Rhodochorton purpureum and *Pleurocladia lacustris* crusts on upper and mid-shore cave walls and ceilings

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

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2016-03-27

A report from:
The Marine Life Information Network, Marine Biological Association of the United Kingdom.

Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/habitats/detail/1078]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

This review can be cited as:
Tyler-Walters, H., 2016. [Rhodochorton purpureum] and [Pleurocladia lacustris] crusts on upper and mid-shore cave walls and ceilings. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. DOI https://dx.doi.org/10.17031/marlinhab.1078.1

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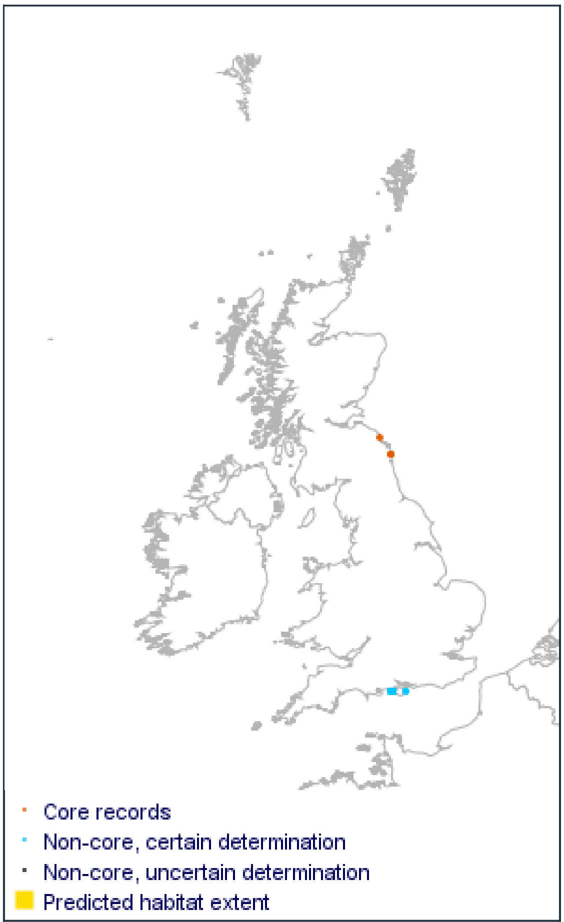

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

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

Summary

UK and Ireland classification

EUNIS 2008	A1.443	*Audouinella purpurea* and *Pilinia maritima* crusts on upper and mid-shore cave walls and ceilings
JNCC 2015	LR.FLR.CvOv.RhoPle	*Rhodochorton purpureum* and *Pleurocladia lacustris* crusts on upper and mid-shore cave walls and ceilings
JNCC 2004	LR.FLR.CvOv.AudPil	*Audouinella purpurea* and *Pilinia maritima* crusts on upper and mid-shore cave walls and ceilings
1997 Biotope		

Description

Golden brown velvety growths of the brown algae *Pleurocladia lacustris* (syn. *Pilinia maritima*) occurring in mats with the red alga *Rhodochorton purpureum* (syn. *Audouinella purpurea*) forming on cave walls and upper littoral levels of cliffs. Fauna is sparse and limited to occasional individuals of the winkle *Littorina saxatilis* and spirorbid polychaetes. This assemblage is thought to be is widespread throughout Britain, although there are currently few records available. More information are needed to validate this description, which is based on information from the Thanet intertidal survey. This biotope is found at the entrances and the inner reaches of caves between a band of RhoCla and the GCv zone above. (Information taken from Connor *et al*., 2004). **Please note** that *Rhodochorton purpureum* is the accepted name for *Audouinella purpurea* and *Pleurocladia lacustris* is the accepted name for *Pilinia maritima*.

Depth range

Upper shore

Additional information

Both of the *Rhodochorton purpureum* (syn. *Audouinella purpurea)* biotopes LR.FLR.CvOv.RhoCla and CvOV.RhoPle are very similar cave habitats and both are dominated by *Rhodochorton purpurea.* While other macroalgae or algal films may also occur, *Rhodochorton purpureum* is the dominant species. Therefore, the following sensitivity review represents both biotopes. Where relevant, differences in the sensitivity of *Cladophora rupestris* or *Pleurocladia lacustris* (syn. *Pilinia maritima*) are highlighted.

Listed By

- none -

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Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotopes LR.FLR.CvOv.RhoCla and CvOv.RhoPil are dominated by the velvety growth of *Rhodochorton purpureum* (syn. *Audouinella purpurea*). In CvOv.RhoCla, *Cladophora rupestris* may be present while *Pleurocladia lacustris* (syn *Pilinia maritima*) occurs in CvOV.RhoPil. CvOV.RhoPil usually occurs above CvOV.RhoCla (Connor *et al.*, 2004). Grazers such as *Littorina saxatilis* and *Patella* spp. occur and probably graze the macroalgae and microalgae present in the biotope. The dominance of *Rhodochorton purpureum* probably depends on the correct environmental conditions of the cave or cliff walls, of light, moisture versus desiccation, and hence wave splash or spray, that prevents competition from other macroalgae (e.g. *Ulva*, *Fucus*) and overgrazing. The presence of these biotopes below the green algal film biotope (CvOv.GCv) but above faunal turf biotope (CvOV.ScaFa and CvOV.FaCr) suggests they occur in lower to upper littoral fringe or supralittoral conditions (see also Conway & Knaggs, 1966). Therefore, *Rhodochorton purpureum* is the dominant important characterizing species in both biotopes, and is used to indicate the sensitivity of the biotope in the following review. Where relevant, differences in the sensitivity of *Cladophora rupestris* or *Pleurocladia lacustris* (syn *Pilinia maritima*) are highlighted.

Resilience and recovery rates of habitat

Rhodochorton purpureum (syn. *Audouinella purpurea*) has a triphasic life cycle that alternates between a gametophyte, tetrasporophyte and carposporophtye stage. The gametophyte and tetrasporophyte phases produce monospores, capable of replacing the parent plant. Gamateophytes produce sexual spores (sperm and carpospores) while the tetrasporophyte produced tetrapsores that give rise to gametophytes (Conway & Knaggs, 1966; Stegenga, 1978). All spores are typically non-motile. Growth and sporulation were greatest at high light intensities (up to 5000 lux) but lowest at low intensity (150 lux) (West, 1972). Vegetative growth was greatest in long day lengths, yet sporulation was greatest in short day lengths (e.g. winter months) (West, 1972). *Rhodochorton purpureum* spores attach to the substratum via a sticky rhizoid (Pearlmutter & Vadas, 1978). However, *Rhodochorton purpureum* can regenerate from fragmented filaments and vegetative growth (Pearlmutter & Vadas,1978). In culture, regeneration was detected within 24-48 hrs, and new cells developed with 20 days in 89% of samples. Filaments may also be transported by grazers. Breeman & Hoeksema (1987) noted that grazers fragmented the thallus but more importantly, carried viable filaments through their digestive tracts and deposited them within their faeces, from which filaments could then grow. They also found small tufts of *Rhodochorton purpureum* on bare substratum growing from sticky detritus rich faecal pellets (Breeman & Hoeksema,1987).

Little information on recruitment or the life history of *Pleurocladia lacustris* (syn *Pilinia maritima*) was found. Wilce (1966) suggested that it was more widespread and common than thought. It is seasonal in the Artic (Wilce, 1966) present in the Arctic summer suggesting that it can recruit annually. Many species of epifauna, such as *Patella* spp. and *Littorina saxatlis* and polychaetes that may be associated with rock crevices, have long lived pelagic larvae and/or are highly motile as adults.

Information on the ecology of reproduction and propagation of the genus *Cladophora* is limited. Reproduction is achieved by the release of quadriflagellate zoospores and biflagellate isogametes ('swarmers') formed in the terminal cells of fronds. The life history consists of an isomorphic (indistinguishable except for the type of reproductive bodies produced) alternation of gametophyte and sporophyte generations, the plants are dioecious (Burrows, 1991). Both zoospores and gametes can be found at most times of the year. Archer (1963, cited in Burrows, 1991) was unable to find any correlation between the time of reproduction, the state of tide or environmental conditions. these basal holdfasts may serve as resistant structures from which new growths can arise. Therefore, it is likely that *Cladophora rupestris* will have a considerable capacity for recovery. The species is widespread around the British Isles and Ireland, and may be found in reproductive condition all year round. Numerous motile 'swarmers' (reproductive propagules) are released and in the water column they can be dispersed over considerable distances. In addition to recruitment by swarmers, new growth may arise from the resistant multicellular branching rhizoids (van den Hoek, 1982) that may remain in situ. For instance, after the *Torrey Canyon* tanker oil spill in mid-March 1967, recolonization by sporelings of *Ulva* and *Cladophora* had colonized by the end of April (Smith, 1968).

Resilience assessment. Although *Rhodochorton purpureum* spores are non-motile, they are numerous. It can also be transported by fragmentation and by grazers. It is recorded from the eulittoral, the supralittoral and 'almost terrestrial' habitats with maritime influence (Conway & Knaggs, 1966). It is also widely distributed in the North East Atlantic (OBIS, 2016) and recorded from Chile, California, Washington and Alaska (West, 1972). Therefore, its life history and distribution suggests that is could recolonize suitable habitat rapidly, although no information on growth rates was found. Similarly, *Cladophora* spp. are probably an opportunistic species capable of rapid recruitment and growth. Although, no direct evidence on *Pleurocladia lacustris* was found, many Ectocarpales are opportunistic species. Therefore, recovery of the dominant species *Rhodochorton purpureum* is probably rapid, even after significant damage, and resilience has been assessed as **High**.

Hydrological Pressures

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

The percentage of plants of *Rhodochorton purpureum* sporulating was greatest at 10°C from Washington and Alaska, but greatest at 15°C in plants from California but plants from Chile sporulated between 10 and 15°C (West, 1972). But sporulation was 'strikingly' inhibited above or below these optima. Gametogenesis was greatest at 15°C but reduced below 10 (West, 1972). Tetrasporophytes survived at 25°C in the laboratory but exhibited aberrant growth (Stegenga, 1978). In the Shetland Isles, Conway & Knaggs (1966) recorded *Rhodochorton purpureum* along the top of cliffs 200 feet high, suggesting that it can tolerate supralittoral conditions, exposed to high summer temperatures and low winter temperatures. It is also widely distributed in the North East Atlantic, and occurs in California, suggesting that it would be resistant of an increase in temperature at the benchmark level within the UK. In addition, the biotopes occur in the darker or shaded areas of caves, protected from strong sunlight and, in the presumably humid or moist areas of caves, protected from desiccation due to the sun and the wind.

Fortes & Lüning (1980) and Lüning (1984) reported that *Cladophora rupetsris* from Helgoland were able to survive at temperatures between 0 -28°C (for a period of a week), so the species is likely to tolerate the benchmark acute increase in temperature, the species is also characteristic of upper shore rock pools, where water and air temperatures are greatly elevated on hot days. The biotope CvOv.AudPil also occurs on the upper littoral level of cliffs, where is could receive heating from sunlight. However, *Pleurocladia lacustis* is recorded from Devon Island in the Arctic, Greenland, Novaya Zemlya, south to the Baltic and the French Mediterranean (Wilce, 1966).

Overall, the important characterizing species are probably resistant of an increase in temperature at the benchmark level within the UK. Therefore, a resistance of **High** is recorded, so that resilience is also **High** and the biotope is assessed as **Not sensitive**.

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

The percentage of plants of *Rhodochorton purpureum* sporulating was greatest at 10°C from Washington and Alaska, but greatest at 15°C in plants from California but plants form Chile sporulated between 10 and 15°C (West, 1972). But sporulation was 'strikingly' inhibited above or below these optima. Gametogenesis was greatest at 15°C but reduced below 10 (West, 1972). In the Shetland Isles, Conway & Knaggs (1966) recorded *Rhodochorton purpureum* along the top of cliffs 200 feet high, suggesting that it can tolerate supralittoral conditions, exposed to high summer temperatures and low winter temperatures. It is also widely distributed in the North East Atlantic, and occurs in California, suggesting that it would be resistant of an increase in temperature at the benchmark level within the UK. In addition, the biotopes occur in the darker or shaded areas of caves, protected from strong sunlight and, in the presumably humid or moist areas of caves, protected from desiccation due to the sun and the wind.

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Overall, the important characterizing species are probably resistant of a decrease in temperature at the benchmark level within the UK. Therefore, a resistance of **High** is recorded, so that resilience is also **High** and the biotope is assessed as **Not sensitive**.

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

Rhodochorton purpureum is recorded as an epiphyte on laminarian stipes in the subtidal, and a lithophyte under fucoids in the littoral, in caves in the littoral or littoral fringe, on cliffs and cliff tops in the supralittoral, and in a freshwater waterfall in a shallow cave (Shetland) (Conway & Knaggs, 1966; Connor *et al.*, 2004; Guiry & Guiry, 2015). In experiments, West (1972) noted that clones of *Rhodochorton purpureum* from the upper littoral showed little response to a change in salinity, and were able to sporulate at 10‰, and 20‰ but that clones from the mid-littoral showed the poorest ability to sporulate at the salinities tested (10, 20 and 30‰). Nevertheless, *Rhodochorton purpureum* found on cave walls is probably resistant of a wide range of salinities as it occupies a littoral fringe or supralittoral position on the shore.

Cladophora rupestris found in intertidal rock pools can withstand 5-30 psu (Jansson, 1974) and as the species is successful in the high intertidal zone it is likely that the species has a broad salinity tolerance (Dodds & Gudder, 1992). However, Thomas *et al.* (1988) found that, at extreme temperatures, *Cladophora rupestris* had a reduced salinity tolerance range, e.g. the most marked inhibition of photosynthesis occurred in conditions of low salinity (0 psu) and high temperatures (25 - 30°C). *Pleurocladia lacustris* was reported from the upper littoral of limestone shores, exposed to freshwater runoff and rainfall until the breakup of the ice sheet, after which conditions are fully marine (Wilce, 1966).

Sensitivity assessment. The important characterizing species are typical of upper littoral and supralittoral habitats. Therefore, they are probably exposed to a wide range of salinities, from running freshwater and rainfall, for fully marine and salt deposited by spray and splash, especially on cliffs. The biotopes are probably resistant of a change in salinity from full to reduced or low. Therefore, resistance is assessed as **High**, so that resilience is **High** and the biotope assessed as **Not sensitive**.

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

Rhodochorton purpureum is recorded as an epiphyte on laminarian stipes in the subtidal, under fucoids in the littoral, in caves in the littoral or littoral fringe, on cliffs and cliff tops in the supralittoral, and in a freshwater waterfall in a shallow cave (Shetland) (Conway & Knaggs, 1966; Connor *et al*., 2004; Guiry & Guiry, 2015). In experiments, West (1972) noted that clones of *Rhodochorton purpureum* from the upper littoral showed little response to a change in salinity, and were able to sporulate at 10‰, and 20‰ but that clones from the mid-littoral showed the poorest ability to sporulate at the salinities tested (10, 20 and 30‰). Nevertheless, *Rhodochorton purpureum* found on cave walls is probably resistant of a wide range of salinities as it occupies a littoral fringe or supralittoral position on the shore.

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Sensitivity assessment. The important characterizing species are typical of upper littoral and supralittoral habitats. Therefore, they are probably exposed to a wide range of salinities, from running freshwater and rainfall, for fully marine and salt deposited by spray and splash, especially on cliffs. The biotopes are probably resistant of a change in salinity from marine to reduced, or reduced to low. Therefore, resistance is assessed as **High**, so that resilience is **High** and the biotope assessed as **Not sensitive**.

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

Tidal influence in mid-littoral to supralittoral caves is probably is probably limited to the floor and sides of the caves, and the upper walls and ceilings only receive spray and splash. However, water movement, splash, spray in caves are probably wave mediated rather than due to tidal streams. Therefore, the biotope is unlikely to be affected by water flow as described by the benchmark and the pressure is **Not relevant**.

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

Rhodochorton purpureum (syn. *Audouinella purpurea*) is recorded from s recorded as an epiphyte on laminarian stipes in the subtidal, and a lithophyte under fucoids in the littoral, in caves in the littoral or littoral fringe, on cliffs and cliff tops in the supralittoral, and in a freshwater waterfall in a shallow cave (Shetland) (Conway & Knaggs, 1966; Connor *et al.*, 2004; Guiry & Guiry, 2015). It is, therefore, found in a variety of emergence regimes. *Cladophora rupestris* is also recorded from the sublittoral fringe to the supralittoral (Connor *et al.*, 1997a) while *Pleurocladia lacustris* (syn *Pilinia maritima*) is primarily recorded from upper littoral or littoral fringe habitats (Wilce, 1966). However, the *Rhodochorton purpureum* dominated biotopes only occur in shaded areas of caves, sheltered from wave action, or on cliff faces, presumably moist and shaded enough to support the biotope. Changes in emergence will probably affect the degree of splash and spray, and, hence, moisture, desiccation and salinity experienced by the biotopes. Therefore, a change in wave exposure will probably affect the upper and lower extent of the biotopes, and result in loss of extent. Therefore, a resistance of **Low** is recorded. Resilience is probably **High** (albeit at Low confidence), therefore, a sensitivity of **Low** 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

These biotopes (CvOv.AudCla and CvOv.AudPil) occur on the entrances and inner reaches of upper to mid-shore caves that are partially sheltered from direct wave action, in moderately wave exposed to wave sheltered shores (Connor *et al.*, 2004). Wave surge, splash and spray keep the rock surface moist while the cave habitat maintains the humidity. AudPil can also occur on upper littoral cliffs. Changes in wave action will probably affect the degree of splash and spray, and, hence, moisture, desiccation and salinity experienced by the biotopes. Therefore, a change in wave exposure will probably affect the upper and lower extent of the biotopes, and result in loss of extent. However, a 3-5% change in significant wave height is unlikely to be significant in wave exposed conditions. Therefore, the biotope is probably **Not sensitive** (resistance and resilience are **High**) at the benchmark level.

Chemical Pressures

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

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.

Smith (1968) reported *Cladophora rupestris* to be amongst algae of unhealthy appearance following exposure to oil dispersants. O'Brien & Dixon (1976) suggested that red algae were the most sensitive group of algae to oil or dispersant contamination. Laboratory studies of the effects of oil and dispersants on several red algal species concluded that they were all sensitive to oil/dispersant mixtures, with little difference between adults, sporelings, diploid or haploid stages (Grandy, 1984, cited in Holt *et al.*, 1995). In addition, Cole *et al.* (1999) suggested that the herbicides Atrazine, Simazine, Diuron, Linuron and the insecticide Dimethoate were probably very toxic to algae.

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

No evidence

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 and supralittoral and cave ceilings are rarely inundated and are, therefore, permanently exposed to the air. 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

Maritime cliff plant and algae communities are probably nutrient poor, i.e. lack nutrients. An increase in nutrients in the form of runoff from adjacent agricultural land may benefit the communities. The opportunistic filamentous algae such as *Ulothrix* sp. and *Urospora* sp. may overgrow these biotopes. However, no evidence concerning the effects of nutrient enrichment on these communities 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

Maritime cliff plant and algae communities are probably nutrient poor, i.e. lack nutrients. An increase in nutrients in the form of runoff from adjacent agricultural land may benefit the communities. The opportunistic filamentous algae such as *Ulothrix* sp. and *Urospora* sp. may overgrow these biotopes. However, no evidence concerning the effects of nutrient enrichment on these communities was found.

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.

	Resistance	Resilience	Sensitivity
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

These biotopes require hard or soft rock substrata. 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.

	Resistance	Resilience	Sensitivity
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. Where present, it is unlikely that chalk would be replaced by sediment in the littoral fringe or supralittoral. Therefore, this pressure is **Not relevant**. However, change in substratum type is address above.

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

Extraction of sediment, as described under this pressure, is **not relevant** in hard rock habitats. However, soft rocks could suffer extraction due to tunnelling, mining or construction. Therefore, removal of chalk from the cliff or caves would remove the surface resulting in loss of the biotope. Resistance would, therefore, be **None** where it occurs on chalk or other soft rocks. But if the existing substratum (chalk) remains in the same habitat (upper littoral fringe to supralittoral) then the biotope would recover rapidly and resilience is probably **High**, therefore, sensitivity to extraction is probably **Medium**.

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

The characterizing species are filamentous, lithophytes, and probably fairly soft and fragile. These algal communities are likely to be removed as a result of any abrasion, e.g. from vessel grounding, the abrasion from chains or cables, or recreational access and trampling, especially where the friable (e.g. chalk) rock surface is removed. Therefore, resistance is probably **Low** (depending on the scale of the impact). However, recovery is likely to be rapid if suitable substratum remains so that resilience is probably **High** and sensitivity is probably **Low**.

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

Penetration by mobile fishing gear is unlikely to occur in caves or on vertical chalk cliffs. However, soft rock, by definition, can be damaged by other penetrative activities, for example during construction. Therefore, where these biotopes occur on chalk (e.g. CvOv.AudPil) resistance is probably **Low** (depending on the scale of the impact). However, recovery is likely to be rapid if suitable substratum remains so that resilience is probably **High** and sensitivity is probably **Low**.

Changes in suspended solids (water clarity)	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

This biotope occurs in mid to upper littoral and littoral fringe and reaches upper walls of caves, probably only exposed to wave splash and rarely inundated. Therefore, an increase in turbidity due to suspended solids (at the benchmark) is unlikely to adversely affect the biotope and **Not relevant** is recorded.

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

The upper, vertical walls of caves are unlikely to be subject to smothering, but the inner reaches of caves with shallow slopes or horizontal ledges may be. In the wave exposed conditions experienced by this biotope, 5 cm of sediment may be removed quickly from the entrance but may persist in the inner reaches of the cave, depending on the shape of the cave. The fine 'velvety' mat of *Rhodochorton purpureum*, filaments of *Cladophora rupestris or Pleurocladia lacustris* may trap sediment and result in localised anoxia near the base of the plant. This may cause death, where the slope of the rock is sufficient for sediment to be deposited and the wave action so limited that sediment is not removed quickly. It is possible, therefore, that a proportion of the biotope (on shallow sloping or horizontal surfaces) could be lost and a resistance of **Medium** is recorded. Resilience is probably **High**, so that a sensitivity of **Low** is suggested, albeit at **Low** confidence.

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

The upper, vertical walls of caves are unlikely to be subject to smothering, but the inner reaches of caves with shallow slopes or horizontal ledges may be. In the wave exposed conditions experienced by this biotope, sediment may be removed quickly from the entrance but may persist in the inner reaches of the cave, depending on the shape of the cave. The fine 'velvety' mat of *Rhodochorton purpureum*, filaments of *Cladophora rupestris or Pleurocladia lacustris* may trap sediment and result in localised anoxia near the base of the plant. This may cause death, where the slope of the rock is sufficient for sediment to be deposited and the wave action so limited that sediment is not removed quickly. It is possible, therefore, that a proportion of the biotope (on shallow sloping or horizontal surfaces) could be lost and a resistance of **Medium** is recorded. Resilience is probably **High**, so that a sensitivity of **Low** is suggested, albeit at **Low** confidence.

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. Caves, especially high on the shore, may accumulate litter blown into the cave by the wind. Large pieces of marine debris blown around by wind or wave action may cause abrasion of the cave wall communities (see above). However, **No evidence** on the effects of litter was found.

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

No evidence was found.

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

No relevant

Introduction of light or shading	Medium Q: Low A: NR C: NR	High Q: Low A: NR C: NR	Low Q: Low A: Low C: Low

Red algae are more shade tolerant than their green or brown equivalents. West (1972) noted that vegetative growth and gametogenesis of *Rhodocorton purpureum* was greatest in long day lengths (summer months), that sporulation and growth were greatest at highest light intensity tested (5000 lux), yet spermatangia and carpogonia production was greatest in short days (winter months), but concluded that the observations were not true photoperiodism. It may be that long summer days promote growth and asexual reproduction while short days and winter months promote sexual reproduction. No evidence on the effects of light on the other characteristic species was found.

These biotopes are characteristic of shaded or dark, moist caves, presumably because green algae would out-compete the dominant species at higher light levels. If artificial lighting was introduced to a cave where this biotope occurred, then it might adversely affect the biotopes by promoting green algal growth. Increased shaded might allow the biotope to increase in extent, or reduce light levels below those needed for the algae to survive. Therefore, a resistance of **Medium** is suggested at **Low** confidence. However, resilience is probably **High**, so that sensitivity is **Low**.

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 caves, 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

Not relevant has been recorded.

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 was found to suggest that the macroalgae that characterize these biotopes were subject to translocation, nor that they were subject to genetic modification or hybridization with other similar species.

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

No evidence was found

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

No evidence was found.

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

The algal communities characteristic of these biotopes are unlikely to be targetted by any commercial or recreational fishery or harvest.

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

Incidental removal the dominant characteristic species would result in loss of the entire biotope. Where present, mobile invertebrate or gastropod fauna are probably not entirely dependent on the biotope for food or habitat and would forage elsewhere. However, soft rock and hard rock cave communities are unlikely to be targetted by any commercial or recreational fishery or harvest. Accidental physical disturbance due to access (e.g. trampling) or grounding is examined under abrasion above.

Bibliography

Anand, P.L., 1937b. An ecological study of the algae of the British chalk cliffs. Part I. *Journal of Ecology*, **25**, 153-188.

Anand, P.L., 1937c. An ecological study of the algae of the British chalk cliffs. Part II. *Journal of Ecology*, **25**, 344-367.

Anonymous, 1999e. Littoral and sublittoral chalk. http://www.ukbap.org.uk/ukplans.aspx?id=31, 2001-09-26

Boney, A.D., 1971. Sub-lethal effects of mercury on marine algae. *Marine Pollution Bulletin*, **2**, 69-71.

Breeman, A.M. & Hoeksema, B.W., 1987. Vegetative propagation of the red alga *Rhodochorton purpureum* by means of fragments that escape digestion by herbivores. *Marine Ecology Progress Series*, **35**, 197-201.

Bryan, G.W., 1984. Pollution due to heavy metals and their compounds. In *Marine Ecology: A Comprehensive, Integrated Treatise on Life in the Oceans and Coastal Waters*, vol. 5. *Ocean Management*, part 3, (ed. O. Kinne), pp.1289-1431. New York: John Wiley & Sons.

Burrows, E.M., 1991. *Seaweeds of the British Isles. Volume 2. Chlorophyta.* London: British Museum (Natural History).

Cole, S., Codling, I.D., Parr, W. & Zabel, T., 1999. Guidelines for managing water quality impacts within UK European Marine sites. *Natura 2000 report prepared for the UK Marine SACs Project.* 441 pp., Swindon: Water Research Council on behalf of EN, SNH, CCW, JNCC, SAMS and EHS. [UK Marine SACs Project.], http://www.ukmarinesac.org.uk/

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. & Reker, J.B., 2004. The Marine Habitat Classification for Britain and Ireland. Version 04.05. ISBN 1 861 07561 8. In JNCC (2015), *The Marine Habitat Classification for Britain and Ireland Version 15.03.* [2019-07-24]. Joint Nature Conservation Committee, Peterborough. Available from https://mhc.jncc.gov.uk/

Connor, D.W., Brazier, D.P., Hill, T.O., & Northen, K.O., 1997b. Marine biotope classification for Britain and Ireland. Vol. 1. Littoral biotopes. *Joint Nature Conservation Committee, Peterborough, JNCC Report* no. 229, Version 97.06., *Joint Nature Conservation Committee, Peterborough, JNCC* Report No. 230, Version 97.06.

Connor, D.W., Dalkin, M.J., Hill, T.O., Holt, R.H.F. & Sanderson, W.G., 1997a. Marine biotope classification for Britain and Ireland. Vol. 2. Sublittoral biotopes. *Joint Nature Conservation Committee, Peterborough, JNCC Report* no. 230, Version 97.06., *Joint Nature Conservation Committee, Peterborough, JNCC* Report no. 230, Version 97.06.

Conway, E. & Knaggs, F.W., 1966. Contributions to our knowledge of the genus *Rhodochorton*: I. *R. purpureum*. In *Some Contemporary Studies in Marine Science* (ed. H. Barnes), pp 195-203. London: George Allen and Unwin Ltd.

Davies, C.E. & Moss, D., 1998. European Union Nature Information System (EUNIS) Habitat Classification. *Report to European Topic Centre on Nature Conservation from the Institute of Terrestrial Ecology, Monks Wood, Cambridgeshire.* [Final draft with further revisions to marine habitats.], Brussels: European Environment Agency.

Dixon, P.S. & Irvine, L.M., 1977. *Seaweeds of the British Isles. Volume 1 Rhodophyta. Part 1 Introduction, Nemaliales, Gigartinales.* London: British Museum (Natural History) London.

Fortes, M.D. & Lüning, K., 1980. Growth rates of North Sea macroalgae in relation to temperature, irradiance and photoperiod. *Helgolander Meeresuntersuchungen*, **34**, 15-29.

George, J.D., Tittley, I., Price, J.H., & Fincham, A.A., 1988. The macrobenthos of chalk shores in North Norfolk and around Flamborough Headland (North Humberside). *Nature Conservancy Council CSD Rep. 833* 149p., Peterborough: Nature Conservancy Council

Grandy, N., 1984. *The effects of oil and dispersants on subtidal red algae*. Ph.D. Thesis. University of Liverpool.

Hammer, L., 1972. Anaerobiosis in marine algae and marine phanerograms. In *Proceedings of the Seventh International Seaweed Symposium, Sapporo, Japan, August 8-12, 1971* (ed. K. Nisizawa, S. Arasaki, Chihara, M., Hirose, H., Nakamura V., Tsuchiya, Y.), pp. 414-419. Tokyo: Tokyo University Press.

Hiscock, K., ed. 1998. *Marine Nature Conservation Review. Benthic marine ecosystems of Great Britain and the north-east Atlantic.* Peterborough, Joint Nature Conservation Committee.

Holt, T.J., Hartnoll, R.G. & Hawkins, S.J., 1997. The sensitivity and vulnerability to man-induced change of selected communities: intertidal brown algal shrubs, *Zostera* beds and *Sabellaria spinulosa* reefs. *English Nature, Peterborough, English Nature Research Report* No. 234.

Holt, T.J., Jones, D.R., Hawkins, S.J. & Hartnoll, R.G., 1995. The sensitivity of marine communities to man induced change - a scoping report. *Countryside Council for Wales, Bangor, Contract Science Report*, no. 65.

JNCC, 2015. The Marine Habitat Classification for Britain and Ireland Version 15.03. (20/05/2015). Available from https://mhc.jncc.gov.uk/

JNCC (Joint Nature Conservation Committee), 1999. *Marine Environment Resource Mapping And Information Database (MERMAID): Marine Nature Conservation Review Survey Database.* [on-line] http://www.jncc.gov.uk/mermaid

Lewis, J.R., 1964. *The Ecology of Rocky Shores.* London: English Universities Press.

Marine Task Force, 1993. *Sensitive Marine Areas in England. First Draft.* English Nature Report, Campaign for a Living Coast.

Norton, T.A., 1992. Dispersal by macroalgae. *British Phycological Journal*, **27**, 293-301.

O'Brien, P.J. & Dixon, P.S., 1976. Effects of oils and oil components on algae: a review. *British Phycological Journal*, **11**, 115-142.

Schiel, D.R. & Foster, M.S., 1986. The structure of subtidal algal stands in temperate waters. *Oceanography and Marine Biology: an Annual Review*, **24**, 265-307.

Smith, J.E. (ed.), 1968. 'Torrey Canyon'. *Pollution and marine life.* Cambridge: Cambridge University Press.

Stegenga, H., 1978. The life histories of *Rhodochorton purpureum* and *Rhodochorton floridulum* (Rhodophyta, Nemiales) in culture. *British Phycological Journal*, **13**, 279-289.

Tittley, I. & Shaw, K.M., 1980. Numerical and field methods in the study of the marine flora of chalk cliffs. In *The shore environment*, vol. 1: *methods* (ed. J.H. Price, D.E.G. Irvine & W.F. Farnham), pp. 213-240. London & New York: Academic Press. [Systematics Association Special Volume, no. 17(a).]

Tittley, I., 1985. Chalk cliff algal communities of Kent and Sussex, Southeast England. *Nature Conservancy Council, Contract Reports*, no. 200., Peterborough: Nature Conservancy Council.

Vadas, R.L., Johnson, S. & Norton, T.A., 1992. Recruitment and mortality of early post-settlement stages of benthic algae. *British Phycological Journal*, **27**, 331-351.

Van den Hoek, C., 1982. The distribution of benthic marine algae in relation to the temperature regulation of their life histories. *Biological Journal of the Linnean Society*, **18**, 81-144.

Vidaver, W., 1972. Dissolved gases - plants. In *Marine Ecology. Volume 1. Environmental factors (3)*, (ed. O. Kinne), 1471-1490. Wiley-Interscience, London.

West, J.A., 1972. Environmental regulation of reproduction in *Rhodochorton purpureum*. In: *Contributions to the Systematics of Benthic Marine Alage of the North Pacific*, (I.A. Abbot & M. Kurogi, eds), pp. 213-230. Kobe, Japan: Japanese Society of Phycology.

Wilce, R.T., 1966. *Pleurocladia lacustris* in Arctic America. *Journal of Phycology*, **2**, 57-66.