Filamentous green seaweeds on low salinity infralittoral mixed sediment or rock

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

Dr Keith Hiscock

2016-03-23

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:
Hiscock, K. 2016. Filamentous green seaweeds on low salinity infralittoral mixed sediment or 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.157.1

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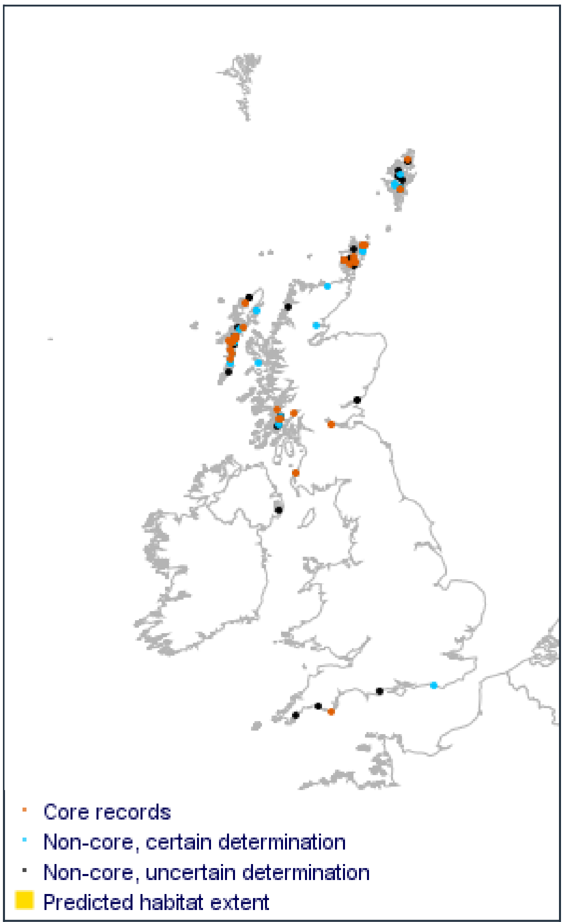
Tufts of green filamentous algae.
Photographer: Anon.



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

Researched by Dr Keith Hiscock **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A5.528	Filamentous green seaweeds on low salinity infralittoral mixed sediment or rock
JNCC 2015	SS.SMp.KSwSS.FilG	Filamentous green seaweeds on low salinity infralittoral mixed sediment or rock
JNCC 2004	SS.SMp.KSwSS.FilG	Filamentous green seaweeds on low salinity infralittoral mixed sediment or rock
1997 Biotope	SS.IMX.KSwMx.FiG	Filamentous green seaweeds on low salinity infralittoral mixed sediment or rock

Description

Shallow muddy sediments, often with boulders, cobbles and pebbles around the edges of lagoons, or other areas that are exposed to wide salinity variations are unsuitable for colonisation by many species. Such areas may be colonized by a dense blanket of ephemeral green algae such as *Ulva* spp., *Chaetomorpha linum*, *Cladophora liniformis* or *Rhizoclonium riparium*. This biotope may also contain some red seaweeds, such as *Furcellaria lumbricalis*, but always at low abundance (compare with PolFur). Amongst the filamentous green algae, grazing molluscs and solitary ascidians may be present. Infauna may typically include *Corophium volutator*, *Heterochaeta costata*, *Tubificoides benedeni* and other taxa suited for low/variable salinity environments. (Information from Connor *et al*., 2004; JNCC, 2015).

Depth range

0-5 m, 5-10 m

Additional information

None.

Listed By

- none -

Further information sources

Search on:

G G JNCC

Habitat review

Ecology

Ecological and functional relationships

Many of the species in this community are reliant on or affected by one-and-other. Some examples of interactions are given below.

- Dense shading by the seasonal growths of green filamentous algae prevents other macrophytes from growing but may offer shelter to invertebrates.
- The aplisiomorph mollusc *Akera bullata* feeds on filamentous algae and is especially found in this sort of very sheltered variable or low salinity biotope (see, for instance, Thompson & Seaward, 1989).
- Absence of significant grazing species because of low salinity conditions most likely is essential to the development of the dense algal mats.
- Mysid shrimps are dependant on a supply of plankton on which to feed.
- By feeding on zooplankton, mysids may enhance eutrophication in nutrient-rich brackish lakes by reducing grazing pressure on phytoplankton. (Aaser *et al*., 1995).
- The three-spined stickleback *Gasterosteus aculeatus* feeds on mysids (Rademacher & Klis, 1996).
- The ascidian *Ciona intestinalis* and the mussel *Mytilus edulis*, where they occurs in the biotope, may have a significant effect on phytoplankton biomass (Riisgård *et al*., 1993 for *Ciona intestinalis*).

Seasonal and longer term change

The biotope shows significant seasonal change especially in algal growth and includes many ephemeral species. For instance, *Cladophora rupestris* attains maximum development in summer, *Cladophora sericea* grows in spring and summer and *Chaetomorpha linum* is abundant in spring and summer (Burrows, 1991). For animal species, Sarda *et al.* (1998) working on saltmarsh communities that included several of the characterizing species in this biotope concluded that macroinfaunal densities peaked in June following spring recruitment. Also, three-spined sticklebacks *Gasterosteus aculeatus* may colonize the habitat seasonally. The ecosystem may be unstable. Riisgård *et al.* (1993) noted that, in a sheltered lagoonal system, during a long period of calm and warm weather, the filamentous algal mat rose to the surface releasing high amounts of nutrients and causing a phytoplankton bloom. One of the mysid species likely to occur in this biotope, *Neomysis integer*, performs a diel vertical migration, rising towards the surface waters during the night and returning to the deeper waters at daylight where it remains throughout the day (Hough & Naylor, 1992).

Habitat structure and complexity

Both hard and soft substrata occur in this biotope with further surfaces for settlement provided by the filamentous algae that dominate the biotope especially in summer. Algae form a smothering blanket that nevertheless might provide a habitat for small crustaceans and snails that gain shelter amongst the filaments and feed on the algae.

Productivity

Dense mats of filamentous green algae may adversely affect primary production though self-shading. Krause-Jensen *et al.* (1996) observed that the self-shading produced by dense mats of *Chaetomorpha linum* could cause a switch from being net productive to a status where consumption exceeded production possibly making such shallow macrophyte communities inherently unstable. Pedersen & Borum (1996) noted that fast growing algae were nitrate limited in experimental studies.

Recruitment processes

Sessile species such as the dominant algae, as well as mussels and ascidians where they occur and the infaunal polychaetes recruit from planktonic propagules. Some others such as the aplisiomorph mollusc *Akera bullata* are likely to recruit from planktonic stages but also by migration. Some other species are highly mobile (for instance, fish, mysids, starfish, crabs) and most likely migrate into the biotope, possibly on a seasonal basis.

Time for community to reach maturity

The species in the biotope are predominantly fast growing and are likely to settle readily from planktonic propagules or migrate into the habitat. Development of the community will depend on the time of year that a suitable habitat becomes available, the proximity of similar biotopes with migratory species that can move-in, and the time taken for a balance to be established. Filamentous green algae would be expected to dominate at first with species such as mysid shrimps and fish colonizing rapidly. Settlement and growth of other species will occur especially during spring and summer. Herbivores such as the aplisiomorph mollusc *Akera bullata* probably do not have a critical role to play in freeing space for settlement of other hard substratum species but domination by filamentous algae may limit space available for, for instance, solitary ascidians and mussels. With the domination by rapidly-settling algae and the presence of migratory species such as mysids, sticklebacks and green shore crabs, it would be expected that the biotope would be recognised within a few months of the habitat being available in proximity to other examples of the biotope. Full species richness would be likely within a year or slightly more.

Additional information

The presence of *Beggiatoa* sp. in the biotope suggests that de-oxygenated pockets occur and that hypoxia may be a feature that component species need to be tolerant of.

Preferences & Distribution

Habitat preferences

Depth Range	0-5 m, 5-10 m
Water clarity preferences	
Limiting Nutrients	Data deficient
Salinity preferences	Full (30-40 psu), Variable (18-40 psu)
Physiographic preferences	
Biological zone preferences	Infralittoral
Substratum/habitat preferences	Mixed

Tidal strength preferences	Very Weak (negligible), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered
Other preferences	See additional information

Additional Information

There appear to be three critical habitat characteristics that determine the development of this biotope: extreme shelter from wave action, very variable, reduced or low salinity, and presence of hard and sediment substrata. Low salinity in particular means that the habitat is unsuitable for many species and a few tolerant species thrive. Absence of significant tidal flow is also important.

Species composition

Species found especially in this biotope

- *Akera bullata*
- *Chaetomorpha linum*
- *Gasterosteus aculeatus*

Rare or scarce species associated with this biotope

-

Additional information

Records of this biotope include a small number of species frequently found and many species that are recorded from one or a few examples. Some of the species representative of sensitivity have been not been researched and information reviews completed at the time this biotope review was prepared. Literature searches have therefore been undertaken (in addition to already reviewed species) for *Chaetomorpha linum*, *Carcinus maenas*, *Akera bullata* and *Gasterosteus aculeatus* for this review.

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The characterizing species and other important habitat factors are based on the JNCC (2015) biotope description. This biotope is characterized by shallow muddy sediments, often with boulders, cobbles and pebbles around the edges of lagoons, or other areas that are exposed to wide salinity variations that prevent colonization by many species. This biotope is characterized by ephemeral green algae such as *Ulva* spp., *Chaetomorpha linum*, *Cladophora liniformis* or *Rhizoclonium riparium* and some red seaweeds, such as *Furcellaria lumbricalis*, (at low abundance). The green seaweeds are considered to characterize the biotope and the sensitivty assessments focus on these species with some general information included on *Furcellaria lumbricalis* and infauna where relevant.

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.

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. For example, following the Torrey Canyon oil spill in March 1967, species of the genus *Ulva* rapidly 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 (Kitching & Thain, 1983).

Maximum growth of the perennial algae *Furcellaria lumbricalis* occurs in March/April (Austin, 1960b) and release of carpospores and tetraspores occurs in December/January (Bird *et al*., 1991). The advantage of being fertile through the winter, as in the case of *Furcellaria lumbricalis*, is the availability of substrata for colonization as other annual species die back (Kain, 1975). As with all red algae, the spores of *Furcellaria lumbricalis* are non-flagellate and therefore dispersal is a wholly passive process (Fletcher & Callow, 1992). In general, due to the difficulties of re-entering the benthic boundary layer, it is likely that successful colonization is achieved under conditions of limited dispersal and/or minimum water current activity. It is expected, therefore, that recruitment of *Furcellaria lumbricalis* would occur from local populations and that establishment and recovery of isolated populations would be patchy and sporadic. *Furcellaria lumbricalis* is highly fecund, an average sized gametophyte being able to produce approximately 1 million carpospores, or a tetrasporophyte, up to 2 million tetraspores (Austin, 1960a). However, the species grows very slowly compared to other red algae (Bird *et al*., 1979) and takes a long time to reach maturity. For example, Austin (1960b) reported that in Wales, *Furcellaria lumbricalis* typically takes 5 years to attain fertility. Christensen (1971) (cited in Bird *et al*., 1991) noted that following harvesting of *Furcellaria lumbricalis* forma *aegagropila* in the Baltic Sea, harvestable biomass had not been regained 5 years after the suspension of harvesting.

The infauna present in this biotope are typically short-lived organisms that grow rapidly and can colonize disturbed environments. Longevity of *Tubificoides* is two years at which point the worm is sexually mature. It is a hermaphrodite and reproduces throughout the year. The larvae are hatched after about 15 days in a cocoon. The worm can form dense communities, but the dispersal potential is very low (MES Ltd, 2010) suggesting this genus may recover slowly from events that depopulate the biotope. However the species exhibits many of the traits of opportunistic species.

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. Other species may take longer to recolonize, however, the characteristic biotope is considered to have recovered based on the filamentous green seaweeds.

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

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).

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

The upper temperature tolerance (that killed half of the test organisms after 96 hours) of the oligochaete *Tubificoides benedii* (studied as *Peloscolex benedeni*) was reported to be 28.5 °C (Diaz, 1980).

Sensitivity assessment. *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'. other associated species, including *Furcellaria lumbricalis*, are also considered to be 'Not sensitive' to this pressure.

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

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

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).

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: Medium C: High	Q: High A: High C: High	Q: High A: Medium C: High

The biotope typically experiences conditions of full (30-40 psu) or variable salinity (JNCC, 2015). The variable salinity experienced by this biotope maintains the biological assemblage of tolerant species by preventing colonization by species that require higher and more stable salinity (JNCC, 2015). An increase in salinity or a decrease in variability may therefore allow colonization by more competitive species altering the character of the biotope.

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).

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

Sensitivity assessment. Based on reported distributions and the results of experiments to assess salinity tolerance thresholds and behavioural and physiological responses it is considered that *Ulva* spp. and the associated species 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.

Salinity decrease (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 salinity (JNCC, 2015). 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. Martins *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*).

Furcellaria lumbricalis occurs in the lowest category on the salinity scale (Connor *et al*., 2004) and is therefore probably relatively tolerant of decreases in salinity. The species forms extensive populations in the main basin of the Baltic Sea where salinity is 6-8 psu in the upper 60-70 m and its extension into the Gulfs of Bothnia and Finland is limited by the 4 psu isohaline (see review by Bird *et al*., 1991). However, if the salinity conditions within the habitat were to become freshwater *Furcellaria lumbricalis* would not be able to survive, as it is a marine species.

Sensitivity assessment. Based on reported distributions and the results of experiments to assess salinity tolerance thresholds and behavioural and physiological responses it is considered that *Ulva* spp. and the associated species would tolerate a change in salinity from full to variable or reduced to low 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.

Water flow (tidal current) changes (local)	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

This biotope is only found in very weak water flow conditions and a decrease in water flow is considered unlikely to directly affect this biotope, although some reduction in growth may occur where waters experience very little movement so that nutrient supply and recharge of deoxygenated waters is reduced.

The key characterizing species of this biotope, *Ulva intestinalis* and *Ulva lactuca* are flexible and conform to the direction of water 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 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 sheltered environments and at the benchmark the increase is relatively minor 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. 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'. An increase in water flow at the benchmark is unlikely to have a significant negative effect on the biological composition of the biotope. However, it must be assumed that if there is an increase in the water flow within the biotope there will also be an increase in the water flow around the lagoon (where this biotope occurs in lagoons). This increase could have a detrimental effect on the structure of the lagoon through erosion. This could consequently lead to the loss collapse of a lagoon wall and completely change the physical environment of the biotope, and lead to the loss of the lagoon biotope altogether. A change in the water flow at the pressure benchmark is unlikely to cause the loss of the lagoon biotope.

Emergence regime changes	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

This biotope occurs in shallow subtidal habitats, shallow examples are not considered to be sensitive to decreased emergence but deeper examples may experience reduced habitat suitability where water depth increases and reduces light penetration. The associated *Ulva* spp. are able to tolerate desiccation stress and they are 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, desiccation stress of germlings 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. *Furcellaria lumbricalis* can also be found from the lower intertidal to 12m subtidally (Bunker *et al.*, 2012).

A significant, long-term, increase in emergence placing this biotope fully in the intertidal may lead to replacement of this biotope with one more typical of the changed conditions with *Elminuius modestus* and littorinids present, a change in grazing pressuire could reduce the biomass of the characterizing, filamentous green algae.

Sensitivity assessment. If shallow sublittoral portions of thebiotope emerged for short periods during the tidal cycle it is considered unlikely that the exposed portions would be negatively impacted, based on the presence of characterizing and associated species in fully intertidal biotopes. Resistance is assessed as 'High' and resilience as 'High' (by default) so that the biotope is considered to be 'Not sensitive'.

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

This biotope is only found in very and extremely wave sheltered conditions (Connor *et al.*, 2004). Key environmental factors structuring this biotope are variable salinity and the mixed substrata as well as the low level of wave exposure. The characterizing species can be found in biotopes where wave exposure exceeds that experienced by this biotope. A more severe increase in wave action would cause some damage to fronds of filamentous green algae resulting in reduced photosynthesis and compromised growth. Furthermore, individuals may be damaged or dislodged by scouring from sand and gravel mobilized by increased wave action (Hiscock, 1983). Austin (1960b) noted that *Furcellaria lumbricalis* from extremely exposed sites have smaller dimensions than individuals from semi-exposed sites and that fronds may be lost due to storm action. Sharp *et al.* (1993) reported *Furcellaria lumbricalis* found cast ashore following storms.

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

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

Chemical Pressures

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

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

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 species 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.

Contamination at levels greater than the benchmark may impact this biotope. 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 (Moss & Woodhead, 1975).

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

Where nutrients and other factors support rapid growth, large blooms of *Cladophora* and *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.

The effects of reduced oxygenation on the red algae within the biotope are not well studied. Lack of oxygen may impair both respiration and photosynthesis (Vidaver, 1972). The associated oligochaete *Tubificoides benedii* inhabits sulfide rich environments and has a high capacity to tolerate anoxic conditions (Nubilier *et al*., 1997; Giere *et al*., 1999). *Tubificoides benedii* is often buried up to 10 cm deep and so has no contact with the surface but has a highly specialized adaptive physiology that allows it to maintain some oxygen consumption even at 2% (approximately 0.18 mg/l) oxygen saturation of the surrounding environment on the Isle of Sylt.

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. 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: Low C: High	High Q: High A: High C: High	Not sensitive Q: High A: Low 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 *Cladophor* and *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, biotopes dominated by ephemeral green algae may develop in response to chronic physical disturbance from sediment instability or sand-scour, or to reduced salinity 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 low salinity, 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. Organic enrichment at the pressure benchmark is unlikely to directly affect macroalgae within the biotope. An input of organic matter to the sediment surface will be utilised by the detritus feeders within the sediments.

The oligochaete *Tubificoides benedii* can be found living in abundance under algal mats (Nubilier et al., 1997). It is opportunistic and responds to organic pollution by increasing the size of the population (Diaz, 1977, cited in Diaz, 1980). Oligochaetes often become the dominant benthic fauna under algal mats (Raffaelli *et al*., 1998). Estuarine oligochaetes tend to become more abundant in areas where pollution or other physical factors result in a reduced habitat diversity and stressful conditions, concomitant with a decrease in polychaetes species (Diaz, 1980). Barnett (1983) found the maximum abundance of the oligochaete *Tubificoides benedii* at a site which received a significant input of both industrial and domestic effluent, including raw sewage, in the Humber estuary.

Sensitivity assessment. 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.

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

This biotope is characterized by the mixed substratum provided by the boulders and cobbles and muddy sediments. Changes to a coarse, clean sediment type or artificial hard substratum would significantly alter the character of the biotope through the loss of the mixed sediments and infauna, although, if the biotope was still sheltered from wave action and exposed to variable salinity, the habitat may still be suitable for typical filamentous algal assemblage. A change to a fine muddy sediment would result in loss of attachment surfaces for green algae, in very wave sheltered areas these may persist as free-growing forms but the typical biotope would be considered to be lost.

Sensitivity assessment. The biotope is considered to have **No** resistance to this pressure based on a change to a coarse or fine sediment substratum or a hard, free draining substratum. Resilience is assessed as **Very low** (the pressure is a permanent change) and sensitivity is assessed as **High**.

	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 to biotopes occurring on bedrock or on mixed substrata consisting of boulders, cobbles and pebbles.

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

Removal of the boulders, cobbles and pebbles would remove the attached algae and associated species which are found within the algal turf. Extraction of the muddy sediment would also remove filamentous green algae (where this is growing on sediments) and the associated infauna such as the oligochaetes. Resistance is, therefore, assessed as 'None', recovery of the filamentous green algae is likely to be rapid and resilience is, therefore, assessed as 'High' so that sensitivity is assessed as 'Medium'.

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

No direct evidence for the sensitivity of filamentous and foliose red algae was found to support assessment of this pressure. The species characterizing this biotope occur on the rock and therefore have no protection from abrasion at the surface. In a recent review, assigning species to groups based on tolerances to bottom disturbance from fisheries, the sponge *Halichondria panicea* were assigned to AMBI Fisheries Group II, described as 'species sensitive to fisheries in which the bottom is disturbed, but their populations recover relatively quickly' (Gittenberger & van Loon, 2011).

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 populations of the characterizing and associated species may be removed, but damaged algal individuals, *in-situ* would be capable of growth and reproduction. Resistance of the biotope, to a single abrasion event is assessed as 'Low' and recovery as 'High', so that sensitivity is assessed as 'Low'.

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

The cobbles and pebbles in the biotope are likely to move as a result of penetration and/or sub surface disturbance. The characterizing and associated species would probably accrue damage from abrasion and scour and attached algae trapped on the undersides of overturned pebbles would be unable to photosynthesise and are likely to be smothered. Penetration and disturbance is also likely to harm infauna.

Sensitivity assessment. This biotope is considered to have 'Low' resistance and 'High' resilience, to this pressure and sensitivity is therefore assessed as 'Low'.

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

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.

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

Sensitivity assessment. The biotope is considered to be 'Not sensitive' to a reduction in suspended solids. The negligible water flows and the very sheltered to extremely wave sheltered conditions within this biotope mean that an increase in suspended sediment would not cause an increase in the level of scour within this biotope. A change in light attenuation may result in a decrease in growth and biomass of algae although both Ulva spp and *Furcellaria lumbricalis* are likely to survive. Both resistance and resilience have been assessed as 'High', resulting in a 'Not sensitive' assessment.

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

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.

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, 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, 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.

Sensitivity assessment. A covering of sediment to a depth of 5 cm is likely to partially cover erect *Cladophora* spp. and may fully cover the flexible *Ulva* spp. Unless the sediment is removed by currents or wave action photosynthesis would be inhibited and fronds of macroalgae may begin to decay. As this biotope occurs in sheltered habitats sediments may be shifted rather than removed, so that exposure to this pressure is prolonged. 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. 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 smothering and scour effects and resistance is assessed as 'Low', recovery is assessed as 'High' and sensitivity is assessed as 'Low'.

Smothering and siltation rate changes (heavy)	None Q: High A: Medium C: High	High Q: High A: High C: High	Medium Q: High A: Medium C: High

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, 2003, references therein) suggesting that resistance to low-level 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, 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.

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. As this biotope occurs in habitats sheltered from currents and wave action the deposit of fine sediment is likely to remain in-situ for prolonged periods nad may be moved rather than removed and shallow examples of this habitat mey even be infilled. Siltation by 30 cm of fine sediment is therefore considered to remove most of the filamentous green algae and red algae and likely to smother infauna, resistance is assessed as 'None', recovery is assessed as 'High' (following habitat recovery) and sensitivity is assessed as 'Medium'.

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: Medium C: High	High Q: High A: High C: High	Not sensitive Q: High A: Medium 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 experienced by 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).

The red algae *Furcellaria lumbricalis* often occurs in relatively turbid waters. Laboratory experiments by Bird *et al.* (1979) revealed that *Furcellaria lumbricalis* was growth saturated at very low light levels (ca 20 µE/m^2/s) compared to other algae such as *Chondrus crispus* (50 - 60 µE/m^2/s) and *Fucus serratus* (100 µE/m^2/s). They suggest that this may be an explanation *why Furcellaria lumbricalis* is able to proliferate in relatively deep and turbid waters. Similarly, in their review, Bird *et al.* (1979) comment that in all studies, saturation and inhibition radiances were low for *Furcellaria lumbricalis* compared to other macroalgae indicating good competitive ability in the attenuated light of deeper or more turbid waters.

Sensitivity assessment. 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. This biotope occurs in sheltered areas and recruitment from within the biotope may be more important in sustaining the population than water transport of propagules from outside the habitat.

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 *Furcellaria lumbricalis* produce spores 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. 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 *Cladophora* and *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

The non-native hydroid, *Cordylophora caspia*, may compete directly with native species for food and space and is found in estuaries and brackish water (from 2-17psu), this biotope may therefore provide suitable habitat (Sweet, 2011i).

In Canada green sea fingers *Codium fragile fragile*, formerly *Codium fragile* subsp *tormentosoides*) has displaced native seaweed species and become the dominant canopy species in some areas, consequently altering community structure and composition, where conditions permit. Most significant impacts have occurred where algal diversity in the invaded area is low. In the UK algal diversity is high and green sea fingers has not yet occurred in nuisance densities (Sweet, 2011j). Generally this species occurs on more sheltered shores and in estuaries and the habitats in which this biotope occurs, where algal diversity is low, may potentially be colonized.

Sensitivity assessment. The low salinity habitat that this biotope is found in may not provide suitable habitat for many INIS. Based on the current lack of information on invasion by INIS resistance is assessed as 'High and resilience as 'High' by default so that the biotope is assessed as 'Not sensitive'. This assessment may require updating in the future as more information becomes available or as distribution patterns of INIS change.

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 produce protective chemical defences against pathogens with production of antimicrobial and antifungal agents. Barton (1901) noted that *Furcellaria lumbricalis* may become infested with nematode worms and reacts by gall formation.

Sensitivity assessment. Based on the lack of evidence for mass mortalities of the characterizing green algal species within this biotope, resistance to this pressure is 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: Low C: High	Low Q: Low A: Low C: Low

Direct, physical impacts from harvesting are assessed through the abrasion and penetration of the seabed pressures. The sensitivity assessment for this pressure considers any biological/ecological effects resulting from the removal of target species on this biotope. 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’.

Extraction of *Furcellaria lumbricalis* was reviewed by Guiry & Blunden (1991). Plinski & Florczyk (1984) noted that over-exploitation of *Furcellaria lumbricalis* resulted in severe depletion of stocks. However, no commercial harvest as yet occurs in Britain or Ireland. Due to the relative small size of the population within this biotope, even small scale hand collecting may have a significant effect, should this species be targeted in the future. The infauna present in the biotope are not targeted.

Sensitivity assessment. Resistance is assessed as 'Low' as the targeted species are attached, conspicuous and accessible (where this biotope occurs at the sublittoral fringe). Resilience is assessed as 'High', based on the characterizing green seaweeds and sensitivity is therefore assessed as 'Low'.

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

Incidental removal of the characterizing filamentous green seaweeds 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 characterizing 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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