



# MarLIN

## Marine Information Network

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

# *Polyides rotunda* and/or *Furcellaria lumbricalis* on reduced salinity infralittoral rock

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/316>]. All terms and the MarESA methodology are outlined on the website (<https://www.marlin.ac.uk>)

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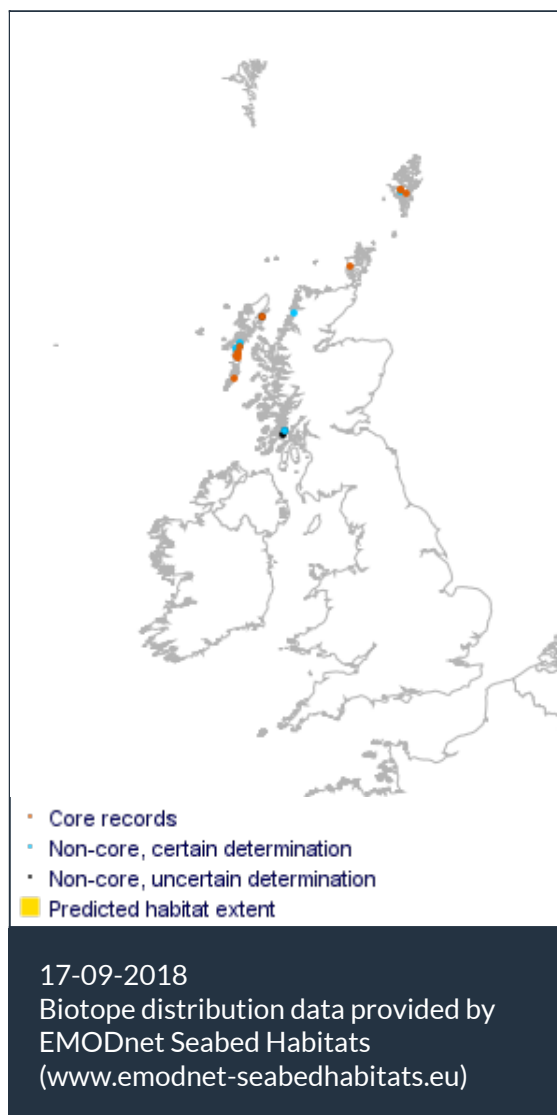
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A turf of *Polyides rotundus*, *Furcellaria lumbricalis* and filamentous brown algae.

Photographer: Anon.

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Researched by Frances Perry & Dr Heidi Tillin

Refereed by This information is not refereed.

## Summary

### ☰ UK and Ireland classification

EUNIS 2008	A3.343	<i>Polyides rotundus</i> and/or <i>Furcellaria lumbricalis</i> on reduced salinity infralittoral rock
JNCC 2015	IR.LIR.Lag.ProtFur	<i>Polyides rotunda</i> and/or <i>Furcellaria lumbricalis</i> on reduced salinity infralittoral rock
JNCC 2004	IR.LIR.Lag.ProtFur	<i>Polyides rotundus</i> and/or <i>Furcellaria lumbricalis</i> on reduced salinity infralittoral rock
1997 Biotope	IR.SIR.Lag.PolFur	<i>Polyides rotundus</i> and/or <i>Furcellaria lumbricalis</i> on reduced salinity infralittoral rock

### 🔍 Description

Bedrock and boulders characterized by a dense turf of the red seaweeds *Polyides rotunda* and/or *Furcellaria lumbricalis*, often with a dense mat of filamentous brown and green

seaweeds including Ectocarpaceae and Cladophora spp. Other red seaweeds presents include *Chondrus crispus*, *Gracilaria gracilis* and coralline crusts as well as the odd brown seaweed *Chorda filum* or *Laminaria* spp. Associated with these seaweeds are a variety of ascidians including *Clavelina lepadiformis*, *Asciella aspersa*, *Asciella scabra* and *Ciona intestinalis* as well as the anemones *Anemonia viridis* and *Actinia equina* and the sponge *Halichondria panicea*. More mobile fauna include the starfish *Asterias rubens*, the crab *Carcinus maenas*, the hermit crab *Pagurus bernhardus*, the opossum shrimps Mysidae and the gastropod *Littorina littorea*. Attached to the rock or cobbles are spirorbid polychaetes and the mussel *Mytilus edulis*. Please notice that part of this diversity is due to large differences between sites (taken from Connor *et al.*, 2004).

## ↓ Depth range

0-5 m

## 🏛️ Additional information

Nearby rock (AscSpAs and FChoG) and seagrass *Ruppia maritima* dominate much of the surrounding muddy sediment (Rup). Mixed sediment supports filamentous green seaweeds e.g. *Cladophora* spp. and *Derbesia marina* on (FiG).

## ✓ Listed By

- none -

## 🔗 Further information sources

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## Sensitivity review

### Sensitivity characteristics of the habitat and relevant characteristic species

This biotope is characterized by its presence exclusively within lagoon habitats. There are only 358 examples of these rare and unusual habitats in the UK (Bamber *et al.*, 2001), which make up a total of 5,184 hectares of coastline habitat (UKNEA, 2011). A number of factors are thought to contribute to the rarity of these habitats in the UK. Many sedimentary lagoons do not appear in many of the areas suitable for them because of the macrotidal regimes found within the North East Atlantic (Barnes, 1991). The high energy coastlines common around the UK mean that shingle lagoons can be both created from off shore glacial deposits and removed, therefore they are often short lived on geological time scales, and are now less common than they were at the end of the last ice age (Bamber *et al.*, 2001). The low energy nature of lagoons also means that they can be susceptible to silting up which can elevate their basins above the level for percolation input. Combined with perimeter shingle ridges being elevated by storms, reducing water input via overtopping, can cause lagoons to become freshwater lakes (Bamber *et al.*, 2001). The somewhat ephemeral nature of lagoons, and their susceptibility to change, means that the succession of habitats and consequently the biotopes found within them can be quicker and more noticeable than those found within other more stable physical environments.

The core records of this specific biotope are found exclusively in Scotland. The substratum in this biotope occurs contains bedrock, boulders, cobbles and pebbles. The bedrock and boulders are usually dominated by *Polyides rotunda* and / or *Furcellaria lumbricalis*. These two species characterize the biological community within this biotope. There are a number of other species found within this biotope. Not all of these species are expected to be found within a single example of this biotope. A large amount of the diversity on the species list is due to the high level of diversity found between sites. Other species include ectocarpaceae, *Chondrus crispus*, *Gracilaria gracilis* and coralline algae. A number of different ascidians can be found within the biotope including *Clavelina lepadiformis*, *Asciella aspersa*, *Asciella scabra* and *Ciona intestinalis*. The dominant grazers within this biotope are mysids and the gastropods *Littorina littorea*. For a full list of species found within this biotope refer to Connor *et al.* (2004).

### Resilience and recovery rates of habitat

The dominant algal species in the biotope are perennial and are present throughout the year. However, they do exhibit seasonality in terms of growth and reproduction. For example, maximum growth of *Furcellaria lumbricalis* occurs in March/April (Austin, 1960b) and release of carpospores and tetraspores occurs in December/January (Bird *et al.*, 1991). The annual algal species, for example the filamentous greens, are likely to proliferate in spring and summer in conjunction with increased irradiance and temperatures, and then die back in autumn and winter. Recruitment processes and recolonization by macroalgae are very dependent on time of year as spores are only available for limited periods. The advantage of being fertile through the winter, as in the case of *Furcellaria lumbricalis*, is the availability of substrata for colonization as other annual species die back (Kain, 1975). Similarly, Pybus (1977) reported that although carposporic plants were present throughout the year in Galway Bay, Ireland, maximum reproduction occurred in the winter and estimated that settling of spores occurred between January and May. Storms and increased wave action are more likely to occur in the winter months and may cause physical damage to the community. Austin (1960b) reported damage to *Furcellaria lumbricalis* plants during storms and Sharp *et al.* (1993) reported that plants may be cast ashore by increased wave action.

Vadas *et al.* (1992) reviewed recruitment and mortality of early post settlement stages of benthic algae. They identified six intrinsic and 17 extrinsic factors affecting recruitment and mortality. They concluded that grazing, canopy and turf effects were the most important but that desiccation and water movement may be as important for the early stages. The review indicated that recruitment is highly variable and episodic and that mortality of algae at this period is high. Chance events during the early post settlement stages are therefore, likely to play a large part in survival. As with all red algae, the spores of *Furcellaria lumbricalis* and *Polyides rotunda* are non-flagellate and therefore, dispersal is a wholly passive process (Fletcher & Callow, 1992). In general, due to the difficulties of re-entering the benthic boundary layer, it is likely that successful colonization is achieved under conditions of limited dispersal and/or minimum water current activity. Norton (1992) reported that although spores may travel long distances (e.g. *Ulva* sp. 35 km, *Phycodrys rubens* 5 km), the reach of the furthest propagule does not equal useful dispersal range, and most successful recruitment occurs within 10 m of the parent plants. It is expected, therefore, that recruitment of *Furcellaria lumbricalis*, *Polyides rotunda* and the majority of other macroalgae in the biotope would occur from local populations and that establishment and recovery of isolated populations would be patchy and sporadic. Scrosati *et al.* (1994) commented that viability of spores of *Chondrus crispus* was low (<30%) and suggested that reproduction by spores probably does not contribute much to maintenance of the intertidal population in Nova Scotia, compared to vegetative growth of gametophytes.

As and when bare substratum becomes available for colonization, for instance following storm events, it is expected that algal recruitment and succession would follow a predictable sequence (Hawkins & Harkin, 1985). Initial colonizers on bare rock are often epiphytic species, suggesting that it is competition from canopy forming algae that usually restricts them to their epiphytic habit (Hawkins & Harkin, 1985). Gradually, the original canopy or turf forming species, in this case *Furcellaria lumbricalis* and *Polyides rotunda* then become established. These findings suggest that interactions between macrophytes are often more important than grazing in structuring algal communities (Hawkins & Harkin, 1985).

*Furcellaria lumbricalis* is highly fecund, an average sized gametophyte being able to produce approximately one million carpospores, or a tetrasporophyte, up to two million tetraspores (Austin, 1960a). However, the species grows very slowly compared to other red algae (Bird *et al.*, 1979) and takes a long time to reach maturity. For example, Austin (1960b) reported that in Wales, *Furcellaria lumbricalis* typically takes five years to attain fertility. Christensen (1971) (cited in Bird *et al.*, 1991) noted that following harvesting of *Furcellaria lumbricalis* forma *aegagropila* in the Baltic Sea, harvestable biomass had not been regained five years after the suspension of harvesting.

Other dominant species within this biotope include *Chondrus crispus*. Recovery of a population of *Chondrus crispus* following a perturbation is likely to be largely dependent on whether holdfasts remain, from which new thalli can regenerate (Holt *et al.*, 1995). Following experimental harvesting by drag raking in New Hampshire, USA, populations recovered to one third of their original biomass after six months and totally recovered after 12 months (Mathieson & Burns, 1975). Raking is designed to remove the large fronds but leave the small upright shoots and holdfasts. The authors suggested that control levels of biomass and reproductive capacity are probably re-established after 18 months of regrowth. It was noted however, that time to recovery was much extended if harvesting occurred in the winter, rather than the spring or summer (Mathieson & Burns, 1975). Minchinton *et al.* (1997) documented the recovery of *Chondrus crispus* after a rocky shore in Nova Scotia, Canada, was totally denuded by an ice scouring event. Initial recolonization was dominated by diatoms and ephemeral macroalgae, followed by furoids and

then perennial red seaweeds. After two years, *Chondrus crispus* had re-established approximately 50% cover on the lower shore and after five years it was the dominant macroalgae at this height, with approximately 100% cover. The authors pointed out that although *Chondrus crispus* was a poor colonizer, it was the best competitor.

**Resilience assessment.** Of the characterizing algal species within this biotope the only species with information available on life expectancy and recruitment is *Furcellaria lumbricalis*. Therefore, the resilience assessment is made based on this. Although the number of species found within this biotope supplied by Connor et al., (2004) is relatively large, it must be noted that the actually biotope biodiversity is often not as high as this list suggests. Therefore, when considering a return to previous ecological function after a pressure can vary between biotope. Biotope resilience is assessed as 'High' where resistance is 'High'. The low flushing times and high water retention rates within lagoons means that if this biotope has a resistance to this biotope of 'Medium' or 'Low' then the resilience will be 'Medium' with full recovery taking between 2 – 10 years. However, if the resistance of the biotope to a pressure at the benchmark is considered to be 'None', the a conservative resilience assessment of 'Low' has been given. This conservative estimate is due to the nature flow of water in and out of lagoons which is likely to restrict the ability of planktonic larvae to enter into and settle within the lagoon. Although the nature of water influx can vary significantly between lagoons. Therefore, each lagoon within which this biotope is found should be assessed on a case by case basis.

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 recognisable 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: Medium A: Medium C: Medium	High Q: Medium A: Medium C: Medium	Not sensitive Q: Medium A: Medium C: Medium

The important species in the biotope have wide geographic ranges and are likely to be tolerant of higher temperatures than those experienced in the British Isles. Although species ranges may not accurately describe their ability to withstand localized changes in temperature. They may to some extent display the limits of the species genetic ability to acclimatize to temperatures.

*Furcellaria lumbricalis* has a wide geographic range, occurring in Europe from northern Norway to the Bay of Biscay. Novaczek & Breeman (1990) recorded that specimens of *Furcellaria lumbricalis* grew well in the laboratory from 0 - 25°C with optimal growth between 10 and 15°C. Growth ceased at 25°C and 100% mortality resulted after 3 months exposure to 27 °C. Similarly, Bird et al. (1979) recorded optimum growth at 15°C and cessation of growth at 25°C with associated necrosis of apical segments.

*Polyides rotunda* is found throughout the North Atlantic Ocean and have related populations in the North Pacific. Growth and survival was tested over a temperature range of -5 to 30°C. *Polyides rotunda* tolerated temperatures from -5 to 27°C, grew well from 5 to 25°C, and had a broad optimal range of 10-25°C. Both *Polyides rotunda* and *Furcellaria lumbricalis* can tolerate three months in darkness at 0°C (Novaczek & Breeman, 1990).

*Chondrus crispus* also has a wide geographical range, occurring in Europe from northern Russia to southern Spain (Dixon & Irvine, 1977). In New Hampshire, USA, *Chondrus crispus* grows abundantly in waters with an annual variation in surface temperature from -1 to +19°C (Mathieson & Burns, 1975).

**Sensitivity assessment.** The ability of the characterizing species to tolerate a wide range of temperatures suggests that a change in this pressure at the benchmark is unlikely to have a negative effect on the biotope. Both resistance and resilience have been assessed as 'High'. This results in a 'Not sensitive' assessment of the biotope.

#### Temperature decrease (local)

High

Q: Medium A: Medium C: Medium

High

Q: Medium A: Medium C: Medium

Not sensitive

Q: Medium A: Medium C: Medium

The important species in the biotope have wide geographic ranges and are likely to be tolerant of higher temperatures than those experienced in the British Isles. Although species ranges may not accurately describe their ability to withstand localized changes in temperature. They may to some extent display the limits of the species genetic ability to acclimatize to temperatures.

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Growth and survival of the key characterizing species, *Polyides rotunda* was tested over a temperature range of -5 to 30°C. *Polyides rotunda* tolerated temperatures from -5 to 27°C, grew well from 5 to 25°C, and had a broad optimal range of 10-25°C (Novaczek & Breeman, 1990). This species tolerated three months in darkness at 0°C (Novaczek & Breeman, 1990).

Dudgeon *et al.* (1990) investigated the effects of freezing on *Chondrus crispus*. Plants from Maine, USA, were frozen at -5°C for 3 hours a day for 30 days. Photosynthesis was reduced to 55% of control values, growth rates were reduced and fronds were eventually bleached and fragmented resulting in biomass losses. Additionally, fronds of *Chondrus crispus* which were frozen daily had higher photosynthetic rates following subsequent freezing events than unfrozen controls, indicating that the species is able to acclimate to freezing conditions (Dudgeon *et al.*, 1990).

**Sensitivity assessment.** The ability of the characterizing species to tolerate a wide range of temperatures suggests that a change in this pressure at the benchmark is unlikely to have a negative effect on the biotope. Both resistance and resilience have been assessed as 'High'. This results in a 'Not sensitive' assessment of the biotope.

#### Salinity increase (local)

Low

Q: High A: Medium C: Medium

High

Q: Medium A: Medium C: Medium

Low

Q: Medium A: Medium C: Medium



IR.LIR.Lag.ProtFur typically occurs in areas of reduced or low salinity (Connor *et al.*, 2004). *Furcellaria lumbricalis* is a euryhaline species which occurs in a wide range of salinity conditions down to 6-8 psu (Bird *et al.*, 1991). In the Kattegat and the Gulf of St Lawrence, it is reported to compete well with other species at salinities ranging from 25-32 psu (see review by Bird *et al.*, 1991). Growth experiments in the laboratory revealed that optimum growth occurred at 20 psu, the species grew well at 10 psu and 30 psu, but that growth declined above 30 psu to negligible levels at 50 psu (Bird *et al.*, 1979). It is expected that an increase in salinity may cause reduced growth and fecundity but that mortality is unlikely.

No specific evidence was found for the salinity tolerance of the key characterizing species *Polyides rotunda*. *Polyides rotunda* is a characterizing species within biotopes at full salinity e.g. IR.HIR.Ksed.ProtAhn (Connor *et al.*, 2004). Mathieson & Burns (1971) recorded maximum photosynthesis of *Chondrus crispus* in culture at 24 psu but rates were comparable at 8, 16 and 32 psu. Photosynthesis continued up to 60 psu. Bird *et al.* (1979) recorded growth of Canadian *Chondrus crispus* in culture between 10 and 50 psu, with a maximum at 30 psu. The species would therefore appear to be extremely tolerant of hypersaline conditions.

**Sensitivity assessment.** The characterizing species within this biotope would be tolerant of an increase in salinity at the pressure benchmark. However, the removal of the biotope from the salinity regime will mean that the chemical characteristics of the biotope have changed. The increase in salinity will also enable species which were previously excluded from the habitat to settle. Therefore, changing the biological community. The combination of these two factors would mean that the biotope would be lost. Consequently the resistance has been assessed as 'Low'. On the return of the habitat to the previous salinity regime, the species which had taken advantage of the increase in salinity would disappear. As the characterizing species would not have died due to the change in salinity the biological community of this biotope would quickly return. Resulting in a resilience of 'High'. Consequently the biotope sensitivity is assessed 'Low'.

#### Salinity decrease (local)

**None**

Q: Medium A: Medium C: Medium

**Low**

Q: Medium A: Medium C: Medium

**High**

Q: Medium A: Medium C: Medium

IR.LIR.Lag.ProtFur typically occurs in areas of reduced or low salinity (Connor *et al.*, 2004). *Furcellaria lumbricalis* occurs in the lowest category on the salinity scale (Connor *et al.*, 2004) and therefore probably relatively tolerant of decreases in salinity. The species forms extensive populations in the main basin of the Baltic Sea where salinity is 6-8 psu in the upper 60-70 m and its extension into the Gulfs of Bothnia and Finland is limited by the 4 psu isohaline (see review by Bird *et al.*, 1991). However, if the salinity conditions within the habitat were to become freshwater *Furcellaria lumbricalis* would not be able to survive, as it is a marine species. No information was found on the effect of low salinities on *Polyides rotunda*. *Chondrus crispus* occurs in estuaries in New Hampshire, USA, where surface water salinity varies from 16-32 psu (Mathieson & Burns, 1975). Mathieson & Burns (1971) recorded maximum photosynthesis of *Chondrus crispus* in culture at 24 psu, but rates were comparable at 8, 16 and 32 psu.

**Sensitivity assessment.** A decrease in salinity at the pressure benchmark would create freshwater conditions for those biotopes already found in low salinity regimes. The marine nature of the characterizing species would mean that a change in the pressure benchmark for a year would cause mortality of the characterizing species and the associated species. Therefore, resistance is 'None'. The need for the biological community to recolonize the habitat from scratch when the salinity regime returns to 'normal' means that the resilience is 'Low'. This gives a sensitivity of 'Medium'.

**Water flow (tidal current) changes (local)****High**

Q: Medium A: Medium C: Medium

**High**

Q: Medium A: Medium C: Medium

**Not sensitive**

Q: Medium A: Medium C: Medium

This biotope is only found in very weak water flow conditions (Connor *et al.*, 2004). Very little information was available on the effect of water flow on *Furcellaria lumbricalis* and *Polyides rotunda*. However, these species are found in biotopes ranging from strong to negligible (Connor *et al.*, 2004). Therefore, these species may decrease in abundance if water flows were to increase above 6 knots (> 3 m/sec).

An increase in water flow at the benchmark is unlikely to have a significant negative effect on the biological composition of the biotope. However, it must be assumed that if there is an increase in the water flow within the biotope there will also be an increase in the water flow around the lagoon. This increase could have a detrimental effect on the structure of the lagoon through erosion. This could consequently lead to the loss collapse of a lagoon wall and completely change the physical environment of the biotope, and lead to the loss of the lagoon biotope altogether.

**Sensitivity assessment.** A change in the water flow at the pressure benchmark is unlikely to cause the loss of the lagoon biotope. However, an increase in this pressure above the given benchmark has the possibility of removing the lagoon completely. Therefore, resistance and resilience are assessed as 'High', resulting in an assessment of 'Not sensitive'.

**Emergence regime changes****Medium**

Q: Medium A: Medium C: Medium

**Medium**

Q: Medium A: Medium C: Medium

**Medium**

Q: Medium A: Medium C: Medium

The infralittoral situation of this biotope means that it is permanently submerged. For this reason an increase in emergence would change the physical conditions of the biotope, which would affect the biological community. The biotope will be replaced by one where the biological community is better suited to the new emergence regime. A decrease in emergence is not relevant to this biotope as it is already submerged all of the time.

*Furcellaria lumbricalis* can be found from the lower intertidal to 12 m subtidally (Bunker *et al.*, 2012). Bunker *et al.* (2012) notes that *Polyides rotunda* occurs from the mid shore down to 24 m depth. Therefore, if examples of this biotope in were to experience an increase in emergence then the species are decrease in abundance, but not suffer complete mortality.

This biotope is recorded from 0 – 5 m (Connor *et al.*, 2004). A change in the emergence is unlikely to expose the substratum to 5m. Therefore part of the biotope is likely to survive on the substratum which is still immersed. This will allow the biotope to remain in part, and will provide a mature adult population from which repopulation can occur when the 'normal' emergence conditions return.

**Sensitivity assessment.** The resistance to this pressure at the benchmark is 'Medium'. It is likely that the characterizing species in the upper part of the biotope will decrease in abundance. The resilience is thought to be 'Medium' as it may take a while for the species to return to their previous abundances after a year at this pressure benchmark. The sensitivity is therefore assessed to be 'Medium'.

**Wave exposure changes (local)****High**

Q: Medium A: Medium C: Medium

**High**

Q: Medium A: Medium C: Medium

**Not sensitive**

Q: Medium A: Medium C: Medium

This biotope is only found in very and extremely wave sheltered conditions (Connor *et al.*, 2004). Both of the characterizing species can be found in biotopes where wave exposure far exceeds that found within IR.LIR.Lag.ProtFur. The benchmark increase would place the biotope in 'sheltered' conditions for one year. A more severe increase in wave action would cause some damage to fronds resulting in reduced photosynthesis and compromised growth. Furthermore, individuals may be damaged or dislodged by scouring from sand and gravel mobilized by increased wave action (Hiscock, 1983). Austin (1960b) noted that *Furcellaria lumbricalis* from extremely exposed sites have smaller dimensions than individuals from semi-exposed sites and that fronds may be lost due to storm action. Sharp *et al.* (1993) reported *Furcellaria lumbricalis* found cast ashore following storms. Dudgeon & Johnson (1992) noted wave induced disturbance of intertidal *Chondrus crispus* on shores of the Gulf of Maine during winter. During one winter 25-30% of cover of large *Chondrus crispus* thalli was lost. Increased wave action above the pressure benchmark would result in some mortality. However, at this pressure benchmark the biological component of this biotope is unlikely to be affected.

An increase in wave exposure at the benchmark will not have a significant negative effect on the biological composition of the biotope. However, it might be assumed that if there is an increase in the wave height within the biotope there will also be an increase in the water flow around the lagoon. This increase could have a detrimental effect on the structure of the lagoon through erosion. This could consequently lead to the loss collapse of a lagoon wall and completely change the physical environment of the biotope, and lead to the loss of the lagoon biotope altogether. A decrease in wave exposure is not possible within this biotope, as it is already found in the most sheltered conditions.

**Sensitivity assessment.** An increase in this pressure above the given benchmark has the possibility of removing the lagoon completely. However, at the pressure benchmark it is very unlikely that the biotope will be affected. Therefore, both the resistance and resilience have been assessed as 'High', resulting in a 'Not sensitive' assessment.

**⚠ 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

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

**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.

<b>Radionuclide contamination</b>	<b>No evidence (NEv)</b>	<b>Not relevant (NR)</b>	<b>No evidence (NEv)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

No evidence.

<b>Introduction of other substances</b>	<b>Not Assessed (NA)</b>	<b>Not assessed (NA)</b>	<b>Not assessed (NA)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

This pressure is **Not assessed**.

<b>De-oxygenation</b>	<b>No evidence (NEv)</b>	<b>Not relevant (NR)</b>	<b>No evidence (NEv)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

The effects of reduced oxygenation on the characterizing red algae are not well studied. Lack of oxygen may impair both respiration and photosynthesis (see review by Vidaver, 1972). No evidence is available to make a sensitivity assessment for the key characterizing algal species. However, the presence of these species in rock pools suggests that they can tolerate some short-term oxygen depletion.

Aerobic organisms in the biotope are certain to be intolerant of anoxia to some degree, and it is expected that, at the very least, growth and reproduction would be compromised by the benchmark decrease in oxygen levels.

**Sensitivity assessment.** The short-term exposure to de-oxygenation at this benchmark decreases the severity of the pressure. However, the isolated nature of saline lagoons will mean that at low tide, when the lagoons are cut off, may become even more de-oxygenated. This may increase the level of de-oxygenation and consequently the severity of the pressure. The lack of evidence regarding the effect of low oxygen levels on the characterizing species within this biotope has led to an assessment of 'No evidence'.

<b>Nutrient enrichment</b>	<b>High</b>	<b>High</b>	<b>Not sensitive</b>
	Q: Medium A: Medium C: Medium	Q: Medium A: Medium C: Medium	Q: Medium A: Medium C: Medium

This pressure relates to increased levels of nitrogen, phosphorus and silicon in the marine environment compared to background concentrations. The nutrient enrichment of a marine environment leads to organisms no longer being limited by the availability of certain nutrients. The consequent changes in ecosystem functions can lead to the progression of eutrophic symptoms (Bricker *et al.*, 2008), changes in species diversity and evenness (Johnston & Roberts, 2009) decreases in dissolved oxygen and uncharacteristic microalgae blooms (Bricker *et al.*, 1999, 2008).

Johansson *et al.* (1998) suggested that one of the symptoms of large scale eutrophication is the deterioration of benthic algal vegetation in areas not directly affected by land-runoff or a point source of nutrient discharge. Altered depth distributions of algal species caused by decreased light penetration and/or increased sedimentation through higher pelagic production have been reported in the Baltic Sea (Kautsky *et al.*, 1986; Vogt & Schramm, 1991). Johansson *et al.* (1998)

studied changes in the benthic algal community of the Skagerrak coast in the Baltic Sea, an area heavily affected by eutrophication, between 1960 and 1997. They noted the disappearance of the red alga, *Polyides rotunda*, but commented that problems existed in their sampling method. They also noted the increase of delicate red algae with foliaceous thalli, e.g. *Delesseria sanguinea* and *Phycodrys rubens*, and tougher red algae with foliaceous thalli, e.g. *Phyllophora* sp. Increases in the delicate algae were most pronounced at the more wave exposed sites, while increases in the tougher algae occurred at the more sheltered sites with high sedimentation. They commented that these results suggest that the increase of delicate species with large growth potential may have been caused by eutrophication, but that the effect is counteracted when eutrophication results in high sedimentation, in which case the tougher *Phyllophora* sp. thrive. Additionally, *Chondrus crispus* and *Furcellaria lumbricalis*, both species with tough thalli, decreased at the wave exposed sites, possibly due to competition from the more vigorous *Phycodrys rubens* and *Delesseria sanguinea*, but persisted at the sites with high sedimentation. These findings suggest that the dominant red algal turf that characterizes the biotope is likely to decline following increases in nutrient levels and faster growing species are likely to proliferate.

In studies of *Chondrus crispus* from Prince Edward Island, Canada, Juanes & McLachlan (1992) concluded that primary production was limited by temperature during the autumn to the spring period and by nitrogen availability when production was maximal in the summer. They suggested that growth of *Chondrus crispus* became nutrient limited at approximately 14°C. To a certain degree, therefore, an increase in the level of nutrients would be likely to enhance growth of algae in the biotope

Johnston & Roberts (2009) undertook a review and meta analysis of the effect of contaminants on species richness and evenness in the marine environment. Of the 47 papers reviewed relating to nutrients as a contaminants, over 75% found that it had a negative impact on species diversity, <5% found increased diversity, and the remaining papers finding no detectable effect. None of the 47 papers considered the impact of nutrients on saline lagoons. Yet this finding is still relevant as the meta analysis revealed that the effect of marine pollutants on species diversity were 'remarkably consistent' between habitats (Johnston & Roberts, 2009). It was found that any single pollutant reduced species richness by 30-50% within any of the marine habitats considered (Johnston & Roberts, 2009). Throughout their investigation there were only a few examples where species richness was increased due to the anthropogenic introduction of a contaminant. These examples were almost entirely from the introduction of nutrients, either from aquaculture or sewage outfalls. However, research into the impacts of nutrient enrichment from these sources on intertidal rocky shores often lead to shores lacking species diversity and the domination by algae with fast growth rates (Abou-Aisha *et al.*, 1995, Archambault *et al.*, 2001, Arévalo *et al.*, 2007, Diez *et al.*, 2003, Littler & Murray, 1975).

Nutrient enrichment alters the selective environment by favouring fast growing, ephemeral species such as *Ulva lactuca* and *Ulva intestinalis* (Berger *et al.*, 2004, Kraufvelin, 2007). Opportunistic algae such as these can't store nutrients in the thallus (unlike larger, long-lived species) and are adapted to efficiently capture and utilise available nutrients in the water column (Pedersen *et al.*, 2009). A large body of field observations and experiments, surveys and laboratory experiments confirm that *Ulva* sp., can utilise high levels of nutrients for growth (Martínez *et al.*, 2012) and that enhanced recruitment (Kraufvelin, 2007) and growth of this genus can occur in enriched areas (Kennison & Fong, 2013; Vaudrey *et al.*, 2010). In areas where nutrient availability is lower either naturally or through management to reduce anthropogenic inputs, *Ulva* sp. may be negatively affected through reduced growth rate and species replacement (Martínez *et al.*, 2012; Vaudrey *et al.*, 2010). Rohde *et al.* (2008) found that both free growing filamentous algae and

epiphytic microalgae can increase in abundance with nutrient enrichment. This stimulation of annual ephemerals may accentuate the competition for light and space and hinder perennial species development or harm their recruitment (Berger *et al.*, 2003; Kraufvelin *et al.*, 2007). Nutrient enrichment can also enhance fouling of *Fucus* fronds by biofilms (Olsen, 2011). Nutrient enriched environments can not only increase algae abundance, but the abundance of grazing species (Kraufvelin, 2007).

Changes in community composition on intertidal rocky shores can happen rapidly, and fast growing ephemeral species can become established quickly in the presence of higher concentrations of nutrients. The establishment and growth of these species are not controlled by wave exposure (Kraufvelin, 2007). However, even though these fast growing ephemeral species can become well established quickly, healthy communities on intertidal rocky shores can survive long periods of time, and maintain ecological function after these species have become established (Bokn *et al.*, 2002, 2003; Karez *et al.*, 2004; Kraufvelin, 2007; Kraufvelin *et al.*, 2007).

**Sensitivity assessment.** A slight increase in nutrients may enhance growth rates but high nutrient concentrations could lead to the overgrowth of the algae by ephemeral green algae and an increase in the number of grazers. However, if the biotope is well established and in a healthy state the biotope could have the potential to persist. The effect of an increase in this pressure to the benchmark level will not have a negative impact on the biotope. Therefore, the resistance and resilience of this biotope are assessed as 'High', giving the biotope an overall assessment of 'Not sensitive'.

## Organic enrichment

Medium

Q: Medium A: Medium C: Medium

Medium

Q: Medium A: Medium C: Medium

Medium

Q: Medium A: Medium C: Medium

The organic enrichment of a marine environment at this pressure benchmark leads to organisms no longer being limited by the availability of organic carbon. The consequent changes in ecosystem functions can lead to the progression of eutrophic symptoms (Bricker *et al.*, 2008), changes in species diversity and evenness (Johnston & Roberts, 2009) and decreases in dissolved oxygen and uncharacteristic microalgae blooms (Bricker *et al.*, 1999, 2008).

Johnston & Roberts (2009) undertook a review and meta analysis of the effect of contaminants on species richness and evenness in the marine environment. Of the 49 papers reviewed relating to sewage as a contaminant, over 70% found that it had a negative impact on species diversity, <5% found increased diversity, and the remaining papers finding no detectable effect. None of the 49 papers considered the impact of sewage on saline lagoons. Yet this finding is still relevant as the meta analysis revealed that the effect of marine pollutants on species diversity were 'remarkably consistent' between habitats (Johnston & Roberts, 2009). It was found that any single pollutant reduced species richness by 30-50% within any of the marine habitats considered (Johnston & Roberts, 2009). Throughout their investigation there were only a few examples where species richness was increased due to the anthropogenic introduction of a contaminant. These examples were almost entirely from the introduction of nutrients, either from aquaculture or sewage outfalls. However, research into the impacts of organic enrichment from these sources on intertidal rocky shores, often lead to shores lacking species diversity and the domination by algae with fast growth rates (Abou-Aisha *et al.*, 1995, Archambault *et al.*, 2001, Arévalo *et al.*, 2007, Diez *et al.*, 2003, Littler & Murray, 1975). This could also occur within saline lagoon habitats, where similar fast growing species such as *Ulva* are found.

Organic enrichment alters the selective environment by favouring fast growing, ephemeral species

such as *Ulva lactuca* and *Ulva intestinalis* (Berger *et al.*, 2004, Kraufvelin, 2007). Rohde *et al.*, (2008) found that both free growing filamentous algae and epiphytic microalgae can increase in abundance with nutrient enrichment. This stimulation of annual ephemerals may accentuate the competition for light and space and hinder perennial species development or harm their recruitment (Berger *et al.*, 2003; Kraufvelin *et al.*, 2007). Nutrient enrichment can also enhance fouling of furoid fronds by biofilms (Olsenz, 2011). Nutrient enriched environments can not only increase algae abundance, but the abundance of grazing species (Kraufvelin, 2007). Bellgrove *et al.* (2010) found that coralline turfs out-competed furoids at a site associated with organic enrichment caused by an ocean sewage outfall.

Changes in community composition on intertidal rocky shores can happen rapidly, and fast growing ephemeral species can become established quickly in the presence of higher concentrations of nutrients. The establishment and growth of these species are not controlled by wave exposure (Kraufvelin, 2007). However, even though these fast growing ephemeral species can become well established quickly, healthy communities on intertidal rocky shores can survive long periods of time, and maintain ecological function after these species have become established (Bokn *et al.*, 2002, 2003, Karez *et al.*, 2004, Kraufvelin, 2007, Kraufvelin *et al.*, 2007).

**Sensitivity assessment.** Little empirical evidence was found to support an assessment of this biotope at this benchmark. *Ulva* sp. could easily increase in abundance, and this species could overgrow the slower growing characterizing species. However, when organic carbon returned to pre-pressure levels the niche for the conditions for the characterizing algae would return. Resistance has been assessed as 'Medium' and resilience has been assessed as 'Medium'. This gives an overall sensitivity score of 'Medium'.

## A Physical Pressures

	Resistance	Resilience	Sensitivity
Physical loss (to land or freshwater habitat)	<b>None</b> Q: High A: High C: High	<b>Very Low</b> Q: High A: High C: High	<b>High</b> 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'.

Physical change (to another seabed type)	<b>None</b> Q: High A: High C: High	<b>Very Low</b> Q: High A: High C: High	<b>High</b> Q: High A: High C: High
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This biotope is characterized by a lagoon formed from bedrock, boulders and cobbles. Removal of this substratum would remove the attachment surface for the macroalgae that characterize this biotope, significantly altering the character of the biotope. Artificial hard substratum may also differ in character from natural hard substratum, so that replacement of natural surfaces with artificial may lead to changes in the biotope through changes in species composition, richness and diversity (Green *et al.*, 2012; Firth *et al.*, 2014) or the presence of non-native species (Bulleri & Airoldi, 2005).

The change in substratum also has the potential to de-stabilize the lagoon structure. This change in structure could make the lagoon more susceptible to erosion from other physical factors at work within the environment.

**Sensitivity assessment.** A change to a sedimentary habitat would reduce habitat suitability for this biotope, resistance is assessed as 'None' and resilience as 'Very Low' as the change is considered to be permanent. Sensitivity is therefore assessed as 'High'.

<b>Physical change (to another sediment type)</b>	<b>Not relevant (NR)</b>	<b>Not relevant (NR)</b>	<b>Not relevant (NR)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not Relevant for bedrock biotopes.

<b>Habitat structure changes - removal of substratum (extraction)</b>	<b>Not relevant (NR)</b>	<b>Not relevant (NR)</b>	<b>Not relevant (NR)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

The species characterizing this biotope occur on rock and would be sensitive to the removal of the habitat. However, extraction of rock substratum is considered unlikely and this pressure is considered to be 'Not relevant' to hard substratum habitats.

<b>Abrasion/disturbance of the surface of the substratum or seabed</b>	<b>Medium</b>	<b>Medium</b>	<b>Medium</b>
	Q: Medium A: Medium C: Medium	Q: Medium A: Medium C: Medium	Q: Medium A: Medium C: Medium

No studies of the effects of trampling or netting on lagoons were found but studies of the effects on emergent algal communities are probably indicative. For example, moderate (50 steps per 0.09 sq. metre) or more trampling on intertidal articulated coralline algal turf in New Zealand reduced turf height by up to 50%, and the weight of sand trapped within the turf to about one third of controls (Schiel & Taylor, 1999). This resulted in declines in densities of the meiofaunal community within two days of trampling. Although the community returned to normal levels within 3 months of trampling events, it was suggested that the turf would take longer to recover its previous cover (Brown & Taylor, 1999). Similarly, Schiel & Taylor (1999) noted that trampling had a direct detrimental effect on furoid algae and coralline turf species on the New Zealand rocky shore. Low trampling intensity (10 tramples) reduced furoid cover by 25%, while high intensity (200 tramples) reduced furoid cover by over 90%, although over 97% cover returned within 21 months after spring trampling; autumn treatments took longer to recover due to the delay in recruitment. Coralline bases were seen to peel from the rocks (Schiel & Taylor, 1999) due to increased desiccation caused by loss of the algal canopy. Brosnan & Cumrie (1994) demonstrated that foliose species (e.g. furoids and *Mastocarpus papillatus*) were the most susceptible to trampling disturbance, while turf forming species were more resistant. Boalch *et al.* (1974) and Boalch & Jephson (1981) noted a reduction in furoid cover (especially of *Ascophyllum nodosum*) at Wembury, Devon, when compared with the same transects surveyed 43 years previously. They suggested that the reduction in furoid cover was due to the large number of visitors and school groups received by the site.

The *Furcellaria lumbricalis* and *Polyides rotunda* red algal turf is likely to be tolerant of abrasion as the fronds are flexible and cartilaginous. The plants' point of attachment to the substratum, the holdfast, is a potential point of weakness. For example, Taylor (1970) (cited in Sharp *et al.*, 1993) stated that clumps of fronds of *Furcellaria lumbricalis* were easily removed from the substratum by drag raking, but only where the plant had a sufficient number of dichotomies (usually more than 3) to snag in the rake. It is likely therefore that the benchmark level of abrasion would cause



detachment and/or damage. Sharp *et al.* (1993) noted that, following detachment, *Furcellaria lumbricalis* plants were capable of reattachment.

Worm & Chapman (1998) suggested that *Chondrus crispus* was highly resistant to intense physical and herbivore induced disturbance, ensuring competitive dominance on the lower shore. However, the benchmark level of abrasion, for example, a scallop dredge, would be expected to remove or damage some fronds, although the holdfasts are likely to escape unscathed. *Chondrus crispus* is capable of regenerating from its holdfasts (e.g. Dudgeon & Johnson, 1992) and so no mortality is expected, although growth and reproduction of the algae would be compromised during regeneration. However, a proportion of the fronds would be removed, together with any associated mesoherbivores, meiofauna, and epiphytes.

**Sensitivity assessment.** The impact of surface abrasion will depend on the footprint, duration and magnitude of the pressure. Based on evidence from the step experiments and the relative robustness of the algal turf found within this biotope, resistance, to a single abrasion event is assessed as 'Medium' (loss of <25% cover/abundance) and resilience is also assessed as 'Medium'. Therefore, the sensitivity is assessed as 'Medium'.

**Penetration or disturbance of the substratum subsurface**

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 species characterizing this biotope group are epifauna or epiflora occurring on hard rock, which is resistant to subsurface penetration. Therefore, 'penetration' is 'Not relevant'. The assessment for abrasion at the surface only is, therefore, considered to equally represent sensitivity to this pressure'. Please refer to 'abrasion' above.

**Changes in suspended solids (water clarity)**

High

Q: Medium A: Medium C: Medium

High

Q: Medium A: Medium C: Medium

Not sensitive

Q: Medium A: Medium C: Medium

Both of the characterizing species, *Furcellaria lumbricalis* and *Polyides rotunda* within this biotope are tolerant to sand cover and scour. Therefore, the algal species that characterize the biotope are not likely to be affected directly by an increase in scour which could be caused by a change in suspended sediment. However, increased suspended sediment will decrease light availability. *Furcellaria lumbricalis* often occurs in relatively turbid waters. Laboratory experiments by Bird *et al.* (1979) revealed that *Furcellaria lumbricalis* was growth saturated at very low light levels (ca 20 $\mu$ E/m<sup>2</sup>/s) compared to other algae such as *Chondrus crispus* (50-60  $\mu$ E/m<sup>2</sup>/s). They suggest that this may be an explanation why *Furcellaria lumbricalis* is able to proliferate in relatively deep and turbid waters. Similarly, in their review, Bird *et al.* (1999) comment that in all studies, saturation and inhibition radiances were low for *Furcellaria lumbricalis* compared to other macroalgae indicating good competitive ability in the attenuated light of deeper or more turbid waters. Increases in turbidity may provide the species with a competitive advantage over other macroalgae.

No direct evidence was found on the ability of *Polyides rotunda* to cope with low light environments. However, Bunker *et al.* (2012) state that *Polyides rotunda* can be found as deep as 24 m.

**Sensitivity assessment.** The negligible water flows and the very sheltered to extremely wave

sheltered conditions within this biotope mean that an increase in suspended sediment would not cause an increase in the level of scour within this biotope. Both of the characterizing species are scour tolerant and are found in conditions where scour is far more severe than what would occur in this biotope. A change in light attenuation would be unlikely to cause any significant issue to the characterizing species as they can both be found in deeper waters than those typical of this biotope. This suggests that they would tolerate a decrease in light attenuation. Both resistance and resilience have been assessed as 'High', resulting in a 'Not sensitive' assessment.

### Smothering and siltation rate changes (light)

Medium

High

Low

Q: Medium A: Medium C: Medium

Q: Medium A: Medium C: Medium

Q: Medium A: Medium C: Medium

*Furcellaria lumbricalis* is tolerant of sand cover (Dixon & Irvine, 1977) and *Furcellaria lumbricalis* persisted in areas of the Baltic Sea where eutrophication resulted in high sediment loads (Johansson *et al.*, 1998). However, recently settled propagules and small developing plants would be buried by 5 cm of sediment and be unable to photosynthesise. For example, Vadas *et al.* (1992) stated that algal spores and propagules are adversely affected by a layer of sediment, which can exclude up to 98% of light.

No direct evidence could be found on the effect of sediment inundation could be found on *Polyides rotunda*. However, this species is known to be a scour tolerant species.

Seapy & Littler (1982) reported a decrease in macroalgal cover from 47.3 to 37.5% on a Californian rocky shore due to sediment deposition on the mid to lower shore following rain and flooding. *Corallina* sp. and *Pelvetia* sp. were the most affected macroalgal species, while associated red algae were only slightly affected by the resultant scour. Macroinvertebrates declined in cover from 15.8% to 6.5%, particularly barnacle species. Daly & Mathieson (1977) examined intertidal zonation on a shore affected by sand scour, and noted that fucoids were reduced to small or young plants, while sand tolerant species dominated on areas affected by sediment. Smothering by 5 cm of sediment is likely to increase scour and be detrimental to the characterizing red algae species. Red algae whose fronds are long enough not to be smothered by 5 cm of sediment could be negatively impacted by the increase in scour. However, all of the characterizing red algae within this biotope are noted for their tolerance to scour and could, therefore, tolerate an increase in this pressure at the benchmark. Germlings are more likely to be smothered and killed and are inherently most susceptible to this pressure. Indeed, all early life stages are smaller in size than adults and are thus most vulnerable to this pressure as even a small load of added sediment will lead to the complete burial. Sediment deposition can reduce macroalgal recruitment by (1) reducing the amount of substratum available for attachment of propagules; (2) scour, removing attached juveniles and (3) burial, altering the light and/or the chemical microenvironment (Devanny & Volve, 1978, Eriksson & Johansson, 2003).

The saline lagoon environment is likely to be more vulnerable to smothering as sediment is likely to accumulate in and be retained by the lagoon itself. This effectively increases the depth of the sediment layer in the pool. The very sheltered and extremely wave sheltered conditions in which this biotope is found means that sediment may be retained for longer than indicated by the benchmark. Overall, while the biotope will remain, smothering is likely to reduce the diversity, exclude grazing littorinids, and smother small epifaunal species such as sponges, bryozoans and ascidians.

**Sensitivity assessment.** Based on the tolerance of the characterizing red algae to sediment inundation and scour, the resistance of the characterizing algae to this pressure at the benchmark

is likely to be high. However, the grazing littorinids are not tolerant of sediment inundation and an increase in the pressure at the benchmark could reduce the number of these gastropods and a number of the other small epiphytic species within this biotope. The resistance is assessed as 'Medium' and resilience is assessed as 'High' resulting in a 'Low' sensitivity.

**Smothering and siltation rate changes (heavy)** No evidence (NEv) Not relevant (NR) No evidence (NEv)  
Q: NR A: NR C: NR Q: NR A: NR C: NR Q: NR A: NR C: NR

No evidence was found to assess this pressure at the benchmark. A deposit at the pressure benchmark would cover all species with a thick layer of fine materials. Species associated with this biotope such as littorinids would not be able to escape and would likely suffer mortality (see evidence for light siltation). Sensitivity to this pressure will be mediated by site-specific hydrodynamic conditions and the footprint of the impact. Where a large area is covered sediments may be shifted by water currents rather than removed. Mortality will depend on the duration of smothering; where wave action rapidly mobilises and removes fine sediments, survival of the characterizing and associated species may be much greater.

**Litter** 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

Not assessed.

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

No evidence.

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

Species characterizing this habitat do not have hearing perception but vibrations may cause an impact, however, no studies exist to support an assessment.

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

In general, subtidal red algae are able to exist at relatively low light levels (Gantt, 1990). Canopy removal experiments in a rocky subtidal habitat in Nova Scotia, Canada by Schmidt & Scheibling (2007) did not find a shift in understory macroalgal turfs (dominated by *Corallina officinalis*, *Chondrus crispus* and *Mastocarpus stellatus*) to more light-adapted species over 18 months.

*Furcellaria lumbricalis* often occurs in relatively turbid waters. Laboratory experiments by Bird *et al.* (1979) revealed that *Furcellaria lumbricalis* was growth saturated at very low light levels (ca 20  $\mu\text{E}/\text{m}^2/\text{s}$ ) compared to other algae such as *Chondrus crispus* (50 - 60  $\mu\text{E}/\text{m}^2/\text{s}$ ) and *Fucus serratus* (100  $\mu\text{E}/\text{m}^2/\text{s}$ ). They suggest that this may be an explanation why *Furcellaria lumbricalis* is able to proliferate in relatively deep and turbid waters. Similarly, in their review, Bird *et al.* (1999) comment that in all studies, saturation and inhibition radiance were low for *Furcellaria lumbricalis*

compared to other macroalgae indicating good competitive ability in the attenuated light of deeper or more turbid waters.

**Sensitivity assessment.** The characterizing species colonize a broad range of light environments from intertidal to deeper subtidal and shaded understorey habitats the biotope is considered to have 'High' resistance and, by default, 'High' resilience and therefore is 'Not sensitive' to this pressure.

#### 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 propagule dispersal. But propagule 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. NB. Collision by grounding vessels is addressed under 'surface abrasion'.

#### Visual disturbance

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant.

### Biological Pressures

Resistance

Resilience

Sensitivity

#### Genetic modification & translocation of indigenous species

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

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

#### Introduction or spread of invasive non-indigenous species

Medium

Q: Medium A: Medium C: Medium

Very Low

Q: Medium A: Medium C: Medium

Medium

Q: Medium A: Medium C: Medium

The brown seaweed *Sargassum muticum* is a non native species which could potentially invade the biotope. *Sargassum muticum* is a non-native macroalgae spreading around the coasts of Britain and Europe (see Eno *et al.*, 1997) and can be found in a range of intertidal and shallow subtidal biotopes. Although, no studies on its effects on saline lagoons were found, studies of its effect on shallow sublittoral macroalgae suggest that it can out-compete fucoids and kelps (Stæhr *et al.*, 2000). An increase in the abundance of *Sargassum muticum* in the Limfjorden (Denmark) from 1990 to 1997 was accompanied by a decrease in the abundance of thick, slow growing macroalgae

such as *Saccharina latissima* (studied as *Laminaria saccharina*), *Codium fragile*, *Halidrys siliquosa*, *Fucus vesiculosus*, and *Fucus serratus*, together with other algae such as *Ceramium virgatum* (as *rubrum*) and *Dictyota dichotoma*. In *Sargassum muticum* removal experiments on the coast of Washington State, Britton-Simmonds (2004) concluded that *Sargassum muticum* reduced the abundance of native canopy algae (especially kelps) by 75% and native understory algae by 50% probably as a result of shading. However, Viejo (1999) noted that mobile epifauna (e.g. amphipods, isopods) successfully colonized *Sargassum muticum* which provided additional habitat. It is likely that *Sargassum muticum* could successfully invade saline lagoons, and would probably out-compete resident fucoids and kelp species, and some red algae. Although the results of studies of feeding preferences for *Sargassum muticum* over native macroalgae vary, *Littorina littorea* does feed on this species so shoreline colonization by this species would mean that food was still available (Withers *et al.* 1975). *Littorina littorea* also grazes on degraded or stressed *Didemnum vexillum* individuals (Valentine *et al.*, 2007) and *Codium fragile* sp. *tomentosoides* (Schiebling *et al.*, 2008), so gains some benefit from the presence of these species.

A number of invasive red algae have been recorded in the UK, including *Bonnemaisonia hamifera* and *Grateloupia turuturu*. There are no reports of these species invading saline lagoon habitats. However, it is possible they could, with possible consequences for the biological community found within this biotope.

**Sensitivity assessment.** There is a chance that the highly successful non-native *Sargassum muticum* might be able to invade this biotope. The biotope may remain, but with a reduced species richness due to the loss of some species of macroalgae. Resistance is 'Medium' and resilience could also be 'Medium', but assumes removal of *Sargassum muticum*, which is unlikely. Hence, a resilience of 'Very low' has been recorded since the biotope is likely to change, although a viable community will remain, therefore, the sensitivity of the biotope is assessed as 'Medium'. Due to the constant risk of new invasive species, the literature for this pressure should be revisited.

#### Introduction of microbial pathogens

No evidence (NEv)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

No evidence (NEv)

Q: NR A: NR C: NR

Barton (1901) noted that *Furcellaria lumbricalis* may become infested with nematode worms and reacts by gall formation. Pathogenic infections have the potential to cause mortality in red algae and so intolerance is assessed as intermediate. As some portion of the population is likely to remain for vegetative regrowth, recovery is likely to occur within 18 months (see additional information below) and recoverability is, therefore assessed as high. No information is available on the impact of microbial pathogens on *Polyides rotunda*. Parasitism by trematodes may cause sterility in *Littorina littorea*. *Littorina littorea* are also parasitized by the boring polychaete, *Polydora ciliate* and *Cliona* sp, which weakens the shell and increases crab predation (Stefaniak *et al.*, 2005).

**Sensitivity assessment.** Based on the lack of evidence for the characterizing red algae species within this biotope an assessment of 'No Evidence' has been given.

#### Removal of target species

Low

Q: Medium A: Medium C: Medium

Medium

Q: Medium A: Medium C: Medium

Medium

Q: Medium A: Medium C: Medium

The harvesting of *Furcellaria lumbricalis* is due to the gelling properties of its extracted structural polysaccharide, furcellaran (Bird *et al.*, 1991). Extraction of *Furcellaria lumbricalis* was reviewed by Guiry & Blunden (1991). Plinski & Florczyk (1984) noted that over-exploitation of *Furcellaria*

*lumbricalis* resulted in severe depletion of stocks. However, no commercial harvest as yet occurs in Britain or Ireland. Overall, while saline lagoons in areas subject to commercial harvesting may be directly affected, most examples of the biotope are unlikely to be affected by commercial harvesting in the UK. However, due to the relative small size of the community, even small scale hand collecting may have a significant effect.

Littorinids are one of the most commonly harvested species of the rocky shore. Large scale removal of *Littorina littorea* may allow a proliferation of opportunistic green algae, such as *Ulva* sp., on which it preferentially feeds. The community structure within the biotope is likely to be altered but some individuals are likely to remain. Experiments designed to test the effects of harvesting by removing individuals at Strangford Lough found that there was no effect of experimental treatments (either harvesting or simulated disturbance) on *Littorina littorea* abundance or body size over a 12 week period (Crossthwaite *et al.* 2012). This suggests that these animals are generally abundant and highly mobile; thus, animals that were removed were quickly replaced by dispersal from surrounding, un-affected populations.

A broad scale study of harvesting in Ireland using field studies and interviews with wholesalers and pickers did suggest that some areas were over harvested but the lack of background data and quantitative records make this assertion difficult to test (Cummins *et al.*, 2002).

**Sensitivity assessment.** This biotope is considered to have 'Low' resistance to removal of targeted species by hand-gatherers and 'Medium' resilience and is therefore, considered to have a 'Medium' sensitivity to this pressure. However, intense collection of the species *Littorina littorea* (the species present in high enough quantities within this biotope to be collected commercially) over extended periods of time could lead to the degradation of the biotope and consequent loss of the biotope.

#### Removal of non-target species

**Low**

Q: Medium A: Medium C: Medium

**Medium**

Q: Medium A: Medium C: Medium

**Medium**

Q: Medium A: Medium C: Medium

Direct, physical impacts from harvesting are assessed through the abrasion and penetration of the seabed pressures. The characterizing species *Furcellaria lumbricalis* and *Polyides rotunda* are also the dominant species within this biotope. The dominance of these characterizing species means that they could easily be incidentally removed from this biotope as by-catch when other species are being targeted. The loss of these species and other associated species would decrease species richness and negatively impact on the ecosystem function.

**Sensitivity assessment.** Removal of a large percentage of the characterizing species would alter the character of the biotope. The resistance to removal is 'Low' due to the easy accessibility of the biotopes location and the inability of these species to evade collection. The resilience is 'Medium', with recovery only being able to begin when the harvesting pressure is removed altogether. This gives an overall sensitivity score of 'Medium'.

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