Fucus spiralis on sheltered variable salinity upper eulittoral rock

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

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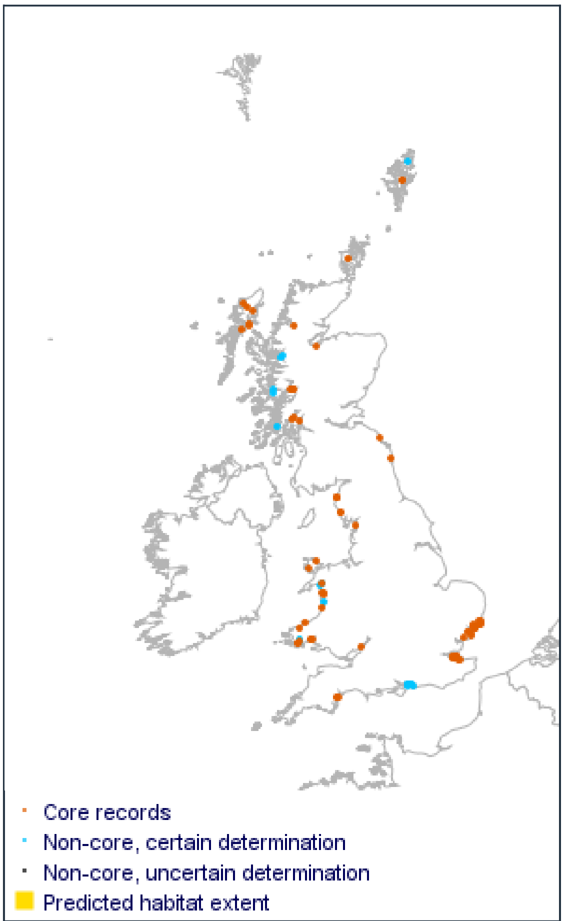

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Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Frances Perry & Emilia d'Avack **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A1.322	*Fucus spiralis* on sheltered variable salinity upper eulittoral rock
JNCC 2015	LR.LLR.FVS.FspiVS	*Fucus spiralis* on sheltered variable salinity upper eulittoral rock
JNCC 2004	LR.LLR.FVS.FspiVS	*Fucus spiralis* on sheltered variable salinity upper eulittoral rock
1997 Biotope	LR.SLR.F.Fspi	*Fucus spiralis* on moderately exposed to very sheltered upper eulittoral rock

Description

Sheltered to extremely sheltered upper eulittoral bedrock or mixed substrata (boulders, large cobbles or shells on mud) in variable salinity conditions characterized by a band of the spiral wrack *Fucus spiralis*. The ephemeral green seaweed *Ulva intestinalis* is usually found in this species poor biotope. The barnacles *Semibalanus balanoides* and *Elminius modestus* can be found where suitable substrata are available, while gammarids can be found underneath the fronds of *Fucus spiralis* and / or underneath the boulders and cobbles. Also found underneath the fronds and among the boulders are the winkles *Littorina saxatilis* and *Littorina littorea* and the crab *Carcinus maenas* (see Connor *et al.*, 2004).

Depth range

Upper shore, Mid shore, Lower shore, 0-5 m

Additional information

This biotope usually lies below a zone dominated by the wrack *Pelvetia canaliculata* (Pel) and occasional clumps of *Pelvetia canaliculata* may be present (usually less than common) amongst the *Fucus spiralis*. In areas of extreme shelter and variable salinity conditions (e.g. in Scottish sea lochs), the *Pelvetia canaliculata* and *Fucus spiralis* zones often merge together forming a very narrow band. During the summer months ephemeral green seaweeds such as *Ulva intestinalis* can be common. The Fspi.VS biotope occurs above the wracks *Ascophyllum nodosum* (Asc.VS) and/or *Fucus vesiculosus* (Fves.VS) zones and these two fucoids may also occur, although *Fucus spiralis* always dominates. It can also be found above a zone dominated by the wrack *Fucus ceranoides* (Fcer). (Information from Connor *et al.*, 2004).

Listed By

- none -

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Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

This species poor biotope is characterized by *Fucus spiralis* and can be found on bedrock, stable boulders and cobbles. *Ulva intestinalis* often contributes to the community composition, especially in the summer. *Pelvetia canaliculata* is common on the shore above this and can be found in patches within this biotope. Where the substrate is suitable *Semibalanus balanoides* and *Elminius modestus* can be found. Littorinids including *Littorina saxatilis* and *Littorina littorea* are dominant faunal grazers. *Carcinus maenas* is the main predator within this biotope, however, it will move through the shore levels with the tide and may not be common at low tide. The variable salinity regime found within this biotope requires all species present to be tolerant to salinities to consistently lower than fully marine. Within this biotope, *Fucus spiralis* acts as an ecosystem engineer. The macroalgae forms a canopy that provides protection from desiccation for underlying fauna, in addition to providing a substratum for a range of epifauna. As ecosystem engineers, fucoid algal canopies modify habitat conditions. This can facilitate the existence and survival of other intertidal species and therefore strongly influencing the structure and functioning of intertidal ecosystems (Jenkins *et al.*, 2008).

Resilience and recovery rates of habitat

Fucus spiralis is a relatively short-lived perennial algae. Maximum lifespans of up to five years (S. H. Brawley, personal observation) have been recorded, but with others observing an average lifespan of two years (Niemeck & Mathieson, 1976). Niemeck & Mathieson (1976) found that *Fucus spiralis* growth rates peak in the summer with fronds increasing in length between 1.9 – 2.8 cm/month, the average increase in length for a year was 1.2 cm/month. Variations in growth rate are found between the north-east and north-west Atlantic (Hariot, 1909; Subrahmanyan, 1961; Niemeck & Mathieson, 1976).

A ten month reproductive cycle has been recorded for *Fucus spiralis* populations in both New Hampshire and the Isle of Man (Niemeck & Mathieson, 1976, Subrahmanyan, 1961). The cycle starts in late January, when the receptacles appear, and concludes in the late summer, July or August, when the gametes are released (Niemeck & Mathieson, 1976). Both Niemeck & Mathieson (1976) and Subrahmanyan (1961) recorded that plants had to reach ~10 cm before forming receptacles, this was found to be at the end of the second year's growth.

No records of significant reductions in the cover of *Fucus spiralis* are available. Little *et al.* (1992) recorded a decline in the cover of *Fucus spiralis* in Lough Hyne between 1955 and 1990/91 but gave no indication of what may have caused the decline. Hawkins & Southward (1992) found that 2 - 5 years after the use of toxic dispersants to clean up oil from the *Torrey Canyon* oil spill Fucoids had returned in dense stands. These dense stands were even found on shores where the use of toxic dispersants was so thorough re-colonization was required to start from bare rock. Hartnoll & Hawkins (1985) and Hawkins & Hartnoll (1985) both reported that *Fucus spiralis* had the ability to recruit quickly to cleared rocky shores especially when grazers are absent. When grazers are excluded from areas of intertidal shores fucoids can be found in zones, which in a balanced ecosystem, they do not normally occur (Burrows & Lodge, 1950, Southward & Southward, 1978).

Fucoid distributions return to their recognized zones when grazers are re-established on a shore (Burrows & Lodge, 1950; Southward & Southward, 1978). Although intertidal shores can rapidly regain fucoids it can take considerably longer for ecosystem function to return if grazers have also been lost (Hawkins & Southward, 1992). If the whole community is removed, recovery is likely to occur at a much lower pace. Indeed, Hawkins & Southward (1992) found that, after the *Torrey Canyon* oil spill, it took between 10 and 15 years for the *Fucus* spp. to return to 'normal' levels of spatial and variation in cover on moderately exposed shores. Therefore, for factors which are likely to totally destroy the biotope, recoverability is likely to be low.

Intertidal rocky shores can have high levels of water flow and mixing (Hawkins & Southward, 1992). As broadcast spawners with external fertilization (Engel *et al.*, 2005) the reproductive capacity of both of these fucoids must allow for these conditions. The hermaphroditic reproductive ability of *Fucus spiralis* may not appear to be advantageous bearing in mind all fertilization is external. However, research has shown that this reproductive method does allow for high fertilization rates (Serrao *et al.*, 1996a; Berndt *et al.*, 2002). The dispersal distance of fucoid eggs is generally within c. 0.5m (Berndt *et al.*, 2002). This can be attributed to the negative buoyancy of eggs, the negative phototaxis of sperm (Brawley *et al.*, 1999), and the release of gametes during calm periods of weather when water movement is low.

Resilience assessment. *Fucus spiralis* attaches to the substratum by a holdfast and is not able to relocate in response to an increase in a pressure. Therefore, the resilience of a population to an increase in pressure which increases damage or mortality will depend on its ability to repopulate the environment. If *Fucus spiralis* remains in small quantities after a disturbance event it is likely that recovery of ecosystem function will occur within 2 – 10 years. The high fertilization rates due to *Fucus spiralis* being hermaphroditic would allow recruitment to take place within one season, as was reported by Ang & Wreede (1992) and Hartnoll & Hawkins (1985). If the impacts of a pressure were so severe that re-colonization had to begin from scratch then it could take between 10 - 15 years for the ecosystem to return to a functional state similar to that prior to the disturbance. This estimate is taken from the evidence provided by Hawkins & Southward (1992) on the recovery of shores after the *Torrey Canyon* oil spill. A resilience of ‘Medium’ has been given as it may take longer than two years for the biotope to return to a functional state equivalent to that prior to the disturbance event.

Note: 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: Medium	High Q: High A: High C: High	Not sensitive Q: High A: High C: Medium

Fucus spiralis can tolerate temperatures from -0.5 to 28°C. The species is well within its temperature range in the UK. Decreases in temperature are unlikely to have any effect because the species extends into northern Norway where water temperatures are cooler. Increase in temperature may be beneficial because the optimum temperature for growth of the species is 15°C (Lüning, 1990). However, *Fucus spiralis* was reported to suffer some damage during the unusually hot summer of 1983 when temperatures were on average 8.3°C higher than normal (Hartnoll & Hawkins, 1985).

Sensitivity assessment. *Fucus spiralis* is found in the middle of its natural temperature range in the British Isles and, therefore, is unlikely to be affected by an increase in 5°C for one month or an increase of 2°C for one year. Resistance, and consequently the resilience, are assessed as 'High' so that the biotope is assessed as 'Not Sensitive' at the pressure benchmark.

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

Fucus spiralis can tolerate temperatures from -0.5 to 28°C. The species is well within its temperature range in the UK. Decreases in temperature are unlikely to have any effect because the species extends into northern Norway where water temperatures are cooler. Increase in temperature may be beneficial because the optimum temperature for growth of the species is 15°C (Lüning, 1990). However, *Fucus spiralis* was reported to suffer some damage during the unusually hot summer of 1983 when temperatures were on average 8.3°C higher than normal (Hartnoll & Hawkins, 1985).

Sensitivity assessment. *Fucus spiralis* is found in the middle of its natural temperature range in the British Isles and, therefore, is unlikely to be affected by an increase in 5°C for one month or an increase of 2°C for one year. Resistance, and consequently the resilience, are assessed as 'High' so that the biotope is assessed as 'Not Sensitive' at the pressure benchmark.

Salinity increase (local)	Low Q: Medium A: Medium C: Medium	Medium Q: High A: High C: Medium	Medium Q: Medium A: Medium C: Medium

This biotope occurs in areas of variable salinity. It is likely that demanding environmental conditions caused by the variability in salinity and the upper eulittoral situation contribute to the low biodiversity within this biotope. An increase in salinity category may enable species able to survive in fully marine conditions to populate the shore, consequently causing a change in the biotope. The biotope LL.LLR.F.Fspi.X has very similar physical characteristics but is found in fully marine conditions so that an increase in salinity category is likely to cause a shift to this biotope.

A decrease in salinity would lead to a reduced salinity regime where salinity does not exceed 30psu. *Fucus spiralis* populations in New Hampshire have been reported to survive between 2 – 32psu (Niemeck & Mathieson, 1976). This species has also been shown to experimentally tolerate salinities of 3 to 34 psu. Both experimental testing and natural range of this species suggest that the species would not be tolerant to long-term increases in salinities. There is no evidence concerning the ability of *Fucus spiralis* gametes to tolerate increases in salinity. However, Niemeck & Mathieson (1976) noted that the initiation and maturation of receptacles in *Fucus spiralis* populations in New Hampshire occurred during periods of high freshwater runoff in the spring. This could possibly indicate that decreases in salinity could be an environmental cue for gamete release. No evidence testing this theory is available. This evidence suggests that *Fucus spiralis* may be able to survive in conditions which are do not reach fully marine salinities as it is not required for reproduction. Although this *Fucus spiralis* may survive these conditions, other species found within this biotope may not, which could lead to a further reduction in species diversity.

Sensitivity assessment. An increase in the salinity within this biotope may encourage further species diversity and a shift to another biotope where the conditions are more diverse. None of the species found within this biotope are intolerant of fully marine conditions, therefore, mortality of species is unlikely, an increase in salinity may even be beneficial for some species. However, an increase in salinity is likely to result in a shift in the biotope and resistance is assessed as 'Low', and resilience is ranked as 'Medium'. This gives the biotope an overall sensitivity assessment of 'Medium' to this pressure at the pressure benchmark.

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

This biotope occurs in areas of variable salinity. It is likely that demanding environmental conditions caused by the variability in salinity and the upper eulittoral situation contribute to the low biodiversity within this biotope.

A decrease in salinity would lead to a reduced salinity regime where salinity does not exceed 30 psu. *Fucus spiralis* populations in New Hampshire have been reported to survive between 2 – 32 psu (Niemeck & Mathieson, 1976). This species has also been shown to experimentally tolerate salinities of 3 to 34 psu. Niemeck & Mathieson (1976) noted that the initiation and maturation of receptacles in *Fucus spiralis* populations in New Hampshire occurred during periods of high freshwater runoff in the spring. This could possibly indicate that decreases in salinity could be an environmental cue for gamete release. No evidence testing this theory was available. This evidence suggests that *Fucus spiralis* may be able to survive in conditions which are do not reach fully marine salinities as it is not required for reproduction. Although *Fucus spiralis* may survive these conditions, other species found within this biotope may not, which could lead to a further reduction in species diversity.

Sensitivity assessment. A decrease in the salinity category within this biotope may not have a negative impact on *Fucus spiralis* as field observations have recorded this species surviving in salinities ranging down to 2 psu. Although, the length of time the species would survive at this minimum is not known and higher salinities may be required for successful reproduction and recruitment. Other species within the biological community of this biotope may not tolerate any decrease in salinity and this could lead to a further reduction in the biodiversity of the biotope. Therefore, resistance and resilience are both assessed as 'Medium', and resilience is ranked as 'Medium'. This gives the biotope an overall sensitivity assessment of 'Medium' to this pressure at the pressure benchmark.

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

Water motion is a key determinant of marine macroalgal production, directly or indirectly influencing physiological rates and community structure (Hurd, 2000). Higher water flow rates increase mechanical stress on macroalgae by increasing drag. This can result in individuals being torn off the substratum. Once removed, the attachment cannot be reformed causing the death of the algae. Any sessile organism attached to the algae will also be lost. 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).

Jonsson *et al*. (2006) found that flow speed of 7-8 m/s completely dislodged *Fucus spiralis* individuals larger than 10 cm. Smaller individuals are likely to better withstand increased water flow as they experience less drag. The risk of dislodgement is greater where algae are attached to pebbles instead of bedrock. Indeed if the substratum is less stable, such as a small stone or mussel shell, 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).

Propagule dispersal, fertilization, settlement, and recruitment are also influenced by water movement (Pearson & Brawley, 1996). In addition, increased water flow will cause scour through greater sediment movement affecting in particular small life stages of macroalgae 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).

The water flows experienced by this biotope range from negligible to 0.5 m/s (Connor *et al.*, 2004). An increase in water flow above 0.5 m/s may result in the loss of some fucoid cover. However, it must be taken into consideration that almost all of the species found in this biotope, including *Fucus spiralis*, are also found in conditions where the water movement created by wave motion far exceed 0.5 m/s

Sensitivity assessment. An increase in water movement can cause a reduction in fucoid cover due to an increase in the physical stress exerted on them. Reduction in reproduction and recruitment success may also occur. However, at the level of the benchmark (0.1-0.2 m/s) a change in water flow is unlikely to have a negative impact on the biotope. Resistance has been recorded as 'High' and resilience is recorded as 'High' (by default) so that the biotope is assessed as 'Not sensitive' at the benchmark level.

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

This biotope is found in the eulittoral zone and is subjected to cyclical immersion and emersion caused by the tides. During the initial stages of drying, when alga are exposed to air, photosynthetic rates increase due to the higher diffusion rate of CO_2 in air relative to water (Johnson *et al*., 1974). *Fucus spiralis* can photosynthesise better in air than in water, as long as desiccation has not exceeded tolerated levels of water reduction (Madsen & Maberly, 1990). However, this peak in photosynthesis is usually followed by a gradual decline in the rate of photosynthesis as the surface of the alga dries, thereby preventing further dissolution and uptake of CO_2 (Beer & Kautsky, 1992). Photosynthesis eventually ceases at a critical state of dehydration when the low water content of the thallus disrupts the functioning of the photosynthetic apparatus (Quadir *et al*. 1979). An increase in the levels of immersion would mean that *Fucus spiralis* would eventually be out-competed by faster growing macroalgae species found lower down on the shore (Chapman, 1990, Lubchenco, 1980). It could be hypothesised that the less efficient photosynthesis of these two species in water is the reason that other plants can grow faster, and out-compete them. However, an increase in emersion may shift the upper shore zone up the shore, even if this is the case it may take some time for the biotope to resume ecological function.

Changes in immersion and emersion times will also affect the ability of macroalgae to uptake nutrients. Hurd & Dring (1991) investigated the ability of macroalgae to uptake phosphate after desiccation. The results showed that macroalgae found higher on the shore were able to recover from desiccation and were able to resume uptake of phosphates faster (Hurd & Dring, 1991). They also hypothesised that patterns of zonation on intertidal rocky shores could be partially driven by the ranging sensitivities of nutrient uptake mechanisms in different species (Hurd & Dring, 1991).

Early life history stages are more susceptible to ultraviolet radiation compared to adults (Henry & Van Alstyne, 2004; Roleda *et al*., 2007). 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 the adjacent bare rock was close to 0% during exposure to aerial conditions. *Fucus* canopies are also likely to protect other underlying species. Mortalities of other species are likely to occur if the canopy is removed.

Sensitivity assessment: A change in the level of emergence on the shore will affect *Fucus spiralis*, as well as other species within the biotope. Changes in the numbers of important species are likely to have profound effects on community structure and may result in loss of the biotope at the extremes of its range. For example, the upper limit of the biotope may lose fucoid cover and change to an alternative biotope dominated by barnacles and limpets or lichens. *Fucus spiralis* can tolerate an emersion period of 1-2 days so an increase in time spent in the air of one hour in per day may limit growth and fecundity rather than survival.

Limpets are able to move down the shore although the loss of a home scar can increase the species vulnerability to predation (Garrity & Levings, 1983). Thus, the biotope is likely to be lost only at the very upper limit of its range. A change in the level of emergence on the shore may also affect the lower distribution limit of all the key species as competition increases lower down the shore. Growth, condition and fecundity are likely to return within several months if pre-impact emersion levels return.

The consequences of an increase in emersion are severe desiccation due to increased time in air. When these factors are combined with high temperatures and light can cause mortalities (Pearson *et al*., 2009). This will lead to a decrease in the band of this biotope at the top of a rocky shore. It would also lead to an increase in the level of emersion of other algae further down the shore. Although there will be a period of mortality, in time it may result in a readjustment of biotopes further down the shore. An increase in immersion is likely to result in an upward movement of biotopes on the shore. Therefore, resistance is assessed as 'Medium' and resilience is 'Medium' giving an overall sensitivity assessment of 'Medium'.

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

The characteristic variable salinity regime of this biotope requires a freshwater influence. The location of this biotope is consequently often near estuaries where marine and freshwater meet. Estuaries are naturally protected areas and have low levels of wave exposure. These two factors are interlinked and create a specific niche within which this biotope is found. As this biotope can be found in extremely sheltered locations, a reduction in wave exposure is unlikely to have any impact on the biological community.

An increase in wave exposure generally leads to a decrease in macroalgae abundance and size (Lewis, 1961; Stephenson & Stephenson, 1972; Hawkins *et al*., 1992; Jonsson *et al*., 2006). Fucoids are highly flexible but not physically robust and an increase in wave exposure can cause mechanical damage, breaking fronds or even dislodging whole algae from the substratum. Fucoids are permanently attached to the substratum and would not be able to re-attach 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 the size of fucoids (Blanchette, 1997) as smaller individuals create less resistance to waves. As exposure increases the fucoid population will become dominated by small juvenile algae more resistant to this pressure than mature individuals. An increase in wave action beyond this would lead to the dominance of the community by grazers and barnacles at the expense of fucoids. A recent study investigated the combined impacts of wave action and grazing on macroalgal distribution. The outcome of this paper was the proposal that recruitment and survival of juvenile fucoids including *Fucus spiralis* are controlled indirectly by wave exposure, through higher limpet densities at exposed locations (Jonsson, 2006).

Different morphological forms of *Fucus spiralis* exist and dominate areas with different environmental conditions. Niemeck & Mathieson (1976) noted that specimens of *Fucus spiralis* further up the shore tended to decrease in length and weight. These smaller forms of *Fucus spiralis* are recorded as *Fucus spiralis* f. *nanus* and reference is made to them within a number of papers. Scott *et al.* (2001) noted that *Fucus spiralis* f. *nanus* plants had a relatively small number of short, thin blades that branched fewer times than *Fucus spiralis* plants. Observations by Scott *et al.* (2001) also found *Fucus spiralis* f. *nanus* higher on the shore than *Fucus spiralis.* However, the two morphotypes can overlap on the shore. Scott *et al.* (2001) suggested that the forms of *Fucus spiralis* exist within a mosaic of stable phenotypes representing populations specifically adapted to the local environment. A change in wave height could induce changes in the morphology displayed by *Fucus spiralis* on the shore. Smaller individuals may become predominant due to the lower levels of drag induced by their smaller surface area.An alternative coping strategy for wave induced forces is thallus toughening. In the North Sea and the Baltic Sea, thalli from exposed *Fucus vesiculosus* were 30% more resistant to tear and breakage compared to conspecifics from more sheltered sites (Nietsch, 2009). No evidence has been found to suggest that this has happened in *Fucus spiralis.* If this biotope was found at the upper limit of its wave exposure tolerance, then a change in near shore significant wave height could force the biotope to change. *Fucus spiralis* biotopes found in situations with greater wave exposure, such as LR.MLR.BF.FspiB, include a greater quantity of barnacles and limpets. However, the salinity regime of this biotope may restrict the ability of these species recruit to the area.

Sensitivity assessment. *Fucus spiralis* is sensitive to an increase in wave action. Increased exposure would result in losses of biomass. However, the wave exposure and salinity regime found within this biotope are indicative of estuarine conditions and consequently an increase in wave exposure is unlikely. Fucus spiralis also dominates biotopes in moderately strong wave exposure, e.g F.Fspi.FS (Connor *et al*., 2004). In addition, a change in significant wave height of 3-5% (the benchmark) is unlikely to have a significant effect on the biology of the community. Therefore, resistance is assessed as 'High' so that resilience is also 'High' and biotope is probably 'Not sensitive' at the benchmark level.

Chemical Pressures

	Resistance	Resilience	Sensitivity

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

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

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

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

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

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

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

Sustained reduction of dissolved oxygen can lead to hypoxic (reduced dissolved oxygen) and anoxic (extremely low or no dissolved oxygen) conditions. Sustained or repeated episodes of reduced dissolved oxygen have the potential to severely degrade an ecosystem (Cole *et al.*, 1999). 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). If levels do drop below 4 mg/l negative effects on these organisms can be expected with adverse effects occurring below 2mg/l (Cole *et al.*, 1999). Reduced oxygen levels are likely to inhibit photosynthesis and respiration but not cause a loss of the macroalgae population directly. However, small invertebrate epifauna 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. Kinne (1970) reported that reduced oxygen concentrations inhibit both algal photosynthesis and respiration. No specific information about the effects of de-oxygenation on the characteristic species was found. *Semibalanus balanoides* can respire anaerobically, so they can tolerate some reduction in oxygen concentration (Newell, 1979). When placed in wet nitrogen, where oxygen stress is maximal and desiccation stress is low, *Semibalanus balanoides* have a mean survival time of 5 days (Barnes *et al*., 1963).

Sensitivity assessment. The characterizing species along with other species within this biotope may be negatively impacted by reduced dissolved oxygen levels. At the level of the benchmark (2 mg/l for 1 week) mortalities could occur as a direct result of a change in this pressure. This biotope is found in sheltered to extremely sheltered locations where levels of water mixing (due to wave action and turbulent flow over rocks) are likely to be low. This could exacerbate the negative impacts of reduced oxygen levels at the benchmark of this pressure. However, the biotope in occurs in the upper eulittoral and consequently a high proportion of time will be spent in the air where oxygen is not limited so the metabolic processes of photosynthesis and respiration can take place. Therefore, resistance is assessed as 'High'. Hence, resilience is assessed as 'High', and the biotope as 'Not sensitive'.

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

The nutrient enrichment of a 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 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. Not all of the 47 papers considered the impact of nutrients on intertidal rocky shores. Yet this finding is still relevant as the meta-analysis revealed that the effect of marine pollutants on species diversity was '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).

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).

Changes in community composition on intertidal rocky shores can happen rapidly, and levels of wave exposure are not a controlling factor for the speed of these changes (Kraufvelin, 2007). However, well established and healthy communities on intertidal rocky shores can survive extended periods of time (Bokn *et al.*, 2002, 2003; Karez *et al.*,2004; Kraufvelin *et al.*, 2006; Kraufvelin, 2007). There is little evidence available on the impacts of nutrient enrichment on the characterizing species of this biotope.

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. However, if the biotope is well established and in a healthy state the biotope could have the potential to persist. However, the effect of an increase in this pressure to the benchmark level should not have a negative impact on the biotope. Therefore, the resistance has been assessed as 'High'. Hence, resilience is also 'High' and sensitivity is assessed as 'Not Sensitive' at the benchmark level.

Organic enrichment	High Q: High A: Medium C: Medium	High Q: High A: High C: Medium	Not sensitive Q: High 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), decreases in dissolved oxygen and uncharacteristic microalgae blooms (Bricker *et al.*, 1999, 2008).

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Changes in community composition on intertidal rocky shores can happen rapidly, and levels of wave exposure are not a controlling factor for the speed of these changes (Kraufvelin, 2007). However, well established and healthy communities on intertidal rocky shores can survive extended periods of time (Bokn *et al*., 2002, 2003; Karez *et al*.,2004; Kraufvelin *et al*., 2006; Kraufvelin, 2007).

Sensitivity assessment. A slight increase organic nutrients may enhance growth rates but high organic nutrient concentrations could lead to the overgrowth of the algae by ephemeral green algae and an increase in the number of grazers. An increase in nutrients could induce higher growth rates in the algae found in this biotope.

Physical Pressures

	Resistance	Resilience	Sensitivity
Physical loss (to land or freshwater habitat)	Low Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

All marine habitats and benthic species are considered to have a resistance of 'None' to this pressure and to be unable to recover from a permanent loss of habitat (resilience is 'Very Low'). Sensitivity within the direct spatial footprint of this pressure is, therefore 'High'. Although no specific evidence is described confidence in this assessment is 'High', due to the incontrovertible nature of this pressure.

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

This biotope occurs on rock substratum. A change towards a sedimentary or soft rock substratum would lead to the direct loss of suitable attachment areas resulting in the loss of *Fucus spiralis*, *Semibalanus balanoides* and associated communities. Resistance is assessed as ‘None’. As this pressure represents a permanent change, recovery is impossible as the suitable substratum for fucoids is lacking. Consequently, resilience is assessed as ‘Very Low’. The habitat, therefore, scores a ‘High’ sensitivity. Although no specific evidence is described confidence in this assessment is ‘High’, due to the incontrovertible nature of this pressure.

Physical change (to another sediment type)	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant 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 are epifauna or epiflora occurring on rock and would be sensitive to the removal of the habitat. However, extraction of rock substratum is considered unlikely and this pressure is considered to be 'Not relevant' to hard substratum habitats.

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

These biotope groups are found in the upper intertidal shore. An area easily accessible by humans especially at low tide. Individual *Fucus* specimens are very 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).

Araujo *et al.* (2009) found that trampling negatively affected *Fucus vesiculosus* abundance and reduced understorey species while promoting the colonisation 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* out-competing *Ascophyllum nodosum* after small-scale disturbances.

Brosnan (1993) investigated the effect of trampling on a number of algal species, including *Fucus distichus*, 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 northeast of England were sufficient to reduce the abundance of fucoids (Fletcher & Frid, 1996). 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 and that the average frond length of *Ascophyllum nodosum, Fucus vesiculosus and Fucus serratus* 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).

Sensitivity assessment. Abrasion of the substratum will cause a reduction in *Fucus* abundance resulting in a 'Low' resistance. Several studies, however, found that the seaweed is able to quickly recolonize the disturbed area, out-competing other macroalgae such as *Ascophyllum nodosum*. Although *Fucus* spp. may return quickly, an equilibrium in the ecosystem may not have been reached, therefore, resistance is 'Medium'. Overall the biotope has a 'Medium' sensitivity to the pressure.

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

Light is an essential resource for all photoautotrophic organisms. Changes in suspended particulate matter (SPM) affect water clarity and have a direct impact on the photosynthesising capabilities of fucoids. 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. Increased siltation can also cover the frond surface of Fucoids with a layer of sediment further reducing photosynthesis and growth rate. Sediment deposition can also interfere with attachment of microscopic stages of seaweeds reducing recruitment. 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 (see 'siltation' pressures).

Fucus spiralis would be affected by turbidity as outlined above when immersed. However, *Fucus spiralis* can spend up to 90% of its time emersed and can photosynthesise more effectively in the air than in water (Madsen & Maberly, 1990). This doesn't mean that there wouldn't be any negative impacts on these two characterizing species. But a change to this pressure at the benchmark is not likely to have any significant negative impacts on the characterizing species. It is likely that other species within this biotope who can only feed at high water may be more negatively affected. In particular filter feeding organisms will have their feeding apparatus clogged with suspended particles leading to a reduction in total ingestion and a reduced scope for growth especially since cleaning the feeding apparatus is likely to be energetically expensive.

Sensitivity assessment. Changes in suspended solids reducing water clarity could have adverse effects on the biotope by hindering photosynthesis and growth in microalgae's as well as reducing species richness and reproductive success. Resistance is thus assessed as 'Medium'. Once conditions return to 'normal' algae are likely to rapidly regain photosynthesising capabilities as well as growth rate. Associated communities will also recover as most of the intolerant species produce planktonic larvae and are therefore likely to be able to recolonize quickly from surrounding areas. Resilience is assessed as 'Medium'. Overall this biotope group scores a 'Medium' sensitivity.

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

Sedimentation can directly affect assemblages inhabiting rocky shores in different ways, particularly by the burial/smothering and scour or abrasion of organisms. *Fucus spiralis* attaches to the substratum by a holdfast. This species is not able to relocate in response to increased sedimentation. Sediment deposition is commonly assumed to 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 micro-environment (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.

The state of the tide will determine the extent of the impact. Indeed, if smothering occurs at low tide when the algae are lying flat on the substratum, then most of the organism as well as the associated community will be covered by the deposition of fine material at the level of the benchmark. Smothering will prevent photosynthesis resulting in reduced growth and eventually death. If however smothering occurs whilst the alga is submerged standing upright then the photosynthetic surfaces of adult plants will be left uncovered. The resistance of this biotope to this pressure may thus vary with time of day. Germlings, however, 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.

Smothering will cause direct mortalities in the associated community, particularly in filter feeding sessile organisms unable to relocate. Low densities of herbivores on rocky shores have frequently been related with areas affected by sedimentation, the presence of herbivores is reduced since their feeding activity and movements might be limited (Airoldi & Hawkins, 2007; Schiel *et al.*, 2006)

This biotope occurs in sheltered to extremely sheltered conditions and none of these areas has particularly high levels of water flow. Higher water flows help to remove excess sediments reducing the time of exposure to this pressure. However within this biotope, especially where it occurs in extremely sheltered conditions, sediment could remain for enough time to cause mortality of the species within the biotope.

Sensitivity assessment. Burial will lower survival and germination rates of spores and cause some mortality in early life stages. Adults are more resistant but will experience a decrease in growth and photosynthetic rates. This pressure will have different impacts on the *Fucus spiralis* biotopes depending where on certain environmental gradients they are found. Wave exposure is especially important for this pressure as it is wave energy which will be able to remove sediment from the shore. Those biotopes within areas which are wave sheltered will not be as negatively affected by this pressure as sediment will be removed by wave action relatively quickly. Those biotopes which are very sheltered from waves will retain sediment for longer, allowing greater negative effects to occur. Resistance and resilience are assessed as 'Medium'. Overall the biotope group 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	Medium Q: High A: High C: Medium	Medium 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 will be enabled by vegetative growth from remaining *Fucus* tissue, resulting in a 'Medium' resilience. Overall the biotope has a 'Medium' 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

Species characterizing this habitat have no hearing perception but vibrations may cause an impact, however no studies exist to support 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

Not relevant – 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.

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 assessed.

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

Important characterizing species within this biotope are not cultivated or translocated. This pressure is, therefore, considered 'Not relevant' to this biotope group.

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

Thompson & Schiel (2012) found that native fucoids show high resistance to invasions by the Japanese kelp *Undaria pinnatifida*. However, the cover of *Fucus vesiculosus* was inversely correlated with the cover of the invasive *Sargassum muticum*, indicating a 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.

The recent introduction of *Gracilaria vermiculophylla* to the Baltic Sea prompted an investigation into its possible impacts on *Fucus vesiculosus*. Hammann *et al*. (2013) found that in the Baltic Sea *Gracilaria vermiculophylla* could impact *Fucus vesiculosus* through direct competition for recourses, decreasing the half-life of germlings, and increasing the level of grazing pressure. To date, *Gracilaria vermiculophylla* has only been recorded in Northern Ireland, and not on mainland Britain. The introduction of this species to intertidal rocky shores around the British Isles could have negative impacts on native fucoids, and could become relevant to this specific biotope.

Sensitivity assessment. Although evidence often indicates that invasive non-native species (INNS) can have a negative impact native species, no evidence can be found on the impacts of INIS on *Fucus spiralis*, the characterizing species of this biotope. Evidence regarding other fucoids indicates that some mortality of characterizing species can occur through direct and indirect consequences of INIS being present. Due to the current lack of INIS which could cause a negative impact on this biotope resistance has been assessed as 'High' since invasive species have the potential to alter the recognizable biotope. Resilience has also been assessed as 'High'. This assessment naturally leads to the conclusion that the biotope is 'Not Sensitive' to this pressure. However, return to 'normal' conditions is highly unlikely if an invasive species came to dominate the biotope. Indeed recovery would only be possible if the majority of the INIS were removed (through either natural or unnatural process) to allow the re-establishment of other species. Therefore, actual resilience will be much lower ('Low' to 'Very Low').

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

No evidence was found.

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

Many macroalgae are harvested for their alginates, which are used in the cosmetic and pharmaceutical industries, for agricultural supply, water treatment, and for human food and health supplements (Bixler & Porse, 2010). There is little information available as to whether *Fucus spiralis* is collected for these reasons. However, if there was collection of this characteristic species the effects are likely to be very similar to that caused by the removal of other fucoids from intertidal rocky shores.

The commercial harvest removes seaweed canopies which will 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 macroalgae affected the metabolic flux of the area. Flows from primary production and community respiration were lower in the impacted area as the removal of the canopy caused changes in temperature and humidity conditions. Suspension feeders were the most affected by the canopy removal as canopy-forming algae are crucial habitats for these species, most of them being sessile organisms. Other studies confirm that loss of canopy had both short and long-term consequences for benthic communities in terms of diversity resulting in shifts in community composition and a loss of ecosystem functioning such as primary productivity (Lilley & Schiel, 2006; Gollety *et al.*, 2008). Stagnol *et al.* (2013) observed *Patella vulgata* recruiting in bare patches of disturbed plots. Experimental studies have shown that limpets control the development of macroalgae by consuming microscopic phases (Jenkins *et al.*, 2005) or the adult stages (Davies *et al.*, 2007). The increase in *Patella vulgata* abundance could thus limit the recruitment and growth of fucoids within the impact zone.

Due to the intolerance of macroalgae communities to human exploitation, the European Union put in place a framework to regulate the exploitation of algae establishing an organic label that implies that 'harvest shall not cause any impact on ecosystems' (no. 710/2009 and 834/2007).

Fucoids may be directly removed or damaged by static or mobile gears that are targeting other species. These direct, physical impacts 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.

Sensitivity assessment. The removal of *Fucus spiralis* would have an impact on the biotope in question it is the characterising species. 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', giving an overall sensitivity score of 'Medium'. However, as there is no direct evidence regarding their removal from intertidal shores, the assessment is made with 'Low' confidence.

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

Direct, physical impacts from harvesting are assessed through the abrasion and penetration of the seabed pressures. The characterizing species *Fucus spiralis* creates a dominant turf 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 this 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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