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Marine Information Network

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

Verrucaria maura on littoral fringe rock

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

Dr Harvey Tyler-Walters

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The Marine Life Information Network, Marine Biological Association of the United Kingdom.

Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/habitats/detail/120]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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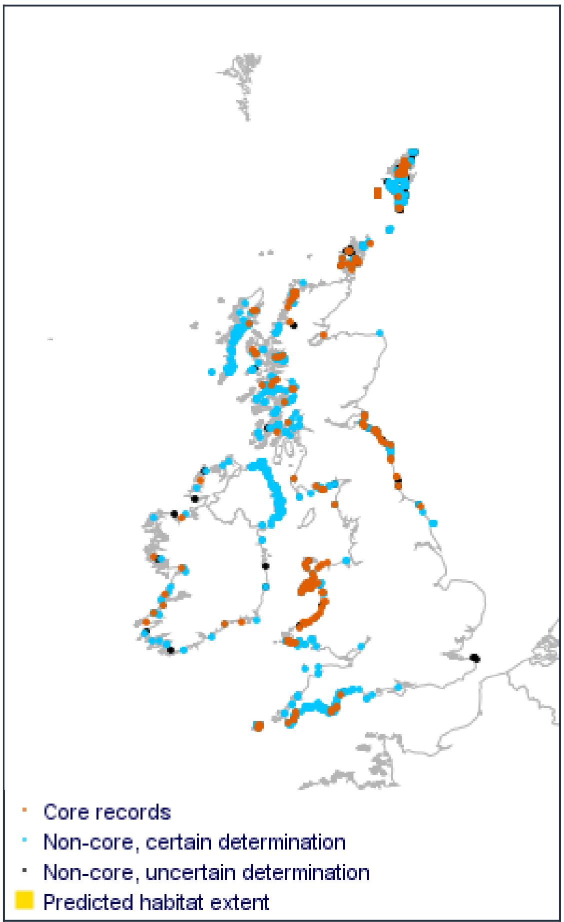
Verrucaria maura **on littoral fringe rock**
Photographer: Anon.



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

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

Summary

UK and Ireland classification

EUNIS 2008	B3.113	*Verrucaria maura* on littoral fringe rock
JNCC 2015	LR.FLR.Lic.Ver	*Verrucaria maura* on littoral fringe rock
JNCC 2004	LR.FLR.Lic.Ver	*Verrucaria maura* on littoral fringe rock
1997 Biotope	LR._.L.Ver	*Verrucaria maura* on littoral fringe rock

Description

Bedrock or stable boulders and cobbles in the littoral fringe covered by the black lichen *Verrucaria maura*. This lichen typically covers the entire rock surface giving a distinct black band in the upper littoral fringe. The winkle *Littorina saxatilis* is usually present. The biotope LR.FLR.Lic.Ver includes two variants, LR.FLR. Lic.Ver.Ver and LR.FLR. Lic.Ver.B, which both occur in a wide range of wave exposures.

LR.FLR. Lic.Ver.Ver is characteristic of upper littoral fringe bedrock, boulders and stable cobbles on very exposed to very sheltered shores which have a blanket covering of the black lichen *Verrucaria maura*. The biotope is a species-poor community consisting mainly of *Verrucaria maura* and *Littorina saxatilis* (Ver.Ver) but occasionally a range of species may be present in low abundance. These species include the yellow lichen *Caloplaca marina* and the winkle *Melarhaphe neritoides*, the barnacles *Chthamalus montagui* and *Semibalanus balanoides* or the ephemeral seaweeds *Porphyra umbilicalis* and *Ulva* spp. can be present in low abundance (see Ver.B). On northern shores *Littorina saxatilis* var. *rudis* can dominate along with the occasional presence of the lichens *Verrucaria mucosa* and *Xanthoria parietina*. *Verrucaria mucosa* can be found overlying stable mud in Northern Ireland sea loughs.

LR.FLR.Lic.Ver.B is characteristic of the lower littoral fringe of very exposed to moderately exposed rocky shores that have a sparse covering of the barnacles *Semibalanus balanoides* and/or *Chthamalus montagui* over the black lichen *Verrucaria maura*. Winkles *Littorina saxatilis* and *Melarhaphe neritoides* are usually present although *Melarhaphe neritoides* tends to be found on more exposed shores. The limpet *Patella vulgata* is often present although at a low abundance. Ver.B. can be dominated by ephemeral seaweeds including the red seaweed *Porphyra umbilicalis*, the green seaweeds *Ulva* spp. or, particularly in the north, microscopic blue-green algae (Cyanophyceae), which overgrow *Verrucaria maura*. The wrack Pelvetia canaliculata may also be present, becoming increasingly more common with greater shelter (see PelB). On northern and eastern shores the barnacle is usually *Semibalanus balanoides*, which is normally restricted to the lower littoral fringe, with a band of *Verrucaria maura* only in the upper littoral fringe (Ver.Ver). On south-west and western shores, the barnacle is usually *Chthamalus montagui* which may extend over the whole of the littoral fringe zone. Ver.B also occurs on vertical faces of moderately exposed shores where the *Pelvetia canaliculata* biotope (PelB) usually dominates on non-vertical faces.

The black lichen zone (Ver) is normally found below the yellow and grey lichen zone (YG). In very sheltered areas there is not always a clear transition from one zone to the next and a mixed zone of YG and Ver.Ver is common. The *Pelvetia canaliculata* can occur on these more sheltered shores. With increasing wave exposure the two black lichen zones become wider and more distinct, and the Ver.Ver gives way to a lichen and barnacle dominated community (Ver.B) in the lower littoral fringe (Information adapted from Connor *et al*., 2004; JNCC, 2015).

Depth range

Upper shore

Additional information

The available evidence, for most pressures, does not distinguish between the biotope LR.FLR.Lic.Ver and its sub-biotopes LR.FLR.Lic.Ver.Ver and LR.FLR. Lic.Ver.B. Therefore, the information is presented at the biotope level LR.FLR.Lic.Ver with some differentiation between the biotopes where appropriate. Unless otherwise indicated all assessments are considered to apply to all the biotopes within the biotope complex.

Listed By

- none -

Further information sources

Search on:

G JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope LR.FLR.Lic.Ver and its sub-biotopes LR.FLR.Lic.Ver.Ver and LR.FLR. Lic.Ver.B are characterized by the abundance of the black lichen *Verrucaria maura*. A significant reduction in the abundance of *Verrucaria maura*, or its loss, would result in loss of the biotopes. *Littorina saxatilis* is also a characterizing species but it is mobile, not dependent on *Verrucaria maura* for habitat, and common in the upper to lower littoral fringe, the upper eulittoral and upper shore rockpools and crevices. If *Littorina saxatilis* was removed it would probably return quickly. The barnacles that characterize Ver.B reach their upper shore limit in Ver.B and are probably more sensitive to change in this biotope than in barnacle dominant biotopes. Similarly, many of the macroalgae that occur are transient or opportunistic (e.g. *Porphyra* spp., *Ulva* spp.) and the gastropod fauna are mobile (e.g. *Patella*) or restricted to crevices (e.g. *Melarhaphe neritoides*). Kronberg (1988) recorded numerous species from the littoral 'black' zone in Europe but noted that the communities were generally species-poor and that most species were mobile, feeding in the 'black' zone temporally, before returning to the more marine or terrestrial regions of origin or to refuges in crevices. Therefore, *Verrucaria maura* is the only species required to recognize these biotopes (Ver, Ver.Ver and Ver.B) and the only species that indicates the sensitivity of this habitat.

Resilience and recovery rates of habitat

Sexual spores and asexual propagules of lichens are probably widely dispersed by the wind and mobile invertebrates while the microalgal symbionts are probably ubiquitous. Lichen growth rates are low, rarely more than 0.5-1 mm/year in crustose species while foliose species may grow up to 2-5 mm/year. For example, crustose lichens were reported to show radial increases of 0.1 mm/month while foliose species grow at 0.4-0.7 mm/month (Fletcher, 1980); *Lichina pygmaea* was reported to grow 3-6 cm/year at one site but only 0.5 mm/year at others (Fletcher, 1980). Dethier & Steneck (2001) recorded a maximum growth rate of 2 mm/year for *Verrucaria mucosa* in the laboratory. However, lichen growth rates varied widely between different locations, between different species and even between different thalli of the same species at the same site (Fletcher, 1980; Sancho *et al.*, 2007). Cullinane *et al.* (1975) noted that many of the lichens lost due to an oil spill in Bantry Bay were probably 20-50 years old, based on their size, and lifespans of lichens have been estimated to be 100 years or more (Jones *et al.*, 1974) and possibly up to 7000 years in the Antarctic (Sancho *et al.*, 2007). However, lichen growth rates vary widely and many but not all lichens of extreme climates have slow growth rates. The highest growth rates are recorded in moist coastal-influenced regions, and lichens from temperature, tropical or sub-tropical areas may grow between a few millimetres to a few centimetres per year (Honeggar, 2008). Honeggar (2008) suggested that longevity in lichens required critical interpretation.

Fletcher (1980) suggested that newly exposed substratum needs to be modified by weathering and that initiation of the new thallus is thought to take several years. Rolan & Gallagher (1991) reported that *Verrucaria* spp. populations were destroyed on the upper shore, 'cleaned' by bulldozing at one site in Sullom voe after the *Esso Bernica* oil spill in 1978. At another site, *Verrucaria maura* was recorded on loose rocks in the littoral, rocks that were presumed to be displaced from the upper shore. Rolan & Gallagher (1991) also reported that lichens recovered within a year or two at four cleared sites, but did not specify the lichen species in question or whether they were littoral or supralittoral species. Crump & Moore (1997) observed that lichens had not colonized experimentally cleared substrata within 12 months. Moore (2006) reported that areas of bare rock (left after rock slices were removed by high-pressure water cleaning) showed no signs of recruitment by *Verrucaria maura* until 6 years after the *Sea Empress* oil spill, and that new colonies had grown to 2 mm in diameter 3 years later (9 years after the spill), and provided 'appreciable cover'.

Resilience assessment. Mobile invertebrate fauna and opportunistic macroalgae will probably recolonize rapidly. Little information on the growth rate of *Verrucaria maura* was found, although if similar to *Verrucaria mucosa* (a maximum of 2 mm/year) growth is slow. Evidence from Moore (2006) suggests that *Verrucaria maura* recolonize bare rock within 6 years and develop 'appreciable' cover within 9 years. Where the cover of *Verrucaria maura* is reduced or damaged regrowth is likely, but recovery is likely to take between 2 and 10 years depending on location and assuming growth rates vary. Similarly, it may colonize and reach 'appreciable cover' on bare rock within 10 years. Therefore, resilience would be assessed as '**Medium**'. However, although the Ver.B. biotope is characterized by *Verrucaria maura* cover and bare rock, Ver and Ver.Ver are characterized by almost complete cover.

Hydrological Pressures

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

Marine lichens are exposed to extremes of temperature from hot, dry summers to cold, frosty winters. Fletcher (1980) noted that few studies implicated high or low temperatures as a factor affecting seashore lichens, but that changes in temperature affect water relations. Increased temperature may increase desiccation (see emergence) although, other factors are involved, such as wind and wave action, precipitation, sunlight and shading.

Fletcher (1980) suggested that the effect of temperature on littoral lichens was inconclusive. For example, *Verrucaria maura* is abundant on both sunny and shaded shores but is considered a shade tolerant plant from North Africa to France and in Scandinavia. Reid (1969; cited in Fletcher, 1980) reported that *Verrucaria mucosa* had the similar temperature resistance to the algae with which it is ecologically associated but that *Verrucaria maura* was even less resistant. However, Fletcher (1980) also suggested that temperature was an important factor for water conservation, in combination with insolation, shade and wind, emersion and precipitation.

Sensitivity assessment. The 'black lichen zone' (Ver) experiences the extremes of hot summers and cold frosty winters and is, therefore, adapted to extreme variation in temperature. It also occurs from North Africa to Scandinavia, so that it is unlikely to be adversely affected by changes in temperature at the benchmark level within Britain and Ireland. Therefore, a resistance of **High** is suggested. Resilience is, therefore, likely to be **High**, and the biotope has been assessed as **Not sensitive** at the benchmark level. Ellis *et al.* (2007) modelled the effect of climate change scenarios on selected terrestrial lichens and identified potential threats to Northern montane and Boreal species, and uncertainties in the fate of species typical of the Atlantic coast margin, but no information on littoral species was found.

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

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Salinity increase (local)	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

The littoral fringe is likely to experience localised evaporation and a resultant increase in surface salinity during neap and low tides in hot summers and/or warm windy conditions. Fletcher (1980) noted that marine lichens in the lower littoral fringe died out in waters less than 20‰ while upper littoral fringe lichens were found in waters of 4-20‰ salinity. However, Fletcher (1980) commented that loss of littoral lichens in estuaries can also be attributed to changes in pH, silt, reduced tidal range, and reduced wave exposure.

Overall, littoral lichens receive regular inundation by seawater, unlike the supralittoral, and may not experience the extremes of salt spray. Nevertheless, there is not enough evidence to assess their sensitivity to hypersaline conditions.

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

The littoral fringe is likely to experience localised evaporation and a resultant increase in surface salinity during neap and low tides in hot summers and/or warm windy conditions. Conversely, it is exposed to rainfall and freshwater runoff during low and neap tides. Fletcher (1980) noted that marine lichens in the lower littoral fringe died out in waters less than 20‰ while upper littoral fringe lichens were found in waters of 4-20‰ salinity. However, Fletcher (1980) commented that loss of littoral lichens in estuaries can also be attributed to changes in pH, silt, reduced tidal range, and reduced wave exposure.

Overall, the limited evidence suggests that littoral lichens would be adversely affected by a reduction of salinity, for example from full to reduced and a resistance of **'Low'** is suggested but at 'Low' confidence. Resilience is probably '**Medium'**, therefore, a sensitivity of **'Medium'** is recorded.

Water flow (tidal current) changes (local)	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 littoral fringe is unlikely to be affected by changes in water flow as described in the pressure benchmark. Runoff due to heavy rainfall is possible but is outside the scope of the pressure. Therefore, the pressure is **Not relevant**.

Emergence regime changes	Low Q: High A: High C: Medium	Medium Q: Medium A: Medium C: Medium	Medium Q: Medium A: Medium C: Medium

The emergence regime, that is the time covered or uncovered by the tide, is likely to change the frequency of drying and wetting of lichens, especially on sheltered shores. Fletcher (1980) noted that littoral lichens are emersed for several weeks during neap tides, during which time they are exposed to the hottest and dryest periods in summer and the coldest and most frost-prone periods in winter. The levels of moisture and relative duration of wet and dry periods are the most important factors controlling vertical zonation in marine lichens. Rates of evaporation and hence desiccation is dependent on the slope and drainage of the shore, the rock type and its porosity, temperature and hence insolation and aspect, and wind exposure. Any activity that changes the exposure of the shore to wind, wave, rain or sunlight is likely to affect littoral lichen communities.

- Littoral lichens lost water faster than they absorbed it, over periods of up to 200 hrs, but that the reverse was true of supralittoral species (Fletcher, 1980).
- *Verrucaria mucosa* (which occurs lower on the shore) is less efficient at water conservation than *Verrucaria maura* (Fletcher, 1980).
- *Verrucaria maura* is the only littoral lichen species found above the littoral fringe, although it is restricted to crevices that retain water (Fletcher, 1980).
- Littoral lichens were able to maintain photosynthesis after 35 days of immersion.
- All littoral species needed to be 30-50% water saturated for respiration and 40% saturated for photosynthesis but achieved maximum photosynthesis at 100% saturation.
- Fletcher (1976; cited in Fletcher, 1980) found no difference in photosynthesis and respiration between *Verrucaria maura* and *Verrucaria mucosa* after two days drought at 0% relative humidity but that the littoral lichens died quickly when exposed to cycles of 21 hr drought, and 3 days submersion over a period of 14 days.

Sensitivity assessment. Water relations (Fletcher 1980) are vital to the zonation of marine lichens and the 'black lichen belt' exists in a distinct balance between immersion and emersion. A decrease in emersion (increased inundation) would probably allow the 'black lichen belt' to extend up the shore (where suitable substratum exists) and replace supralittoral lichens at the bottom of the supralittoral. However, the lower littoral fringe would probably be lost to competition from macroalgae or barnacles, depending on the exposure of the shore. Conversely, an increase in emersion (reduced inundation) would probably result in loss of the upper limit of the *Verrucaria maura* belt and its replacement by supralittoral lichens typical of the yellow-orange belt (e.g. *Caloplaca* spp.). Therefore, a decrease in emersion is likely to result is a slow shift in the biotope up the shore but an increase in emergence is likely to result in a rapid loss of *Verrucaria* spp. at its upper limit, based on observations by Fletcher (1976; cited in Fletcher, 1980). Hence, a resistance of **Low** is suggested. As resilience is probably **Medium**, a sensitivity of **Medium** is recorded.

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

LR.FLR.Lic.Ver and Ver.Ver are recorded from very wave exposed to very wave sheltered conditions while Ver.B his only recorded from wave exposed conditions (Connor *et al.*, 2004). The 'black lichen band' tends to be wider in more wave exposed conditions, as the influence of wave action and splash are carried further up the shore. Therefore, changes in wave exposure may either increase or decrease the width of the 'black lichen band' depending on the nature of the shore. The extent of the band (especially Ver.B.) may extend on sheltered shore exposed to increase wave action but be reduced on wave exposed shores where the wave action is reduced, which suggests a **Low** resistance to change. Ver.B may be particularly sensitive to reduced wave exposure as it is only recorded from wave exposed shores. However, a change in significant wave height of 3-5% (the benchmark) is probably not significant on wave exposed shores, and might only be of minor benefit in the long-term on very sheltered shores. Therefore, a resistance of **High** is recorded, so that, a resilience of **High** and sensitivity of **Not sensitive** are recorded at the benchmark level.

Chemical Pressures

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

Lichens are known indicators of heavy metals in the environment, especially iron (Seaward, 2008). Seashore lichens often indicate environmental concentrations of heavy metals or accumulate them, frequently to very high levels (Fletcher, 1980). The accumulation of high levels of heavy metals may deter grazers (Gerson & Seaward, 1977). For example, *Verrucaria maura* was reported to accumulate Fe to 2.5 million times over the concentration in seawater, and Zn by a factor of 8000. Some species accumulate lead (Pb) to 100 ppm and cadmium (Cd) to 2 ppm of thallus dry weight (Fletcher, 1980). Heavy metals may be derived from rainfall, and dust as well as seawater (Fletcher, 1980). Gerson & Seaward (1977) noted that accumulated heavy metals could potentially accumulate up lichen-based food webs, e.g. the lichen to caribou to man food chain in Alaska. However, no information on bioaccumulation through littoral lichen communities was found. Overall, the ability of lichens to accumulate heavy metals to such high levels suggests a 'High' resistance to the heavy metal ions studied. Therefore, the lichen community is probably **'Not sensitive** to heavy metal contamination.

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.

Several studies have documented the effects of oil spills on marine lichen communities, although in many cases is difficult to separate the effects of oiling from the effects of dispersants.

- Ranwell (1968) noted that *Verrucaria maura* and *Verrucaria mucosa* were killed after the *Torrey Canyon'* due to oiling but especially emulsifiers (Kerosene based).
- Cullinane *et al.* (1975) recorded an oily film on the surface of *Verrucaria maura* but no apparent damage after the oil spill in Bantry Bay.
- Oiling and subsequent clean-up cause loss of (unspecified) lichen cover after the *Sea Empress* oil spill (Moore, 2006) but noted that high pressure washing did not kill *Verrucaria maura.*

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. Several studies have documented the effects of oil spills on supralittoral lichen communities, although in many cases is difficult to separate the effects of oiling from the effects of dispersants. Most studies concluded that the decontamination methods, (including dispersants) were more toxic to lichens than the oil itself (see Hydrocarbon and PAH contamination above).

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

Lichens have also been reported to accumulate radionuclides in a similar manner to other heavy metals (see above) (Gerson & Seaward, 1977; Fletcher, 1980). Radionuclides could potentially accumulate up food webs based on lichen species, however, no further 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	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 littoral fringe is rarely inundated and is often exposed to the air. For example, Fletcher (1980) noted that *Lichina confinis*, a species that occurs at the top of the littoral fringe, spent a maximum of 1% of time submerged each year while *Verrucaria striatula*, a species that occurs in the lower littoral fringe below the *Verrucaria maura*, spent a maximum of 44% of time submerged each year. Therefore, the 'black lichen belt' characterized by Ver.Ver and Ver.B are exposed to the air for the majority of the time. Even if the water lapping over the littoral fringe was deoxygenated, wave action and turbulent flow over the rock surface would probably aerate the water column. Hence, the biotope is unlikely to be exposed to deoxygenated conditions.

Nutrient enrichment	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

Nutrient levels are a determining factor in supralittoral lichen zonation (Fletcher, 1980) but the evidence of the importance of nutrient in the in the littoral fringe is less clear. Wootton (1991) examined the effects of bird guano on rocky shore lichens in the San Juan archipelago, Washington. *Verrucaria mucosa* cover declined in areas affected by guano but the decline was only significant in wave exposed sites where the cover of *Prasiola meridionalis* increased. Connor *et al.* (2004) noted that *Prasiola* and opportunistic algae (e.g. *Ulva* and *Porphyra*) grow over the *Verrucaria* belt. However, no evidence on the effects on *Verrucaria maura* was found.

Organic enrichment	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

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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

The lichen community typical of this biotope is only found on hard substrata and dominates rocks in the littoral fringe. A change to a sedimentary substratum, however unlikely, would result in the permanent loss of the biotope. Therefore, the biotope has a resistance of **'None'**, with a '**Very low'** resilience (as the effect is permanent) and, therefore, a sensitivity of '**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 sediment type)	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 on hard rock biotopes.

Habitat structure changes - removal of substratum (extraction)	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 on hard rock biotopes.

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

Fletcher (1980) reported that the species diversity of lichens decreased in areas subject to mechanical damage, such as trampling, the passage of boats or vehicles, mining or physical removal due to building works. In disturbed areas, the 'normal' lichen flora is replaced by disturbance tolerant species, typically faster-growing species. For example, the littoral zone is dominated by *Arthopyrenia halodytes* in disturbed areas (Fletcher, 1980). Dethier (1994) noted that *Verrucaria mucosa* was less susceptible to experimental brushing with 'steel brush' than other crustose species in the littoral, but that it became more susceptible to damage from a steel and a nylon brush when completely submerged. However, no information on *Verrucaria maura* was found. *Verucaria maura* was not killed by high pressure washing during the *Sea Empress* oil spill cleanup (Moore, 2006) but was removed by bulldozing of the shore after the *Esso Bernica* oil spill (Rolan & Gallagher, 1991), although it was removed because the surface of the rock itself was removed or damaged.

Sensitivity assessment. There is little direct evidence on the effect of surface abrasion on the 'black lichen belt'. *Verucaria maura* is crustose and closely adherent to the rock surface so may resist abrasion and only be removed where the abrasion destroys the rock surface. However, the observation that fast growing lichen species come to dominate areas subject to disturbance (Fletcher, 1980) suggests that the 'black lichen belt' may be sensitive. Gastropods would probably be removed by abrasion and barnacle crushed, except where they occur in crevices. Overall, a resistance of **Medium** is suggested to represent localised damage of the rock surface or long-term disturbance but with **Low** confidence. As resilience is probably **Medium** and sensitivity assessment of **Medium** is recorded.

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

Penetration is unlikely to be relevant to hard rock substrata. Therefore, the pressure is **Not relevant**.

Changes in suspended solids (water clarity)	Medium Q: Low A: NR C: NR	Medium Q: Medium A: Medium C: Medium	Medium Q: Low A: Low C: Low

The littoral fringe is rarely submerged and is often exposed to the air. For example, Fletcher (1980) noted that *Lichina confinis*, a species that occurs at the top of the littoral fringe, spent a maximum of

1% of time submerged each year while *Verrucaria striatula*, a species that occurs in the lower littoral fringe below the *Verrucaria maura*, spent a maximum of 44% of time submerged each year. Therefore, the 'black lichen belt' characterized by Ver.Ver and Ver.B are exposed to the air for the majority of the time. Hence, an increase in turbidity may not adversely affect the availability of light. Nevertheless, Fletcher (1980) noted that littoral fringe lichens die back in estuarine conditions but that loss of littoral lichens in estuaries can also be attributed to changes in salinity, pH, silt, reduced tidal range, or reduced wave exposure. Therefore, an increase in turbidity due to suspended solids (at the benchmark) may be detrimental and a resistance of **'Medium'** is suggested but at Low confidence. As resilience is probably **'Medium'**, sensitivity is assessed as **'Medium'** at the benchmark level.

Smothering and siltation rate changes (light)	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 on the effect of siltation or smothering by sediment on littoral lichens was found. The lack of littoral lichens in estuaries was attributed to siltation amongst other factors by Fletcher (1980) but not to smothering alone. Therefore, no sensitivity assessment was made.

Smothering and siltation rate changes (heavy)	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 on the effect of siltation or smothering by sediment on littoral lichens was found. The lack of littoral lichens in estuaries was attributed to siltation amongst other factors by Fletcher (1980) but not to smothering alone. Therefore, no sensitivity assessment was made.

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	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.

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

Not relevant

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

Verrucaria maura is well developed on both shaded and sunny coasts in Britain and Ireland but is considered a shade plant in North Africa, France and Scandinavia (Fletcher, 1980). *Verrucaria mucosa* and green forms of *Verrucaria striatula* increase in abundance on shaded shores and may, therefore, increase in abundance in the 'black lichen belt'. However, the artificial increase in light or shade may not adversely affect the littoral fringe, although seasonal opportunistic algae may be excluded and complete shade (darkness) may exclude even the lichens in the long-term. Therefore, resistance is probably **High**, albeit at **Low** confidence, so that resilience is **High** and the biotope is probably **Not sensitive** at the benchmark level.

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

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

The pressure definition is not directly applicable to the littoral fringe so **Not relevant** has been recorded. Collision via ship groundings or terrestrial vehicles is possible but the effects are probably similar to those of abrasion above.

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

Lichens have no visual receptors, so the pressure is **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 on the translocation, breeding or species hybridization in lichens 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

Essl & Lambdon (2009) reported that that only five species of lichen were thought to be alien in the UK, which is ca 0.3% of the UK's lichen flora. All five species were *Parmelia* spp. epiphytes and unlikely to occur in the supralittoral. Essl & Lambdon (2009) note that no threat to competing natives has yet been demonstrated. Although they note that information on the presence or spread of non-indigenous lichens is unclear due to the lack of data on lichen distribution across Europe. Therefore, there is currently not enough evidence on which to base an assessment.

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

No evidence on disease or pathogens mediated mortality was found.

Removal of target species	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No information concerning the use of marine lichens was found. Extraction of lichens will undoubtedly reduce their abundance but probably not the extent of the supralittoral zone. However, **No evidence** of targetted removal was found.

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

Verrucaria spp. are crustose lichens, thin and closely attached to the surface of hard rocks. It is very unlikely that they would be removed accidentally by any fishery activity at a commercial or recreational scale. Physical removal from rock by abrasion, or by removal of pieces of rock could occur during oil spill cleanup by high-pressure washing or bulldozing (Rolan & Gallagher, 1991; Moore, 2006) but physical abrasion is addressed under the relevant pressure above. Therefore, this pressure was considered to be **Not relevant**.

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