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

Beggiatoa spp. on anoxic sublittoral mud

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

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Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/habitats/detail/181]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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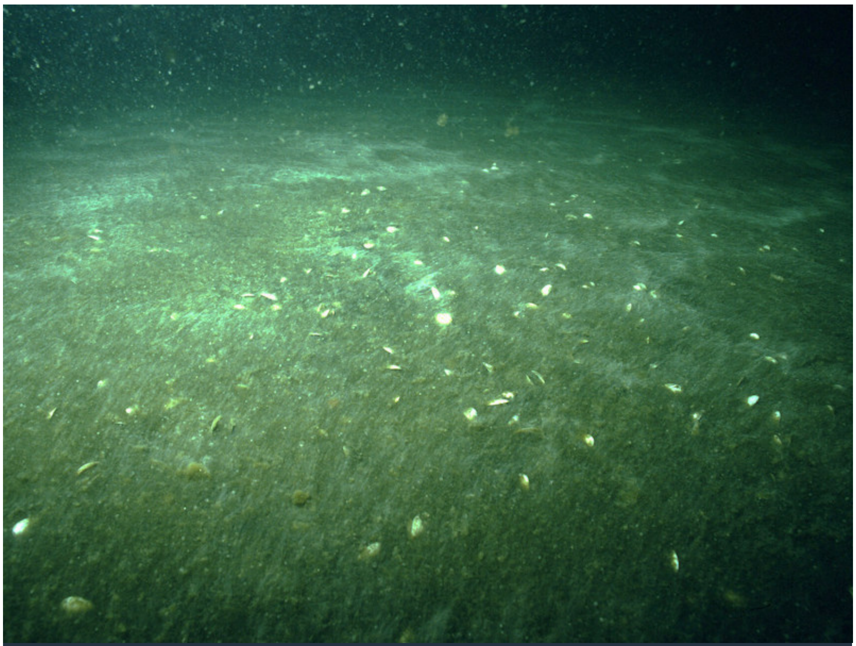

***Beggiatoa spp.* on anoxic sublittoral mud**
Photographer: Keith Hiscock
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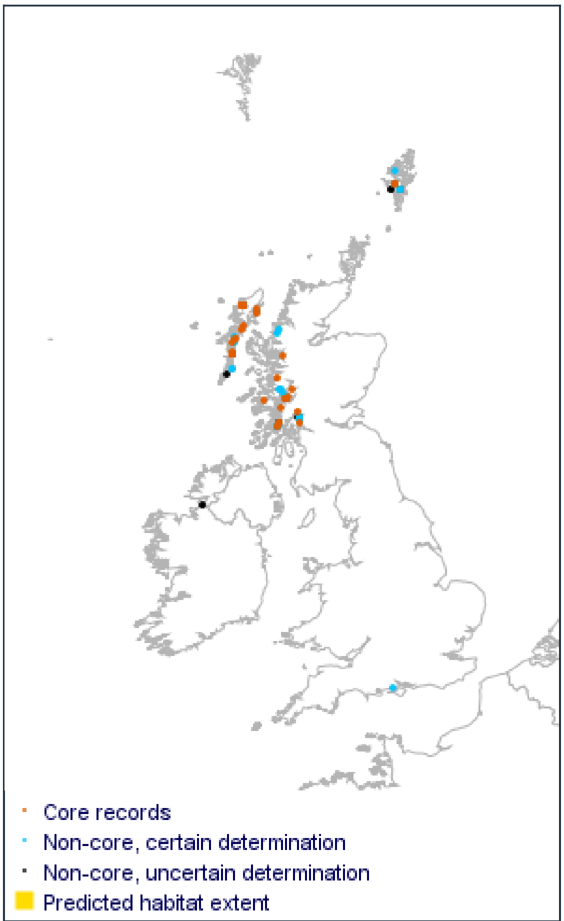

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Jacqueline Hill & Dr Harvey Tyler-Walters **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A5.7211	*Beggiatoa* spp. on anoxic sublittoral mud
JNCC 2015	SS.SMu.IFiMu.Beg	*Beggiatoa* spp. on anoxic sublittoral mud
JNCC 2004	SS.SMu.IFiMu.Beg	*Beggiatoa spp.* on anoxic sublittoral mud
1997 Biotope	SS.CMU._.Beg	*Beggiatoa spp.* on anoxic sublittoral mud

Description

Sublittoral soft anoxic mud, often in areas with poor water exchange with the open sea, can have a conspicuous bacterial mat covering of *Beggiatoa* species. The anoxia may be a result of natural conditions of poor water exchange in some sea lochs (and many Scandinavian fjords) or artificially under fish farm cages from nutrient enrichment. The fauna is normally impoverished at such sites, with few elements of the infaunal communities present in other muddy biotopes. Scavenging species such as *Asterias rubens* and *Carcinus maenas* are typically present where the habitat is not too anoxic but in extreme conditions of anoxia little survives other than the *Beggiatoa*. The polychaete *Ophiodromus flexuosus* occurs in high densities at the interface between oxygenated and deoxygenated sediments (in Norwegian fjords). (Information taken from the Marine Biotope Classification for Britain and Ireland, Version 97.06: Connor *et al.*, 1997a, 2004).

Depth range

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

Additional information

None entered

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Habitat review

Ecology

Ecological and functional relationships

Mats of the sulphur reducing, filamentous bacteria *Beggiatoa* spp. occur at sites of organic pollution, often in areas of soft anoxic mud where there is poor water exchange with the open sea. *Beggiatoa* mats occur on the surface of the sediment at the hypoxic/anoxic interface. *Beggiatoa* sp. are characterized by their gliding motility, lack of photosynthetic pigments, and the presence of sulphur globules around the cytoplasm (Hagen & Nelson, 1997). The underlying sediment is primarily depauperate, the low oxygen levels resulting in death or loss of most mega and macrofauna. A few tolerant polychaetes, gastrotrichs, and nematodes may occur (e.g. see Bernhard *et al.*, 2000). The *Beggiatoa* excludes other heterotrophic bacteria and most other macrofauna with few elements of the infaunal communities that are found in other muddy biotopes.

Beggiatoa sp. utilize sulphides leaching from the sediment, and oxidize them to sulphate to liberate energy for growth but also require simple organic acids and alcohols for growth (Williams & Unz, 1989; Hagen & Nelson, 1997).The other organisms present (e.g. ciliates, nematodes, and euglenoid flagellates) are probably decomposers, feeding on organic matter. However, Bernhard *et al.* (2000) noted several species of protist contained symbiotic bacteria that were presumably chemoautotrophs. The sediment below the mats is populated by chemoautotrophic bacteria, that remineralize organic matter, producing methane, or sulphides of hydrogen (H_2S), iron or manganese and are probably very similar to microbial communities found at depth in other sediments (for a summary see Davies *et al.*, 1996).

The few remaining tolerant species are probably deposit feeders on the microbial rich sediment or scavengers (e.g. crabs, hermit crabs, and starfish) feeding on dead or dying fauna.

Seasonal and longer term change

The development of *Beggiatoa* mats are related to environmental conditions such as organic input and oxygen content which may have seasonal trends in some areas. Anoxic conditions may also develop in deep water due to the presence of a thermocline in the summer months e.g. some Fjords (Diaz & Rosenberg, 1995; Gustafsson & Nordberg, 1999) and Aberiddy Quarry (Hiscock & Hoare, 1973).

Habitat structure and complexity

The biotope has little structural complexity because the surface of the sediment is covered with a mat of the filamentous bacteria reducing access to sediments for infaunal organisms. Scavenging species such as *Asterias rubens* and *Carcinus maenas* are typically present where the habitat is not too anoxic but in extreme conditions of anoxia little survives other than the *Beggiatoa*. The polychaete *Ophiodromus flexuosus* occurs in high densities at the interface between oxygenated and deoxygenated sediments (in Norwegian fjords). The mats provide habitat for an abundant meiofaunal community (Bernhard *et al.*, 2000) such as nematodes and small ciliates (Spies & Davis, 1979). The combination of anoxic conditions and the related production of sulphides (e.g. H_2S) is highly toxic to most life (see Diaz & Rosenberg, 1995) and the underlying sediment may be effectively abiotic. Where conditions are not anoxic but severely hypoxic, *Beggiatoa* may be patchy, with an impoverished infauna present.

Productivity

Productivity in this biotope is limited to the anaerobic chemoautotrophic productivity of infaunal bacteria and of the sulphur-oxidising bacteria *Beggiatoa* sp. *Beggiatoa* sp. utilize sulphides leaching from the sediment, and oxidize them to sulphate to liberate energy for growth but also require simple organic acids and alcohols for growth (Williams & Unz, 1989; Hagen & Nelson, 1997). Diaz & Rosenberg (1995) noted that area dominated by bacterial mats, the benthic-pelagic coupling is weakened and the food chain shortened. However, they also noted that bacterial mats may be important sources of organic matter in coastal upwelling oxygen minimum zones.

Recruitment processes

Bacterial colonies can spread rapidly via asexual reproduction. In many species resting stages, spores and cysts may occur that allow some bacteria to survive for long periods returning to normal growth when conditions are good. *Beggiatoa* sp. are probably ubiquitous.

Time for community to reach maturity

Although growth rates of *Beggiatoa* in natural environments are not known, the generation time for many bacteria is short and growth is usually exponential in optimal conditions (e.g. in some bacteria the population can double in 20 minutes). Therefore, in the right conditions, a *Beggiatoa* mat is likely to develop rapidly.

Additional information

None entered.

Preferences & Distribution

Habitat preferences

Depth Range	0-5 m, 5-10 m, 10-20 m
Water clarity preferences	Not relevant
Limiting Nutrients	Not relevant
Salinity preferences	Full (30-40 psu), Variable (18-40 psu)
Physiographic preferences	
Biological zone preferences	Infralittoral
Substratum/habitat preferences	Mud
Tidal strength preferences	Very Weak (negligible), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered, Sheltered, Very sheltered
Other preferences	High organic content, low oxygen and sulphides

Additional Information

Mats of *Beggiatoa* spp. occur on the surface of organic rich, anoxic sediments, at the hypoxic/anoxic interface, and oxidize sulphides to sulphates. For example Bernhard *et al.* (2000) reported mats of *Beggiatoa* spp. on the surface of sediments at a depth of ca 600m, in which the oxygen concentration was < 1μM (ca 0.02 μl/l) in the top 2-3 cm of sediment and sulphide concentrations were >0.1 μM.

Species composition

Species found especially in this biotope

- *Beggiatoa sp.*

Rare or scarce species associated with this biotope

-

Additional information

The MNCR recorded 149 species in records of this biotope. However, only scavenging *Carcinus maenas* and *Asterias rubens* were recorded as common. Numerous other species occur at low abundance or in only a few records of the biotope, probably reflecting the patchy nature of the *Beggiatoa* spp. mats.

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

This biotope is characterized by mats of the bacterium *Beggiatoa* spp. Since no or very few other macrofaunal species at least are present in the biotope the sensitivity of *Beggiatoa* is representative of the sensitivity of the whole biotope.

Resilience and recovery rates of habitat

Bacterial colonies can spread rapidly via asexual reproduction. In many species resting stages, spores and cysts may occur which allows some bacteria to survive for long periods returning to normal growth when conditions are good. *Beggiatoa* is probably ubiquitous. Jørgensen (1977) noted that *Beggiatoa* spp. was present in the upper few centimetres oxic sediment in Limfjorden, Denmark. It was absent from fine and medium sand but in mud occured at high densities around faecal pellets. Although growth rates of *Beggiatoa* are not known, the generation time for many bacteria is short (e.g. in some bacteria the population can double in 20 minutes). In the right conditions, a *Beggiatoa* mat is likely to develop very rapidly so that resilience is probably **High** (< 2 years).

Hydrological Pressures

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

Beggiatoa spp. mats have been reported from sulphur springs, deep water at ca 600 m, fjords, coastal marine sediments, salt marshes, organic-rich freshwater sediments, natural oil seeps and deep-sea hydrothermal vents (e.g. Spies & Davis, 1979; Hagen & Nelson, 1997). There was no information found regarding the temperature requirements of *Beggiatoa*, and the temperature requirements of individual strains of the bacterium are likely to vary. However, given its occurrence in the vicinity of hydrothermal vents, it is unlikely to be affected by increases in temperature at the benchmark level. In addition, Hiscock *et al.* (2001) suggested that increases in temperature because of global warming may result in more thermal stratification events in enclosed areas. Increased stratification will isolate deeper waters of sheltered sites and *Beggiatoa* spp. biotopes may occur where they did not previously exist. Therefore, resistance and resilience are probably **High** and the biotope is assessed as **Not sensitive**.

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

Beggiatoa spp. mats have been reported from sulphur springs, deep water at ca 600 m, fjords, coastal marine sediments, salt marshes, organic-rich freshwater sediments, natural oil seeps and deep-sea hydrothermal vents (e.g. Spies & Davis, 1979; Hagen & Nelson, 1997). There was no information found regarding the temperature requirements of *Beggiatoa*, and the temperature requirements of individual strains of the bacterium are likely to vary. However, its occurrence within the East Siberian Sea (OBIS, 2016) and the deep sea suggest it is unlikely to be affected by increases in temperature at the benchmark level. Therefore, resistance and resilience are probably

High and the biotope is assessed as **Not sensitive**.

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

There is no information regarding the development of *Beggiatoa* mats in hypersaline waters. Freshwater strains and marine strains are different so an increase in salinity in brackish water sites may remove the freshwater strains of the bacterium, e.g. freshwater strains were unable to grow in salty conditions (Williams & Unz, 1989). However, if conditions of high nutrient and low oxygen concentration remain mats may then be formed by marine strains. Therefore, a resistance of **High** is suggested but with low confidence. Hence, resilience is **High** and the biotope is assessed as **Not sensitive**.

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

Beggiatoa mats form in sewage waste water and in marine conditions. However, freshwater strains and marine strains are different so a decrease in salinity may remove the marine strains. For example, freshwater strains were unable to grow in salty conditions (Williams & Unz, 1989). However, if conditions of high nutrient and low oxygen concentration remain mats may then be formed by freshwater strains. Therefore, a resistance of **High** is suggested but with low confidence. Hence, resilience is **High** and the biotope is assessed as **Not sensitive**.

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

The biotope normally develops in areas of low water flow rate, such as sea lochs and fjords, where hypoxic or anoxic conditions are able to develop. Any further decrease in water flow is unlikely and assessed further. An increase in water flow is likely to result in increased mixing of the water column, and dispersal of any thermocline or halocline in the area, an increase in oxygenation of the water column and loss of the conditions required for growth of *Beggiatoa* spp. In areas where anoxic or hypoxic conditions are caused by organic enrichment, then increased water flow is likely to mitigate and reduce the level of hypoxia. However, an increase of 0.1-0.2 m/s (the benchmark) may reduce the level of hypoxia in naturally hypoxic areas. Therefore, a resistance of **Low** is suggested but with Low confidence. Resilience is likely to be **High** so that sensitivity is assessed as **Low**.

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 pressure benchmark is relevant only to littoral and shallow sublittoral fringe biotopes.

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

The biotope develops in areas of very little water movement (wave sheltered to extremely wave sheltered conditions). Therefore, a further decrease in wave action is unlikely. An increase in wave action is likely to wash the mats away and increase mixing or the water column and, hence, oxygenation. However, a 3-5% change in significant wave height is unlikely to have a significant effect, especially at depth. Therefore, resistance and resilience are probably **High** and the biotope is assessed as **Not sensitive**.

Chemical Pressures

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

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

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

In many areas around the world (e.g. see Spies & Davis, 1979) mats of *Beggiatoa* are associated with localized intense oil seepage and so the biotope is likely to be relatively resistant of hydrocarbons. Nevertheless, this pressure is **Not assessed** .

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.

Radionuclide contamination	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence was found.

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

This pressure is **Not assessed**.

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

Jørgensen (1977) noted that *Beggiatoa* spp. was present in the upper few centimetres oxic sediment in Limfjorden, Denmark. But mats of *Beggiatoa* are usually associated with hypoxic or anoxic conditions (Diaz & Rosenberg, 1995; Connor *et al.*, 1997a,2004). For example, during the autumn of 1993 and 1994 when the oxygen content of the bottom water in the Koljoford on the west coast of Sweden dropped, *Beggiatoa* mats covered the seafloor (Gustafsson & Nordberg, 1999). In Maine coastal waters in the U.S.A, the formation of *Beggiatoa* mats was linked to lack of oxygen when current speed was reduced for 2 h or longer during a tidal cycle. The formation of

Beggiatoa mats only occurs when oxygen supply is reduced below the threshold level required to oxidize sedimented organic matter (Findlay, 2002). In Caol Scotnish, Loch Sween, bacterial mats of *Beggiatoa* were reported in the immediate vicinity of salmon cages in 1987. By 1988, the bacterial mats covered most of the seabed in the basin and the sediment was close to anoxic (Atkinson, 1989; Hughes, 1998a).

Therefore, the development of the biotope is dependent on hypoxic and anoxic conditions in the sediment. The biotope is assessed as **Not sensitive** (resistance and resilience are **High**) to deoxygenation. However, the biotope would be destroyed and lost by increased oxygen levels.

Nutrient enrichment	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not sensitive Q: NR A: NR C: NR

Mats of *Beggiatoa* are usually associated with and develop in the presence of high organic loadings such as found under salmon farm cages (Lumb, 1989; Davies *et al*., 1996, Atkinson, 1989) and coastal areas of eutrophication (Graco *et al*., 2001). Therefore, an increase in nutrients will encourage the development of the bacterial mats. The biotope is probably Not sensitive (resistance and resilience are High) to nutrient enrichment. Nevertheless, the biotope is assessed as **Not sensitive** at the pressure benchmark that assumes compliance with good status as defined by the WFD.

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

Mats of *Beggiatoa* are usually associated with and develop in the presence of high organic loadings such as found under salmon farm cages (Lumb, 1989; Davies *et al*., 1996, Atkinson, 1989) and coastal areas of eutrophication (Graco *et al*., 2001). Therefore, an increase in nutrients will encourage the development of the bacterial mats. The biotope is assessed as **Not sensitive** (resistance and resilience are **High**) to organic enrichment.

Physical Pressures

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

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

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

If sedimentary substrata were replaced with rock substrata the biotope would be lost, as it would no longer be a sedimentary habitat as described under the habitat classification. Jørgensen (1977) noted that *Beggiatoa* was absent from fine and medium sands in the Limfjorden, Denmark but abundant on muds. Therefore, a change to rock substratum would probably result in loss of *Beggiatoa* mats.

Sensitivity assessment. Resistance to the pressure is considered '**None**', and resilience '**Very low**' or 'None' (as the pressure represents a permanent change) and the sensitivity of this biotope is assessed as '**High**'.

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

Beggiatoa spp. is recorded from muds and decaying plant matter (Jørgensen, 1977). Jørgensen (1977) noted that *Beggiatoa* was absent from fine and medium sands in the Limfjorden, Denmark but abundant on muds. Similarly, this biotope (IFiMu.Beg) is only recorded from muds (Connor *et al*., 2004). Therefore, a change in sediment type by one Folk class (see Long, 2006), e.g. from mud to sandy mud and sand would result in loss of the biotope. Therefore, a resistance of **None** is recorded. As the change is permanent, resilience is **Very low** and sensitivity is assessed as **High**.

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

The mats of *Beggiatoa* spp. sit on the surface of the substratum. Extraction of sediment to 30 cm (the benchmark) could remove the bacterial mats in the affected area. Hence, the resistance is probably **None** and resilience is probably **High**, resulting in a sensitivity of **Medium**.

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

The bacteria produces a polysaccharide matrix that binds the bacteria together and to the substratum. But mats of *Beggiatoa* form on soft mud and so are likely to be broken up by abrasion or physical disturbance. Therefore, a resistance of **Low** is suggested with Low confidence. However, resilience is probably **High** so that the sensitivity is assessed as **Low**.

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

The bacteria produces a polysaccharide matrix that binds the bacteria together and to the substratum. But mats of *Beggiatoa* form on soft mud and so are likely to be broken up by abrasion or physical disturbance. Therefore, a resistance of **Low** is suggested with Low confidence. However, resilience is probably **High** so that the sensitivity is assessed as **Low**.

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

Beggiatoa spp. has no dependency on light or detritus, and no feeding structures to clog with sediment. This biotope is recorded from sheltered areas, on fine sediments, subject to high suspended sediment loads. Therefore, resistance is probably **High** and, hence, resilience is also **High,** and the biotope is probably **Not sensitive** at the benchmark level.

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

Beggiatoa spp. sit at the anoxia / hypoxia interface and can 'glide' across the surface of the substratum. It occurs in muds in sheltered areas and is probably adapted to high sediment loads and accretion rates. However, no information on rapid sedimentation was found. The bacterium is found within the top few centimetres of the sediment (Jørgensen, 1977) so that the bacterium itself would probably survive smothering but the mats would probably disappear temporarily. Therefore, a resistance of **Low** is suggested with Low confidence but resilience is **High** so that the sensitivity is assessed as **Low**.

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

Beggiatoa spp. sit at the anoxia / hypoxia interface and can 'glide' across the surface of the substratum. It occurs in muds in sheltered areas and is probably adapted to high sediment loads and accretion rates. However, no information on rapid sedimentation was found. The bacterium is found within the top few centimetres of the sediment (Jørgensen, 1977) so that the bacterium itself would probably survive smothering but the mats would probably disappear temporarily. Therefore, a resistance of **Low** is suggested with Low confidence but resilience is **High** so that the sensitivity is assessed as **Low**.

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

Not assessed.

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

No evidence was found

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

Motile bacteria may respond to local vibration but the important characteristic species are unlikely to respond to noise as described under this pressure.

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

Beggiatoa sp. utilize sulphides leaching from the sediment, and oxidize them to sulphate to liberate energy for growth but also require simple organic acids and alcohols for growth (Williams & Unz, 1989; Hagen & Nelson, 1997).The other organisms present (e.g. ciliates, nematodes, and euglenoid flagellates) are probably decomposers, feeding on organic matter. However, Bernhard *et al.* (2000) noted several species of protist contained symbiotic bacteria that were presumably chemoautotrophs. The sediment below the mats is populated by chemoautotrophic bacteria, that remineralize organic matter, producing methane, or sulphides of hydrogen (H_2S), iron or manganese and are probably very similar to microbial communities found at depth in other sediments (for a summary see Davies *et al.*, 1996). Therefore, the biotope has not dependency on light and resistance is assessed as **High**. Therefore, resilience is **High** and the biotope is assessed as **Not sensitive.**

Barrier to species movement	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 - this pressure is considered applicable to mobile species, e.g. fish and marine mammals rather than seabed habitats. Physical and hydrographic barriers may limit the dispersal of seed. But seed dispersal is not considered under the pressure definition and benchmark.

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.

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

Not relevant

Biological Pressures

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

No evidence of genetic modification, breeding, or translocation was found.

Introduction or spread of invasive non-indigenous species	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence was found.

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

No evidence was found.

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

Beggiatoa spp. are unlikely to be targeted by commercial or recreational fisheries or other harvest. The presence of mats of *Beggiatoa* spp. indicate that conditions are anoxic and potentially abiotic.

Removal of non-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 presence of mats of *Beggiatoa* spp. indicate that conditions are anoxic and potentially abiotic. Affected areas are unlikely to be targeted by commercial or recreational fisheries or other harvest.

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