Ascophyllum nodosum with epiphytic sponges and ascidians on variable salinity infralittoral rock

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***Ascophyllum nodosum* with epiphytes (SIR.AscSAs).**
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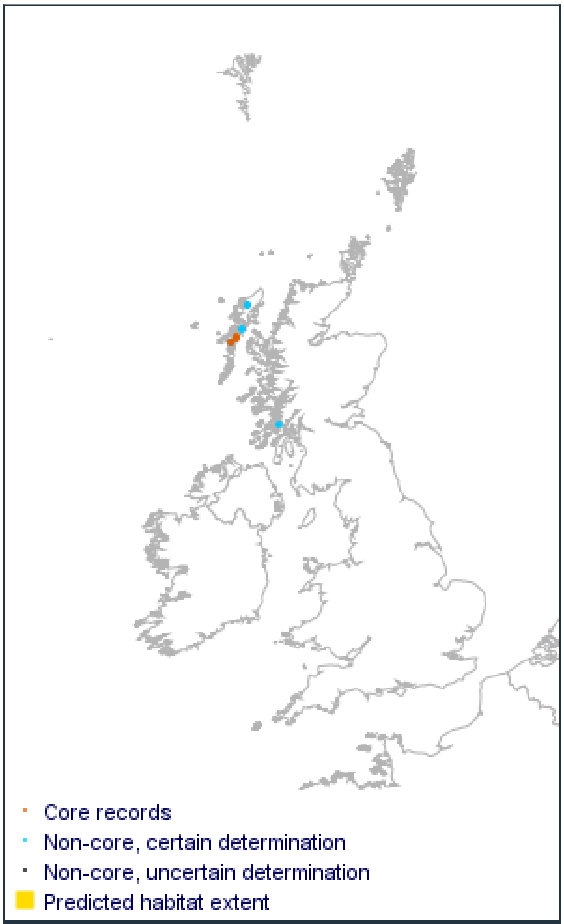

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Frances Perry **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A3.342	*Ascophyllum nodosum* and epiphytic sponges and ascidians on variable salinity infralittoral rock
JNCC 2015	IR.LIR.Lag.AscSpAs	*Ascophyllum nodosum* with epiphytic sponges and ascidians on variable salinity infralittoral rock
JNCC 2004	IR.LIR.Lag.AscSpAs	*Ascophyllum nodosum* with epiphytic sponges and ascidians on variable salinity infralittoral rock
1997 Biotope	IR.SIR.Lag.AscSAs	*Ascophyllum nodosum* with epiphytic sponges and ascidians on variable salinity infralittoral rock

Description

Dense subtidal stands of *Ascophyllum nodosum*, heavily epiphytised by sponges and ascidians in lagoon-like habitats. The wracks Fucus vesiculosus and Fucus serratus can be present along with the brown seaweed *Chorda filum* and the red seaweed *Polyides rotunda*. The crab *Carcinus maenas* can be present between the *Ascophyllum nodosum* holdfasts along with the shrimps Mysidae. (Information from Connor *et al.*, 1997a, b, 2004).

Depth range

Lower shore, 0-5 m

Additional information

Nearby rock often supports similar biotopes of submerged fucoids and green seaweeds (FChoG). Slightly deeper rock often supports *Saccharina latissima* (Slat.Ft), usually surrounded by more extensive areas of sediment. Seagrass beds thrive well in the muddy sand of these lagoons and often cover large areas. They include both *Ruppia maritima* and *Zostera marina* (Rup and Zmar). (Information from Connor *et al.*, 2004).

Listed By

- none -

Further information sources

Search on:

G g G JNCC

Habitat review

Ecology

Ecological and functional relationships

- The biotope is found in very shallow submerged rocky habitats in lagoons, subject to variable or permanently reduced salinity conditions. These particular habitat conditions lead to a variety of seaweed-dominated communities which include fucoids and green filamentous species. The fucoids, more typical of intertidal habitats, penetrate into the subtidal under the reduced salinity conditions which are not tolerated by kelps.
- The biotope is dominated by dense stands of *Ascophyllum nodosum*. The species, and the other macroalgae in the biotope, increase the amount of space available for attachment, they provide shelter from wave action, desiccation and heat, and they are an important food source. High abundances of the characterizing algae may contribute to the oxygen budget of lagoons. In the North Atlantic for example, *Ascophyllum nodosum* is of great ecological importance because of its high abundance on most sheltered rocky shores, where it must be a major contributor to the oxygen budget of shallow waters to a wide range of intertidal animals (Stengel & Dring, 1997).
- *Ascophyllum nodosum* plants provide a substratum for a variety of attached animal species including the sponge *Halichondria panicea*, the sea squirts *Ciona intestinalis* and *Botryllus schlosseri* and some erect bryozoans.
- Growth of epiphytic sponges and ascidians may be slower than in tide-swept habitats because the biotope has weak tidal streams and wave exposure and so will have a limited supply of suspended particles necessary for suspension feeding. However, low water flow environments will favour active rather than passive suspension feeders.

Seasonal and longer term change

Ascophyllum nodosum has a very long lifespan where individual fronds can survive for 10-15 years and the holdfast for several decades. The longevity of *A. nodosum* contributes to the stability of the biotope. Other fucoid plants found in the biotope, such as *Fucus serratus*, have lifespans in the order of 3-5 years. However, growth rates of macroalgae do show seasonal changes. For example, in Strangford Lough in Northern Ireland, Stengel & Dring (1997) observed the growth of *Ascophyllum nodosum* to be highly seasonal with low growth rates during November and December, and highest growth rates in late spring and early summer. A decline in growth in mid-summer was observed at all shore levels. Faunal groups in the biotope are also likely to show seasonal variation in growth rates and recruitment.

Habitat structure and complexity

Fucoid biotopes provide a variety of habitats and refugia for other species. The dense beds of *Ascophyllum nodosum* and the other fucoids in the biotope increases the structural complexity of the habitat providing a variety of resources that are not available on bare rock. Fronds provide space for attachment of encrusting or sessile epifauna and epiphytic algae and provide shelter from wave action, desiccation and heat for invertebrates. For example, the immediate effects of the removal of *Ascophyllum* plants are to: destroy the epifauna and flora; increase desiccation; increase predation; increase erosion and aid settlement of other species (Boaden & Dring, 1980). Crevices in the bedrock and overhangs on fucoid rocky shores also increase habitat complexity by providing refugia for a variety of species.

Productivity

On rocky shores, only about 10% of the primary production is directly cropped by herbivores (Raffaelli & Hawkins, 1996) and this is likely to be similar for lagoon-like habitats. Macroalgae, such as *Ascophyllum nodosum* and other fucoids, exude considerable amounts of dissolved organic carbon which are 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 and can make a contribution to the food of many marine species through the production of planktonic larvae and propagules which contribute to pelagic food chains. However, in lagoon-like habitats such as the SIR.AscSAs biotope, where tidal flows and wave exposure are weak larvae and propagules probably enter the food chain of local ecosystems rather than inshore subtidal or offshore ecosystems.

Recruitment processes

Many rocky shore plants and animals, possess a planktonic stage: gamete, spore or larvae which float in the plankton before settling and metamorphosing into adult form. This strategy allows species to rapidly colonize new areas that become available such as gaps created by storms. For these organisms it has long been evident that recruitment from the pelagic phase is important in governing the density of populations on the shore (Little & Kitching, 1996). Both the demographic structure of populations and the composition of assemblages may be profoundly affected by variation in recruitment rates.

- Fucoid plants are recruited from pelagic sporelings that settle on the substratum. Recruitment of *Ascophyllum nodosum* is generally poor and in the intertidal few germlings are found on the shore. However, in the sheltered conditions of the lagoon-like SIR.AscSAs biotope, recruitment from local plant stands may be more effective.
- The sponges and ascidians characterizing the biotope all have planktonic larvae and are fairly short-lived. There is therefore, high recruitment and high turnover.

Time for community to reach maturity

The time for an *Ascophyllum nodosum* community to reach maturity is likely to be many years because the main characterizing species has very poor recruitment and is very slow growing. *Ascophyllum nodosum* does not reach sexual maturity until about 5 years of age and, in the intertidal, individual fronds can live to be up to 15 years old and whole plants for several decades. In their work on fucoid recolonization of cleared areas at Port Erin, Knight and Parke (1950) observed that even eight years after the original clearance there was still no sign of the establishment of an *Ascophyllum nodosum* population. There is a long-recognised shortage of sporelings (David, 1943) and the failure of the species to recolonize denuded areas for decades. However, the species is extremely fertile every year and Printz (1956) suggests it must be assumed that some special combination of climatic or environmental conditions is needed for an effective recolonization. If plants are not removed completely *Ascophyllum nodosum* plants cut within 10-15cm of the base recover fully in 4-5 years (Printz, 1956). The epiphytic species are likely to colonize algae very rapidly. Most epiphytic species are likely to have planktonic larvae and rapid growth so that colonization of the algae will be rapid. For example, settlement of new colonies of *Halichondria panicea* within one year is likely and the species increases in size by about 5% per week (Barthel, 1988). Recovery of the sea squirt *Ciona intestinalis*, may take a little longer if adult populations have been lost because the species probably has limited dispersal because the larval stage is very short (hours or days) and larvae are often retained near the adults by mucus threads. However, in Plymouth reproduction is recorded as occurring all year round so recovery from loss within a few years should be possible. Even if some other epiphytic species take longer to return the recovery of the biotope is likely to limited by the recovery of the key species *Ascophyllum nodosum*.

Additional information

Information on the biotope has been based greatly on the general biology and ecology of *Ascophyllum nodosum* in the more common intertidal full salinity habitat. It is possible that in reduced and variable salinity lagoonal habitats life history characteristics of the species, such as growth rates, longevity and reproduction may be different.

Preferences & Distribution

Habitat preferences

Depth Range	Lower shore, 0-5 m
Water clarity preferences	
Limiting Nutrients	Nitrogen (nitrates), Phosphorus (phosphates)
Salinity preferences	Full (30-40 psu), Low (<18 psu), Reduced (18-30 psu)
Physiographic preferences	Enclosed coast / Embayment, Isolated saline water (Lagoon)
Biological zone preferences	Infralittoral, Sublittoral fringe
Substratum/habitat preferences	Bedrock, Cobbles, Gravelly mud, Large to very large boulders, Sand, Small boulders
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Very Weak (negligible), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered, Ultra sheltered
Other preferences	

Additional Information

Species composition

Species found especially in this biotope

Rare or scarce species associated with this biotope

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Additional information

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

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

The salinity regime within this biotope makes it suitable for *Fucus ceranoides*, a fucoid whose entire life cycle is adapted to tolerate low salinities. These adaptations mean that other species of fucoid can’t compete within the same habitat. *Fucus ceranoides* is susceptible to high levels of grazing from littorinids to the point of their distribution being limited by them (Norton, 1986). However, the salinity conditions within this biotope mean that littorinids are not able to survive, allowing *Fucus ceranoides* to dominate. The biological community within this biotope is characteristically sparse and many of the other species have life histories which make them opportunistic, short lived and ephemeral. Such species include *Ulva lactuca* and *Ulva* (Syn *Enteromorpha*) *intestinalis*. The only identified grazing species come from the family Mysidae. The characterizing species identified for this biotope are the macroalgae *Fucus ceranoides* and *Ulva lactuca*, for without it the biotope would not be present. Other species contribute to the biological composition of the biotope but are not crucial to its presence.

Resilience and recovery rates of habitat

Recolonization of *Fucus* dominated areas may take between one to three years in British waters and is especially rapid in areas cleared of grazers (Hartnoll & Hawkins, 1985; Hawkins & Hartnoll, 1985). The lack of fucoid grazers is notable within this biotope. The relatively short lifespan of *Fucus ceranoides*, three to five years (Lein, 1984; Brawley, 1992a; Bäck *et al*., 1991), and annual reproduction would allow this species to recolonize a shore quickly. Good recruitment could allow a mature stand of *Fucus ceranoides* to be present within three years. Fucoids don’t have a planktonic dispersal stage and consequently their dispersion capacity above 50 m is minimal (Chapman, 1995; Serrão *et al*., 1997; Dudgeon *et al*., 2001; taken from Neiva *et al*., 2012). In addition to a low dispersal capacity, *Fucus ceranoides* is found in relatively small and isolated populations in intertidal estuarine areas (Neiva *et al*., 2012). Sperm in fucoids has a greater dispersal capacity (>10 m) than eggs (<0.5 m) (Serrão *et al*., 1997). Therefore, if there were to be a case of longer distance gamete fertilization within *Fucus ceranoides* it is more likely to be the sperm contributing to the gene flow (Neiva *et al*., 2012). Yet the short lifespan, sensitivity to changes in salinity, and the effect of dilution (Serrão *et al*., 1996) would limit the reach of *Fucus ceranoides* sperm. A mass mortality event of *Fucus ceranoides* within a lagoon due to high sensitivity to a pressure would require the long distance transport of drifting fertile fronds (Neiva *et al*., 2012). The frequency of such events must be low. However, Neiva *et al.* (2012) deduced that this must have been the only mechanism via which *Fucus ceranoides* was able to recolonize northern Europe since the last ice age. There are no documented examples of this, but it is reasonable to assume that the frequency of a successful relocation to a new habitat location is low.

Unlike many communities, the community structure within this biotope does not appear to be greatly altered by a grazing species. *Littorina littorea* is a dominant grazer on many rocky intertidal and subtidal habitats where salinity regimes are either full (30 – 40 psu) or variable (18 – 40 psu) (Connor *et al*., 2004). However, in lab experiments *Littorina littorea* grazing activity is significantly reduced below salinities of 17% (Norton, 1986). In the Firth of Clyde the seaward limit of *Fucus ceranoides* coincides with the inland limit of littorinids (Norton, 1986). In the field *Littorina littorea* is replaced by amphipods as the dominant mesograzer when salinities regularly fall below 12% (Johannesson *et al*., 1988). The main grazers present within this biotope are mysids. Mysids are similar to amphipods in their feeding habits, and it is likely that fill the functional niche that amphipods do within the LR.LLR.FVS.Fcer biotope. In IR.LIR.Lag.FcerUlv and LR.LLR.FVS.Fcer these grazing crustaceans are presumably present because the reduced to low salinity regimes are not suitable for littorinids. Among other things mysids consume macroalgae. Macroalgae has been found to contribute as much as 68% of the total diet of a species of mysid (Kibirige *et al*., 2003). This consumption could have a strong impact on the weight of macroalgae and the structuring of the biotope in question. However, strong predation on amphipods within a *Fucus vesiculosus* habitat found that macroalgae biomass did not change (Eriksson *et al*., 2011). This was due to omnivorous shrimps grazing the macroalgae when their main food source i.e. the amphipods were removed. Thus preventing a trophic cascade and a change in biotope. Within this biotope mysids appear to be the dominant grazing species. Predicting how species, such as omnivorous shrimps, may indirectly affect this biotope when immersed is difficult because these species are not considered in intertidal biotopes. No evidence can be found on the impact of mysid grazing on the characterizing species, *Fucus ceranoides* and *Ulva* sp.. This lack of evidence, combined with the comparatively low 'typical abundance' and '% contribution to similarity' between the core records of this biotope means that mysids have not been included as a characterizing species within this biotope assessment. However, any pressure which may cause significant changes in the abundance in mysids and could have a negative impact on the biotope will be taken into consideration when assessing the effects of pressures. Many species of mysids have short life histories, and will be able quickly repopulate an area (Fish & Fish, 1996).

Both *Ulva* (was *Enteromorpha*) *intestinalis* and *Ulva lactuca* 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. They exhibit a broad tolerance 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* 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* sp. 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 100% coverage within one year. Such evidence suggests that these species will rapidly return to this biotope.

Resilience assessment. This biotope is characteristically low in biodiversity, and the species that contribute to the biological community are often ephemeral and short lived. Except for *Fucus ceranoides* many of the species, including *Ulva* sp., have planktonic stages which allow for significant dispersal capabilities. If a pressure were to reduce the abundance of *Fucus ceranoides*, the species would be able to recruit from the remaining population and a return to a mature stand could occur within three years. The return of the remaining biological community and previous ecological function would be quick due to the ephemeral and opportunistic character of the species. For pressures where some *Fucus ceranoides* population remains resilience is assessed as 'Medium'. However, for pressures where the benchmark level would cause complete removal of *Fucus ceranoides*, and recovery of the characterizing species relies on transport of mature broken fragments to new habitats a resilience of 'Low' is given.

Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	Medium Q: High A: High C: Medium	Medium Q: High A: Medium C: Medium	Medium Q: High A: Medium C: Medium

Schonbeck & Norton (1979) demonstrated that fucoids can increase tolerance in response to gradual change in temperature through a process known as 'drought hardening'. However, acute changes in temperatures may cause damage to macroalgae and other species. Temperature ranges of species may not accurately describe their ability to withstand localized changes in temperature. Yet they will display the limits of the species genetic ability to acclimatize to temperatures. Juvenile life stages of organisms can be less tolerant to environmental conditions than more mature stages.

In the north east Atlantic *Fucus vesiculosus* occurs from Northern Russia to Morocco (Powell, 1963). *Fucus vesiculosus* is able to tolerate temperatures as high as 30 °C (Lüning, 1990) and did not show any sign of damage during the extremely hot UK summer of 1983, when average temperatures were 8 °C hotter than normal (Hawkins & Hartnoll, 1985). *Fucus vesiculosus* also tolerates extended periods of freezing in the northern part of its range.

Ascophyllum nodosum is found in the middle of its range in the British Isles, with populations in the north east Atlantic as far south as Portugal and extending north to the White Sea. *Ascophyllum nodosum* is unlikely to be affected by a short-term change of 5°C, as it was not damaged during the unusually hot summer of 1983 when the average temperature was 8.3°C higher than normal (Hawkins & Hartnoll, 1985). *Ascophyllum nodosum* can tolerate certain levels of exposure as they are regularly exposed to rapid and short-term variations in temperature. Both exposure at low tide or rising tide on a sun-heated shore involves considerable temperature changes, and during winter the air temperature may be far below freezing point. Growth of *Ascophyllum nodosum* has been measured between 2.5 and 35°C with an optimum between 10 and 17°C (Strömgren, 1977).

Ascophyllum nodosum can be damaged by thermal pollution if the water temperature remains above 24°C for several weeks (Lobban & Harrison, 1997), and temperatures exceeding 27°C cause direct mortality (Keser *et al*., 2005). Water temperature is an excellent predictor of gamete release in *Ascophyllum* (Bacon & Vadas, 1991). Consequently changes in temperatures could impact on gamete release. Investigations into the tolerance of *Ascophyllum nodosum* germlings from Norway, to temperatures between 7°C -17°C found that there was no difference in survival rates within the given range (Steen & Rueness, 2004). Germination of *Ascophyllum nodosum* has been recorded between the temperatures of 4°C - 23°C.

Other species found within this biotope are probably tolerant of temperature changes at the benchmark level as they are widely distributed in the UK.

Sensitivity assessment. The characterizing species *Ascophyllum nodosum* and *Fucus vesiculosus* are found in the middle of their habitat range in the British Isles. Although the range of these species can extend down to Portugal, if the temperature changes occur over a short period leaving no time for acclimation then there could be some damage caused to the microalgae's. However, if the changes are more gradual then the algae may have time to acclimate which would not produce any significant negative impact. The benchmark scenario which is likely to cause the most stress to this biotope is an increase of 5°C for one month. The sensitivity assessment for this scenario gives both resistance and resilience a score of 'Medium'. Meaning that the biotope has a 'Medium' sensitivity to this pressure at the benchmark.

Temperature decrease (local)	Medium Q: High A: High C: Medium	Medium Q: High A: Medium C: Medium	Medium Q: High A: Medium C: Medium

Schonbeck & Norton (1979) demonstrated that fucoids can increase tolerance in response to gradual change in temperature through a process known as 'drought hardening'. However, acute changes in temperatures may cause damage to macroalgaes and other species. Temperature ranges of species may not accurately describe their ability to withstand localized changes in temperature. Yet they will display the limits of the species genetic ability to acclimatize to temperatures. Juvenile life stages of organisms can be less tolerant to environmental conditions than more mature stages.

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Ascophyllum nodosum is found in the middle of its range in the British Isles, with populations in the north east Atlantic as far south as Portugal and extending north to the White Sea. Growth of *Ascophyllum nodosum* has been measured between 2.5 and 35°C with an optimum between 10 and 17°C (Strömgren, 1977). Water temperature is an excellent predictor of gamete release in *Ascophyllum* (Bacon & Vadas, 1991). Consequently changes in temperatures could impact on gamete release. Investigations into the tolerance of *Ascophyllum nodosum* germlings from Norway, to temperatures between 7°C -17°C found that there was no difference in survival rates within the given range (Steen & Rueness, 2004). Germination of *Ascophyllum nodosum* has been recorded between the temperatures of 4°C - 23°C.

Other species found within this biotope are moderately tolerant of temperature changes at the benchmark level. Those species which are mobile, such as *Carcinus maenas* have the opportunity to move away from areas if physical conditions become too harsh.

Sensitivity assessment. The characterizing species *Ascophyllum nodosum* and *Fucus vesiculosus* are found in the middle of their habitat range in the British Isles. Although the range of these species can extend up to the White Sea, if the temperature changes are acute and occur over a short period leaving no time for acclimation then there could be some damage caused to the microalgae's. However, if the changes are more gradual then the algae may have time to acclimate which would not produce any significant negative impact. The sensitivity assessment for this scenario gives both resistance and resilience a score of 'Medium'. Meaning that the biotope has a 'Medium' sensitivity to this pressure at the benchmark.

Salinity increase (local)	None Q: High A: High C: Medium	Medium Q: High A: Medium C: Medium	Medium Q: High A: Medium C: Medium

Variation in salinity within saline lagoons is a characteristic of the habitat that they create. In larger lagoons is it also possible to get different salinities within different areas of the lagoon itself. Therefore, all species found within saline lagoon communities must be able to tolerate salinity fluctuations. All lagoons are affected by short, medium and long-term changes in salinity (Bamber *et al.*, 2001). Semi-diurnal tides cause differences in salinity over short periods, response to changes in rainfall can cause the medium term changes and seasonal rainfall and drought can cause longer term salinity trends (Bamber *et al.*, 2001). Intertidal macroalgae, such as those found within this biotope, often experience large but short-term changes in salinities (Lobban & Harrison, 1997). However, intertidal macroalgae tolerances to longer term changes in salinities can be minimal and can quickly reduce photosynthetic abilities and cause mortality. This biotope is only found in variable salinity conditions (18 – 40 psu) (Connor *et al.*, 2004), an increase in the salinity would create fully marine conditions (30 – 40 psu).

Investigations into the salinity tolerances of both *Ascophyllum nodosum* and *Fucus vesiculosus* in laboratory controlled conditions found that the photosynthetic capabilities of both species decreased with reduced salinities. *Ascophyllum nodosum* tolerated seven days at salinities of five, and all samples died after 15 days at salinities of 5 (Connan & Stengel, 2011).

Fucus vesiculosus is well adapted to cope with varying salinities and can grow in full saline to brackish conditions. Indeed *Fucus vesiculosus* is the dominant large perennial seaweed in the Baltic Sea growing in salinities down to 4 psu (Kautsky, 1992). Bäck *et al.* (1991) compared *Fucus vesiculosus* individuals from Atlantic and the Baltic populations. Both populations were able to withstand wide range of salinities in laboratory cultures, yet some differences were recorded. The Atlantic population showed better growth in higher salinities and virtually no growth at 5 ppt. Those individuals kept at 5 ppt mortality occurred after seven weeks. In contrast the Baltic wracks grew better in conditions with lower salinities. Growth was negligible at the highest tested salinity (45 ppt). Back *et al.* (1991) demonstrate that sensitivity of *Fucus vesiculosus* to changes in salinity differ between populations.

Serrao *et al.* (1996a) found that lower salinities can negatively affect both the fertilization rates and recruitment success of *Fucus vesiculosus*. Serrao *et al.* (1996a) also concluded that the osmotic tolerances of *Fucus vesiculosus* gametes limit the species distribution in the Baltic Sea. These studies show that low salinities limit the recruitment and fertilization success of fucoids. There is also evidence suggesting that reduced salinities can influence the rate of receptacle maturation in fucoids (Munda, 1964). Rate of fructification in both *Ascophylum nodosum* and *Fucus vesiculosus* has been measured to increase in diluted seawater (Munda, 1964).

Baardseth (1970) noted that *Ascophyllum nodosum* is euryhaline with a salinity tolerance of about 15 to 37 psu. Studies undertaken by Chock & Mathieson (1979) found *Ascophyllum nodosum* plants in the laboratory photosynthesised at salinities from 0 to 40 psu although the long-term effects within this range were not evaluated. No information could be found on the effects of an increase in salinity on the reproductive cycle of *Ascophyllum nodosum.*

A number of the other species within the biotope can also be found within rockpools where hyper saline conditions can be found (Newell, 1979). Consequently an increase in salinity within the benchmark of this pressure would not cause any significant mortalities.

Sensitivity assessment. An increase in salinity for this biotope would mean salinity levels would become fully marine. All species within this biotope are tolerant to fully marine conditions and mortality events would not occur. However, the biotope would be lost as the occurrence of fully marine conditions would encourage further species and create a different fully marine biotope. The resistance of this biotope is given as ‘Low’; the resilience is ‘Medium’ as although the biotope is likely to have changed the characterizing species are likely to be very similar. This would allow relatively quick recovery from this pressure. The sensitivity of this biotope to the pressure at this benchmark is ‘Medium’.

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

Variation in salinity within saline lagoons is a characteristic of the habitat that they create. In larger lagoons is it also possible to get different salinities within different areas of the lagoon itself. Therefore, all species found within saline lagoon communities must be able to tolerate salinity fluctuations. All lagoons are affected by short, medium and long-term changes in salinity (Bamber *et al.*, 2001). Semi-diurnal tides cause differences in salinity over short periods, response to changes in rainfall can cause the medium term changes and seasonal rainfall and drought can cause longer term salinity trends (Bamber *et al.*, 2001). Intertidal macroalgae, such as those found within this biotope, often experience large but short-term changes in salinities (Lobban & Harrison, 1997). However, intertidal macroalgae tolerances to longer term changes in salinities can be minimal and can quickly reduce photosynthetic abilities and cause mortality. This biotope is only found in variable salinity conditions (18 – 40 psu) (Connor *et al.*, 2004), a decrease in salinity regime would create reduced salinity conditions (18 – 30 psu).

Intertidal macroalgaes often experience large but short-term changes in salinities Lobban & Harrison (1994). Salinities within these habitats vary due to weather conditions such as rain fall at low tide and evaporation from rock pools on hot days. Intertidal shores within estuarine environments can also experience considerable short-term changes in salinities. However, intertidal macroalgae tolerances to longer term changes in salinities are minimal and can quickly reduce photosynthetic abilities and cause mortality.

Fucus vesiculosus is well adapted to cope with varying salinities and can grow in full saline to brackish conditions. Indeed *Fucus vesiculosus* is the dominant large perennial seaweed in the Baltic Sea growing in salinities down to 4 psu (Kautsky, 1992). Bäck *et al.* (1991) compared *Fucus vesiculosus* individuals from Atlantic and the Baltic populations. Both populations were able to withstand wide range of salinities in laboratory cultures, yet some differences were recorded. The

Atlantic population showed better growth in higher salinities and virtually no growth at 5 ppt. Those individuals kept at 5 ppt mortality occurred after seven weeks. In contrast the Baltic wracks grew better in conditions with lower salinities. Growth was negligible at the highest tested salinity (45 ppt). Back *et al.* (1991) demonstrate that sensitivity of *Fucus vesiculosus* to changes in salinity differ between populations.

Serrao *et al.* (1996a) found that lower salinities can negatively affect both the fertilization rates and recruitment success of *Fucus vesiculosus*. Serrao *et al.* (1996a) also concluded that the osmotic tolerances of *Fucus vesiculosus* gametes limit the species distribution in the Baltic Sea. These studies show that low salinities limit the recruitment and fertilization success of fucoids. There is also evidence suggesting that reduced salinities can influence the rate of receptacle maturation in fucoids (Munda, 1964). Rate of fructification in both *Ascophylum nodosum* and *Fucus vesiculosus* has been measured to increase in diluted seawater (Munda, 1964).

Ascophyllum nodosum is euryhaline with a salinity tolerance of about 15 to 37 psu (Baardseth, 1970). The species can also withstand periodic emersion in freshwater (Baardseth, 1970) and frequently inhabits estuaries where salinity is variable. Doty & Newhouse (1954) reported *Ascophyllum nodosum* from estuarine waters with a maximum salinity of 17.3 psu and a minimum of 0 psu. Chock & Mathieson (1979) found *Ascophyllum nodosum* plants in the laboratory photosynthesised at salinities from 0 to 40 psu although the long-term effects within this range were not evaluated. In the Teign Estuary in South Devon, *Ascophyllum nodosum* inhabits areas subject to salinities as low as 8 psu (Laffoley & Hiscock, 1993). Investigations into the salinity tolerance of *Ascophyllum nodosum* in laboratory controlled conditions found that the photosynthetic capabilities of this species decreased with reduced salinities. *Ascophyllum nodosum* tolerated seven days at salinities of 5, and all samples died after 15 days at salinities of 5 (Connan & Stengel, 2011). There is some evidence to suggest that reduced salinities can influence the rate of receptacle maturation in fucoids (Munda, 1964). Rate of fructification in *Ascophyllum nodosum* has been measured to increase in diluted seawater (Munda, 1964).

A number of the other species within the biotope can also be found within rockpools where hyposaline conditions can be found (Newell, 1979). Consequently a decrease in salinity within the benchmark of this pressure would not cause any significant mortalities.

Sensitivity assessment. A decrease in salinity for this biotope would create a reduced salinity regime. The species within this biotope including the characterizing species would be able to withstand these reductions in salinities. However, there may be reductions in the reproductive success and growth rates. Both the resistance and resilience of this biotope is given as 'Medium'. The sensitivity of this biotope to the pressure at this benchmark is assessed as 'Medium'.

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

Water motion is a key determinant of marine macroalgal ecology, influencing physiological rates and community structure (Hurd, 2000). Higher water flow rates increase mechanical stress on macroalgae by increasing drag. Fucoids are highly flexible but not physically robust and an increase in water flow could cause mechanical damage, breaking fronds or even dislodging whole algae from the substratum. Fucoids are however, highly flexible and are able to re-orientate their position in the water column to become more streamlined. This ability allows fucoids to reduce the relative velocity between algae and the surrounding water, thereby reducing drag and lift (Denny *et al.*, 1998). Fucoids are permanently attached to the substratum and would not be able to reattach if removed. Organisms living on the fronds and holdfasts will be washed away with the algae whereas free-living community components could find new habitat in surrounding areas. Wave exposure has been shown to limit size of fucoids (Blanchette, 1997) as smaller individuals create less resistance to water movement, it is likely that water flow exerts a very similar pressure on fucoids.

The presence of this biotope within conditions with minimal tidal flow suggests that there is unlikely to be a negative impact of a decrease in the mean spring bed flow velocity of 0.2 m/s in flow rate. Yet some water flow is required to supply vital nutrients and gases and to remove waste products. If the reduction meant that water flow stopped all together then the biotope may suffer negative impacts, due to stagnant conditions.

An increase in this pressure at the bench mark rate within a biotope which is already found at the top of the tolerance for water flows may be negatively affected. The highest water flow that would be created within this biotope taking into consideration the level of the benchmark is 0.7 m/s. This flow rate is not high enough to remove the two characterizing species.

Fucus vesiculosus individuals of 10 cm or larger have been recorded to be completely removed at 7-8 m/s (Jonsson *et al.*, 2006). A much greater flow rate than what is experienced at the extreme end of this benchmark within this biotope. Flow rates at which adult *Ascophyllum nodosum* are removed are not known. However, Thomson & Wernberg (2005) provide strong evidence that with an increase in thallus size there is an increase in the break force required to remove algae. Consequently the force required to remove *Ascophyllum nodosum* from a shore is likely to be comparable to that of *Fucus vesiculosus.* In addition, *Ascophyllum nodosum* biotopes which are found in areas with tidal streams in excess of 6 knots, compared to the 3 knot maximum found within this biotope. This evidence suggests that the characterizing macroalgae populations are unlikely to be torn from the substratum at the level of this bench mark. The risk of dislodgement would only be greater where algae are attached to pebbles instead of bedrock. Indeed if sediment type is small and the substratum is less stable, individuals may eventually reach a critical size when the drag force exceeds gravity and the plant will be moved together with its substratum (Malm, 1999). This risk is increased during the late phase of reproduction for *Fucus vesiculosus* when its receptacles become swollen and gas-filled increasing the uplifting force of water flow (Isaeus, 2004).

Propagule dispersal, fertilization, settlement, and recruitment are also influenced by water movement (Pearson & Brawley, 1996). An increase, in water flow could have negative impacts on the reproductive success of *Ascophyllum nodosum.* Experiments on the effect of wave action on *Ascophyllum nodosum* showed that a low-velocity wave can remove 99% of 15 minute old zygotes from experimental tiles Vadas *et al.* (1990). Further investigation with the use of refuges found that 75-90% of zygotes as old as four hours could be removed by a single wave. Current speeds of over 20cm/s makes attachment success of *Ascophyllum nodosum* very poor (Vadas *et al.*, 1992). These studies show the need for periods of calm conditions for successful recruitment for *Ascophyllum nodosum.* An increase in the mean water flow will reduce the time during which attachment is possible. In addition, greater water flow can increase scour through increased sediment movement. Small life stages of macroalgae are likely to be affected by removing new recruits from the substratum and hence reducing successful recruitment (Devinny & Volse, 1978) (see ‘siltation’ pressures). Changes in water motion can thus strongly influence local distribution patterns of *Fucus* spp. (Ladah *et al.*, 2008).

On the other hand, a reduction in water flow can cause a thicker boundary layer resulting in lower absorption of nutrients and CO_2 by the macroalgae. Slower water movement can also cause oxygen deficiency directly impacting the fitness of algae (Olsenz, 2011).

Sensitivity assessment. The water flow within this biotope is weak to very weak (Connor *et al*., 2004). A change in the water flow at the pressure benchmark is unlikely to cause the loss of the lagoon biotope. However, an increase in this pressure above the given benchmark has the possibility of removing the lagoon completely. A decrease in water flow could reduce the removal of waste products and the return of nutrients and gases. For this reason biotopes which experience the lowest levels of water flow naturally may be more affected than those found in areas with more water movement. However, this is unlikely to cause any mass mortality, more a decrease in the health of the biotope. An increase in the level of water flow would be more likely to affect the reproductive and recruitment success of the species. Again this would not cause a mass mortality, but more a decrease in the health of the biotope. The resistance and resilience have been assessed as 'High', so the biotope is assessed as 'Not Sensitive'.

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

Fucus vesiculosus can tolerate desiccation until the water content is reduced to ~ 30%. If desiccation occurs beyond this level, irreversible damage occurs. Individuals at the top of the shore probably live at the upper limit of their physiological tolerance and therefore, are likely to be unable to tolerate increased desiccation and would be displaced by more physiologically tolerant species. Tolerance to this pressure is likely to vary on a geographical scale. Gylle *et al*. (2009) found that *Fucus vesiculosus* populations that occur naturally in fully saline conditions had a higher emersion stress tolerance compared to brackish populations.

Early life history stages are more susceptible to this pressure compared to adults (Henry & Van Alstyne, 2004). Germlings are, however, protected from desiccation by the canopy of adults. A study by Brawley & Jonhnson (1991) showed that germling survival under adult canopy was close to 100% whereas survival on adjacent bare rock was close to 0% during exposure to aerial conditions. The *Fucus* canopy is also likely to protect other underlying species to a great extent. Mortalities of other components of the community will however, occur if the canopy is removed (see 'abrasion' pressure).

In the British Isles, populations of *Ascophyllum nodosum* can suffer from bleaching and consequent mortality during exceptionally hot weather (Schonbeck & Norton, 1978, Hawkins & Hartnoll, 1985, Norton, 1985). However, these mortality events do not occur every year and tend to occur when the effects of unusually hot conditions combine with periods of rapid change, which do not allow for macroalgaes to acclimate (Raffielli & Hawkins, 1996).

Stengel & Dring (1997) reported that growth rates in *Ascophyllum nodosum* decreased with height on the shore, correlating with an increase in environmental severity. *Ascophyllum nodosum* productivity is affected by desiccation when water loss exceeds 50% (Brinkhuis *et al*., 1976). Higher temperatures can increase the rate of desiccation and consequently lead to a loss of productivity, and eventually mortality (Keser *et al*., 1981).

When Stengel & Dring (1997) transplanted *Ascophyllum nodosum* from the lower shore to the upper shore, 80% of the transplants died within 3 months. In contrast, 100% of the individuals from the upper shore transplanted to the lower shore survived, as did all of the controls. The plants which survived transplantation to the upper shore acclimated to the conditions on the upper shore, yet their survival was determined by thallus morphology a predetermined genetic attribute which may be fixed (Stengel & Dring, 1997). Choi & Norton (2005) also carried out transplantation experiments and found that the growth rates of *Ascophyllum nodousm* decreased dramatically from the lower shore to the upper shore.

The southern and northern range limits of a number of intertidal macroalgae fall within Portugal. Lima *et al.* (2007) mapped the re-adjustment of 129 macroalgal ranges in relation to the change in air and sea temperatures observed within the North Eastern Atlantic over the past 50 years. Significant differences in distributions of algae were found, yet there were disparity in the level of change found in the ranges of those of warm and cold adapted species. The species that were at the northern limit of their range in Portugal showed a greater change in distribution than the cold adapted species. Roughly half of the cold adapted species, including *Ascophyllum nodosum*, showed no significant change in their distribution. Lima *et al.* (2007) suggested that the cold adapted species had greater tolerance to adverse conditions for longer periods of time than the warm adapted species.

Information regarding the effect of changes in the level of exposure on *Ascophyllum nodosum* germlings is not available. Germlings will be protected from desiccation stresses to a certain extent because of the protection provided to them by the fucoid canopy. Increases in temperature will be one of the effects changes in exposure will have on germlings. For further information refer to temperature pressure. Dense aggregations of algae can reduce the effect of more severe physical conditions such as those experienced with greater levels of exposure. Clumping enables organisms to retain moisture and reduce heat stress (Scrosati & DeWreede, 1998, Stafford & Davies, 2005).

Sensitivity assessment. Desiccation and the associated osmotic stress, especially when combined with high temperatures can cause mortalities (Pearson *et al*., 2009). The sensitivity of the characterizing species to emersion pressure will depend on the health and demography of individual populations, with germlings being most vulnerable life stage to this pressure.

Both *Fucus vesiculosus* and *Ascophyllum nodosum* have a level of resistance to an increase in emersion. However, at the level of the benchmark there is likely to be a change in biotope, with the upper extreme of the biotope being most sensitive to change as it is already at the upper tolerance limits. The change in this pressure at the benchmark is likely to see a downwards shift of the biotope. *Fucus vesiculosus* can repopulate an area faster than *Ascophyllum nodosum. Ascophyllum nodosum* can take as many as twelve years to recover, with return of ecosystem functioning taking considerably longer. If emergence does not remove the entire biotope from the shore, and only removes the top part of the biotope then recruitment will occur from the surviving individuals. This will allow the area to be repopulated after the year at reduced emergence. Resistance of this biotope to pressure at the stated benchmark has been assessed as 'Low' and resilience is assessed as 'Medium'. Overall the biotope has a 'Medium' sensitivity to changes in emergence regime at the pressure benchmark. In regards to the lagoon habitat within which this biotope occurs; if a change in the water level occurs within the lagoon it could affect the inflow regime. A decrease in emergence may cut the lagoon off from the sea for longer, and an increase may cause overtopping of the sea barrier. Due to the range of lagoon sizes, the different ways in which saltwater ingresses into them, and the height of the sill, each lagoon must be considered case by case.

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

All of the characterizing species within this biotope are found in other biotopes that are more wave exposed than a lagoon (Connor *et al.*, 2004). If there were to be a change in wave exposure in the biotope then none of the characterizing species would be affected.

Sensitivity assessment. This biotope is only found in extremely wave sheltered conditions. An increase in the wave height at the benchmark is very unlikely to have a negative impact on the sea barrier in the lagoon through greater erosion. This could lead to the collapse of a lagoon wall and completely change the physical environment of the biotope, and lead to the loss of the lagoon biotope altogether. A decrease in water flow could reduce the removal of waste products and the return of nutrients and gases. For this reason biotopes which experience low levels of water flow naturally may be more affected than those found in areas with more water movement. However, this is unlikely to cause any mass mortality, more a decrease in the health of the biotope. An increase in the level of water flow would be more likely to affect the reproductive and recruitment success of the species. Again this would not cause a mass mortality, but more a decrease in the health of the biotope. The resistance and resilience have been assessed as 'High'. This gives the biotope an overall sensitivity of '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.

Hydrocarbon & PAH contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

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

Synthetic compound contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

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

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

No evidence.

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

This pressure is **Not assessed**.

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

Reduced oxygen concentrations have been shown to inhibit both photosynthesis and respiration in macroalgae (Kinne, 1977). Despite this, macroalgae are thought to buffer the environmental conditions of low oxygen, thereby acting as a refuge for organisms in oxygen depleted regions especially if the oxygen depletion is short-term (Frieder *et al*., 2012). Reduced oxygen levels are likely to inhibit respiration whilst immersed, but it is unlikely to cause a loss of the macroalgae population directly. This biotope is found in an intertidal position and consequently a proportion of time will be spent in air where oxygen is not limited. As long as certain physical conditions are not exceeded, respiration and photosynthesis will be able to continue.

Although the macroalgae species within this biotope may not be negatively affected some of the associated fauna may be lost, causing a reduction in species richness. Josefson & Widbom (1988) investigated the response of benthic macro and meiofauna to reduced dissolved oxygen levels in the bottom waters of a fjord. At dissolved oxygen concentrations of 0.21 mg/l, the macrofaunal community was eradicated and was not fully re-established 18 months after the hypoxic event. However, meiofauna seemed unaffected by de-oxygenation. Mobile species will be able to relocate to more optimal conditions, whereas immobile species such as barnacles are likely to be put under more stress by de-oxygenation.

The extremely wave sheltered conditions and the weak to very weak water flows which are characteristic of this biotope mean that water mixing is not very strong. Water retention rates within lagoons are also known to be high, with very low flushing times. Therefore, water movement within this area will not reverse any oxygen depletion quickly, possibly exacerbating any negative effects.

Sensitivity assessment. The characterizing species *Fucus ceranoides* and *Ulva* sp. would not be negatively affected by a decrease in oxygen within the water column for at the benchmark level of this pressure. However, some of the associated faunal community within this biotope may be negatively affected. Mobile species may relocate to less physiologically taxing conditions, and would be able to return when the pressure abated. A reduction in oxygen levels at the benchmark for this pressure would not result in mortalities. Resistance is assessed as 'High' as is the resilience, giving the biotope a sensitivity score of 'Not sensitive'.

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

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

Johnston & Roberts (2009) undertook a review and meta-analysis of the effect of contaminants on species richness and evenness in the marine environment. Of the 47 papers reviewed relating to nutrients as a contaminants, over 75% found that it had a negative impact on species diversity, <5% found increased diversity, and the remaining papers finding no detectable effect. Of the 47 papers none considered the impact of nutrients on lagoons. Yet this finding is still relevant to this biotope as the meta analysis revealed that the effect of marine pollutants on species diversity were ‘remarkably consistent’ between habitats (Johnston & Roberts, 2009). It was found that any single pollutant reduced species richness by 30-50% within any of the marine habitats considered (Johnston & Roberts, 2009). Throughout their investigation there were only a few examples where species richness was increased due to the anthropogenic introduction of a contaminant. These examples were almost entirely from the introduction of nutrients, either from aquaculture or sewage outfalls. However, research into the impacts of nutrient enrichment from these sources on intertidal rocky shores often lead to shores lacking species diversity and the domination by algae with fast growth rates (Littler & Murray, 1975; Abou-Aisha *et al*., 1995; Archambault *et al*., 2001; Diez *et al*., 2003; Arévalo *et al*., 2007). The lagoon habitat within which this biotope is found is not studied within this paper. However, the characterizing species are most commonly found on intertidal rocky shores and therefore, this statement has been considered to be relevant to this assessment.

Major declines of *Fucus vesiculosus* have been reported from all over the Baltic Sea. These declines have been associated to eutrophication from nutrient enrichment (Kautsky *et al*., 1986). Nutrient enrichment alters the selective environment by favouring fast growing, ephemeral species such as *Ulva lactuca* and *Ulva intestinalis* (Berger *et al*., 2004, Kraufvelin, 2007). Rohde *et al*. (2008) found that both free growing filamentous algae and epiphytic microalgae can increase in abundance with nutrient enrichment. This stimulation of annual ephemerals may accentuate the competition for light and space and hinder perennial species development or harm their recruitment (Berger *et al*., 2003; Kraufvelin *et al*., 2007). Nutrient enrichment can also enhance fouling of *Fucus* fronds by biofilms (Olsenz, 2011). Nutrient enriched environments can not only increase algae abundance, but the abundance of grazing species (Kraufvelin, 2007). High nutrient levels may directly inhibit spore settlement and hinder the initial development of *Fucus vesiculosus* (Bergström *et al*., 2003).

White *et al*. (2011) investigated the effects of nutrient effluent from land based finfish farms on the morphologies of *Ascophyllum nodosum* in the vicinity of the outfall pipes. It was estimated that the nitrogen effluent from the farm was 1500kg / y. The background levels of nitrite at the test site were 300 µM, in comparison the ambient nitrite levels in southwest Nova Scotia were 3 µM (White *et al*., 2011). *Ascphyllum nodosum* at the test sites were found to be younger than those at the control sites, but significantly larger. This experiment suggested that nutrient effluent could have positive impacts on *Ascophyllum nodosum.* Yet it must be noted that the effect of the effluent on the rest of the biological community was not studied.

Changes in community composition on intertidal rocky shores can happen rapidly, and fast growing ephemeral species can become established quickly in the presence of higher concentrations of nutrients. The establishment and growth of these species are not controlled by wave exposure (Kraufvelin, 2007). However, even though these fast growing ephemeral species can become well established quickly, healthy communities on intertidal rocky shores can survive long periods of time, and maintain ecological function after these species have become established (Bokn *et al*., 2002; 2003, Karez *et al*.,2004, Kraufvelin *et al*., 2006; Kraufvelin, 2007).

Sensitivity assessment. A slight increase in nutrients may enhance growth rates but high nutrient concentrations could lead to the overgrowth of the algae by ephemeral green algae and an increase in the number of grazers. If the biotope is well established and in a healthy state the biotope could persist. The extremely wave sheltered conditions and the weak to very weak water flows which are characteristic of this biotope mean that water mixing is not very strong. Lagoons are also known to have high levels of water retention rates which could exacerbate the negative impacts of this pressure. However, the biotope is ‘Not Sensitive’ at the pressure benchmark assuming compliance with good status as defined by the WFD.

Organic enrichment	Medium Q: Medium A: Medium C: Medium	Medium Q: Medium A: Medium C: Medium	Medium Q: Medium A: Medium C: Medium

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

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

Major declines of *Fucus vesiculosus* have been reported from all over the Baltic Sea. These declines have been associated to eutrophication from nutrient enrichment (Kautsky *et al*., 1986). Nutrient enrichment alters the selective environment by favouring fast growing, ephemeral species such as *Ulva lactuca* and *Ulva intestinalis* (Berger *et al*., 2004, Kraufvelin, 2007). Rohde *et al*. (2008) found that both free growing filamentous algae and epiphytic microalgae can increase in abundance with nutrient enrichment. This stimulation of annual ephemerals may accentuate the competition for light and space and hinder perennial species development or harm their recruitment (Berger et al., 2003; Kraufvelin *et al*., 2007). Nutrient enrichment can also enhance fouling of fucoid fronds by biofilms (Olsenz, 2011). Nutrient enriched environments can not only increase algae abundance, but the abundance of grazing species (Kraufvelin, 2007). High nutrient levels may directly inhibit spore settlement and hinder the initial development of *Fucus vesiculosus* (Bergström *et al*., 2003). Bellgrove *et al*. (2010) found that coralline turfs out-competed fucoids at a site associated with organic enrichment caused by an ocean sewage outfall.

Changes in community composition on intertidal rocky shores can happen rapidly, and fast growing ephemeral species can become established quickly in the presence of higher concentrations of nutrients. The establishment and growth of these species are not controlled by wave exposure (Kraufvelin, 2007). However, even though these fast growing ephemeral species can become well established quickly, healthy communities on intertidal rocky shores can survive long periods of time, and maintain ecological function after these species have become established (Bokn *et al*., 2002; 2003; Karez *et al*.,2004; Kraufvelin *et al*., 2006b; Kraufvelin, 2007).

Sensitivity assessment. Little empirical evidence was found to support an assessment of this biotope at this benchmark. Due to the negative impacts that can be experienced with the introduction of excess organic carbon both resistance and resilience have been assessed as 'Medium'. This gives an overall sensitivity score of 'Medium'.

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 '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 is characterized by a lagoon formed from bedrock, boulders and cobbles. Removal of this substratum would remove the attachment surface for the macroalgae that characterize this biotope, significantly altering the character of the biotope. Artificial hard substratum may also differ in character from natural hard substratum, so that replacement of natural surfaces with artificial may lead to changes in the biotope through changes in species composition, richness and diversity (Green *et al*., 2012; Firth *et al*., 2014) or the presence of non-native species (Bulleri & Airoldi, 2005).

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

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

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

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

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

No studies of the effects of trampling or netting on lagoons were found but studies of the effects on emergent algal communities are probably indicative. Trampling on the rocky shore has been observed to reduce fucoid cover which decreased the microhabitat available for epiphytic species, increased bare space and increased cover of opportunistic species such as *Ulva* (Fletcher & Frid, 1996a). The location of this biotope within a saline lagoon means that the area is easily accessible by humans especially at low tide. Individual microalgae’s are flexible but not physically robust. Fucoids are intolerant of abrasion from human trampling, which has been shown to reduce the cover of seaweeds on a shore (Holt *et al.*, 1997).

Brosnan (1993) investigated the effect of trampling on a number of algal species, including *Fucus vesiculosus*, on an intertidal rocky shore in Oregon. The effects of 250 tramples per plot, once a month for a year were recorded. Abundances of algae in each plot were reduced from 80% to 35% within a month of the introduction of the pressure and remained low for the remainder of the experiment.

As few as 20 steps / m^2 on stations on an intertidal rocky shore in the north-east of England were sufficient to reduce the abundance of fucoids (Fletcher & Frid, 1996a). This reduction in the complexity of the algae community, in turn, reduced the microhabitat available for epiphytic species. Trampling pressure can thus result in an increase in the area of bare rock on the shore (Hill *et al.*, 1998). Chronic trampling can affect community structure with shores becoming dominated by algal turf or crusts (Tyler-Walters, 2005). Pinn & Rodgers (2005) compared the biological communities found on two intertidal rocky shore ledges in Dorset. They found that the ledge which had a higher number of visitors had few branching algal species, including fucoids, but had greater abundances of crustose and ephemeral species (Pinn & Rodgers, 2005). The densities of fucoids were recorded from the intertidal rocky shore at Wembury, Devon in 1930 (Colman, 1933) and 1973 (Boalch *et al.*, 1974). Boalch *et al.* (1974) found a reduction in fucoids on the shore at Wembury compared to Coleman's 1932 findings, and that the average frond length of *Ascophyllum nodosum and Fucus vesiculosus* was smaller.

Fucus vesiculosus is able to generate vegetative regrowth in response to wounding from physical disturbance. McCook & Chapman (1992) experimentally tested the recovery of damaged *Fucus vesiculosus*. The study found that vegetative sprouting of *Fucus vesiculosus* holdfasts made a significant addition to the regrowth of the canopy, even when holdfasts were cut to less than 2 mm tissue thickness. Four months after cutting, sprouts ranged from microscopic buds to shoots about 10 cm long with mature shoots widespread after 12 months. Vegetative regrowth in response to wounding has been suggested as an important mean of recovery from population losses (McLachan & Chen, 1972).

Ascophyllum nodosum seems to be particularly intolerant of damage from trampling (Flavell, unpublished; cited in Holt *et al.*, 1997). It is also likely to be removed if shores are mechanically cleaned following oil spills. Araujo *et al.* (2009) found that trampling negatively affected both *Ascophyllum nodosum* and *Fucus vesiculosus* abundances and reduced understorey species while promoting the colonization by ephemeral green algae. However, within a year of the disturbance event, *Fucus vesiculosus* recovered and greatly increased in cover becoming the dominant canopy forming species, replacing a pre-disturbance *Ascophyllum nodosum* community. The replacement of *Ascophyllum nodosum* with *Fucus vesiculosus* may have been due to the poor recovery rate of *Ascophyllum nodosum.* The increase in abundance suggests the competitive superiority of *Fucus vesiculosus* individuals in occupying newly available space in the disturbed patches. Similar results were found by Cervin *et al*. (2005) and Araujo *et al*. (2012) with *Fucus vesiculosus* outcompeting *Ascophyllum nodosum* after small-scale disturbances.

Rita *et al.* (2012) also undertook experiments on the effect of trampling on *Ascophyllum nodosum* and its associated communities. It was concluded that trampling caused significant damage to both the macroalgae and the understory communities, which had not recovered within five years of the initial experiment.

Sensitivity assessment. Abrasion of the substratum will cause a reduction in the abundances of both characterizing species, as well as other species found in the associated community. Therefore, the resistance is 'Low'. Experiments undertaken on the trampling effects on *Ascophyllum nodosum* have shown that for the community to return to its pre-experimental state can take in excess of 10 years, consequently, the resilience is assessed as 'Low', giving a sensitivity of 'High'.

Penetration or disturbance of the substratum subsurface	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

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

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

Light is an essential resource for all photoautotrophic organisms. A change in turbidity would affect light availability to photosynthesising organisms during immersion. This could lower both the growth rate and the biomass of photosynthetic organisms. Changes in the suspended sediment load could also change the levels of scour within the biotope. Those species which are not tolerant to an increase in scour would consequently decrease in abundance. Alternatively, if there was a decrease in the level of scour, competition may increase for the scour tolerant species as new species settle within the biotope. Due to the weak to very weak water flows and extremely wave sheltered position of this biotope, scour is not considered to have an important effect.

The distribution of both *Ascophyllum nodosum* and *Fucus vesiculosus* occur along a depth gradient which strongly correlates with light penetration. In areas with low sedimentation *Fucus vesiculosus* can survive down to 9-10 m depth (Eriksson & Bergstrom, 2005). Changes in suspended solids affecting water clarity will have a direct impact on the photosynthesising capabilities of *Fucus vesiculosus.* Irradiance below light compensation point of photosynthetic species can compromise carbon accumulation (Middelboe *et al*., 2006). Kõuts *et al.* (2006) found decreases in light intensity in the vicinity of the dredging site resulted in the net decline of *Fucus vesiculosus* biomass. A decrease in light penetration in the Kiel Fjord caused by an increase in phytoplankton density and shading from filamentous algae has caused an upwards shift of the lower depth limit of *Fucus vesiculosus* (Rohde *et al*., 2008).

Sensitivity assessment. This biotope is found in the subtidal shore and is permanently immersed. An increase in suspended sediment may cause the biotope to be lost at its lowest extent due to a decrease in light levels. The levels of water movement within this biotope, through water flow and wave exposure, are very unlikely to cause any significant damage through scour. Consequently, the resistance and resilience of this biotope have been assessed as 'Medium'. The sensitivity of this biotope to this pressure at the benchmark is 'Medium'.

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

A discrete event where 5 cm of sediment is deposited into the lagoon will partially cover the stipe and holdfast of the characterizing species. Leaving the fronds sediment free, and able to continue photosynthesis. The low water flow and wave sheltered position on this biotope will mean that the sediment will not be removed from the shore quickly.

However, germlings are likely to be smothered and killed in both scenarios and are inherently most susceptible to this pressure. Indeed early life stages are smaller in size than adults and are thus most vulnerable to this pressure as even a small load of added sediment will lead to the complete burial. Sediment deposition can reduce macroalgal recruitment by (1) reducing the amount of substratum available for attachment of propagules; (2) scour, removing attached juveniles and (3) burial, altering the light and/or the chemical microenvironment (Devinny & Volse, 1978, Eriksson & Johansson, 2003). Berger *et al.* (2003) demonstrated that both interference with sediment during settlement, and burial after attachment, were significant causes of mortality for *Fucus vesiculosus* germlings. Eriksson & Johansson (2003) found that sedimentation had a significant negative effect on the recruitment success of *Fucus vesiculosus.* Even fine sediment fractions can reduce the successful attachment of fucoids by as much as 90% (Schiel & Foster, 2006).

Ascophyllum nodosum is intolerant of sediments as shown by the shore comparisons undertaken by Daly & Mathieson (1977). Daly & Mathieson (1977) compared two rocky shores which were similar except for the level of sediment movement experienced on the shore. The shore with more sediment movement was devoid of *Ascophyllum nodosum.* In contrast, *Fucus vesiculosus* could be found on both shores. It was suggested that the ability of *Fucus vesiculosus* to be found on the shore affected by sedimentation was due to its ability to regenerate from its holdfast.

Another consideration for this biotope is the effect that sedimentation may have on the physical aspect of the lagoon. If saline lagoons become silted up then the basin can be raised above percolation input, causing the lagoon to become a freshwater lake (Bamber *et al.*, 2001). Each lagoon will respond differently to 5 cm of sediment inundation and there is no evidence to suggest how different lagoons might respond.

Sensitivity assessment. *Fucus vesiculosus* adults are relatively tolerant to sediment inundation and can regenerate from their holdfasts. *Ascophyllum nodosum* adults are sediment intolerant, and germlings of both species are intolerant of even small levels of sediment. Many of the smaller species found within the associated community will be totally smothered by 5 cm. This biotope is found in extremely wave sheltered conditions. Therefore, sediment is likely to be retained for long periods of time, allowing greater negative effects to occur. Resistance has been assessed as 'Low' and resilience is assessed as 'Medium'. Overall the biotope probably has a 'Medium' sensitivity to smothering at the level of the benchmark.

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

Several studies found that increasing the vertical sediment burden negatively impact fucoids survival and associated communities. At the level of the benchmark (30 cm of fine material added to the seabed in a single event) smothering is likely to result in mortalities of understorey algae, invertebrate grazers and young (germling) fucoids. Resistance is assessed as ‘Low’ as all individuals exposed to siltation at the benchmark level are predicted to die. Once conditions return to normal, recovery is going to be slow due to the length of time it takes for *Ascophyllum nodosum* to recover. This results in a ‘Very Low’ resilience. Overall the biotope has a ‘High’ sensitivity to siltation at the pressure benchmark.

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	Not relevant (NR) 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

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

Introduction of light or shading	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

Increased levels of diffuse irradiation correlate with increased growth in macroalgae (Aguilera *et al*., 1999). As *Fucus vesiculosus* and *Ascophyllum nodosum* are found in the middle their natural range in the British Isles an increase in the level of diffuse irradiation will not cause a negative impact on the species or the biotope. 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.

Barrier to species movement	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

This pressure is considered applicable to mobile species, e.g. fish and marine mammals rather than seabed habitats. Physical and hydrographic barriers may limit propagule dispersal. But propagule dispersal is not considered under the pressure definition and benchmark. Therefore, this pressure is considered ‘Not Relevant’ for this biotope.

Death or injury by collision	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant to seabed habitats. NB. Collision by grounding vessels is addressed under ‘surface abrasion’.

Visual disturbance	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant.

Biological Pressures

	Resistance	Resilience	Sensitivity
Genetic modification & translocation of indigenous species	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

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

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

Thompson & Schiel (2012) found that native fucoids show high resistance to invasions by the Japanese kelp *Undaria pinnatifida*. However, cover of *Fucus vesiculosus* was inversely correlated with the cover of the invasive *Sargassum muticum* indicating competitive interaction between the two species (Stæhr *et al*., 2000). Stæhr *et al*. (2000) determined that the invasion of *Sargassum muticum* could affect local algal communities through competition mainly for light and space.

Gracilaria vermiculophylla is suggested to be one of the most successful marine non-native species (Kim *et al*., 2010, Sfriso *et al*., 2010 taken from Thomsen *et al*., 2013). This species invades wave sheltered, shallow water areas, and have been found in biotopes naturally dominated by fucoid canopies (Weinberger *et al*., 2008). Hammann *et al*. (2013) found that in the Baltic Sea *Gracilaria vermiculophylla* could impact *Fucus vesiculosus* through direct competition for resourses, decreasing the half-life of germlings, and increasing the level of grazing pressure. To date *Gracilaria vermiculophylla* has only been recorded in Northern Ireland. The introduction of this species to infralittoral shores around the British Isles could have negative impacts on native fucoid biotopes, and could become relevant to this specific biotope.

Sensitivity assessment. Fucoid species have been negatively affected by both the direct and indirect consequences of INNS being present. However, no evidence can be found on the impacts of INNS on *Fucus vesiculosus* and *Fucus serratus* within this biotope. For this reason the effect of this pressure has been given as ‘No Evidence’. Literature for this pressure should be revisited.

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

No evidence.

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

Seaweeds have been collected from the middle of the 16th century for the iodine industry. Modern day industrial uses for seaweed are extensive and include fertilizer, animal feed, alginate extracts (Phillipi *et al.*, 2014), water treatment, and human food and health supplements (Bixler & Porse, 2010). *The characteristic fucoid algae within this biotope are commercially collected*. These commercial harvests remove seaweed canopies which have important effects on the wider ecosystem.

Stagnol *et al.* (2013) investigated the effects of commercial harvesting of intertidal fucoids on ecosystem biodiversity and functioning. The study found that the removal of the macroalgae canopy affected the metabolic flux of the area. Flows from primary production and community respiration were lower on the impacted area as the removal of the canopy caused changes in temperature and humidity conditions (Stagnol *et al.*, 2013). Bertness *et al.* (1999) found that the presence of an *Ascophyllum nodosum* canopy reduced maximum daily rock temperatures by 5-10 °C. It was also reported that water loss via evaporation was an order of magnitude less than in areas where the fucoid canopy had been removed (Bertness *et al.*, 1999).

Stagnol *et al.* (2013) found that suspension feeders were the most affected by the canopy removal as canopy-forming algae are crucial habitats for these species. Other studies confirm that loss of canopy had both short and long-term consequences for benthic community diversity resulting in shifts in community composition and a loss of ecosystem functioning such as primary productivity (Lilley & Schiel, 2006; Gollety *et al.*, 2008).

Studies on the effects of commercial harvesting on the faunal communities associated with *Ascophyllum nodosum* have found that removing this key species can reduce abundances of epifauna found on the un-harvested biomass (Jarvis & Seed, 1996, Johnson & Scheibling, 1987; taken from Phillipi *et al.*, 2014). Changes in *Ascophyllum nodosum* abundance have also been found to affect the large, mobile fauna such as crabs or grazing gastropods (Bertness *et al.*, 1999; Fegley, 2001; Jenkins *et al.*, 1999, 2004, Phillipi *et al.*, 2014).

However, Phillipi *et al.* (2014) replicated commercial harvesting techniques in Maine, USA where *Ascophyllum nodosum* fronds were removed 40.6 cm from the holdfast and the lowest lateral branch must remain with the holdfast (DMR, 2009). The experiment looked specifically at the effect of canopy reduction on infaunal species living within the soft sediments within intertidal rocky shores where *Ascophyllum nodosum* was present. The experiment found that invertebrate species found living on and within sediments were not negatively affected by the harvesting activity (Phillipi *et al.*, 2014).

Sensitivity assessment. The removal of *Fucus vesiculosus* and *Ascophyllum nodosum* canopy will significantly change the community composition of the biotope. The quantity of biomass removed from the shore and the regularity of removal will all affect how quickly the biotope will be able to recover. *Fucus vesiculosus* and *Ascophyllum nodosum* have a 'Low' resistance to removal as both of them are easy to locate and have no escape strategy. Resilience is 'Low', however, recovery will only be able to start when the pressure is removed from the shore i.e. harvesting is no longer occurring. A sensitivity of 'High' is recorded.

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

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

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

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