Ulva spp. on freshwater-influenced and/or unstable upper eulittoral rock

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

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2015-07-31

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

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This review can be cited as:
Tillin, H.M. & Budd, G., 2015. [Ulva] spp. on freshwater-influenced and/or unstable upper eulittoral rock. 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.104.1

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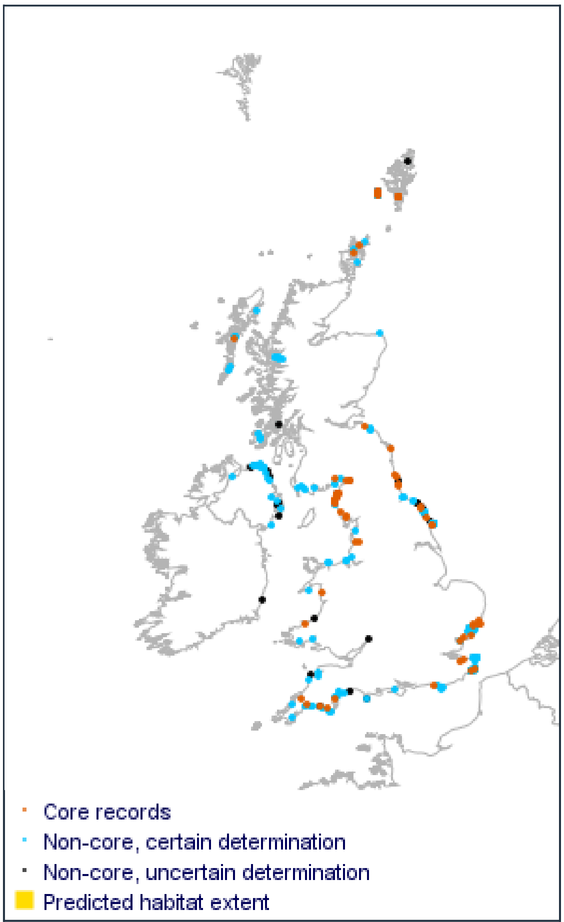
Fallen chalk blocks covered in *Enteromorpha*.
Photographer: David George



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

Researched by Dr Heidi Tillin & Georgina Budd **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A1.451	*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock
JNCC 2015	LR.FLR.Eph.Ulv	*Ulva* spp. on freshwater-influenced and/or unstable upper eulittoral rock
JNCC 2004	LR.FLR.Eph.Ent	*Enteromorpha spp.* on freshwater-influenced and/or unstable upper eulittoral rock
1997 Biotope	LR.MLR.Eph.Ent	*Enteromorpha spp.* on freshwater-influenced or unstable upper eulittoral rock

Description

Upper shore hard substratum that is relatively unstable (e.g. soft rock) or subject to considerable freshwater runoff is typically very species poor and characterized by a dense mat of *Ulva* spp., which can include *Ulva lactuca*. It occurs in a wider zone spanning from the supralittoral down to the upper eulittoral, across a wide range of wave exposures range. This biotope is generally devoid of fauna, except for occasional limpets *Patella vulgata*, winkles *Littorina littorea* or *Littorina saxatilis* and barnacles *Semibalanus balanoides* (Information revised from Connor *et al*., 2004; JNCC).

Depth range

Upper shore

Additional information

The biotope is characterized by seaweeds and is generally devoid of fauna, except for the occasional limpet, *Patella vulgata*, winkles, *Littorina littorea*, *Littorina saxatilis* and barnacles *Semibalanus balanoides*.

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Habitat review

Ecology

Ecological and functional relationships

The community predominantly consists of algae which cover the rock surface and creates a patchy canopy. In doing so, the algae provides an amenable habitat in an otherwise hostile environment, exploitable on a temporary basis by other species. For instance, *Ulva intestinalis* provides shelter for the orange harpacticoid copepod, *Tigriopus brevicornis*, and the chironomid larva of *Halocladius fucicola* (McAllen, 1999). The copepod and chironomid species utilize the hollow thalli of *Ulva intestinalis* as a moist refuge from desiccation when rockpools completely dry. Several hundred individuals of *Tigriopus brevicornis* have been observed in a single thallus of *Ulva intestinalis* (McAllen, 1999). The occasional grazing gastropods that survive in this biotope no doubt graze *Ulva*.

Seasonal and longer term change

- During the winter, elevated levels of freshwater runoff would be expected owing to seasonal rainfall. Also, winter storm action may disturb the relatively soft substratum of chalk and firm mud, or boulders may be overturned.
- Seasonal fluctuation in the abundance of *Ulva* spp. Would therefore be expected with the biotope thriving in winter months. *Porphyra* also tends to be regarded as a winter seaweed, abundant from late autumn to the succeeding spring, owing to the fact that the blade shaped fronds of the gametophyte develop in early autumn, whilst the microscopic filamentous stages of the spring and summer are less apparent (see recruitment process, below).

Habitat structure and complexity

Habitat complexity in this biotope is relatively limited in comparison to other biotopes. The upper shore substrata, consisting of chalk, firm mud, bedrock or boulders, will probably offer a variety of surfaces for colonization, whilst the patchy covering of ephemeral algae provides a refuge for faunal species and an additional substratum for colonization. However, species diversity in this biotope is poor owing to disturbance and changes in the prevailing environmental factors, e.g. desiccation, salinity and temperature. Only species able to tolerate changes/disturbance or those able to seek refuge will thrive.

Productivity

The biotope is characterized by primary producers. Rocky shore communities are highly productive and are an important source of food and nutrients for neighbouring terrestrial and marine ecosystems (Hill *et al.*, 1998). Macroalgae exude considerable amounts of dissolved organic carbon which is taken up readily by bacteria and may even be taken up directly by some larger invertebrates. Dissolved organic carbon, algal fragments and microbial film organisms are continually removed by the sea. This may enter the food chain of local, subtidal ecosystems, or be exported further offshore. Rocky shores make a contribution to the food of many marine species through the production of planktonic larvae and propagules which contribute to pelagic food chains.

Recruitment processes

The life histories of common algae on the shore are generally complex and varied, but follow a basic pattern, whereby there is an alternation of a haploid, gamete-producing phase (gametophyte-producing eggs and sperm) and a diploid spore-producing (sporophyte) phase. All have dispersive phases which are circulated around in the water column before settling on the rock and growing into a germling (Hawkins & Jones, 1992).
Ulva intestinalis is generally considered to be an opportunistic species, with an 'r-type' strategy for survival. The r-strategists have a high growth rate and high reproductive rate. For instance, the thalli of *Ulva intestinalis*, which arise from spores and zygotes, grow within a few weeks into thalli that reproduce again, and the majority of the cell contents are converted into reproductive cells. The species is also capable of dispersal over a considerable distance. For instance, Amsler & Searles (1980) showed that 'swarmers' of a coastal population of *Ulva* reached exposed artificial substrata on a submarine plateau 35 km away.
The life cycle of *Porphyra* involves a heteromorphic (of different form) alternation of generations, that are either blade shaped or filamentous. Two kinds of reproductive bodies (male and female (carpogonium)) are found on the blade shaped frond of *Porphyra* that is abundant during winter. On release these fuse and thereafter, division of the fertilized carpogonium is mitotic, and packets of diploid carpospores are formed. The released carpospores develop into the 'conchocelis' phase (the diploid sporophyte consisting of microscopic filaments), which bore into shells (and probably the chalk rock) and grow vegetatively. The conchocelis filaments reproduce asexually. In the presence of decreasing day length and falling temperatures, terminal cells of the conchocelis phase produce conchospores inside conchosporangia. Meiosis occurs during the germination of the conchospore and produces the macroscopic gametophyte (blade shaped phase) and the cycle is repeated (Cole & Conway, 1980).

Time for community to reach maturity

Disturbance is an important factor structuring the biotope, consequently the biotope is characterized by ephemeral algae able to rapidly exploit newly available substrata and that are tolerant of changes in the prevailing conditions, e.g. temperature, salinity and desiccation. For instance, following the *Torrey Canyon* tanker oil spill in mid March 1967, which bleached filamentous algae such as *Ulva* and adhered to the thin fronds of *Porphyra*, which after a few weeks became brittle and were washed away, regeneration of *Porphyra* and *Ulva* was noted by the end of April at Marazion, Cornwall. Similarly, at Sennen Cove where rocks had completely lost their cover of *Porphyra* and *Ulva* during April, by mid-May had occasional blade-shaped fronds of *Porphyra* sp. up to 15 cm long. These had either regenerated from basal parts of the '*Porphyra*' phase or from the 'conchocelis' phase on the rocks (see recruitment processes). By mid-August these regenerated specimens were common and well grown but darkly pigmented and reproductively immature. Besides the *Porphyra*, a very thick coating of *Ulva* (as *Enteromorpha*) was recorded in mid-August (Smith 1968). Such evidence suggests that the community would reach maturity relatively rapidly and probably be considered mature in terms of the species present and ability to reproduce well within six months.

Additional information

No text entered.

Preferences & Distribution

Habitat preferences

Depth Range	Upper shore
Water clarity preferences	
Limiting Nutrients	Nitrogen (nitrates), Phosphorus (phosphates)
Salinity preferences	Full (30-40 psu), Variable (18-40 psu)
Physiographic preferences	Enclosed coast / Embayment, Open coast
Biological zone preferences	Upper eulittoral, Upper littoral fringe
Substratum/habitat preferences	Bedrock, Large to very large boulders, Small boulders, Chalk, Mud
Tidal strength preferences	Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Exposed, Moderately exposed, Sheltered, Very exposed
Other preferences	Chalk, firm mud, bedrock, boulders.

Additional Information

No text entered.

Species composition

Species found especially in this biotope

- *Porphyra spp.*
- *Ulva spp.*

Rare or scarce species associated with this biotope

-

Additional information

The biotope is generally devoid of macrofauna, except for the occasional limpet, winkle or barnacle, but these species are not considered to be indicative of the sensitivity of the biotope. Mobile species from either adjacent terrestrial or littoral biotopes may be recorded but are likely to be transient.

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The description of this biotope and information on the characterizing species is taken from Connor *et al.* (2004). The biotope is found where physical disturbance, such as sediment instability, sand-scour, or exposure to fresh water run-off, prevents the development of a longer-lived biological assemblage, such as the Fucoid dominated biotopes, more typical of stable rocky shores. The LR.FLR.Eph biotope is characterized by a dense mat of green seaweeds of the genus *Ulva*. The genus *Ulva* currently contains 23 taxonomically accepted species (Guiry & Guiry, 2015), although the genus is now more generally accepted as a synonym for *Enteromorpha* (Hayden *et al.*, 2003). Identification of *Ulva* to the species level can be problematic and in some instances species can only be distinguished by experts or by genetic analysis and understanding of the taxonomic relationships between green algal species and higher taxonomic levels is rapidly evolving.

The sensitivity assessments are largely based on *Ulva intestinalis* (formerly *Enteromorpha intestinalis*) and *Ulva lactuca*, as these are typical characterizing species. Due to the high levels of disturbance, or otherwise unfavourable conditions, the biotope is species poor and animals that do occur in the biotope are found in low abundances as the biotope is generally unfavourable for typical rocky shore species. Occasional limpets *Patella vulgata*, winkles *Littorina littorea* or *Littorina saxatilis* and barnacles *Semibalanus balanoides* may also occur in this biotope. The associated species contribute to species richness and the ecological function of this biotope. Experimental manipulation of densities has shown that grazing by littorinids and limpets can remove significant amounts of ephemeral algae and prevent blooms forming (Lein, 1980; Robles 1982; Albrecht, 1998; Jenkins *et al.*, 2005), the associated species are, therefore, considered within the sensitivity assessments, particularly where the pressure may result in an increase in abundance that could alter the character of the biotope.

The biotope is maintained by environmental factors such as physical disturbance or inputs of freshwater and these are considered within the sensitivity assessments where they may be altered by the pressure.

Resilience and recovery rates of habitat

The *Ulva* sp. that characterize this biotope are classified as opportunistic species that are able to rapidly colonize newly created gaps across a range of sediment types, shore heights, wave exposures and salinity regimes. The life history characteristics that support this opportunism are the broad tolerances for a wide range of conditions (Vermaat & Sand-Jensen, 1987) and high growth and reproduction rates. *Ulva* sp. release zoospores and gametes (collectively called swarmers) to the water column in high numbers. *Ulva* sp. can form the swarmers from normal thallus cells that are transformed into reproductive tissue rather than having to produce specialised reproductive structures (Lersten & Voth, 1960), so that a significant portion of the macroalga's biomass is allocated to the formation of zoospores and gametes (Niesenbaum, 1988). *Ulva* sp. have extended reproduction periods (Smith, 1947) and swarmers are capable of dispersal over a considerable distance. For instance, Amsler & Searles (1980) showed that swarmers of a coastal population of *Ulva* (as *Enteromorpha*) reached exposed artificial substrata on a submarine plateau 35 km away.

The supply of swarmers in vast numbers to the coastline (Niesenbaum, 1988) is reflected in the fast recovery rates of this genus. *Ulva intestinalis* is amongst the first multicellular algae to appear on substrata that have been cleared following a disturbance, e.g. following the *Torrey Canyon* oil spill in March 1967, species of the genus *Ulva r*apidly recruited to areas where oil had killed the herbivores that usually grazed on them, so that a rapid greening of the rocks (owing to a thick coating of *Ulva* spp.) was apparent by mid-May (Smith, 1968). The rapid recruitment of *Ulva* spp. to areas cleared of herbivorous grazers was also demonstrated by Kitching & Thain (1983). Following the removal of the urchin *Paracentrotus lividus* from areas of Lough Hyne, Ireland, *Ulva* grew over the cleared area and reached a coverage of 100% within one year.

Other species that are associated with this biotope, including the limpet *Patella vulgata*, the barnacle *Semibalanus balanoides* and littorinds generally have slower recovery rates than *Ulva* spp. due to episodic recruitment and slower growth. Where individuals are removed from a small area, adult limpets and *Littorina saxatilis* may recolonize from surrounding patches of habitat where these are present. The barnacles and limpets and the winkle *Littorina littorea* are common, widespread species that spawn annually producing pelagic larvae that can disperse over long distances. It is therefore likely that adjacent populations will provide high numbers of larvae, although recruitment may be low due to habitat unsuitability and the presence of dense *Ulva* spp. preventing settlement on rock surfaces. *Littorina saxatilis* however brood young and do not have a pelagic life stage, recovery will therefore depend on the presence of adults in close proximity to impacted areas. As the associated species are present only in some examples of the biotope and occur at low densities when they are present, their absence will not substantially alter the character of the biotope. They are therefore, not specifically considered within the resilience assessments as the biotope can be considered to have recovered before these species re-establish. Indeed, as limpets and littorinds graze on the macroalgae characterizing the biotope and can prevent blooms of *Ulva* spp. and *Porphyra* sp. forming (Robles, 1982; Albrecht, 1998), their presence in large numbers would not benefit this biotope.

Resilience assessment. The high recovery potential of the *Ulva* spp. that characterize this biotope, mean that recovery is assessed as 'High' (within 2 years) for any level of perturbation (where resistance is 'None', 'Low', 'Medium' or 'High'. Depending on the season of the impact and level of recovery, the biotope may have recovered within less than six months. It should be noted that this biotope is maintained by chronic disturbances such as freshwater exposure or sand scour, that prevent a typical succession process occurring: recovery rates will therefore depend on the recovery of the disturbance regime. Recovery may also be prevented where large numbers of grazers become established, this will again depend on changes in the key environmental factors maintaining the biotope. Where changes would permanently favour grazers recovery would be judged as 'Very Low'. It should be noted however that some changes in abundance of grazers and algae may be cyclical and part of normal fluctuations within the group of biotopes classified as LR.FLR.Eph.Eph.

NB: 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: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

Intertidal species are exposed to extremes of high and low air temperatures during periods of emersion. They must also be able to cope with sharp temperature fluctuations over a short period of time during the tidal cycle. In winter air temperatures are colder than the sea, conversely in summer air temperatures are much warmer than the sea. Species that occur in this intertidal biotope are therefore generally adapted to tolerate a range of temperatures.

The key characterizing *Ulva* spp. are distributed globally and occur in warmer waters than those surrounding the UK suggesting that they can withstand increases in temperature at the pressure benchmark. *Ulva* spp. are characteristic of upper shore rock pools, where water and air temperatures are greatly elevated on hot days. Empirical evidence for thermal tolerance to anthropogenic increases in temperature is provided by the effects of heated effluents on rocky shore communities in Maine, USA. *Ascophyllum* and *Fucus* were eliminated from a rocky shore heated to 27-30 °C by a power station whilst *Ulva intestinalis* (as *Enteromorpha intestinalis*) increased significantly near the outfall (Vadas *et al*., 1976).

Barnacles, *Semibalanus balanoides*, limpets, *Patella vulgata* and littorinids may occur at low densities in this biotope. Laboratory studies suggest that adults of these species can tolerate temperature increases. The median upper lethal temperature limit in laboratory tests on *Littorina littorea*, *Littorina saxatilis* and *Semibalanus balanoides* was approximately 35°C (Davenport & Davenport, 2005). *Patella vulgata* can also tolerate high temperatures. The body temperature of *Patella vulgata* can exceed 36°C in the field, (Davies, 1970); adults become non-responsive at 37-38°C and die at temperatures of 42°C (Evans, 1948). Although adults may be able to withstand acute and chronic increases in temperature at the pressure benchmark, increased temperatures may have sub-lethal effects on the population by impacting the success of reproduction phases. The distribution of both the key characterizing species, *Semibalanus balanoides* and *Patella vulgata* are 'northern' with their range extending from Portugal or Northern Spain to the Arctic circle. Populations in the southern part of England are therefore relatively close to the southern edge of their geographic range. Reproductive and recruitment success in both species is linked to temperature. Temperatures above 10 to 12°C inhibit reproduction in *Semibalanus balanoides* (Barnes, 1957 & 1963; Crisp & Patel, 1969; Rognstad *et al*., 2014; Jenkins *et al*., 2000). Increased temperatures are likely to lead to replacement by the warm water species *Chthamalus montagui* and *Chthamalus stellatus* (Southward *et al*., 1995). Increased temperatures may alter spawning cues and reproduction success in *Patella vulgata* populations. Observations suggest that spawning is initiated in autumn storms with greater wave action when seawater temperatures drop below 12°C (Bowman 1985; Bowman & Lewis; 1986; LeQuesne, 2005). In northern Portugal warming seas appear to be linked to a shortening of the reproductive period and the lack of multiple spawning events in *Patella vulgata* and other northern species (Ribeiro *et al*., 2009).

Sensitivity assessment. Adults of the associated species *Patella vulgata*, *Littorina saxatilis* and *Semibalanus balanoides* and *Patella vulgata* are considered likely to be able to tolerate an acute or chronic increase in temperature at the pressure benchmark, although the timing of acute and chronic increases would alter the degree of impact and hence sensitivity. An acute change occurring on the hottest day of the year and exceeding thermal tolerances would lead to mortality. Sensitivity of *Patella vulgata* and *Semibalanus balanoides* to longer-term, broad-scale perturbations would potentially be greater due to effects on reproduction but these changes may lead to species replacements and are not considered to significantly affect the character of the biotope. *Ulva* spp., are the key characterizing elements that define this biotope and are considered to tolerate increases in temperature at the pressure benchmark. Biotope resistance is therefore assessed as 'High' and recovery as 'High' (by default) so that the biotope is assessed as 'Not sensitive'.

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

Many intertidal species are tolerant of freezing conditions as they are exposed to extremes of low air temperatures during periods of emersion. They must also be able to cope with sharp temperature fluctuations over a short period of time during the tidal cycle. In winter air temperatures are colder than the sea, conversely in summer air temperatures are much warmer than the sea. Species that occur in the intertidal are therefore generally adapted to tolerate a range of temperatures, with the width of the thermal niche positively correlated with the height of the shore that the animal usually occurs at (Davenport & Davenport, 2005).

The key species characterizing this biotope, *Ulva intestinalis* and *Ulva lactuca*, are found in Arctic regions (Guiry & Guiry, 2015 and references therein), *Ulva* sp. (as *Enteromorpha*) were reported to be tolerant of a temperature of -20°C (Kylin, 1917). Vermaat & Sand-Jensen (1987) found that rapid deep freezing of Ulva lactuca collected in Roskilde Fjord, Denmark killed the plants. However, individuals from the same area when collected from frozen ice, survived and resumed growth, the plants are able to survive more gradual natural freezing (Vermaat & Sand-Jensen, 1987).

Barnacles, *Semibalanus balanoides*, limpets, *Patella vulgata* and littorinids may occur at low densities in this biotope. Laboratory studies suggest that adults of these species can tolerate temperature decreases. The tolerance of *Semibalanus balanoides* collected in the winter (and thus acclimated to lower temperatures) to low temperatures was tested in the laboratory. The median lower lethal temperature tolerance of *Semibalanus balanoides* collected in winter from Great Cumbrae, Scotland was -14.6°C (Davenport & Davenport, 2005).The same series of experiments indicated that median lower lethal temperature tolerances for *Littorina saxatilis* and *Littorina littorea* were -16.4 and -13°C respectively. In experiments *Littorina littorea* were able to tolerate temperatures down to -8°C for 8 days (Murphy, 1983). In colder conditions an active migration may occur down the shore to a zone where exposure time to the air (and hence time in freezing temperatures) is less. The limpet, *Patella vulgata* can also tolerate long periods of exposure to the air and can consequently withstand wide variations in temperature. Adults are also largely unaffected by short periods of extreme cold. Ekaratne & Crisp (1984) found adult limpets continuing to grow over winter when temperatures fell to -6°C, and stopped only by still more severe weather. However, loss of adhesion after exposure to -13°C has been observed with limpets falling off rocks and therefore becoming easy prey to crabs or birds (Fretter & Graham, 1994). In the very cold winter of 1962-3, when temperatures repeatedly fell below 0°C over a period of 2 months, large numbers of *Patella vulgata* were found dead (Crisp, 1964). Periods of frost may also kill juvenile *Patella vulgata*, resulting in recruitment failures in some years (Bowman & Lewis, 1977).

The distribution of *Semibalanus balanoides* and *Patella vulgata* are 'northern' with their range extending from Portugal or Northern Spain to the Arctic circle. Over their range they are therefore subject to lower temperatures than in the UK, although distributions should be used cautiously as an indicator of thermal tolerance (Southward *et al.*, 1995). The barnacle *Semibalanus balanoides* is primarily a 'northern' species with an arctic-boreal distribution. Long-term time series show that recruitment success is correlated to lower sea temperatures (Mieszkowska *et al*., 2014).

Sensitivity assessment. The presence of *Ulva* spp. in arctic regions and the freezing tolerances reported by Vermaat & Sand-Jensen (1987) indicate that *Ulva* spp., would have 'High' resistance to decreases in temperature at the acute and chronic benchmarks. The wide temperature tolerance range of *Patella vulgata* and *Littornia saxatilis* suggest that the acute and chronic decreases in temperature described by the benchmark would not lead to mortalities. Similarly, based on global temperatures and the link between cooler winter temperatures and reproductive success, *Semibalanus balanoides* is also considered to be unaffected at the pressure benchmark. Based on the characterizing and associated species, this biotope is considered to have 'High' resistance and 'High resilience (by default) to this pressure and is therefore considered to be 'Not sensitive'. The timing of changes and seasonal weather could result in greater impacts on species. An acute decrease in temperature coinciding with unusually low winter temperatures may exceed thermal tolerances and lead to mortalities of the associated species although this would not alter the character of the biotope.

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

The biotope typically experiences conditions of full (30-40 psu) or variable (reduced, owing to freshwater runoff) salinity. The key characterizing *Ulva* species can survive hypersaline conditions in supralittoral rockpools subjected to evaporation and is considered to be a very euryhaline species, tolerant of extreme salinities ranging from 0 psu to 136 psu (Reed & Russell, 1979). Some variations in salinity tolerance between populations of *Ulva intestinalis* have been found, however, suggesting that plants have some adaptation to the local salinity regime. Alströem-Rapaport *et al*., (2010), found that in the brackish Baltic Sea, *Ulva intestinalis* uses a variety of reproductive modes which was considered to partly explain the high rates of colonisation and adaptability of the species.

Reed & Russell (1979) found that the ability to regenerate from cut thalli varied according to the salinity conditions of the original habitat, and that the pattern of euryhalinity in parental material and offspring was in broad agreement (Reed & Russell (1979). Eulittoral zone material showed decreased percentage regeneration in concentrated seawater: 51, 68, 95, 102 & 136 psu) when compared to littoral fringe populations of *Ulva intestinalis* (as *Enteromorpha intestinalis*). Increased salinity is most likely to occur in the region of the littoral fringe and supralittoral zone and specimens from these areas were able to tolerate very high salinities, a significant decrease in regeneration only being recorded after exposure to concentrated seawater (102 psu and 136 psu) for > 7 days (Reed & Russell, 1979).

In the laboratory, the associated species *Semibalanus balanoides* was found to tolerate salinities between 12 and 50 psu (Foster, 1970). Young *Littorina littorea* inhabit rock pools where salinity may increase above 35psu. Thus, key species may be able to tolerate some increase in salinity.

Sensitivity assessment. The characterizing *Ulva* species and the associated species are considered able to tolerate increases in salinity. Based on reported distributions and the results of experiments to assess salinity tolerance thresholds and behavioural and physiological responses it is considered that *Ulva* and the associated littorinids, barnacles and limpets would tolerate a change in salinity from variable or reduced to full and some salinity increases above full salinity. As the associated species occur only in low numbers and do not characterize the biotope the sensitivity assessment is based on the *Ulva* species alone. Biotope resistance is assessed as 'High' and resilience as 'High' (by default), based on no effect to recover from and the biotope is considered to be 'Not sensitive'.

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

The biotope typically experiences conditions of full (30-40 psu) or variable (reduced, owing to freshwater runoff) salinity. The key characterizing *Ulva* species can survive hypersaline conditions in supralittoral rockpools subjected to evaporation and is considered to be a very euryhaline species, tolerant of extreme salinities ranging from 0 psu to 136 psu (Reed & Russell, 1979). Some variation in salinity tolerance between populations of *Ulva intestinalis* have been found, however, suggesting that plants have some adaptation to the local salinity regime. Alströem-Rapaport *et al.* (2010), found that in the brackish Baltic Sea, *Ulva intestinalis* uses a variety of reproductive modes which was considered to partly explain the high rates of colonisation and adaptability of the species. Reed & Russell (1979) found that the ability to regenerate from cut thalli varied according to the salinity conditions of the original habitat, and that the pattern of euryhalinity in parental material and offspring was in broad agreement (Reed & Russell (1979). For example; eulittoral zone material showed decreased percentage regeneration in all salinities (dilute: 0, 4.25, 8.5, 17 & 25.5 psu, and concentrated seawater: 51, 68, 95, 102 & 136 psu) except 34 psu, when compared to littoral fringe populations of *Ulva intestinalis* (as *Enteromorpha intestinalis*). None of the eulittoral zone material was able to regenerate in freshwater or concentrated seawater, whilst littoral fringe and rock pool material was able to do so.

Reduced salinity has also been reported to affect the growth rate of *Ulva intestinalis*. Martins *et al.* (1999) observed that in years with high precipitation and significant increase of freshwater runoff to the Mondego estuary (west Portugal), that *Ulva intestinalis* (as *Enteromorpha intestinalis*) failed to bloom. In the laboratory, the growth rate of *Ulva intestinalis* was measured against a range of salinities, from 0 to 32 psu. *Ulva intestinalis* showed the lowest growth rates at extremely low salinity values (less than or equal to 3 psu), and for salinity less than or equal to 1 psu, the algae died. Growth rates at a salinity lower than 5 psu and higher than 25 psu were also low, in comparison to growth between a salinity of 15 and 20 psu, where *Ulva intestinalis* showed the highest growth rates. Martin *et al.* (1999) concluded that episodes of reduced salinity were an important external parameter in controlling the growth of *Ulva intestinalis*. However, elsewhere *Ulva intestinalis* is known to thrive in areas of the supralittoral zone that receive freshwater runoff. Local conditions may also mediate the ability to tolerate reduced salinities. Kamer & Fong (2001) found that high nitrogen enrichment mitigated the negative effects that reduced salinity had on *Ulva intestinalis* (as *Enteromorpha intestinalis*).

Evidence on salinity tolerances was also found for the associated species that occur in low numbers in this biotope. Like other intertidal species these are exposed to changes in salinity resulting from evaporation or run-off and consequently can tolerate changes in salinity. Populations of *Patella vulgata* extend into the mouths of estuaries surviving in salinities down to about 20psu. However, growth and reproduction may be impaired in reduced salinity. Little *et al.* (1991), for example, observed reduced levels of activity in limpets after heavy rainfall and in the laboratory activity completely stopped at 12psu although individuals died only when the salinity was reduced to 3-1psu (Fretter & Graham, 1994). In experiments where freshwater was trickled over the shell, Arnold (1957) observed limpets withdrawing and clamping the shell onto the substratum. There appears to be an increasing tolerance of low salinities from the lower to the upper limit of distribution of the species on the shore (Fretter & Graham, 1994) suggesting local acclimation. Similarly, *Semibalanus balanoides* are tolerant of a wide range of salinity and can survive periodic emersion in freshwater, e.g. from rainfall or freshwater run-off, by closing their opercular valves (Foster, 1971b). They can also withstand large changes in salinity over moderately long periods of time by falling into a "salt sleep" and can be found on shores (example from Sweden) with large fluctuations in salinity around a mean of 24 (Jenkins *et al*., 2001). In areas of permanently reduced salinity the Australian barnacle *Austrominius* (formerly *Elminius*) modestus may be favoured, as this species is more tolerant of lower salinities), although this is balanced against its lower tolerance of wave exposure

Littorina littorea is found in waters of full, variable and reduced salinities (Connor *et al*., 2004) and so populations are not likely to be highly intolerant of decreases in salinity. Therefore, it appears that the biotope would have low intolerance to a decrease in salinity. On return to normal conditions recovery is likely to be very rapid.

Sensitivity assessment. The characterizing *Ulva* species and the associated species *Littorina littorea* are considered able to tolerate a change from full to variable or variable to reduced salinity. However, based on reported distributions and the results of experiments to assess salinity tolerance thresholds and behavioural and physiological responses in *Patella vulgata* and *Semibalanus balanoides* it is considered that these species would tolerate a change in salinity from full to variable but that a change from variable to reduced salinity may reduce habitat suitability. As these species occur only in low numbers and do not characterize the biotope the sensitivity assessment is based on the *Ulva* species alone. Biotope resistance is therefore assessed as 'High' and resilience as 'High', based on no effect to recover from and the biotope is considered to be 'Not sensitive'.

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

The key characterizing species of this biotope, *Ulva intestinalis* and *Ulva lactuca* are flexible and conform to the direction of the flow reducing drag and breakage. However, experimental studies show that exposure to currents results in sloughing of tissue and higher current velocities result in breakage of the thallus.

Kennison & Fong (2013) found that *Ulva intestinalis* settled on ceramic tiles and deployed in the field were subject to greater losses of biomass from sloughing of tissue at mean flow speeds of 0.2 m/s (approximately 16% of biomass) than the 8% loss from individuals subject to lower flows (0.15 m/s).

These results agree with those from another study by Flindt *et al.* (2007) that subjected *Ulva* spp. to increased water flows in flume tanks. They distinguished *Ulva* sp. and *Enteromorpha* sp. in their sloughing experiments but not to species level. Water flow rates were increased from still incrementally by 0.005 m/s and the amount of biomass sloughed off was measured. At a current speed of 0.12 m/s, 3-4% of biomass of *Ulva* sp. was removed, increasing to 4-7% at 0.15 m/s and 40-50% at 0.4 m/s. *Enteromorpha* sp. were slightly more resistant; at current flows of 0.2 m/s 1% of biomass was sloughed, increasing to 20% at 0.35 m/s. Flindt *et al*., (2007) estimated from regression models that the current speeds at which all *Ulva* spp., would be totally removed were 0.82 m/s and 1.28 m/s for *Enteromorpha* sp. Note, *Enteromorpha* is now a synonym of *Ulva*. The authors assume that the *Enteromorpha* sp. mentioned in their study relate to the more filamentous and tube-like growth form of *Ulva intestinalis.*

Modelled predictions of thallus breakage based on laboratory studies of *Ulva lactuca* on bivalve shells estimate that large *Ulva lactuca* (>50 cm in length) are unlikely to persist where currents exceed 0.5 m/s, whereas smaller individuals (24 cm in length) are unlikely to be present where current speeds exceed 1 m/s (Hawes & Smith, 1995). Increased water flows may also be beneficial where these enhance recruitment. Increased water velocities can enhance recruitment through increased larval supply (Kennison & Fong, 2013). Houghton *et al.* (1973) observed that swarmers of *Ulva* were able to settle onto surfaces subjected to water speeds of up to 10.7 knots, suggesting that changes may not inhibit settlement.

Sensitivity assessment. Increased water flow rates may detach and remove biomass of the *Ulva* spp, that characterize this biotope. Experiments suggest that the pressure benchmark is biologically relevant, i.e. increases at the pressure benchmark could result in loss and detachment. However as this biotope occurs in the upper eulittoral or littoral fringe (Connor *et al*., 2014) it will only be exposed for limited periods and rapid growth of *Ulva* sp. May mitigate the loss of tissue during the growing season. The experiments do not detail the amount of time that individuals were exposed to flows so that extrapolating the results to predicted losses, particularly for breakage is problematic. On exposed shores, wave exposure may also be a more significant factor controlling breakage and sloughing than water flows. Based on the breakage studies (Hawes & Smith, 1995), resistance of *Ulva* sp., to an increase in water flow at the pressure benchmark is assessed as 'Medium' as smaller individuals can persist at flow rates that are almost double those of larger plants and duration of exposure is limited. Resilience is assessed as 'High' and sensitivity is assessed as 'Low'.

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

The biotope can be found in a wide range of shore heights, spanning the supralittoral down to the upper eulittoral, across a wide range of wave exposures (Connor *et al*., 2004). Unlike many other biotopes in the intertidal, emergence is a secondary factor structuring this biotope, which occurs where chronic disturbances such as freshwater influence, sand scour or sediment instability prevent the development of a biotope typical of more stable habitat conditions dominated by Fucoids for example, *Fucus spiralis*, *Fucus ceranoides*, or *Pelvetia canaliculata*. Where conditions allow, Connor *et al*. (2004) report that this biotope is usually found above a zone dominated by a mixture *Ulva* spp. and *Porphyra* spp. (LR.FLR.Eph.UlvPor), or a Fucoid dominated zone (Fspi; Fcer). It can be found below a zone dominated by yellow and grey lichens or in very sheltered areas the seagrass *Ruppia maritima* (Connor *et al*., 2004).

As *Ulva intestinalis* is able to tolerate dessication stress it is often very abundant on the high shore where desiccation stress is the primary factor controlling seaweed distribution, and may even be found above the tidal limits of the shore. *Ulva intestinalis* (studied as *Enteromorpha intestinalis*) can survive several weeks of living in completely dried out rock pools, while becoming completely bleached on the uppermost layers, but remaining moist underneath the bleached fronds. However, dessication stress of germlimgs may be lower than adults Hruby & Norton (1979) found that 7-14 day old germlings of *Ulva* (studied as *Enteromorpha*) were more tolerant of desiccation than earlier stages, so an increase in desiccation stress may impact more adversely on newly settled germlings than more mature plants

Ulva intestinalis tends to preferentially inhabit rock pools or is associated with trickles of freshwater that cross the shore, and in such positions the risk of desiccation is reduced. Owing to increased emergence, the species that graze on *Ulva intestinalis* are likely to be less active, owing to risk of desiccation, and the seaweed may benefit from reduced grazing pressure. *Ulva intestinalis* is unlikely to be directly affected by a decrease in the emergence regime, as it occurs in the subtidal zone. However,a decrease in emergence would reduce the effect of the freshwater influences that in some instances maintain the biotope and would increase habitat suitability for some grazers, increasing predation pressure on *Ulva*. spp. However in many instances the biotope develops in areas where sediment instability or sand scour prevents the development of a biotope more typical of rocky shores. As changes in emergence would not alter these structuring factors the biotope may not change substantially.

Increased emergence may reduce habitat suitability for the associated barnacle species, *Semibalanus balanoides. Chthamalus* spp. are more tolerant of desiccation stress than *Semibalanus balnoides* and increased emergence may therefore lead to species replacement although this would not substantially alter the character of the biotope. The mobile species present within the biotope, *Patella vulgata* and the littorinids are able to relocate to preferred shore levels, an increase in emergence may result in migration downshore, while decreased emergence may increase habitat suitability of upper littoral fringe biotopes for these species. The littorinids are able to relocate to preferred shore levels, an increase in emergence may result in migration downshore, while decreased emergence may increase habitat suitability of upper littoral fringe biotopes for these species. Grazing by littornids and other species can have a significant structuring impact on biotopes dominated by ephemeral algae (Robles 1982, Albrecht, 1998). An increase in grazers and grazing within this biotope may remove large amounts of algal biomass preventing blooms.

Sensitivity assessment. This biotope, particularly where it occurs on the mid or lower shore, is considered to be 'Not sensitive' to increased emergence or a decrease in mean sea level. However, where this biotope occurs right at the very top of the shore, a change at the pressure benchmark may result in a change to a lichen biotope. Increased submergence would reduce the effects of freshwater influences through dilution. Where freshwater inputs are the chronic disturbing factor that maintain the biotope, this will result in a reduction in suitability, depending on the duration of submergence. Increased grazing by littorinids and other grazers facilitated by increased immersion and salinity would also be likely to reduce the biomass of *Ulva* spp. in this instance. Resistance is assessed as 'Low' and resilience as 'High' (following habitat recovery). Sensitivity is, therefore, assessed as 'Low'.

Wave exposure changes (local)	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

The key environmental factors structuring this upper shore biotope are disturbance from sediment instability, sediment scour or freshwater inputs rather than wave exposure. This biotope is found in shores where exposure ranges from very exposed, exposed, moderately exposed or sheltered (Connor et al., 2014) and changes in the pressure benchmark are not considered to have an effect.

Sensitivity assessment. Based on the range of wave exposures that this biotope occurs in, resistance is assesed as 'High' and resilience as High (by default) and the biotope is assessed as 'Not sensitive.

Chemical Pressures

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

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

Contamination by non-synthetic chemicals, at levels greater than the pressure benchmark may adversely impact the biotope. The order of metal toxicity to algae varies, with the algal species and experimental conditions, but generally the order is Hg>Cu>Cd>Ag>Pb>Zn (Rice et al., 1973; Rai *et al*., 1981). The effects of copper on macrophytes have been more extensively studied than the effects of any other metal owing to its use in antifouling paints. Lewis *et al*. (1998) investigated the influence of copper exposure and heatshock on the physiology and cellular stress response of *Ulva intestinalis* (as *Enteromorpha intestinalis*). Heat shock proteins (HSPs) are known to be expressed in response to a variety of stress conditions, including heavy metals (Lewis *et al*., 1999). *Ulva intestinalis* was exposed to a range of copper concentrations (0-500 µg -1 for 5 days, to assess the effect of copper exposure on stress proteins (Stress-70 levels) and physiology of the seaweed. Stress-70 was induced by copper exposure, but was found to be no better an indicator of copper exposure than measurement of growth, which is inhibited by copper.

Species of the genus *Ulva* seem to be especially suitable for monitoring heavy metals in coastal areas and estuaries as it is ubiquitous in both and laboratory experiments have shown that accumulation of Cu, Zn, Cd and Pb by four different species of *Ulva* (as *Enteromorpha*) was sufficiently similar to justify pooling samples of the genus for field monitoring (Say *et al*., 1990). However, the interactions of salinity and temperature with toxicity are not always clear and may hinder cross-comparison of samples and surveys. For instance, Munda (1984) found that the Zn, Mn and Co accumulations in *Ulva intestinalis* (as *Enteromorpha intestinalis*) could be enhanced by decreasing the salinity.

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.

Hydrocarbon contamination, at levels greater than the benchmark, e.g. from spills of fresh crude oil or petroleum products, may cause significant loss of *Ulva* spp. Likely effects include smothering, inhibition of respiration and photosynthesis, bleaching and interference with reproduction, so that affected populations may be destroyed. However, the genus tends to recover very rapidly from oil pollution incidents. For instance, after the *Torrey Canyon* tanker oil in 1967, grazing species were killed, and a dense flush of ephemeral green algae (*Ulva*, *Blidingia*) appeared on the rocky shore within a few weeks and persisted for up to one year (Smith, 1968).

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.

Some evidence for adverse effects of chemical pollution on the key characterizing species, *Ulva* *intestinalis*, has been found. Although herbicides tend not to be used directly in the marine environment, they can enter estuarine areas via river discharge and runoff. Paraquat and 3AT were tested for their effects on the settlement, germination and growth of *Ulva* (as *Enteromorpha*) (Moss & Woodhead, 1975). They found that zygotes were able to develop into filaments in the presence of Paraquat at 7 mg/L, but that germination was deferred at higher concentrations. Zygotes demonstrated increased resistance when they settled in clumps on the substratum, and green thalli of *Ulva* were more susceptible than ungerminated zygotes. *Ulva* was more intolerant of 3AT than to Paraquat.

However, synthetic chemicals used as antifouling agents may be directly introduced into the marine environment. Scarlett *et al.* (1997) analyzed water samples taken from the Plymouth Sound locality for the presence of the s-triazine herbicide, Irgarol 1051, which is an ingredient of antifouling paints used on pleasure boats and ships. Irgarol 1051 was detected at all sampling sites within the Sound; the highest levels were found in close proximity to areas of high boat density, especially where water flow was restricted within marinas, although concentrations within the semi-enclosed Sutton Harbour were less than values predicted from leach rate data. The highest detected concentration of over 120 ng/L significantly inhibited the growth of *Ulva intestinalis* (as *Enteromorpha intestinalis*) spores under laboratory conditions; the no effect concentration was 22 ng/L. Photosynthetic efficiency in the adult frond of *Ulva intestinalis* from Sutton Harbour marina was inhibited by Irgarol 1051 in the laboratory with an EC 50 (72 h) of 2.5 µg/L. A small adverse impact on *Ulva intestinalis* reproduction within harbours is therefore likely.

Following the *Torrey Canyon* tanker oil spill, copious amounts of solvent based detergents were sprayed directly on to the shore. Algae on the higher shore was especially affected, and included *Ulva intestinalis* (as *Enteromorpha intestinalis*) in high level rock pools where it was killed (Smith, 1968).

Radionuclide contamination	High Q: High A: High C: NR	High Q: High A: High C: High	Not sensitive Q: High A: High C: Low

The key, characterizing *Ulva* spp. are known to be able to acquire large concentrations of substances from surrounding water. In the vicinity of the Sellafield nuclear plant, England, *Ulva* (as *Enteromorpha*) sp. accumulated zirconium, niobium, cerium and plutonium-239, however the species appeared to be unaffected by the radionuclides (Clark, 1997). Based on this evidence, the resistance of the biotope to this pressure at the benchmark, is assessed as 'High', resilience is assessed as 'High' (by default), and the biotope is assessed as 'Not sensitive'.

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

This pressure is **Not assessed**.

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

Where nutrients and other factors support rapid growth, large blooms of *Ulva* spp. can occur, as these die and decay, they can create anoxic conditions in the water column and the sediments they overlay. Some tolerance for anoxia may therefore be expected that allows a proportion of the population to survive and reproduce during and after these conditions.

Vermaat & Sand-Jensen (1987) tested the survival of discs of *Ulva lactuca* during prolonged exposure to anoxia. The 113 mm^2 discs were taken from wild plants collected in the Roskilde Fjord, Denmark in late autumn. Anoxic conditions were created in the laboratory by bubbling with N_2 gas. Exposure to anoxia for two months did not affect survival but did result in increased respiration and a decrease in growth. Corradi *et al*., (2006) used similar sized thallus discs from *Ulva* spp. (113 mm^2), collected from the lagoon Sacca di Goro (Po River Delta) during spring to test the effects of hypoxia on gamete production for *Ulva* sp. The test oxygen concentrations ranged from 1.78 – 4.02 µmol /L (the benchmark of 2mg/l refers to 64 µmol/L). The exposure to hypoxia was not lethal to the discs and following resumption of normal oxygen conditions gametes were produced.

Experimental evidence for the associated species *Patella vulgata* and *Semibalanus balanoides* indicate that these species are unlikely to be adversely affected by water column hypoxia at the pressure benchmark. *Semibalanus balanoides* can respire anaerobically, so they can tolerate some reduction in oxygen concentration (Newell, 1979). When placed in wet nitrogen, where oxygen stress is maximal and desiccation stress is low, *Semibalanus balanoides* have a mean survival time of 5 days (Barnes *et al*., 1963). Limpets can survive for a short time in anoxic seawater; Grenon & Walker, (1981) found that in oxygen free water limpets could survive up to 36 hours, although Marshall & McQuaid (1989) found a lower tolerance for *Patella granularis*, which survived up to 11 hours in anoxic water. However, *Patella vulgata* is an intertidal species, being able to respire in air, and in this biotope would only be exposed to low oxygen in the water column intermittently during periods of tidal immersion. In addition, in areas of wave exposure and moderately strong current flow low oxygen levels in the water are unlikely to persist for very long as oxygen levels will be recharged by the incorporation of oxygen in the air into the water column or flushing with oxygenated waters.

In addition, the associated species, *Littorina saxatilis*, like *Patella vulgata*, is an air breather when emersed, so can respire during the tidal cycle.

Sensitivity assessment. No direct evidence for the effects of hypoxia on whole plants in-situ was available. However, the results of the laboratory experiments which tested parts of *Ulva* individuals to either prolonged anoxia or short-term hypoxia at levels that exceed the benchmark, indicate that *Ulva* have 'High' resistance to this pressure and 'High' resilience by default. The associated species, littorinids, *Patella vulgata* and *Semibalanus balanoides* are considered to be 'Not Sensitive' to de-oxygenation at the pressure benchmark. The experiments cited as evidence (Grenon & Walker, 1981 and Barnes *et al*.,1963) exceed the duration and/or magnitude of the pressure benchmark. As this biotope occurs in wave exposed conditions or high on the shore some mitigation of hypoxic conditions would be expected from water movements increasing dissolved oxygen in the water column and exposure to air during the tidal emersion cycle. Biotope resistance is, therefore, assessed as 'High' and resilience as 'High' (no effect to recover from), resulting in a sensitivity of 'Not sensitive'.

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

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

The criteria for status under the WFD with regard to nutrient enrichment is concerned with the presence or absence of 'blooms' of opportunistic algae , including the key characterizing *Ulva* spp. found in this biotope, that act as indicators of enrichment (eutrophication). The abundance and biomass of these species is used in the implementation of the WFD as indicators to assess condition of waterbodies. The criteria for achieving good status states that there should be: 'limited cover (<15%) and low biomass (<500g/m^2) of opportunistic macroalgal blooms…macroalgae cover shows slight signs of disturbance with slight deviation from reference conditions' (Wells *et al*., 2014).

The high abundance and biomass of *Ulva* spp, that characterize this biotope would suggest that this biotope would fail to achieve 'good status'. Theoretically, compliance with good status would require a significant loss of characterizing species, suggesting that the biotope would be sensitive to this pressure at the benchmark (i.e. it represents a significant impact for biotope character). However, the biotope is considered to develop in response to chronic physical disturbance from sediment instability or sand-scour, or to freshwater inputs and therefore its presence is not necessarily an indicator of abnormal nutrient loading. Typical blooms of opportunistic macroalgae, occur in sheltered areas such as estuaries (Kennison & Fong, 2013) and are likely to form as unattached mats over sediments rather than rocky shores, the character of these is therefore different to the assessed biotope.

Opportunistic algae, including *Ulva* spp. cannot 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 the characterizing *Ulva* spp, 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* spp. may be negatively affected through reduced growth rate and species replacement (Martínez *et al*., 2012; Vaudrey et al., 2010).

Sensitivity assessment. If nutrient levels were to increase (exceeding the pressure benchmark) enhanced growth of *Ulva* spp. would be expected in response and this is not considered to significantly alter the character of the biotope. *Ulva* spp. may decline in response to reductions in nutrient levels, in habitats where other species more typical of undisturbed species are able to recolonize. However, as this biotope is structured by disturbance rather than nutrient enrichment, other species are not considered to establish following decreases in nutrient levels and *Ulva* spp, would be likely to remain the dominant species. The biotope is therefore considered to have 'High' resistance to this pressure and 'High' resilience (by default) and is assessed as 'Not sensitive'.

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

No empirical evidence was found to support an assessment for the key characterizing *Ulva* spp., or the associated species; *Semibalanus balanoides*, *Patella vulgata* and *Littorina saxatilis* that are present at low abundances within this biotope. As organic matter particles in suspension or re-suspended could potentially be utilised as a food resource by the barnacles present within the biotope (Cabral-Oliveira *et al*., 2014) with excess likely to be rapidly removed by wave action, overall resistance of the biological assemblage within the biotope is considered to be 'High' and resilience was assessed as 'High', so that this biotope is judged to be 'Not sensitive'.

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

This biotope occurs on hard substrata where the key characterizing *Ulva* spp. and associated species, *Semibalanus balanoides* can attach. A soft sedimentary habitat would be unsuitable for these species and the associated species *Patella vulgata* (although littorinids occur on sediment). A change to a soft sedimentary biotope would lead to the development of a biological assemblage more typical of the changed conditions.

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'.

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 to this biotope which occurs predominantly on bedrock (Connor *et al*., 2004).

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

The key characterizing *Ulva* spp., and associated species are epifauna or epiflora occurring 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.

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

No direct evidence was found to assess how the key, characterizing, *Ulva* spp. respond to surface abrasion. The fronds are very thin and could be torn and damaged and individuals may be removed from the substratum, altering the biotope through changes in abundance and biomass. *Ulva* spp.

cannot repair damage or re-attach but tearing and cutting of the fronds has been shown to stimulate gamete production (Corradi *et al*., 2006) and damaged plants would still be able to grow and reproduce. *Ulva* spp. can also form unattached mats (particularly in response to nutrient enrichment): damage and removal may, therefore, not lead to mortality of impacted individuals.

The barnacles, limpets and littorinids that occur in low densities in this biotope, have some protection from hard shells or plates but abrasion may damage and kill individuals or detach these. All removed barnacles would be expected to die as there is no mechanism for these to reattach. Removal of limpets and barnacles may result in these being displaced to a less favourable habitat and injuries to foot muscles in limpets may prevent reattachment. Although limpets and littorinids may be able to repair shell damage, broken shells while healing will expose the individual to more risk of desiccation and predation. Evidence for the effects of abrasion are provided by a number of experimental studies on trampling (a source of abrasion) and on abrasion by wave thrown rocks and pebbles.

The effects of trampling on barnacles appears to be variable with some studies not detecting significant differences between trampled and controlled areas (Tyler-Walters & Arnold, 2008). However, this variability may be related to differences in trampling intensities and abundance of populations studied. The worst case incidence was reported by Brosnan & Crumrine (1994) who found that a trampling pressure of 250 steps in a 20x20 cm plot one day a month for a period of a year significantly reduced barnacle cover (*Semibalanus glandula* and *Chthamalus dalli*) at two study sites. Barnacle cover reduced from 66% to 7% cover in 4 months at one site and from 21% to 5% within 6 months at the second site. Overall barnacles were crushed and removed by trampling. Barnacle cover remained low until recruitment the following spring. Long *et al*. (2011) also found that heavy trampling (70 humans /km/hrs) led to reductions in barnacle cover. Single step experiments provide a clearer, quantitative indication of sensitivity to single events of direct abrasion. Povey & Keough (1991) in experiments on shores in Mornington peninsula, Victora, Australia, found that in single step experiments 10 out of 67 barnacles, (*Chthamlus antennatus* about 3mm long), were crushed. However, on the same shore, the authors found that limpets may be relatively more resistant to abrasion from trampling. Following step and kicking experiments, few individuals of the limpet C*ellana trasomerica*, (similar size to *Patella vulgata*) suffered damage or relocated (Povey & Keough, 1991). One kicked limpet (out of 80) was broken and 2 (out of 80) limpets that were stepped on could not be relocated the following day (Povey & Keough, 1991). On the same shore less than 5% of littorinids were crushed in single step experiments (Povey & Keough, 1991).

Shanks & Wright (1986), found that even small pebbles (<6 cm) that were thrown by wave action in Southern California shores could create patches in aggregations of the barnacle, *Chthamalus fissus*, and could smash owl limpets (*Lottia gigantea*). Average, estimated survivorship of limpets at a wave exposed site, with many loose cobbles and pebbles allowing greater levels of abrasion was 40% lower than at a sheltered site. Severe storms were observed to lead to almost total destruction of local populations of limpets through abrasion by large rocks and boulders. In sites with mobile cobbles and boulders increased scour results in lower densities of *Littorina* spp. compared with other, local sites with stable substratum (Carlson *et al*., 2006).

Sensitivity assessment. The impact of surface abrasion will depend on the footprint, duration and magnitude of the pressure. In response to a single event of abrasion a proportion of the *Ulva* population may be removed, but damaged individuals, *in-situ* would be capable of growth and reproduction. Based on additional evidence for the associated species from the step experiments (Povey & Keough, 1991) and the relative robustness of the associated species, the resistance of the biotope, to a single abrasion event is assessed as 'Medium' and recovery as 'High', so that sensitivity is assessed as 'Low'. Resistance will be lower (and hence sensitivity greater) to abrasion events that exert a greater crushing force than the trampling examples the assessment is based on). The confidence assessment for resistance, reflects the lack of direct evidence available for the key characterizing *Ulva* spp. It should be noted that in some areas where the biotope is found, chronic abrasion from sand scour or sediment instability is a key factor that maintains the biotope, however, Ulva maintain their presence through fast recovery from damage and removal rather than being resistant to the pressure. For this biotope the sensitivity assessment refers to a temporary reduction in condition, measured as the abundance and biomass of characterizing species.

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 rock which is resistant to subsurface penetration. The assessment for the abrasion pressure is therefore considered to equally represent sensitivity to this pressure.

Changes in suspended solids (water clarity)	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

Siltation, which may be associated with increased suspended solids is assessed separately. As a photoautotroph, the key characterizing *Ulva* spp., is likely to benefit from reduced turbidity, as the light attenuating effects of turbid water reduce photosynthesis. However experiments have shown that *Ulva* is a shade tolerant species and can compensate for reduced irradiance by increasing chlorophyll concentration and light absorption at low light levels. *Ulva* spp. were able to survive over two months in darkness and to begin photosynthesising immediately when returned to the light (Vermaat & Sand-Jensen, 1987). Limited shading from suspended sediments is therefore not considered to negatively affect this genus. Suspended sediments may however have abrading effects on the fronds of *Ulva* spp. Tolhurst *et al*. (2007) found that *Ulva intestinalis* germlings kept in tanks and exposed to 100 mg/l of suspended sediment showed reduced growth. Similarly, Hyslop & Davies (1998) found that *Ulva lactuca* lost weight when kept in flasks with 1 g/l of colliery waste that was shaken for 1 hour every day for 8 days. The experimental solids level, however, exceeds the pressure benchmark.

Sensitivity assessment. The exposure of this upper shore biotope to suspended sediments in the water column will be limited to the short immersion periods, however silts deposited on the leaves during emersion may remain on the fronds inhibiting photosynthesis in sheltered areas. The biotope is considered to be 'not sensitive' to a reduction in suspended solids, although this may reduce food supply to the barnacles that occur in this biotope. An increase in suspended solids may lead to some sub-lethal abrasion of fronds but this will be compensated by the high growth rates exhibited by *Ulva* spp. Resistance is therefore assessed as 'High' and resilience as 'High' (by default) so that the biotope is considered to be 'Not sensitive'.

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

Observations and experiments indicate that *Ulva* spp. have relatively high tolerances for the stresses induced by burial (darkness, hypoxia and exposure to sulphides). Vermaat & Sand-Jensen , (1987) exposed thallus discs (113 mm^2) of *Ulva lactuca* to darkness and anoxia and sulphides at winter temperatures. It was found that these conditions did not affect survival over two months, although exposure to anoxia increased respiration and reduced growth (Vermaat & Sand-Jensen, 1987). These experiments were undertaken using *Ulva lactuca* collected from Roskilde Fjord, Denmark. Corradi *et al*., (2006) subjected *Ulva* sp. collected from the Sacca di Goro, Italy to similar stressors (hypoxia 1.78 – 4.02 µmol /L, or sulphide at 1mM, both treatments in darkness) for 3,5 or 7days at 20°C. The thallus discs survived but no gametes were produced until recovery in oxygenated conditions. The high tolerance of darkness, anoxia and hydrogen sulphides allows buried fragments of *Ulva* sp. to overwinter, protected from frosts. Kamermans et al., (1998) found that parts of *Ulva* thalli that were collected from the Veerse Meer lagoon in the Netherlands could resume growth in the spring when returned to the surface. *Ulva* spp. in sheltered areas are often unattached to the substratum and therefore are not considered a direct proxy for attached *Ulva* spp. in this biotope.

Although *Ulva* spp. present in sedimentary habitats may be able to survive the chemical stress of burial and re-grow from surviving fragments, evidence for attached individuals from rocky shores suggest that resistance to this pressure may be lower. *Ulva lactuca* is a dominant species on sand-affected rocky shores in New Hampshire (Daly & Mathieson, 1977) although Littler *et al*., (1983) suggest that *Ulva* sp., are present in areas periodically subject to sand deposition not because they are able to withstand burial but because they are able to rapidly colonise sand-scoured areas (such as this biotope). *Ulva* spp. have, however, been reported to form turfs that trap sediments (Airoldi *et al*. 2003, references therein) suggesting that resistance to chronic rather than acute siltation events may be higher. In general, propagules, early post-settlement stages and juveniles suffer severe stress and mortality from sediments (Airoldi *et al*. 2003). Hyslop *et al*. (1997) compared the composition, abundance and distribution of dominant plants and animals at several rocky shores affected or unaffected by dumping of colliery wastes along the coastline of northeast England. They reported that while the distribution of animals was not related to colliery wastes, diversity of macroalgae was significantly negatively correlated with colliery waste inputs and particularly dramatic reductions in cover at the affected sites were observed for *Ulva lactuca*. The authors suggested that, because colliery waste leaches much of its toxic chemical content into the sea, detrimental effects were most likely related to the physical presence of sediments.

The associated species, *Patella vulgata*, *Semibalanus balanoides* and *Littorina saxatilis* are likely to be negatively affected by siltation although no direct evidence was found for the sensitivity of the latter two. The lower limits of *Semibalanus balanoides* (as *Balanus balanoides*) appear to be set by levels of sand inundation on sand-affected rocky shores in New Hampshire (Daly & Mathieson, 1977), suggesting that this species is sensitive to the deposition of relatively coarse sediments, although whether this is due to repeated scour events removing juveniles rather than siltation effects (i.e. smothering, prevention of feeding) is not clear. Experiments have shown that the addition of even thin layers of sediment (approximately 4 mm) inhibit grazing and result in loss of attachment and death after a few days Airoldi & Hawkins (2007). The laboratory experiments are supported by observations on exposed and sheltered shores with patches of sediment around Plymouth in the south west of England as *Patella vulgata* abundances were higher where deposits were absent (Airoldi & Hawkins (2007). Littler *et al*., (1983) found that the another limpet species, *Lottia gigantea* on southern Californian shores was restricted to refuges from sand burial on shores subject to periodic inundation by sands.

Sensitivity assessment. The available evidence indicates that *Ulva* spp. can survive some of the stressors associated with burial but would be sensitive to abrasion and scouring forces resulting from the deposition and removal of sediments. Even small deposits of sediments are likely to result in local removal of limpets and limpets are considered to have 'Low' resistance to this pressure based primarily on observations and experiments of Airoldi & Hawkins, (2007). The sensitivity assessment for the biotope is based on *Ulva* spp. Siltation by 5 cm of fine sediments is considered to remove a proportion of the population through scour effects and resistance is assessed as 'Low-Medium', recovery is assessed as 'High' and sensitivity is assessed as 'Low'.

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

Observations and experiments indicate that *Ulva* spp. have relatively high tolerances for the stresses induced by burial (darkness, hypoxia and exposure to sulphides). Vermaat & Sand-Jensen , (1987) exposed thallus discs (113 mm^2) of *Ulva lactuca* to darkness and anoxia and sulphides at winter temperatures. It was found that these conditions did not affect survival over two months, although exposure to anoxia increased respiration and reduced growth (Vermaat & Sand-Jensen, 1987). These experiments were undertaken using *Ulva lactuca* collected from Roskilde Fjord, Denmark. Corradi *et al*., (2006) subjected *Ulva* sp. collected from the Sacca di Goro, Italy to similar stressors (hypoxia 1.78 – 4.02 µmol /L, or sulphide at 1mM, both treatments in darkness) for 3,5 or 7days at 20^{o}C. The thallus discs survived but no gametes were produced until recovery in oxygenated conditions. The high tolerance of darkness, anoxia and hydrogen sulphides allows buried fragments of *Ulva* sp. to overwinter, protected from frosts. Kamermans et al., (1998) found that parts of *Ulva* thalli that were collected from the Veerse Meer lagoon in the Netherlands could resume growth in the spring when returned to the surface. *Ulva* spp. in sheltered areas are often unattached to the substratum and therefore are not considered a direct proxy for attached *Ulva* spp. in this biotope.

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Sensitivity assessment. The available evidence indicates that *Ulva* spp. can survive some of the stressors associated with burial but would be sensitive to abrasion and scouring forces resulting from the deposition and removal of sediments. Even small deposits of sediments are likely to result in local removal of limpets and limpets are considered to have 'Low' resistance to this pressure based primarily on observations and experiments of Airoldi & Hawkins, (2007). The sensitivity assessment for the biotope is based on *Ulva* spp. Siltation by 30 cm of fine sediments is considered to remove a proportion of the population through scour effects and resistance is assessed as 'Low', recovery is assessed as 'High' and sensitivity is assessed as 'Low'.

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

Not assessed.

Electromagnetic changes	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence.

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: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

A number of experiments have demonstrated that the key characterizing species *Ulva lactuca*, has high tolerance for shading and can survive periods of darkness. Vermaat & Sand-Jensen (1987) found that *Ulva lactuca*, collected from Roskilde Fjord in Denmark in late autumn had extremely high shade tolerances. Increasing chlorophyll concentration and light absorption allowed the individuals (studied experimentally as thallus discs of 113mm^2) to continue to grow at the lowest irradiance tested (0.6 µE m^2/s). This corresponds to the lowest light-levels of deep-living marine macroalgae and phytoplankton growing under ice (Vermaat & Sand-Jensen, 1987). *Ulva lactuca* was able to survive two months in darkness and was able to resume growth immediately when transferred to the light (Vermaat & Sand-Jensen, 1987).

No direct evidence to assess this pressure was found for the key characterizing species *Patella vulgata* and the littorinids. As both species occur on open rock and in crevices and *under Fucus canopies* they are considered tolerant of a range of light conditions. Light levels have, however been demonstrated to influence a number of phases of the reproductive cycle in *Semibalanus balanoides*. In general light inhibits aspects of the breeding cycle. Penis development is inhibited by light (Barnes & Stone, 1972) while Tighe-Ford (1967) showed that constant light inhibited gonad maturation and fertilization. Davenport & Crisp (unpublished data from Menai Bridge, Wales, cited from Davenport *et al*., 2005) found that experimental exposure to either constant darkness, or 6 h light: 18 h dark photoperiods induced autumn breeding in *Semibalanus*. They also confirmed that very low continuous light intensities (little more than starlight) inhibited breeding. Latitudinal variations in timing of the onset of reproductive phases (egg mass hardening) have been linked to the length of darkness (night) experienced by individuals rather than temperature (Davenport *et al*., 2005). Changes in light levels associated with climate change (increased cloud cover) were considered to have the potential to alter timing of reproduction (Davenport *et al*., 2005) and to shift the range limits of this species southward. However, it is not clear how these findings may reflect changes in light levels from artificial sources, and whether observable changes would occur at the population level as a result. There is, therefore, 'No evidence' on which to base an assessment for this species.

Sensitivity assessment. Changes in light levels from anthropogenic sources may have the potential to alter reproduction in *Semibalanus balanoides*, however it is not clear how these effects would ramify to the population level. The key *Ulva* spp. that characterizes the biotope are considered to have 'High' resistance to changes in light level, although extreme changes such as complete darkness would prevent photosynthesis and growth and high light levels may be damaging. Recovery is assessed as 'High' by default and the biotope is judged to be 'Not sensitive '.

Barrier to species movement	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

No direct evidence was found to assess this pressure. The key characterizing Ulva spp. produce large amounts of motile swarmers, throughout the growing season (Niesenbaum, 1988) . The level of supply of potential recruits is considered to be so great that barriers and changes in tidal excursion will not negatively impact populations. The associated species *Patella vulgata* and *Semibalanus balanoides* also produce planktonic larvae that are transported by water movements.. Barriers that reduce the degree of tidal excursion may alter larval supply to suitable habitats from source populations. Conversely the presence of barriers may enhance local population supply by preventing the loss of larvae from enclosed habitats. *Littorina saxatilis* have either limited dispersal or produce crawl away juveniles rather than pelagic larvae (direct development). Barriers and changes in tidal excursion are not considered relevant to these species as dispersal is limited. As the key characterizing *Ulva* spp. species are widely distributed and have larvae capable of long distance transport, resistance to this pressure is assessed as 'High' and resilience as 'High' by default. This biotope is therefore considered to be 'Not sensitive'.

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	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

The key characterizing *Ulva* spp. may be cultivated for use as biofilters to mitigate pollution, as biomass for biofuel generation or for pharmaceuticals and food. No information was found on current production in the UK and no evidence was found for the effects of gene flow between cultivated species and wild populations. As wild populations are widely distributed and water flow may aid dispersal of swarmers, populations are not considered to be genetically isolated. It is therefore considered that resistance to changes in genetic structure are 'High' and that resilience is therefore 'High' by default and the biotope is 'Not sensitive'. The use of genetically modified organisms in the future, which may transfer novel genetic material to wild populations may result in harmful impacts and this assessment would require updating if such scenarios arise.

Introduction or spread of invasive non-indigenous species	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

This biotope occurs where either fresh-water influences or physical disturbances, such as abrasion, prevent the development of a more diverse rocky shore assemblage. Due to the environmental stressors that maintain the biotope the habitat is unsuitable for colonization by most species including invasive, non-indigenous species. The non-indigenous barnacle *Austrominius modestus* (formerly *Elminius modestus*), may replace the native *Semibalanus balanoides*, particularly in sheltered areas or where salinity is reduced. This is not considered to significantly alter the character of the biotope.

Sensitivity assessment. Based on the high-levels of environmental stress and the lack of habitat overlap and reported impacts with currently recognised invasive, non-indigenous species, this biotope is considered to have 'High' resistance and 'High' resilience to this pressure and is therefore assessed as 'Not sensitive'.

Introduction of microbial pathogens	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

No evidence was found that outbreaks of microbial pathogens significantly impact populations of the key characterizing *Ulva* spp. Macroalgae, including Ulva spp. produce protective chemical defences against pathogens (antimicrobial and antifungal agents (Pramitha & Lipton, 2014). Resistance to this pressure is therefore assessed as 'High' and recovery as 'High' (by default) so that the biotope is considered to be 'Not sensitive'.

Removal of target species	Low Q: Low A: NR C: NR	High Q: High A: High C: High	Low Q: Low A: Low C: Low

The winkle *Littorina littorea* and the limpet *Patella vulgata* occur in low densities in this biotope and may be gathered by hand. However, as these are not key characterizing species the biotope is not considered sensitive to their removal or the reduction in grazing pressure that may result. The key characterizing *Ulva* spp. may be collected from the wild for use in pharmaceuticals and food. Removal of this species in high quantities would alter the character of the biotope, resulting in reclassification. Resistance to harvesting is assessed as 'Low' as the genus, is relatively large, attached and accessible and, therefore, has no escape or other avoidance mechanisms. Resilience is assessed as 'High' as cleared areas will be readily colonized. Sensitivity is, therefore, assessed as 'Low'.

Removal of non-target species	Low Q: Low A: NR C: NR	High Q: High A: High C: High	Low Q: Low A: Low C: Low

Incidental removal of the characterizing *Ulva* species would alter the character of the biotope. The ecological services such as primary production provided by these species would also be lost.

Sensitivity assessment. Removal of a large percentage of the characterising species would alter the character of the biotope, so that it was bare rock. Resistance is therefore assessed as 'Low' and recovery as 'High' and sensitivity is therefore assessed as 'Low'.

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