauna. However, in the North Sea large stocks of copepods develop, which consume the summer production of phytoplankton (Fransz & Gieskes, 1984). The faecal pellets do not reach the deep water, being recycled higher in the water column (Krause, 1981) so limiting this source of food to benthos in the summer months. This could explain the low biomass of infauna in the northern North Sea (K**ü**nitzer *et al*., 1992).

## Habitat structure and complexity

The biotope has very little surface structural complexity as most species are infaunal, however, the bioturbating megafauna can create considerable structural complexity below the surface, relative to sediments that lack such animals.

- The sediment surface may appear pitted by small burrows of infaunal species, with arm tips of *Amphiura chiajei* stretching out over the surface but these are not likely to provide a significant habitat for other fauna. Infaunal and epifaunal species colonize the area and foraminifera tests may also be present in large numbers on the surface of the sediment.
- Most species living within the sediment are restricted to the area above the anoxic layer, the depth of which will vary depending upon sediment particle size and organic content. Some structural complexity is provided by the burrows of macrofauna. Burrows and the bioturbatory activity that creates them allows a much larger volume of sediment to become oxygenated, enhancing the survival and diversity of a considerable variety of smaller infaunal species (Pearson & Rosenberg, 1978).

## Productivity

Macroalgae are absent from COS.ForThy and consequently productivity is mostly secondarily derived from detritus and organic material. Allochthonous organic material is therefore derived from plankton including dead plankton sinking to the seabed and other animal productivity. Autochthonous organic material is also formed by benthic microalgae (microphytobenthos e.g. diatoms and euglenoids) and heterotrophic micro-organism production. Organic material is degraded by micro-organisms and the nutrients recycled.

### Recruitment processes

No information is known about the reproduction and recruitment of foraminifera within this biotope.

Larval development of *Thyasira equalis* is lecithotrophic and the pelagic stage is very short or quite suppressed. This agrees with the reproduction of other *Thyasira* sp., and in some cases (*Thyasira gouldi*) no pelagic stage occurs at all (Thorson, 1946). This means that larval dispersal is limited. No information relating to fecundity of *Thyasira* species within the biotope was found, however information is available for another *Thyasira* sp., and it is possible that fecundity is similar in species within the COS.ForThy biotope. Spawning of *Thyasira gouldi* occurs throughout the year, with up to 750 eggs produced each time. No information is available on the mechanism of spawning or the number of spawnings per year.

Other species that usually occur in the biotope, such as polychaetes and brittlestars usually have planktonic development, an annual reproductive cycle and are fecund.

### Time for community to reach maturity

Little is known about the mode of reproduction and recoverability of foraminifera. All other characteristic species within the biotope are fecund and species such as polychaetes and brittlestars are likely to recover fairly quickly. However, the larval development of *Thyasira equalis* is lecithotrophic and the pelagic stage is very short or quite suppressed. This agrees with the reproduction of other *Thyasira* sp., and in some cases (*Thyasira gouldi*) no pelagic stage occurs at all (Thorson, 1946). This means that larval dispersal is limited.

- Between 1979 and 1980, deoxygenation of bottom waters resulted in the depletion of *Thyasira equalis* and *Thyasira sarsi* from 550/m□ to almost zero. However, by 1987 200/m□ were present (Dando & Spiro, 1993).
- After a decline in the abundance of *Thyasira flexuosa* in Penobscot Bay, Maine, after trawler disturbance, populations were reported to recover within 3.5 months (Sparks-McConkey & Watling, 2001).

Explanations for the high recovery of these populations could be due to high post-settlement survival, or new populations of adults washed in by bedload transport to colonize the area.

### Additional information

No text entered.

## Preferences & Distribution

### Habitat preferences

| | |
|---|---|
| **Depth Range** | 50-100 m |
| Water clarity preferences | |
| **Limiting Nutrients** | No information found |
| **Salinity preferences** | Full (30-40 psu) |
| **Physiographic preferences** | |
| **Biological zone preferences** | Circalittoral |
| **Substratum/habitat preferences** | Mud |
| **Tidal strength preferences** | Very Weak (negligible) |
| **Wave exposure preferences** | |
| **Other preferences** | |

### Additional Information

- Differences in the faunal composition between Atlantic (Loch Nevis, Scotland) and northern North Sea sites (Forties oil field & Fladen Ground) have been described.
    - In the northern North Sea high densities of *Saccammina* sp., *Psammosphaera* sp., *Astrohiza arenaria* (Foraminifera), *Thyasira equalis* (bivalve) and Polychaetes such as *Spiophanes kroyeri* and *Tharyx* sp. were present in abundance (McIntyre, 1961; Hartley, 1984; Stephen, 1923). Whereas, in the Atlantic high densities of *Crithionina granum* (foraminifera), *Thyasira flexuosa* (bivalve) and Polychaetes were present in abundance McIntyre (1961).
    - Densities of foraminifera varied as follows; Stephen (1923) found 1074/m$^2$ of *Saccammina* sp. and *Psammosphaera* sp., and 190/m$^2$ of *Astrorhiza arenaria*. McIntyre (1961) found that in the Fladen Grounds dead tests of *Saccammina* sp. were more abundant (>10,000/m$^2$) and *Astrorhiza arenaria* was not as common. However, the number of live foraminifera species would probably be much less; McIntyre (1961) estimated the abundance of living *Saccammina* sp. to be 263/m$^2$.
- At sites in the northern North Sea, communities live in constant Boreal water where the bottom temperature among foraminifera communities has been noted to have a low range (Stephens, 1923), with temperatures and salinities remaining fairly constant, oscillating between 6 and 8°C and salinities of 35.20-35.26ppm (McIntyre, 1961). However, the Atlantic community lives in varying Boreal water (McIntyre, 1961).

Ockelmann (1958) indicated that records of *Thyasira flexuosa* in east Greenland and Jan Mayen were thought to actually refer to *Thyasira gouldi* and *Thyasira equalis* respectively, as *Thyasira flexuosa* has a boreal-lusitanian main distribution and is absent from arctic waters.

## Species composition

### Species found especially in this biotope

### Rare or scarce species associated with this biotope

-

### Additional information

In addition to species mentioned in the biotope description, polychaetes such as *Exogone verugera*, *Nephtys* spp., *Aricidea catherinae* and *Minuspio cirrifera*, and brittlestars, *Amphiura* sp. are also abundant in the biotope (Connor *et al.*, 1997a) and information on these species has been used.

# Sensitivity review

## Sensitivity characteristics of the habitat and relevant characteristic species

The biotope is characterized by  by foraminiferans such as *Saccammina*, *Psammosphaera*, *Haplophragmoides*, *Crithionina* and *Astorhiza* and the bivalve *Thyasira* sp. (e.g. *Thyasira croulinensis and Thyasira  pygmaea*). Little evidence was found  to assess the sensitivity of these species and the assessments are relatively generic and based on a number of formanifera  and *Thyasira* spp.The biotope is characterized by  by foraminiferans such as *Saccammina*, *Psammosphaera*, *Haplophragmoides*, *Crithionina* and *Astorhiza* and the bivalve *Thyasira* sp. (e.g. *Thyasira croulinensis and Thyasira  pygmaea*). Little evidence was found  to assess the sensitivity of these species and the assessments are relatively generic and based on a number of formanifera  and *Thyasira* spp. The biotope is characterized by foraminiferans such as *Saccammina*, *Psammosphaera*, *Haplophragmoides*, *Crithionina* and *Astorhiza* and the bivalve *Thyasira* sp. (e.g. *Thyasira croulinensis* and *Thyasira  pygmaea*). Little evidence was found  to assess the sensitivity of these species and the assessments are relatively generic and based on a number of formanifera  and *Thyasira* spp.

## Resilience and recovery rates of habitat

Little is known about the mode of reproduction, growth rate and recoverability of foraminifera. In the absence of such information, assessment of recovery potential has to be precautionary and may be more than five years.

The larval development of *Thyasira equalis* is lecithotrophic and the pelagic stage is very short or suppressed.  This agrees with the reproduction of other *Thyasira* sp., and in some cases (e.g. *Thyasira gouldi*) no pelagic stage occurs at all (Thorson, 1946, 1950). This means that larval dispersal is limited.  If mortality of *Thyasira* sp. occurs, there would have to be nearby populations for recovery to occur.  Where some individuals survive, due to the fact that larvae spend little or no time in the water column, post-settlement survival may be higher, and the population may be able to recover.  It is also possible that adults could be brought into the area by bed load transport, enabling colonization (Riley, 2002).  Sparks-McConkey and Watling (2001) found that a population of *Thyasira flexuosa* in Penobscot Bay, Maine recovered rapidly (within 3.5 months) following trawler disturbance that resulted in a decrease in the population.  Benthic reproduction allows recolonization of nearby disturbed sediment and leads to rapid recovery where a large proportion of the population remains to repopulate the habitat.

**Resilience assessment:** Removal of the characterizing *Thyasira* spp. would result in the biotope being lost and/or re-classified. Where the habitat is suitable, recovery of *Thyasira* spp. is expected to be ‘High’ based on recruitment form the local population. Where perturbation removes a portion of the population or even causes local extinction (resistance **‘High’**, **‘Medium’** or **‘Low’**) resilience is likely to be **‘High’** for as long as habitat is suitable and recruitment from neighbouring areas is possible. 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. Given low dispersal potential of *Thyasira* spp, recruitment to re-colonize impacted area may take longer. However, once an area has been recolonized, restoration of the biomass of the characterizing species is likely to occur quickly and resilience is likely to be **‘Medium’** (full recovery within 2-10 years). Little is known about the ecology and recovery of foraminiferans. Water transport of adults is likely to support recovery. The assessment is therefore based on *Thyasira* spp.

## Hydrological Pressures

| | Resistance | Resilience | Sensitivity |
|---|---|---|---|
| **Temperature increase (local)** | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

The distribution of fossilised foraminifera is used to track changes in bottom water temperatures, as each species occurs in a particular temperature range (Archer & Martin, 2001) suggesting that some species are intolerant of temperature changes.

*Thyasira flexuosa* does not occur in the southernmost part of the North Sea but is distributed from Norway to the Azores, and extends into the Mediterranean (Tillin & Tyler-Walters, 2014).

In the northern North Sea, foraminiferan dominated biotopes containing *Thyasira equalis*, *Saccammina* sp., *Psammosphaera* sp. and *Astrohiza arenaria* is present in ‘constant Boreal water’ where the bottom temperature among foraminifera communities has been noted to have a low temperature range (Stephen, 1923), with temperatures oscillating between 6 and 8 °C (McIntyre, 1961).The foraminiferan and Thyasira biotopes of the Forties  Further south, a greater range of bottom temperatures occurs and the biotope is not present. But this could also be due to an increase in sediment particle size with decreasing depth in this area. However, the Atlantic community which contains *Thyasira flexuosa* and *Crithionina granum* lives in ‘varying Boreal water’, with temperatures varying between 7 and 13 °C (McIntyre, 1961).

**Sensitivity assessment.** Available information suggests that the community is highly dependent on a relatively constant temperature and that different species of *Thyasira* sp. and foraminifera thrive in different temperature ranges. This pressure is not assessed due to lack of evidence.

| | | | |
|---|---|---|---|
| **Temperature decrease (local)** | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

There is no information on the response of the biotope to a decrease in temperature. *Thyasira flexuosa* does not occur in the southernmost part of the North Sea but is distributed from Norway to the Azores, and extends into the Mediterranean (Tillin & Tyler-Walters, 2014). However, *Thyasira* populations in the British Isles are restricted to areas where the bottom waters remain cool all year round (Jackson, 2007). No specific information on temperature tolerances of *Thyasira* spp. was found.

The distribution of fossilised foraminifera is used to track changes in bottom water temperatures, as each species occurs in a particular temperature range (Archer & Martin, 2001). This suggests that they are intolerant of temperature changes.

In the northern North Sea, foraminiferan domianted biotopes containing *Thyasira equalis*, *Saccammina* sp., *Psammosphaera* sp. and *Astrohiza arenaria* is present in ‘constant Boreal water’ where the bottom temperature among foraminifera communities has been noted to have a low temperature range (Stephen, 1923), with temperatures oscillating between 6 and 8 °C (McIntyre, 1961). Further south, a greater range of bottom temperatures occurs and the biotope is not present. But this could also be due to an increase in sediment particle size with decreasing depth in this area. However, the Atlantic community which contains *Thyasira flexuosa* and *Crithionina granum* lives in ‘varying Boreal water’, with temperatures varying between 7 and 13 °C (McIntyre, 1961).

**Sensitivity assessment.** Available information suggests that the community is highly dependent on a relatively constant temperature and that different species of *Thyasira* sp. and foraminifera thrive in different temperature ranges. This pressure is not assessed due to lack of evidence.

| | | | |
|---|---|---|---|
| **Salinity increase (local)** | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

No evidence.

| | | | |
|---|---|---|---|
| **Salinity decrease (local)** | Low<br>Q: Low A: NR C: NR | Medium<br>Q: Low A: NR C: NR | Medium<br>Q: Low A: Low C: Low |

*This biotope is found in full salinity (30-35 ppt). Thyasira* spp. can inhabit waters of reduced salinity with 25-30 psu being optimal. However, adults exposed to lower than optimal salinities produced non-viable or slow developing eggs (Jackson, 2007).

This circalittoral biotope that has not been recorded from locations with brackish waters and so is probably highly intolerant of a decrease in salinity. In the northern North Sea, foraminiferan dominated biotopes containing *Thyasira equalis*, *Saccammina* sp., *Psammosphaera* sp. and *Astrohiza arenaria*, is present where salinities remain fairly constant, between 35.20 and 35.26 ppm (McIntyre, 1961). However, the Atlantic community which contains *Thyasira flexuosa* and *Crithionina granum* (foraminifera) occurs in waters where salinity varies between 33.86 and 34.33 (McIntyre, 1961). This suggests that the community is highly dependent on a relatively constant salinity. Mobile species would be able to avoid the change in salinity by moving away, but localised densities would decline.

**Sensitivity assessment.** Resistance has been assessed as 'Low'. Recoverability may be 'Medium' and sensitivity is assessed as 'Medium'.

| | | | |
|---|---|---|---|
| **Water flow (tidal current) changes (local)** | Medium<br>Q: Low A: NR C: NR | High<br>Q: Low A: NR C: NR | Low<br>Q: Low A: Low C: Low |

This biotope occurs in deep waters where tidal flows are weak (<0.5 m/s) (JNCC, 2015). The community occurs in fine soft mud that only develops in areas of weak tidal streams. Following an increase in water flow rate at the pressure benchmark the surface sediments and epifaunal foraminifera may be subject to some winnowing but the cohesive nature of subtidal muds will limit the impact. The lower substratum inhabited by mature specimens of *Thyasira* sp., infaunal foraminifera, polychaetes and other species are likely to remain unchanged.

**Sensitivity assessment.** Since the majority of characterizing species are likely to persist, resistance has been assessed as 'Medium' as some removal of epifaunal foraminifera may occur. On return to normal water flow rates, resilience is assessed as 'High' as water transport from periodic storm events may restore populations of adult foraminifera. Biotope sensitivity is, therefore, assessed as 'Low.

| | | | |
|---|---|---|---|
| **Emergence regime changes** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

Not relevant to sublittoral biotopes.

| | | | |
|---|---|---|---|
| **Wave exposure changes (local)** | High<br>Q: Low A: NR C: NR | High<br>Q: High A: High C: High | Not sensitive<br>Q: Low A: Low C: Low |

As this biotope occurs in circalittoral habitats it is not directly exposed to the action of breaking waves. The characterizing *Thyasira* spp. and associated polychaete species that burrow are protected within the sediment but the characterizing foraminiferans would be exposed to oscillatory water flows at the seabed. No specific evidence was found to assess this pressure.

**Sensitivity assessment.** The biotope is considered to be ‘Not sensitive’ to changes in wave height, at the pressure benchmark, based on the depth of the habitat.

## Chemical Pressures

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

Not Sensitive at the pressure benchmark that assumes compliance with all relevant environmental protection standards.

| | | | |
|---|---|---|---|
| **Hydrocarbon & PAH contamination** | Not Assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR |

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

| | | | |
|---|---|---|---|
| **Synthetic compound contamination** | Not Assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR |

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

| | | | |
|---|---|---|---|
| **Radionuclide contamination** | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

No evidence.

| | | | |
|---|---|---|---|
| **Introduction of other substances** | Not Assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR |

This pressure is **Not assessed**.

| | | | |
|---|---|---|---|
| **De-oxygenation** | Low<br>Q: High A: High C: NR | High<br>Q: High A: Low C: NR | Low<br>Q: High A: Low C: Low |

Dando & Spiro (1993) found that numbers of *Thyasira equalis* and *Thyasira sarsi* decreased rapidly following the de-oxygenation of bottom water in the deep basin of Gullmar fjord in 1979-80.

**Sensitivity assessment:** A proportion of the characterizing species in these biotopes is likely to be lost, a resistance of 'Low' (>75% loss) is suggested based on *Thyasira spp*. Resilience is probably **'**High', and therefore the biotopes' sensitivity to this pressure if likely to be 'Low'.

| | | | |
|---|---|---|---|
| **Nutrient enrichment** | High<br>Q: High A: High C: High | High<br>Q: High A: High C: High | Not sensitive<br>Q: High A: High C: High |

This pressure relates to increased levels of nitrogen, phosphorus and silicon in the marine environment compared to background concentrations. The pressure benchmark is set at compliance with Water Framework Directive (WFD) criteria for good status, based on nitrogen concentration (UKTAG, 2014).

**Sensitivity assessment.** This biotope is considered to have 'High' resistance to this pressure and 'High' resilience, (by default) and is assessed as 'Not sensitive'.

| | | | |
|---|---|---|---|
| **Organic enrichment** | Low<br>Q: High A: Medium C: NR | High<br>Q: High A: Low C: NR | Low<br>Q: High A: Low C: Low |

Many of the species present are deposit feeders characteristic of organically enriched areas. An input of organic matter at the pressure benchmark is likely to provide a food subsidy to these species.

*Thyasira* spp. are characteristic of organically enriched offshore sediments and have been identified as a 'progressive' species, i.e. one that shows increased abundance under slight organic enrichment (Leppakoski, 1975, cited in Gray, 1979). In the development of the AMBI index to assess disturbance (including organic enrichment), both Borja *et al.* (2000) and Gittenberger & van Loon (2011) assigned *Thyasira flexuosa* to their Ecological Group III (defined as 'species tolerant to excess organic matter enrichment). These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations)'.

**Sensitivity assessment** The evidence presented suggests that the majority of the characterizing and associated species in the biotopes are likely to be able to utilize additional organic load as food and are present in enriched habitats. Biotope resistance is therefore assessed as 'High' and resilience as 'high' so that the biotope is assessed as 'Not sensitive'.

## Physical Pressures

| | Resistance | Resilience | Sensitivity |
|---|---|---|---|
| **Physical loss (to land or freshwater habitat)** | None<br>Q: High A: High C: High | Very Low<br>Q: High A: High C: High | High<br>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.

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| **Physical change (to another seabed type)** | None<br>Q: High A: High C: High | Very Low<br>Q: High A: High C: High | High<br>Q: High A: High C: High |

The biotope is characterized by the sedimentary habitat (JNCC, 2015), a change to an artificial or rock substratum would alter the character of the biotope leading to reclassification and the loss of the sedimentary community including the characterizing bivalves, polychaetes and echinoderms that live buried within the sediment.

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

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|---|---|---|---|
| **Physical change (to another sediment type)** | Low<br>Q: Low A: NR C: NR | Very Low<br>Q: Low A: NR C: NR | High<br>Q: Low A: Low C: Low |

The change referred to at the pressure benchmark is a change in sediment classification (based on Long, 2006) rather than a change in the finer-scale original Folk categories (Folk, 1954). For muddy sediments, resistance is assessed based on a change to either mixed sediments or sand and muddy sands . The characterizing *Thyasira* spp. prefer fine sediments including mud, muddy sand and sandy mud (Jackson, 2007).

**Sensitivity assessment:** A change in Folk class from mud to sand or muddy sand would probably not eliminate the characterizing Thyasira spp and the habitat may still be suitable for foraminiferans, however, some grades of mixed sediments with low fractions of fine sediments would probably be unsuitable. Resistance is therefore assessed as ‘Low’ (loss of 25-75%) and resilience is considered 'Very low’ given the permanent nature of this pressure. Sensitivity is therefore assessed as ‘High’.

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| **Habitat structure changes - removal of substratum (extraction)** | None<br>Q: Low A: NR C: NR | Medium<br>Q: Low A: NR C: NR | Medium<br>Q: Low A: Low C: Low |

Resistance is assessed as ‘None’ as extraction of the sediment swill remove the characterizing and associated species present. Resilience is assessed as ‘Medium’ as foraminiferans may require longer than two years to re-establish (see resilience section) and sediments may need to recover (where exposed layers are different). Biotope sensitivity is therefore assessed as ‘Medium’.

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| **Abrasion/disturbance of the surface of the substratum or seabed** | Medium<br>Q: Low A: NR C: NR | High<br>Q: Low A: NR C: NR | Low<br>Q: Low A: Low C: Low |

No evidence was found to assess this pressure. Abrasion may result in some damage and mortality, resistance is therefore assessed as 'Medium' and resilience as 'High', biotope sensitivity is therefore assessed as 'Low'.

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| **Penetration or disturbance of the substratum subsurface** | Low<br>Q: High A: High C: High | High<br>Q: High A: High C: NR | Low<br>Q: High A: High C: Low |

Activities that disturb the surface and penetrate below the surface would remove /damage epifauna and infaunal species such as the characterizing species within the direct area of impact.

The shells of *Thyasira* spp. are thin and fragile and penetration and disturbance of the sediment is likely to lead to damage and mortality within the population. Sparks-McConkey & Watling (2001) found that trawler disturbance resulted in a decline of *Thyasira flexuosa* in Penobscot Bay, Maine. However, the population recovered after 3.5 months. The direct mortality (percentage of initial density) of *Thyasira flexuosa* from trawling was estimated as 0-28%, based on samples taken with a Day grab before and 24 hours after trawling (Ball *et al*., 2000a).

Gilkinson *et al*. (1998) found that otter trawling that disturbed the sediment displaced small bivalves but that these were unharmed. Sediment penetration may therefore, disturb and displace foraminiferans but these may survive due to small size and robust tests.

**Sensitivity assessment:** A proportion of the characterizing species in these biotopes is likely to be lost or severely damaged, depending on the scale of the activity (see abrasion pressure). Therefore, a resistance of ‘Low’ (>75% loss) is suggested based on *Thyasira spp*. Resilience is probably ‘High’ (where foraminiferan populations undergo only small declines), and therefore biotope sensitivity to this pressure is likely to be ‘Low’.

| | | | |
|---|---|---|---|
| **Changes in suspended solids (water clarity)** | High<br>Q: Low A: NR C: NR | High<br>Q: High A: High C: High | Not sensitive<br>Q: Low A: Low C: Low |

No evidence. Changes in suspended solids are considered unlikely to affect the characterizing species and resistance is assessed as 'High' and resilience as 'High' so that the biotope is considered to be 'Not sensitive'.

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|---|---|---|---|
| **Smothering and siltation rate changes (light)** | None<br>Q: Low A: NR C: NR | Medium<br>Q: Low A: NR C: NR | Medium<br>Q: Low A: Low C: Low |

Bijkerk (1988, results cited from Essink, 1999) indicated that the maximal overburden through which small bivalves could migrate was 20 cm in sand for *Donax* and approximately 40 cm in mud for *Tellina* sp. and approximately 50 cm in sand. No further information was available on the rates of survivorship or the time taken to reach the surface. This suggests that the characterizing species *Thyasira* spp. may be able to re-borrow through similar overburdens. *Thyasira flexuosa* have ‘highly extensible feet’ (Dando & Southward, 1986) allowing them to construct channels within the sediment and to burrow to 8 cm depth.

Epifaunal foraminifera may not be able to burrow to the surface and at least a proportion of the population may be lost. However, little information on foraminiferan biology was found, and so, in the absence of information tolerance has been assessed as 'None', albeit with very low confidence.

Loss of the characterizing species of foraminifera would mean that the biotope is no longer SS.SMu.OMu.ForThy and so resistance is assessed as 'None'. Resilience is assessed as 'Medium' and sensitivity is assessed as 'Medium'.

| | | | |
|---|---|---|---|
| **Smothering and siltation rate changes (heavy)** | None<br>Q: Low A: NR C: NR | Medium<br>Q: Low A: NR C: NR | Medium<br>Q: Low A: Low C: Low |

Bijkerk (1988, results cited from Essink, 1999) indicated that the maximal overburden through which small bivalves could migrate was 20 cm in sand for *Donax* and approximately 40 cm in mud for *Tellina* sp. and approximately 50 cm in sand. No further information was available on the rates of survivorship or the time taken to reach the surface. This suggests that the characterizing species *Thyasira* spp. may be able to re-borrow through similar overburdens. *Thyasira flexuosa* have ‘highly extensible feet’ (Dando & Southward, 1986) allowing them to construct channels within the sediment and to burrow to 8 cm depth.

Epifaunal foraminifera may not be able to burrow to the surface and at least a proportion of the population may be lost. However, little information on foraminiferan biology was found, and so, in the absence of information, tolerance has been assessed as 'None', albeit with very low confidence. Loss of the characterizing species of foraminifera would mean that the biotope is no longer SS.SMu.OMu.ForThy and so resistance is assessed as 'None'. Resilience is assessed as 'Medium' and sensitivity is assessed as 'Medium'.

| | | | |
|---|---|---|---|
| **Litter** | Not Assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR | Not assessed (NA)<br>Q: NR A: NR C: NR |

**Not assessed.**

| | | | |
|---|---|---|---|
| **Electromagnetic changes** | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

No evidence.

| | | | |
|---|---|---|---|
| **Underwater noise changes** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

Not relevant.

| | | | |
|---|---|---|---|
| **Introduction of light or shading** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

Not relevant.

| | | | |
|---|---|---|---|
| **Barrier to species movement** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

Not relevant to off-shore biotopes.

| | | | |
|---|---|---|---|
| **Death or injury by collision** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>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)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

Not relevant.

## Biological Pressures

| | Resistance | Resilience | Sensitivity |
|---|---|---|---|
| **Genetic modification & translocation of indigenous species** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

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

| | | | |
|---|---|---|---|
| **Introduction or spread of invasive non-indigenous species** | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

No evidence.

| | | | |
|---|---|---|---|
| **Introduction of microbial pathogens** | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR | No evidence (NEv)<br>Q: NR A: NR C: NR |

More than 20 viruses have been described for marine bivalves (Sinderman, 1990). Bacterial diseases are more significant in the larval stages and protozoans are the most common cause of epizootic outbreaks that may result in mass mortalities of bivalve populations. Parasitic worms, trematodes, cestodes and nematodes can reduce growth and fecundity within bivalves and may in some instances cause death (Dame, 1996).

Little information specifically concerning the effects of microbial pathogens and parasites on the viability of the characterizing species was found. A viral infection of the mutualist bacterium living on the gills of *Thyasira gouldi* has been suggested as the reason for a major decline in the Loch Etive population (Jackson, 2007, references therein),

**Sensitivity assessment.** No direct evidence of the biotopes being affected by the introduction of microbial pathogens was found to assess this pressure.

| | | | |
|---|---|---|---|
| **Removal of target species** | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR | Not relevant (NR)<br>Q: NR A: NR C: NR |

No species within the biotope are targeted by commercial or recreational fishers or harvesters. This pressure is therefore considered ‘Not relevant’.

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|---|---|---|---|
| **Removal of non-target species** | Low<br>Q: Low A: NR C: NR | High<br>Q: High A: Low C: Medium | Low<br>Q: Low A: Low C: Low |

Removal of the characterizing species would reduce the ecological services provided by these species such as secondary production and nutrient cycling.

**Sensitivity assessment.** Species within the biotope are relatively sedentary or slow moving although the infaunal position of *Thyasira* spp. may protect this genus from removal. Biotope resistance is therefore assessed as ‘Low’ and resilience as ‘High’ as the habitat is likely to be directly affected by removal but *Thyasira* spp. will recolonize rapidly. Some variability in species recruitment, abundance and composition is natural and therefore a return to a recognisable biotope should occur within 2 years. Repeated chronic removal would, however, impact recovery.

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