Sargassum muticum on shallow slightly tide-swept infralittoral mixed substrata

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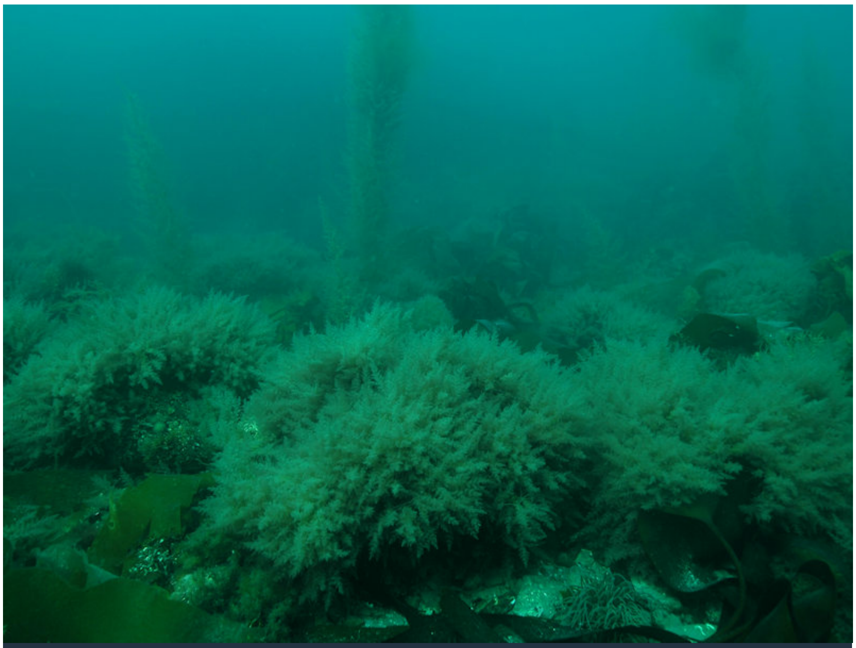

Sargassum muticum **on shallow slightly tide-swept infralittoral mixed substrata**
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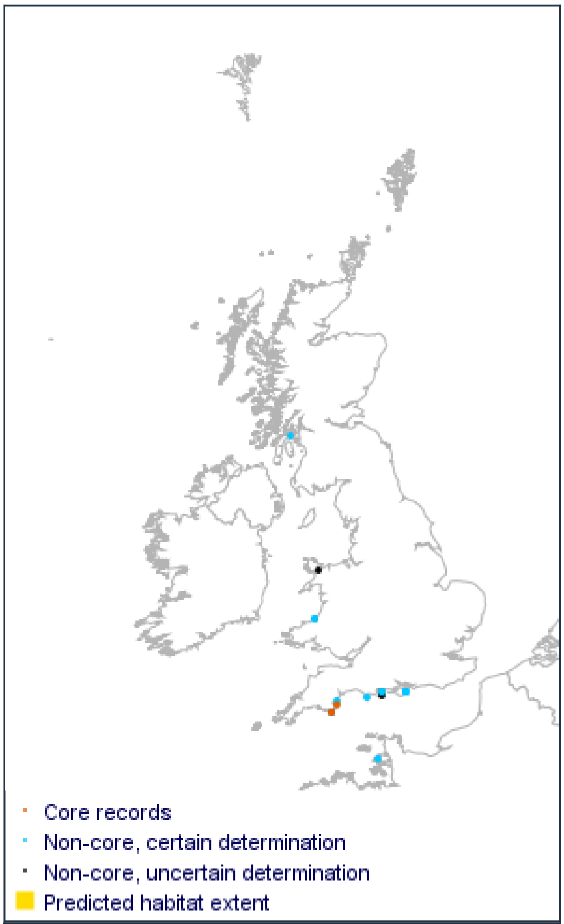

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Frances Perry & Dr Heidi Tillin **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A3.315	*Sargassum muticum* on shallow slightly tide-swept infralittoral mixed substrata
JNCC 2015	IR.LIR.K.Sar	*Sargassum muticum* on shallow slightly tide-swept infralittoral mixed substrata
JNCC 2004	IR.LIR.K.Sar	*Sargassum muticum* on shallow slightly tide-swept infralittoral mixed substrata
1997 Biotope		

Description

Mixed substrata from the sublittoral fringe to 5m below chart datum dominated by the brown seaweed *Sargassum muticum*. This invasive non-native brown seaweed can form a dense canopy on areas of mixed substratum (typically 0-10 % bedrock on 90-100 % sandy sediment). The substrate on which this *Sargassum muticum* dominated community is able to develop is highly variable, but particularly prevalent on broken rock and pebbles anchored in sandy sediment. The pebbles, cobbles and broken bedrock provide a substrate for alga such as the kelp *Saccharina latissima*. During the spring, *Sargassum muticum* has large quantities of epiphytic ectocarpales and may also support some epifauna e.g. the hydroid *Obelia geniculata* commonly found on kelp. The brown seaweed *Chorda filum*, which thrives well on these mixed substrata, is also commonly found with *Sargassum muticum* during the summer months. In Strangford Lough, where this biotope occurs, the amphipod *Dexamine spinosa* has been recorded to dominate the epiphytic fauna (this is known to be commonly found in Zostera spp. beds). *Sargassum muticum* is also found on hard, bedrock substrates within *Saccharina latissima* canopies. *Sargassum muticum* plants on hard substrate area, under a dense *Saccharina latissima* canopy, are typically smaller and at a much lower density, especially where a lush, under-storey exists with red seaweeds such as *Ceramium nodolosum*, *Gracilaria gracilis*, *Chylocladia verticillata*, *Pterosiphonia plumula* and *Polysiphonia elongata* and the green seaweeds Cladophora sp., *Ulva lactuca* and *Bryopsis plumosa*. The anthozoan *Anemonia viridis* and the crab *Necora puber* can be present. Information taken from Connor *et al.* (2004) however more information is necessary to validate this description.

Depth range

0-5 m

Additional information

-

Listed By

- none -

Further information sources

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G 8 G JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The description of this biotope and information on the characterizing species is taken from Connor *et al.*, (2004). This biotope, IR.LIR.K.Sar, describes mixed substrata from the sublittoral fringe to 5m below chart datum (BCD). The invasive non-native species, *Sargassum muticum*, is the dominant macrophyte within this biotope, and is considered the main characterizing species. *Sargassum muticum* is able to dominate this shallow sublittoral habitat where the substrata is mixed. When bedrock and boulders contribute to 15 – 100% of the substrata, then *Saccharina latissima* (syn. *Laminaria saccharina*) dominates. Within examples of this biotope *Saccharina latissima* can be found frequently growing on more stable sediment fractions, but is not found in greater abundance than *Sargassum muticum.* In addition to these phaeophyceae, the Rhodophyta *Gracilaria gracilis* and *Ceramium virgatum* (syn. *Ceramium nodulosum*) are characterizing species of this biotope. This biotope is found in fully marine (30 – 40 psu), wave sheltered conditions, with moderately strong (1 – 3 knots) tidal currents.

Both *Sargassum muticum* and *Saccharina latissima* are considered to be ecosystem engineers as they alter the canopy that their fronds create modify habitat conditions. Although other species are important to this biotope, if this species were missing the biotope would still exist. The canopy provides shade for the various underlying seaweeds in addition to providing a substratum for epifauna and being the primary food resource for grazers. This can facilitate the existence and survival of other species and therefore strongly influencing the structure and functioning of the ecosystem. Therefore, the sensitivity assessment is based on the key structuring species, although the sensitivity of other species is addressed where relevant.

Resilience and recovery rates of habitat

Sargassum muticum possesses life history characteristics which make it an effective colonizer and competitor and it is an invasive species across much of its range. The base/holdfast is perennial (Davison, 1999) and is more tolerant of high air temperatures and desiccation (Norton, 1977) allowing the plant to survive and retain space during periods where conditions are less favourable. The high growth rate (10 cm per day), allows this species to rapidly dominate and shade other algae. The species can reproduce sexually and self-fertilize or asexually and reaches reproductive maturity annually from the first year. Detached fronds are able to continue to grow into new plants and to produce germlings which is an effective mechanism for widespread dispersal supporting colonization or recolonization over a wide area. In comparison, like other brown and red algae, dispersal via propagules is limited. According to Lüning (1990), the eggs of most large perennial algae are adapted for rapid sinking. In *Sargassum muticum*, eggs have a dispersal range of as little as 3 m in the intertidal region (Critchley, 1981; Kendrick & Walker, 1995). Though this distance can increase significantly with water movement (Norton & Fetter, 1981; Deysher & Norton, 1982). *Sargassum muticum* exploits gaps within native algal cover (Davison, 1999) and then rapidly grows and outshades native algae. Space pre-emption by crustose and turf forming algae inhibits *Sargassum muticum* recruitment (Britton-Simmons, 2006; Deysher and Norton, 1982) and light pre-emption, by canopy and understorey algae reduces *Sargassum muticum* survivorship (Britton-Simmons, 2006). *Sargassum muticum* was first found attached in the British Isles in Bembridge on the Isle of Wight in 1971 (Farnham *et al.*, 1973). Since then it has spread rapidly along the English south coast at about 30 km/year (Farnham *et al.* 1981). In north-west American the speed of invasion is about 60 km/year, mostly by drifting, fertile adults (Farnham *et al.* 1981).

Saccharina latissima (formerly *Laminaria saccharina*) is an opportunistic seaweed which has a relatively fast growth rate. *Saccharina lattisma* is a perennial kelp which can reach maturity in 15-20 months (Sjøtun, 1993) and has a life expectancy of 2-4 years (Parke, 1948). *Saccharina lattisma* is widely distributed in the north Atlantic from Svalbard to Portugal (Birket *et al*., 1998a; Conor *et al*., 2004; Bekby & Moy 2011; Moy & Christie, 2012). *Saccharina lattisima* has a heteromorphic life strategy (Edwards, 1998). Mature sporophytes broadcast spawn zoospores from reproductive structures known as sori (South & Burrows, 1967; Birket et al., 1998a). Zoospores settle onto rock and develop into gametophytes, which following fertilization, germinate into juvenile sporophytes. Laminarian zoospores are expected to have a large dispersal range. However, zoospore density and the rate of successful fertilization decreases exponentially with distance from the parental source (Fredriksen *et al*., 1995). Hence, recruitment can be influenced by the proximity of mature kelp beds producing viable zoospores (Kain, 1979; Fredriksen *et al*., 1995). *Saccharina lattisma* recruits appear in late winter early spring beyond which is a period of rapid growth, during which sporophytes can reach a total length of 3 m (Werner & Kraan, 2004). In late summer and autumn growth rates slow and spores are released from autumn to winter (Parke, 1948; Lüning, 1979; Birket *et al*., 1998a). The overall length of the sporophyte may not change during the growing season due to marginal erosion but growth of the blade has been measured at 1.1 cm/day, with a total length addition of ≥2.25 m per year (Birkett *et al*., 1998a). *Saccharina lattisma* is a rapid colonizing species and appear early in algal succession. Leinaas & Christie (1996) removed *Strongylocentrotus droebachiensis* from “Urchin Barrens” and observed a succession effect. Initially the substrate was colonized by filamentous algae, after a couple of weeks these were out-competed and the habitat dominated by *Saccharina latissimi*. However, this was subsequently out-competed by *Laminaria hyperborea*. In the Isle of Man, Kain (1975) cleared sublittoral blocks of Laminaria hyperborea at different times of the year for several years. The first colonizers and succession community differed between blocks and at what time of year the blocks were cleared. *Saccharina lattisima* was an early colonizer. However, within 2 years of clearance the blocks were dominated by Laminaria hyperborea. In 2002, a 50.7-83% decline of *Saccharina latissima* was discovered in the Skaggerak region, South Norway (Moy *et al*., 2006; Moy & Christie, 2012). Survey results indicated a sustained shift from *Saccharina latissima* communities to those of ephemeral filamentous algal communities. The reason for the community shift was unknown, but low water movement in wave and tidally sheltered areas combined with the impacts of dense human populations, e.g. increased land run-off, was suggested to be responsible for the dominance of ephemeral turf macro-algae. Multiple stressors such as eutrophication, increasing regional temperature, increased siltation and overfishing may also be acting synergistically to cause the observed habitat shift.

Gracilaria gracilis is widely distributed however in the North Atlantic is found from south west Norway (Rueness, 1977) and extends to South Africa (Anderson *et al*., 1999). *Gracilaria gracilis* is widely distributed, in the North Atlantic specifically is found from south west Norway (Rueness, 2005) and extends to South Africa (Anderson *et al*., 1999). *Gracilaria gracilis* is a perennial red seaweed, individuals are composed of an annual erect thalli which grow from a perennial holdfast (Martín *et al*., 2011). *Gracilaria gracilis* has a complex life history; reproducing sexually through haploid and diploid spores (Martín *et al*., 2011) and through vegetative fragmentation (Rueness *et al*., 1987). Mature individuals consist of erect annual thalli growing from a perennial holdfast (Martín *et al*., 2011). Vegetative growth is limited to approximately 6 months each year (Kain & Destcombe, 1995) during which thalli can reach 60cm (Bunker *et al*., 2012). Thalli become reproductively active within 2 and half months from March-September (Engel & Destombe, 2002). *Gracilaria gracilis* is recorded throughout the British Isles (AlgaeBase, 2015; NBN, 2015). However, IR.LIR.K.Sar is restricted to the south and south-west of England.

Ceramium spp. may regenerate from very small fragments of thalli attached to the substratum or the development of germlings from settled spores (Dixon, 1960). *Ceramium virgatum* (syn. *Ceramium nodulosum*) has been shown to recruit rapidly to cleared surfaces. For instance, experimental panels were colonized by Ceramium virgatum within a month of being placed in both Langstone Harbour (Brown *et al*., 2001) and in the outer harbour of the Isle of Helgoland (Wollgast *et al*., 2008).

Resilience sensitivity. Resilience of the species within this biotope have the ability to recover rapidly following disturbance.*Sargassum muticum* is a highly successful invasive non-native species and has extremely fast growth rates. *Saccharina latissima* has been shown to be an early colonizer within algal succession, appearing within 2 weeks of clearance, and can reach sexual maturity within 15-20 months. *Gracilaria gracilis* and *Ceramium virgatum* have rapid growth rates. *Gracilaria gracilis* is also capable of reaching sexual maturity within one year. Resilience has therefore been assessed as ‘High’.

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)	None Q: High A: Medium C: Medium	High Q: High A: High C: Medium	Medium Q: High A: Medium C: Medium

Average Sea Surface Temperatures (SST) in the British Isles range from 8-16 °C in summer and 6-13 °C in winter (Beszczynska-Möller & Dye, 2013). This natural variability of temperatures in the British Isles means that there will be different impacts of the pressure at this benchmark depending where in the country the biotope is found.

Water temperatures in other parts of *Sargassum muticum’s* range exceed those which are experienced within the British Isles. *Sargassum muticum* can grow in water temperatures between 3 °C and 30 °C (Norton, 1977; Hales & Fletcher, 1989). In its native Japan, *Sargassum muticum* experiences an annual temperature range of between 5 °C and 28 °C. In southern California, it survives in shallow lagoons and tidal pools that reach temperatures of 30 °C and rarely fall below 14 °C (Norton, 1977). In Alaska, *Sargassum muticum* occurs where temperatures range between 3 °C and 10 °C (Hales & Fletcher, 1989). Strong (2003) found that stands of *Sargassum muticum* in Strangford Lough caused strong temperature stratification, including significant cooling of the water just above the sediment, while a thin layer at the surface canopy experienced elevated temperatures 11 °C above ambient due to heat absorption of the canopy. Strong (2003) proposed that warmer water temperatures could increase gamete production and extend the reproductive period.

The temperature isotherm of 19-20 °C has been reported as limiting *Saccharina latissima* geographic distribution (Müller *et al*., 2009). Gametophytes can develop in ≤23 °C (Lüning, 1990) but the optimal temperature range for sporophyte growth is 10-15 °C (Bolton & Lüning, 1982). Bolton & Lüning (1982) experimentally observed that sporophyte growth was inhibited by 50-70 % at 20 °C and following 7 days at 23 °C all specimens completely disintegrated. In the field, *Saccharina latissima* has shown significant regional variation in its acclimation to temperature changes. Gerard & Dubois (1988) observed sporophytes of *Saccharina latissima* which were regularly exposed to ≥20 °C could tolerate these temperatures, whereas sporophytes from other populations which rarely experience ≥17 °C showed 100% mortality after 3 weeks of exposure to 20 °C. Therefore the response of *Saccharina latissima* to a change in temperatures is likely to be locally variable.

The optimal temperature for *Gracilaria gracilis* growth was found to be 18 °C, but high growth was recorded up to 25.5 °C (Rebello *et al*., 1996). *Gracilaria gracilis* northern range edge is south western Norway where it exclusively occurs in shallow bays in which summer temperatures exceed 20 °C (Rueness, 1977). Lüning (1990) reported that *Ceramium virgatum* survived temperatures from 0 to 25 °C with optimal growth occurring at 15 °C. The species is therefore likely to be tolerant of higher temperatures than it experiences in the seas around Britain and Ireland.

Sensitivity assessment. A change in this pressure at the benchmark will remove species from their optimal conditions. *Sargassum muticum*, *Gracilaria gracilis* and *Ceramium virgatum* are not likely to be negatively afftected. However, ecotypes of *Saccharina lattisima* have been shown to have different temperature optimums (Gerard & Dubois, 1988). For acute 5 °C increases in temperature for a period of 1 month combined with high summer temperatures could cause large scale mortality of *Saccharina lattisma*. A 2 °C increase in temperature for a year, combined with high summer temperatures, could similarly result in large scale mortality of *Saccharina lattisima* ecotypes. Resistance has been assessed as 'None', and resilience as 'High', giving the biotope a sensitivity of 'Medium'.

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

Average Sea Surface Temperatures (SST) in the British Isles range from 8-16 °C in summer and 6-13 °C in winter (Beszczynska-Möller & Dye, 2013). This natural variability of temperatures in the British Isles means that there will be different impacts of the pressure at this benchmark depending where in the country the biotope is found.

The temperature range in which *Sargassum muticum* may grow is between 3 °C and 30 °C (Norton, 1977; Hales and Fletcher, 1989). Early life stages are more sensitive and reductions in temperature from 17 °C to 7 °C decrease germling growth (Steen, 2003). *Sargassum muticum* experiences colder waters than the UK over parts of its geographic range and it has successfully invaded the cold waters of southern Alaska (Hales & Fletcher, 1989) and Scandinavia (Karlsson & Loo, 1999). It can survive short periods of freezing temperatures (Norton, 1977), although a single hour exposed to temperatures of -9°C was lethal to the entire plant (Norton, 1977). The branches can survive at –1 ˚C (Norton, 1977) and the holdfast and stipe can survive lower temperatures (Critchley et al., 1987; Karlsson, 1988). In Sweden, early colonists observed in 1987 were noted to survive the winter, despite formation of ice on the nearby sea surface (Karlsson & Loo, 1999).

Saccharina lattissima is widespread throughout the arctic. *Saccharina lattissima* has a lower temperature threshold for sporophyte growth at 0 °C (Lüning, 1990). Subtidal red algae can survive at -2 °C (Lüning, 1990; Kain & Norton, 1990). The distribution and temperature tolerances of these species suggests they likely be unaffected by temperature decreases assessed within this pressure. *Gracilaria gracilis* is widespread throughout the UK (Bunker *et al*., 2012). However, the northern range edge of *Gracilaria gracilis* is within south west Norway, where it is restricted to shallow bays in which summer temperatures exceed 20 °C.

Lüning (1990) reported that *Ceramium virgatum* survived temperatures from 0 to 25 °C with optimal growth at about 15 °C. This species is therefore likely to be tolerant of lower temperatures than it experiences in the seas around Britain and Ireland.

Sensitivity assessment. The temperature tolerances of the characterizing species within this biotope suggest that this pressure, at the benchmark, would have limited effect. The range of this biotope is also limited to the south coast of England, where water temperatures are warmer than those further north. Consequently, resistance and resilience are assessed as 'High' and the biotope is considered 'Not Sensitive'.

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

Local populations may be acclimated to the prevailing salinity regime and may therefore exhibit different tolerances to other populations subject to different salinity conditions. Therefore caution should be used when inferring tolerances from populations in different regions. This biotope is found in full (30-40 ppt) salinity (Connor *et al*., 2004).

Hales & Fletcher (1989) conducted salinity tolerance experiments on *Sargassum muticum* germlings collected from Bembridge, Isle of Wight. Germlings were tolerant of salinities 6.8 % – 34 % for the entire four week laboratory experiment (Hales & Fletcher, 1989). Optimal growth occurred at a temperature of 25°C and a salinity of 34 ‰ (Hales & Fletcher, 1989). No evidence was found for tolerance of salinities above 34 ‰. Karsten (2007) tested the photosynthetic ability of *Saccharina latissima* under acute 2 and 5 day exposure to salinity treatments ranging from 5-60 psu. A control experiment was also carried at 34 psu. *Saccharina latissima* showed high photosynthetic ability at >80 % of the control levels between 25-55 psu (Karsten, 2007). Optimal salinities for *Gracilaria gracilis* growth have been recorded at 30 ‰ (Rebello *et al*., 1996). However, *Gracilaria gracilis* can be found in rock pools (South & Burrows, 1967; Engel & Destombe, 2002). Therefore, is likely to be able to tolerate higher salinities.

Ceramium virgatum can be found in rock pools on the mid shore. The ability of this species to tolerate rock pools where short-term hypersalinity is common, suggests that it has some tolerance to increased salinities. However, the effects of long-term exposure to hypersaline conditions are unknown.

Sensitivity assessment. There is little empirical evidence to support this assessment. The information available suggests that the characterizing species within this biotope survive best in fully saline conditions. The ability of these species to tolerate rock pool environments suggests that they can survive in hypersaline conditions for short periods of time. The long-term tolerances for these species to hypersalinities are not known. This uncertainty has resulted in a resistance of 'Medium', a resilience of 'High'. Giving a sensitivity of 'Low'.

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

Hales & Fletcher (1989) conducted salinity tolerance experiments on *Sargassum muticum* germlings collected from Bembridge, Isle of Wight. In experimentation germlings were tolerant of salinities 6.8 – 34 % for the entire four week laboratory experiment (Hales & Fletcher, 1989). Optimal growth occurred at a temperature of 25 °C and a salinity of 34 % (Hales & Fletcher, 1989). No evidence was found for tolerance of salinities above 34 %. Norton (1977) found that, in culture, vegetative branches of *Sargassum muticum* could tolerate minimum salinities down to 9 ppt but growth rates were much reduced. Transplanted mature plants (Steen, 2004) were also found to show a decrease in growth and reproductive rate at a station with salinities in the range of approximately 9.5 ppt to 17.4 ppt over a six month period. Field studies have also observed an absence of *Sargassum muticum* in shallow Alaskan waters (6 m) at a salinity of 8.64 ppt due to snow melt (Norton, 1977). Steen (2004) suggested that *Sargassum muticums* invasive capability decreased at lower salinities. In salinities below 15 ppt *Sargassum muticum* can no longer successfully invade a habitat. *Sargassum muticum* becomes less competitive with other species at salinities lower than 25 ppt. However, since brackish ecosystems are often characterized by low biodiversity, it has been hypothesised that these areas will be more vulnerable to colonization by *Sargassum muticum* if it is able to withstand hyposaline conditions (Elmgren & Hill, 1997).

Karsten (2007) tested the photosynthetic ability of *Saccharina latissima* under acute two and five day exposure to salinity treatments ranging from 5-60 psu. A control experiment was also carried at 34 psu. *Saccharina latissima* showed high photosynthetic ability at >80 % of the control levels between 25-55 psu. Hyposaline treatment of 10-20 psu led to a gradual decline of photosynthetic ability. After 2 days at 5 psu *Saccharina latissima* showed a significant decline in photosynthetic ability at approximately 30 % of control. After 5 days at 5 psu *Saccharina latissima* specimens became bleached and showed signs of severe damage. The experiment was conducted on *Saccharina latissima* from the Arctic, and the authors suggest that at extremely low water temperatures (1-5°C) macroalgae acclimation to rapid salinity changes could be slower than at temperate latitudes. It is therefore possible that resident *Saccharina latissima* of the UK maybe be able to acclimate to salinity changes more effectively.

Gracilaria gracilis can reportedly tolerate wide salinity fluctuations (Bunker *et al.*, 2012). Furthermore *Gracilaria gracilis* is recorded from biotopes which occur in reduced salinity regimes (<18-40‰), such as SS.SMp.KSwSS.SlatGraVS (Connor *et al.*, 2004) which suggests *Gracilaria gracilis* can tolerate low salinity environments. *Ceramium virgatum* occurs over a very wide range of salinities. The species penetrates almost to the innermost part of Hardanger Fjord in Norway where it experiences very low salinity values and large salinity fluctuations due to the influence of snowmelt in spring (Jorde & Klavestad, 1963).

Sensitivity assessment. A change from a fully marine (30 – 40 psu) regime to a variable salinity (18 – 40 psu) for a year will lead to a loss of biodiversity within this biotope. *Sargassum muticum, Gracilaria gracilis* and *Ceramium virgatum* are all able to tolerate fluctuations in salinities. However, *Saccharina latissima* kept in lower salinities (e.g. 10 – 20 psu) begin to lose their ability to photosynthesise (Karsten, 2007). A change in the pressure in this benchmark is likely to see a reduction in *Saccharina latissima*, and all of the epifauna associated with this ecosystem engineering characteristic species. However, the three remaining species are likely to be able to persevere. Resistance has been assessed as 'Medium' and resilience as 'High'. Therefore the sensitivity of this biotope to a decrease in salinity has been assessed as 'Low'.

Water flow (tidal current) changes (local)	High Q: High A: Medium C: Medium	High Q: High A: High C: Medium	Not sensitive Q: High 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. Many macroalgae are, however, highly flexible and are able to re-orientate their position in the water column to become more streamlined. This ability allows algae to reduce the relative velocity between algae and the surrounding water, thereby reducing drag and lift (Denny *et al*., 1998).

Propagule dispersal, fertilization, settlement, and recruitment are also influenced by water movement (Pearson & Brawley, 1996). In addition, increased water flow will cause scour though 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). 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).

No empirical information could be found on the tolerance of either *Sargassum muticum*, *Gracilaria gracilis* or *Ceramium virgatum* to an increase in water flow.

Peteiro & Freire (2013) measured *Saccharina latissima* growth from two sites, the first had maximal water velocities of 0.3 m/sec and the second had 0.1 m/sec. At the first site *Saccharina latissima* had significantly larger biomass than at site two (16 kg/m to 12 kg/m respectively). Peteiro & Freire (2013) suggested that faster water velocities were beneficial to *Saccharina latissima* growth. However, Gerard & Mann (1979) measured *Saccharina latissima* productivity at greater water velocities and found *Saccharina latissima* productivity was reduced in moderately strong tidal streams (≤1 m/sec) when compared to weak tidal streams (<0.5 m/sec).

Sensitivity assessment. An increase in water movement can cause a reduction in algae 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 an increase in water flow is unlikely to have a negative impact on the characterizing species within this biotope. Resistance has been recorded as 'High' and resilience is recorded as 'High' giving an overall sensitivity of 'Not Sensitive'.

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

IR.LIR.K.Sar is found from the sublittoral fringe into the shallow sublittoral. Therefore, this biotope is likely to be exposed during some extreme spring low tides. During which time the biotope would be emersed for short periods of time. Consequently the characterizing species must have some tolerance to very short periods of exposure to air. However, as this biotope is sublittoral in nature any increase in emergence will cause mortality of the characterizing species, and the loss of the biotope.

Sargassum muticum is found on the lower shore and sublittoral and in rockpools. Although rockpools allow *Sargassum muticum* to occur further up the shore, individuals in rock pools are usually smaller and may have lower reproductive rates (plants are often small and reproduction may be impaired (Fletcher & Fletcher, 1975a). Fronds exposed to air in hot sunshine can die within an hour and three hours exposure can kill fronds in the shade (Norton, 1977). An increase in emergence may therefore expose *Sargassum muticum* to unfavourable conditions resulting in reduced growth or mortality. The holdfast can survive and is more resistant to desiccation, so that recovery may be rapid from short-term desiccation events.

The algal mat covering the substratum, predominantly of the red seaweed *Ceramium virgatum*, may be more intolerant of an increase in desiccation. *Ceramium virgatum* occurs profusely in rockpools, on the lower shore and in the subtidal but not on the open shore away from damp places suggesting that it is intolerant of desiccation. As a consequence of an increase in emergence, the algal cover may become diminished.

Sensitivity assessment. Resistance has been assessed as 'Low' and resilience as 'High'. Therefore, sensitivity of this biotope to a change in emergence is considered as 'Low'.

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

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). Many macroalgae 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. All of the characterizing species within this biotope 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 more mobile species could find new habitat in surrounding areas.

The structure of kelps enables them to survive a range of wave conditions from exposed to sheltered conditions (Connor *et al*., 2004, Harder *et al*., 2006). Physiological differences between kelps are evident between low wave exposure and medium-high wave exposure.

No empirical information can be found on the effects of wave exposure on *Sargassum muticum* or *Ceramium virgatum*. Bunker *et al*. (2012) reports that *Gracilaria gracilis* is most common in wave sheltered sites. However, *Gracilaria gracilis* has been recorded from biotops that are recorded from moderately wave exposed conditions (e.g. SS.SMp.KSwSS.SlatGraFS) (Connor *et al*., 2004).

Sensitivity assessment. This biotope is found from extremely sheltered to sheltered conditions. An increase in local wave height (e.g. to strong or moderately strong exposure) may increase local sediment mobility, potentially increase dislodgment or relocation of the characterizing species (South & Burrows, 1967; Birkett et al., 1998b). An increase in wave exposure, may therefore result in significant change to or loss of the biotope. However, an increase in nearshore significant wave height of 3-5% is not likely to have a significant effect on biotope structure. Resistance has been assessed as 'High', and resilience as 'High'. Therefore sensitivity has been assessed as '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	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 direct evidence was found to assess this pressure for any of the characterizing species. For this reason an assessment of ‘No Evidence’ has been given.

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

Conolly & Drew (1985) found *Saccharina latissima* sporophytes had relatively higher growth rates when in close proximity to a sewage outlet in St Andrews, UK, compared to other sites along the east coast of Scotland. At St Andrews, nitrate levels were 20.22μM, which represents an approximate 25 % increase compared to other sites (approx. 15.87 μM). Handå *et al.* (2013) also reported that *Saccharina latissima* sporophytes grew approx. 1 % faster per day when in close proximity to Norwegian salmon farms, where elevated ammonium could be readily absorbed by sporophytes. Read *et al.* (1983) reported after the installation of a new sewage treatment works, which reduced the suspended solid content of liquid effluent by 60 % in the Firth of Forth, *Saccharina latissima* became abundant where previously it had been absent. Bokn *et al.* (2003) conducted a nutrient loading experiment on intertidal fucoids. Three years into the experiment no significant effect had been observed in the communities. However, four years into the experiment a shift occurred from perennials to ephemeral algae. Although Bokn *et al.* (2003) focussed on fucoids the results could indicate that long-term (>4 years) nutrient loading can result in community shift to ephemeral algae species. Disparities between the findings of the aforementioned studies are likely to be related to the level of organic enrichment.

Smit (2002) suggested that dissolved inorganic nitrogen from fish factory waste in Saldanha Bay, South Africa could maintain *Gracilaria gracilis* growth when natural nutrient sources were low. Hily *et al.* (1992) found that, in conditions of high nutrients, *Ceramium virgatum* (as *Ceramium rubrum*) dominated substrata in the Bay of Brest, France. *Ceramium* spp. are also mentioned by Holt *et al.* (1995) as likely to smother other species of macroalgae in nutrient enriched waters. Fletcher (1996) quoted *Ceramium virgatum* (as *Ceramium rubrum*) to be associated with nutrient enriched waters. Therefore, algal stands of *Ceramium virgatum* are likely to benefit from elevated levels of nutrients.

Johnston & Roberts (2009) conducted a meta-analysis, which reviewed 216 papers to assess how a variety of contaminants (including sewage and nutrient loading) affected 6 marine habitats (including subtidal reefs). A 30-50 % reduction in species diversity and richness was identified from all habitats exposed to the contaminant types. Johnston & Roberts (2009) also highlighted that macroalgal communities are relative tolerant to contamination, but that contaminated communities can have low diversity assemblages which are dominated by opportunistic and fast growing species (Johnston & Roberts, 2009 and references therein).

No evidence was available on the impact of nutrient enrichment on the characterizing species *Sargassum muticum.*

Sensitivity assessment. Although short-term exposure to nutrient enrichment may not affect seaweeds directly, indirect effects such as turbidity may significantly affect photosynthesis and result in reduced growth and reproduction and increased competition form fast growing but ephemeral species. However, the pressure benchmark is set at compliance with Water Framework Directive (WFD) criteria for good status, based on nitrogen concentration (UKTAG, 2014). Therefore, this biotope is considered to be 'Not sensitive' at the pressure benchmark.

Organic enrichment	Medium Q: High A: Medium C: Medium	High Q: High A: High C: Medium	Low 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) and decreases in dissolved oxygen and uncharacteristic microalgae blooms (Bricker *et al.*, 1999, 2008).

Conolly & Drew (1985) found *Saccharina latissima* sporophytes had relatively higher growth rates when in close proximity to a sewage outlet in St Andrews, UK, compared to other sites along the east coast of Scotland. At St Andrews, nitrate levels were 20.22µM, which represents an approx. 25% increase compared to other sites (approx. 15.87 µM). Handå *et al.* (2013) also reported *Saccharina latissima* sporophytes grew approximately 1 % faster per day when in close proximity to Norwegian salmon farms, where elevated ammonium could be readily absorbed by sporophytes. Read *et al.* (1983) reported after the installation of a new sewage treatment works, which reduced the suspended solid content of liquid effluent by 60% in the Firth of Forth, *Saccharina latissimi* became abundant where previously it had been absent. Bokn *et al.* (2003) conducted a nutrient loading experiment on intertidal fucoids. Three years into the experiment no significant effect had been observed in the communities. However, four years into the experiment a shift occurred from perennials to ephemeral algae. Although Bokn *et al.* (2003) focussed on fucoids the results could indicate that long-term (>4 years) nutrient loading can result in community shift to ephemeral algae species. Disparities between the findings of the aforementioned studies are likely to be related to the level of organic enrichment.

No direct evidence can be found for *Sargassum muticum*, *Gracilaria gracilis* or *Ceramium virgatum*.

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. Not all of the 49 papers considered the impact of sewage on the shallow sublittoral. Yet this finding is 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.

Organic 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 enriched environments can not only increase algae abundance, but the abundance of grazing species (Kraufvelin, 2007).

Sensitivity assessment. Little empirical evidence was found to support an assessment of this biotope at this benchmark. IR.LIR.K.Sar occurs in sheltered to extremely sheltered wave exposures. It does occur in moderately strong tidal streams (1 – 3 knots) (Connor *et al*., 2004). This water flow will disperse organic matter reducing the level of exposure quickly after the pressure event. Due to the potential negative impacts that have been reported to result from the introduction of excess organic carbon, resistance has been assessed as ‘Medium’ and resilience has been assessed as ‘High’. This gives an overall sensitivity score of ‘Low’.

Physical Pressures

	Resistance	Resilience	Sensitivity
Physical loss (to land or freshwater habitat)	None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

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

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

If sediment were replaced with rock or artificial substrata, this would represent a fundamental change to the biotope. All the characterizing species within this biotope can grow in rock biotopes (Birkett et al., 1998b; Connor *et al*., 2004). However, IR.LIR.K.Sar, by definition is a mixed substrata biotope and a change in sediment to rock would change the biotope into a rock based habitat complex.

Sensitivity assessment. Resistance to the pressure is considered 'None', and resilience 'Very low'. Sensitivity has been assessed as 'High'.

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

The benchmark for this pressure refers to a change in one Folk class. The pressure benchmark originally developed by Tillin *et al.* (2010) used the modified Folk triangle developed by Long (2006) which simplified sediment types into four categories: mud and sandy mud, sand and muddy sand, mixed sediments and coarse sediments. The change referred to is therefore a change in sediment classification rather than a change in the finer-scale original Folk categories (Folk, 1954). The change in one Folk class is considered to relate to a change in classification to adjacent categories in the modified Folk triangle. For mixed sediments and sand and muddy sand habitats a change in one Folk class may refer to a change to any of the sediment categories.

IR.LIR.K.Sar occurs on mixed substrata, therefore within this pressure a change in one folk class relates to a change to either "Coarse sediment", "Mud and sandy Mud" and "Sand and sandy mud". Macroalgae are likely to successfully recruit onto the larger sediment/small rock fractions within these biotopes (e.g. gravel, pebbles, cobbles). Therefore, if the proportion of stabilised large sediment/small rock fractions increased this may benefit these biotopes. Conversely if the proportion of smaller sediment fractions increased within these biotopes (as with "Mud and sandy Mud" and "Sand and sandy mud") then macro-algal recruitment would likely be significantly reduced.

Sensitivity assessment. Resistance has been assessed as 'None' and resilience as Very low (the pressure is a permanent change) Therefore sensitivity has been assessed as 'High'.

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

Abrasion of the substratum e.g. from bottom or pot fishing gear, cable laying etc. may cause localised mobility of the substrata and mortality of the resident community. The effect would be situation dependent. However, if bottom fishing gear were towed over a site it may mobilise a high proportion of the substrata and cause high mortality in the resident community.

The effect of trampling on shallow algal communities was examined by a single Mediterranean study (Milazzo et al., 2002). Experimental trampling of 18 transects were carried out at 0, 10, 25, 50, 100 and 150 passes and the community examined immediately after and three months later in the shallow infralittoral (0.3-0.5 m below mean low water). Percentage cover and canopy were significantly affected by trampling, the degree of effect increasing in proportion with trampling intensity. Intermediate trampling treatments (25, 50 and 100 tramples) were similar in effect but significantly different from 0 and 10 tramples. After 150 tramples, percentage cover was significantly lower. Erect macroalgae were particularly susceptible, e.g. the canopy forming *Cystoseira brachicarpa v. balearica* and *Dictyota mediterranea*. At low to intermediate trampling intensity, *Dictyota mediterranea* was strongly damaged while *Cystoseira brachicarpa v. balearica* lost fronds. At high trampling intensities, *Dictyota mediterranea* was completely removed while *Cystoseira brachicarpa v. balearica* was reduced to holdfasts. Low to intermediate trampling intensities (10, 25, 50 tramples) resulted in a loss of algal biomass of 50 g/m^2 , while 100 or 150 tramples resulted in a loss of ca 150 g/m^2. Recovery was incomplete after three months and significant differences in effect were still apparent between trampling treatments. Overall, trampling reduced percentage algal cover and canopy. However, the study focused on the canopy forming species and lower turf forming species were not mentioned.

In summary the above evidence suggests that shallow infralittoral algal communities are susceptible to the effects of trampling by pedestrians. Again the canopy forming, erect species seem to be the most susceptible. Trampling of sublittoral fringe communities could occur as coasteerers haul themselves out of the water at the bottom of the shore. Therefore, sublittoral fringe communities in the UK could be susceptible but there is limited evidence at present (Tyler-Walters 2005).

Sensitivity assessment. Resistance has been assessed as ‘Low’, Resilience as ‘High’. Sensitivity has been assessed as ‘Low’.

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

The characterizing species of this biotope occurs on rock which is resistant to subsurface penetration. The assessment for abrasion at the surface only is therefore considered to equally represent sensitivity to this pressure.

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

Suspended Particle Matter (SPM) concentration has a positive linear relationship with sub surface light attenuation (Kd) (Devlin *et al.*, 2008). Light availability and water turbidity are principal factors in determining depth range at which macroalgae can be found (Birkett et al., 1998bb).

No direct evidence was found to assess *Sargassum muticum*. As this species is buoyant and floats on the surface of rockpools it is considered to be relatively resistant to an increase in suspended sediments at the pressure benchmark, although some sublethal reductions in photosynthesis may occur due to decreased light penetration on lower branches and increased scour on tissues.

Light penetration influences the maximum depth at which laminarians can grow and it has been reported that laminarians grow at depths at which the light levels are reduced to 1 percent of incident light at the surface. Maximal depth distribution of laminarians therefore varies from 100 m in the Mediterranean to only 6-7 m in the silt laden German Bight. In Atlantic European waters, the depth limit is typically 35 m. In very turbid waters the depth at which kelp is found may be reduced, or in some cases excluded completely (e.g. Severn Estuary), because of the alteration in light attenuation by suspended sediment (Lüning, 1990; Birkett et al. 1998a). *Laminarians* show a decrease of 50% photosynthetic activity when turbidity increases by 0.1/m (light attenuation coefficient =0.1-0.2/m; Staehr & Wernberg, 2009). However, IR.LIR.K.Sar does not extend below 5 m and consequently is unlikely to be negatively affected at the pressure benchmark.

Red algae are known to be shade tolerant and are common components of the understorey on seaweed dominated shores. Therefore, a decrease in light intensity is unlikely to adversely affect the biotope. An increase in light intensity is unlikely to adversely affect the biotope as plants can acclimate to different light levels. Hily *et al.* (1992) found that, in conditions of high turbidity, the characterizing species *Ceramium virgatum* (as *Ceramium rubrum*) dominated sediments in the Bay of Brest, France. It is most likely that *Ceramium virgatum* thrived because other species of algae could not. Whilst the field observations in the Bay of Brest suggested that an increase in abundance of *Ceramium virgatum* might be expected in conditions of increased turbidity, populations where light becomes limiting will be adversely affected. However, in shallow depths and the intertidal, photosynthesis can occur during low tides (as long as sediments are not deposited) and *Ceramium virgatum* may benefit from increased turbidity through decreased competition.

Sensitivity Assessment. A decrease in turbidity is likely to support enhanced growth (and possible habitat expansion) and is therefore not considered in this assessment. An increase in water turbidity is likely to primarily affect photosynthesis therefore growth and density of the canopy forming seaweeds. Resistance is therefore assessed as 'High' and resilience as 'High' so that the biotope is considered to be 'Not sensitive'. An increase in suspended solids above the pressure benchmark may result in a change in species composition with an increase in species seen in very turbid, silty environments.

Smothering and siltation rate changes (light)	High Q: Low A: Medium C: Medium	High Q: Low A: Medium C: Medium	Not sensitive Q: Low A: Medium C: Medium

Smothering by 5 cm of sediment material during a discrete event, is unlikely to damage mature examples of *Saccharina latissima* or *Sargassum muticum*. However, it may provide a physical barrier to zoospore settlement and therefore could negatively impact on recruitment processes (Moy & Christie, 2012). Laboratory studies showed that kelp and gametophytes can survive in darkness for between 6-16 months at 8 °C. *Saccharina latissima* would probably survive smothering by a discrete event and once returned to normal conditions gametophytes resumed growth or maturation within one month (Dieck, 1993).

There is no information on the effect of smothering on the other characterizing species, *Gracilaria gracilis* and *Ceramium virgatum*. *Gracilaria gracilis* and *Ceramium virgatum* reach a maximum of 60 cm and 51 cm respectively. Mature organisms are unlikely to be negatively affected by 5 cm of sediment deposits. However, juveniles are more likely to die due to sediment deposition.

IR.LIR.K.Sar is recorded in moderately strong tidal streams (≤1.5 m/sec) (Connor *et al.*, 2004). In tidally exposed biotopes deposited sediment is unlikely to remain for more than a few tidal cycles (due to water flow or wave action). In sheltered biotopes deposited sediment could remain but are unlikely to remain for longer than a year.

Sensitivity assessment. Deposition of 5 cm of fine material in a single incident is unlikely to result in significant mortality before sediments are removed by current and wave action. Burial will lower survival and germination rates of algal spores and may lead to some mortality of spores and early stages of foliose red algae. Adults are likely to be more resistant to this pressure at the benchmark. However, there is very little evidence to support the assessment. Although there may be some mortality of some species in the biotope the characterizing species are unlikely to experience mortality due to this pressure at the benchmark. Resistance is assessed as ‘High’ based on the likely rapid removal of the majority of smothering sediments within a couple of tidal cycles, resistance will be lower where sediment remains in place for longer. Resilience is assessed also assessed as ‘High’. Overall the biotope is considered to be ‘Not Sensitive’ at the level of the benchmark.

Smothering and siltation rate changes (heavy)	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence was found to assess this pressure at the benchmark. A deposit at the pressure benchmark would cover all species with a thick layer of fine materials. Species associated with this biotope such as limpets and littorinids would not be able to escape and would likely suffer mortality (see evidence for light siltation). Sensitivity to this pressure will be mediated by site-specific hydrodynamic conditions and the footprint of the impact. Where a large area is covered sediments may be shifted by water currents rather than removed. Mortality will depend on the duration of smothering; where wave action rapidly mobilises and removes fine sediments, survival of the characterizing and associated species may be much greater.

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

Shading of this biotope (e.g. by the construction of pontoons or jetties) would limit the availability of light, and have similar effects to that of increased turbidity (see above) in the affected area. *Sargassum muticum* and kelp species are likely to be excluded, while shade tolerant red algae may increase in abundance, or be reduced to encrusting corallines or faunal turfs depending on the degree of shading.

Sensitivity assessment. There is so little evidence upon which to base this assessment. The sensitivity assessment has been given as 'No evidence'.

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 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 therefore considered not relevant to this biotope.

Introduction or spread of invasive non-indigenous species	Low Q: Medium A: Medium C: Medium	Very Low Q: High A: High C: Medium	High Q: Medium A: Medium C: Medium

Undaria pinnatifida has received a large amount of research attention as a major INIS which could out-compete native UK kelp habitats (Farrell & Fletcher, 2006; Thompson & Schiel, 2012; Brodie *et al.*, 2014; Heiser *et al.*, 2014). *Undaria pinnatifida* was first recorded in the UK, Hamble Estuary, in June 1994 (Fletcher & Manfredi, 1995) and has since spread to a number of British ports. *Undaria pinnatifida* is an annual species, sporophytes appear in Autumn and grow rapidly throughout winter and spring during which they can reach a length of 1.65 m (Birkett et al., 1998bb). Farrell & Fletcher (2006) suggested that native short lived species that occupy similar ecological niches to *Undaria pinnatifida*, such as *Saccharina latissima* or *Chorda filum*, are likely to be worst affected and out-competed by *Undaria pinnatifida.* Where present, an abundance of *Undaria pinnatifida* has corresponded to a decline in *Saccharina lattisima* (Farrel & Fletcher, 2006) and *Laminaria hyperborea* (Hieser *et al.*, 2014).

In New Zealand, Thompson & Schiel (2012) observed that native fucoids could out-compete *Undaria pinnatifida* and re-dominate the substratum. However, Thompson & Schiel (2012) suggested the fucoid recovery was partially due to an annual *Undaria pinnatifida* die back, which as noted by Heiser *et al.*, (2014) does not occur in Plymouth sound, UK. *Undaria pinnatifida* was successfully eradicated on a sunken ship in Clatham Islands, New Zealand, by applying a heat treatment of 70 °C (Wotton *et al.*, 2004). However, numerous other eradication attempts have failed, and as noted by Fletcher & Farrell, (1999) once established *Undaria pinnatifida* resists most attempts of long-term removal. The biotope is unlikely to fully recover until *Undaria pinnatifida* is fully removed from the habitat, which as stated above is unlikely to occur.

Sensitivity assessment. If *Undaria pinnatifida*, a species which has been identified as a significant risk to this biotope, were to invade resistance to the pressure is considered 'Low', and resilience 'Very Low'. The sensitivity of this biotope to this pressure is assessed as 'High'. It should be noted that due to the nature of this pressure, new INIS are constantly introduced. For this reason evidence should be frequently revisited. Replacement of red algal turfs by other similar species may lead to some subtle effects on local ecology but at low abundances the biotope would still be recognisable from the description.

Introduction of microbial pathogens	Medium Q: Medium A: Medium C: Medium	High Q: High A: High C: Medium	Low Q: Medium A: Medium C: Medium

Laminarians may be infected by the microscopic brown alga *Streblonema aecidioides*. Infected algae show symptoms of Streblonema disease, i.e. alterations of the blade and stipe ranging from dark spots to heavy deformations and completely crippled thalli. Infection can reduce growth rates of host algae (Peters & Scaffelke, 1996). The marine fungi *Eurychasma spp* can also infect early life stages of *Laminarians* however the effects of infection are unknown (Müller *et al.*, 1999).

Gracilaria gracilis is also susceptible to bacterial pathogens. Farmed and natural populations of *Gracilaria gracilis* within Saldanha Bay, South Africa have experienced a number of large die-offs since 1989. During these die backs thalli have become bleached and/or rotten as a result of *Pseudoalteromonas gracilis* B9 infection (Schroeder *et al.*, 2003).

No information can be found on the effect of microbial pathogens on *Sargassum muticum* or *Ceramium virgatum.*

Sensitivity assessment. Resistance to the pressure at the benchmark is considered 'Medium' based on the potential susceptibility of two of the characterizing species. However, resilience is still assessed as 'High'. The sensitivity of this biotope to introduction of microbial pathogens is assessed as ‘Low’

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

The Seaweed Industry Association (www.seaweedindustry.com) report that *Sargassum muticum* is often gathered from the shore or floating mats to be used as fertilizer or compost and that many coastal populations make use of *Sargassum muticum* as food source. There has been recent commercial interest in *Saccharina lattisma* as a consumable called “sea vegetables” (Birkett et al., 1998b). However, *Saccharina lattissima* sporophytes are typically matured on ropes (Handå et al., 2013) and not directly extracted from the seabed, as with *Laminaria hyperborea* (Christie *et al.*, 1998). *Gracilaria gracilis* is commercially harvested for the production of agar (Marinho-Soriano, 2001). Over-exploitation of *Gracilaria gracilis* has, in some regions, resulted in depletion of natural stocks. As a result, various culture techniques have been developed to increase yields. Natural stocks are still harvested but in some instances has been restricted to gathering beach cast (Martín *et al.*, 2011). There is no evidence to suggest that *Ceramium virgatum* is collected for either commercial or personal use.

Sensitivity assessment. A number of key species are harvested, this may alter the character of the biotope resulting in reclassification. The removal of *Sargassum muticum* or *Saccharina latissima* will lead to a change in biotope, although these changes may be short-lived where recovery occurs from holdfasts. The harvest of *Gracilaria gracilis* and *Ceramium virgatum* would lead to a change in the nature of the biotope. Biotope resistance is assessed as ‘Low’ as the species are readily harvested and removed, and resilience is assessed as ‘High’, therefore, sensitivity is judged to be ‘Low’.

Removal of non-target species	Low Q: Medium A: Medium C: Medium	High Q: High A: High C: Medium	Low 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 ceranoides* is a 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 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 ‘High’, with recovery only being able to begin when the harvesting pressure is removed altogether. This gives an overall sensitivity score of ‘Low’.

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