Saccorhiza polyschides and other opportunistic kelps on disturbed sublittoral fringe rock

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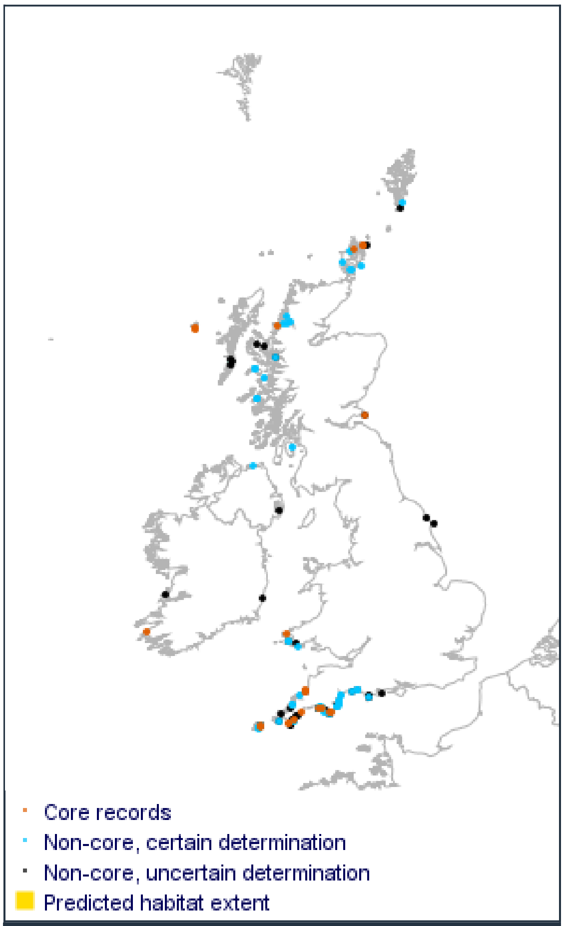

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Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Thomas Stamp **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A3.121	*Saccorhiza polyschides* and other opportunistic kelps on disturbed upper infralittoral rock
JNCC 2015	IR.HIR.KSed.Sac	*Saccorhiza polyschides* and other opportunistic kelps on disturbed sublittoral fringe rock
JNCC 2004	IR.HIR.KSed.Sac	*Saccorhiza polyschides* and other opportunistic kelps on disturbed sublittoral fringe rock
1997 Biotope	IR.MIR.SedK.Sac	*Saccorhiza polyschides* and other opportunistic kelps on disturbed upper infralittoral rock

Description

Exposed low-lying reefs in the sublittoral fringe or upper infralittoral (generally above 5m depth), mainly in the southwest and west, dominated by the kelp *Saccorhiza polyschides*. This opportunistic colonizer replaces *Laminaria digitata* or *Laminaria hyperborea* as the dominant kelp, following 'disturbance' of the canopy. This may be the result of storms, when loose sediment and even cobbles or boulders are mobilised, scouring most seaweeds and animals from the surrounding rock. As *Saccorhiza polyschides* is essentially a summer annual (occasionally it lasts into a second year), it is also particularly common close to rock/sand interfaces which become too scoured during winter months to prevent the longer-living kelps from surviving. As a result of the transient nature of this biotope, its composition is varied; it may contain several other kelp species, including *Laminaria digitata*, *Saccharina latissima* and *Alaria esculenta*, at varying abundances. *Laminaria* spp. sporelings can also be a prominent feature of the site. Beneath the kelp, (scour-tolerant) red seaweeds including *Corallina officinalis*, *Kallymenia reniformis*, *Plocamium cartilagineum*, *Chondrus crispus*, *Dilsea carnosa* and encrusting coralline algae are often present. Foliose red seaweeds such as *Callophyllis laciniata*, *Cryptopleura ramosa* and *Palmaria palmata* also occur in this biotope. *P. palmata* and *Delesseria sanguinea* often occur as epiphytes on the stipes of *L. hyperborea*, when it is present. The foliose green seaweed *Ulva* spp. is fast to colonise newly cleared areas of rock and is often present along with the foliose brown seaweed *Dictyota dichotoma*. Due to the disturbed nature of this biotope, fauna are generally sparse, being confined to encrusting bryozoans and/or sponges, such as *Halichondria panicea* and the gastropod *Gibbula cineraria*. (Information from Connor *et al*., 2004).

Depth range

Lower shore, 0-5 m

Additional information

-

Listed By

- none -

Further information sources

Search on:

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, and IR.HIR.KSed.XKScrR are within the sediment affected or disturbed kelp and seaweed communities (IR.HIR.KSed) habitat complex. As a result of nearby sediment scouring or seasonally unstable infralittoral rock, opportunistic brown seaweeds; *Desmarestia spp.*, *Saccharina latissima* (formerly *Laminaria saccharina*) & *Saccorhiza polyschides* can proliferate. *Laminaria hyperborea* can be present within the community but does not become fully established, due to the disturbed nature of IR.HIR.KSed biotopes and sporophytes do not typically survive beyond a couple of seasons (Connor *et al.*, 2004).

The understory community can vary locally and is characterized by scour tolerant or ephemeral red seaweeds, such as *Corallina officinalis*, *Plocamium cartilagineum*, *Chondrus crispus*, *Dilsea carnosa*, and encrusting coralline algae. Faunal diversity and abundance are also generally low and typically limited to encrusting bryozoans and/or sponges. In areas sheltered from sediment scour or sediment, the biological diversity increases and *Laminaria hyperborea* becomes more dominant (Connor *et al.*, 2004).

In undertaking this assessment of sensitivity, an account is taken of knowledge of the biology of all characterizing species/taxa in the biotope. However, 'indicative species' are particularly important in undertaking the assessment as they structure and characterize the biotope. . For this sensitivity assessment the opportunistic brown seaweeds; *Desmarestia spp.*, *Saccharina latissima* and *Saccorhiza polyschides* are the primary foci of research. Examples of important species groups are mentioned where appropriate.

Resilience and recovery rates of habitat

Desmarestia spp., *Saccorhiza polyschides* & *Saccharina latissima* (formerly *Laminaria saccharina*) are opportunistic seaweeds which have relatively fast growth rates when compared to other perennial species, and dominate areas subject to recurrent disturbance or in areas where environmental conditions limit competition from *Laminaria hyperborea*.

Desmarestia spp. and *Saccharina latissima* are widely distributed in the north Atlantic from Svalbard to Portugal (Birket *et al.*, 1998; Connor *et al.*, 2004; Bekby & Moy 2011; Moy & Christie 2012), *Saccorhiza polyschides* from mid-Norway to Ghana, and present in parts of the Mediterranean (Lüning, 1990). *Desmarestia spp.* are a genus of annual seaweeds with a life expectancy of ca 8 months (Gagnon *et al.*, 2013). *Saccorhiza polyschides* is also termed as an annual and can reach maturity in 8 months, although sporophytes that do not reach maturity within the first growth season can overwinter and have a life expectancy of 16 months (Birket *et al.*, 1998; Fernández, 2011), during which time fronds can reach a length of 3-4m (D. Birkett, pers. obs in Birkett *et al.*, 1998b). *Saccharina lattisima* is a perennial kelp which can reach maturity in 15-20 months and has a life expectancy of 2-4 years.

Demarestiales and *Laminariales* have heteromorphic life strategies (Edwards, 1998). Mature sporophytes broadcast zoospores which settle onto the rock and develop into gametophytes, following fertilization these germinate into juvenile sporophytes. Kelp zoospores are expected to have a large dispersal range, but zoospore density and the rate of successful fertilization decreases exponentially with distance from the parental source (Fredriksen *et al.*, 1995). Hence, recruitment following disturbance can be influenced by the proximity of mature kelp beds producing viable zoospores to the disturbed area (Kain, 1979; Fredriksen *et al*., 1995). The exact mechanism of zoospore release in *Desmarestia spp.* is unknown but it may occur during a period of senescence (mentioned below)(Gagnon *et al*., 2013). *Saccorhiza polyschides* & *Saccharina latissima* both release zoospores from reproductive structures known as sori, located centrally on the blade (*Saccharina latissima* & *Saccorhiza polyschides*), stipe and holdfast/bulb (*Saccorhiza polyschides*).

Desmarestia spp. and *Saccorhiza polyschides* sporophytes appear from March-April, beyond which is a period of rapid growth. *Desmarestia spp.* reach their maximum size by September (ca 60 cm). Sporophytes then begin to decay (known as the senescence period) and typically die off by late October (Edwards, 1998; Gagnon *et al*., 2013). *Saccorhiza polyschides* sporophytes are capable of growing ≤6.2 cm per week (Norton, 1970; Fernández, 2011) and reaching a maximum length of 3-4 m (Birket *et al*., 1998; Fernández, 2011). The onset of maturity triggers a phase of senescence in which growth ceases and the frond erodes, resulting in the blade becoming progressively smaller and by winter the entire sporophyte can disappear (Birkett *et al*., 1998b; Fernández, 2011). *Saccharina latissima* recruits appear in late winter early spring beyond which is a period of rapid growth, in late summer and autumn growth rates slow and spores are released from autumn to winter (Parke, 1948; Lüning, 1979; Birkett *et al*., 1998b). The overall length of the sporophyte may not change during the growing season due to marginal erosion because the 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*., 1998b).

Light intensity and temperature are key development triggers for *Desmarestia spp.* (Edwards, 1998). However, other factors, such as nutrient availability and the abundance of coralline algae may also influence recruitment (Edwards, 1998). *Desmarestia spp.* sporophytes are typically rare in areas with established kelp canopies but have rapid growth in response to increases in light intensity and changes from red-blue wavelengths, indicating an opportunistic life history when kelp canopies are thinned/cleared (Chapman & Burrows, 1970; Müller & Lüthe, 1981; Edwards, 1998). Edwards (1998) found *Desmarestia ligulata* recruitment was cued by seasonal changes in day length but the recruitment was increased in areas where kelp canopies were cleared. In kelp clearances, *Desmarestia ligulata* was capable of rapidly achieving ca 50-90% coverage whereas abundance remained low under kelp canopies at ca <10% coverage. Field and experimental observations of *Desmarestia aculeata* in Port Erin, UK have found that light intensity is a principal factor in the development of gametophyte and sporophyte development, and hence recruitment processes (Kain, 1966; Chapman & Burrows, 1970). In winter, a season in which *Desmarestia aculeata* sporophytes are absent from marine habitats, Kain (1966) collected visually bare stones from Port Erin, Isle of Man. When the stones were exposed to high illumination (2,780 lux) for 18 hours a day and maintained at 5°C, *Desmarestia aculeata* sporophytes grew successfully. Demonstrating that increases in light intensity are an important trigger for *Desmarestia spp.* growth and recruitment.

Saccharina lattisma can be quite ephemeral in nature and appear early in algal succession. For example, Lienaas & Christie (1996) removed *Strongylocentrotus droebachiensis* from “Urchin Barrens” and observed a succession effect. The substratum was colonized initially by filamentous algae, but after a couple of weeks, these were out-competed and the habitat dominated by *Saccharina latissima* which themselves were 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. However, *Saccharina lattisma* was an early colonizer, but within 2 years of clearance the blocks were dominated by *Laminaria hyperborea*.

Resilience assessment. All three canopy forming seaweeds that characterize IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, and IR.HIR.KSed.XKScrR are opportunistic species with rapid colonization and growth rates. Both *Desmarestia spp.* & *Saccorhiza polyschides* are capable of reaching maturity within a year. *Saccharina latissima* has been shown to be an early colonizer within macroalgal succession, appearing within 2 weeks of clearance. Therefore, resilience has been assessed as '**High**'.

Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	None Q: High A: High C: High	High Q: High A: High C: High	Medium Q: High A: High C: High

Saccorhiza polyschides has a wide geographic distribution and can tolerate a wide range of temperatures. Sporophyte growth can occur from 3-24°C and gametophyte development from 5-25°C (Norton, 1977). Fernández (2011) however suggested that summer temperatures of >20°C sustained for longer than a period of 30 days may inhibit development and recruitment.

Desmarestiales are unusual in that they produce and accumulate sulphuric acid within intracellular vacuoles (McClintock *et al.*, 1982; Connor *et al.*, 2004; Gagnon *et al.*, 2013). Seasonal increases in temperatures limit the ability of the storage vacuoles to contain the acid and release it into the surrounding environment. The continued release of acid results in progressive decolourisation, tissue degradation and mortality of *Desmarestia* sporophytes (Gagnon *et al.*, 2013). Gagnon *et al.* (2013) exposed *Desmarestia viridis* samples during 30 hour salinity and temperature treatments. At 29 and 32psu (MNCR: Full Salinity scale), *Desmarestia viridis* was able to tolerant to changes in temperature from 5-12°C, but exposure to 18°C was lethal to sporophytes.

The geographic distribution of *Saccharina latissima* is determined by the 19-20°C isotherm (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 significant regional variation in its acclimation to temperature change. For example, 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.

Anderson *et al.* (2011) transplanted *Saccharina latissima* from the Skagerrak region, Norway an area which has experienced a 50.7-83% *Saccharina latissima* decline since 2002 (Moy & Christie, 2012). Since 1960-2009 sea surface temperatures in the region have regularly exceeded 20°C (the temperature at which *Saccharina latissima* growth is severely inhibited) and so has the number of days which remain above 20°C. Anderson *et al.* (2011) hypothesised that high sea temperatures were indirectly linked to *Saccharina latissima* deforestation in the region, causing high epiphytic loading of sporophyte fronds (estimated to cover 80 & 100% of transplanted sporophytes). High sea temperatures have been linked to the slow growth of *Saccharina latissima* which is likely to decrease the photosynthetic ability of, and increase the vulnerability of *Saccharina latissima* to epiphytic loading, bacterial and viral attacks (Anderson *et al.*, 2011).

Desmarestiales are sensitive to high temperatures and low salinities (Gagnon *et al.*, 2013).

Desmarestiales are unusual in that they produce and accumulate sulphuric acid (H_2SO_4) within intracellular vacuoles (McClintock *et al.*, 1982; Connor *et al.*, 2004; Gagnon *et al.*, 2013). Increases in temperatures and low salinities limit the ability of the storage vacuoles to contain the acid and release it into the surrounding environment. The continued release of acid results in progressive decolourisation, tissue degradation and mortality of *Desmarestia* sporophytes (Gagnon *et al.*, 2013). Gagnon *et al.* (2013) exposed *Desmarestia viridis* samples during 30 hour salinity and temperature treatments, observing at 29 and 32 psu (MNCR: Full Salinity scale) *Desmarestia viridis* was tolerant to changes in temperature from 5-12°C, exposure to 18°C was lethal to sporophytes. Furthermore, sporophytes that had already begun the senescence phase were exposed to 10.8 ± 0.3°C and completely shed all tissue from the stipe and laterals within ca15 days, whereas those exposed to lower temperatures of 2.5± 0.1°C lasted ca30 days. Gagnon *et al.* (2013) also observed *Desmarestia spp*. degraded progressively in low salinity treatments of 26, 23 & 20psu (<20psu was not tested). Therefore indicating *Desmarestia spp.* are highly sensitive to both high temperature (12-18°C) and low salinities (<26 psu).

IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR are distributed throughout the UK (Connor *et al.*, 2004). Northern to southern Sea Surface Temperature (SST) ranges from 8-16°C in summer and 6-13°C in winter (Beszczynska-Möller & Dye, 2013)

Sensitivity assessment. Acute 5°C increases in temperature for a period of 1 month combined with high summer temperatures may exceed the threshold temperature of 18-20°C in biotopes within the south of the UK, which would likely cause mortality of *Desmarestia spp.*, and severely limit *Saccorhiza polyschides* recruitment & *Saccharina latissima* sporophyte growth. A 2°C increase in temperature for a period of 1 year would likely result in the exceeding an 18°C temperature threshold in the south of the UK. This temperature threshold would likely result in high mortality of *Desmarestia spp. Saccharina latissima* that is not acclimated to similar temperatures may also experience high and rapid mortality. Resistance has been assessed as '**None**', Resilience as '**High**'. Sensitivity has been assessed as '**Medium**'.

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

Demarestia spp. are a cold water adapted genus with a polar distribution, which can grow abundantly in water temperatures of ca 0.5°C (Gagnon *et al.*, 2013). *Saccharina latissima* is also widely spread throughout the Arctic and 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). These temperatures are well below that considered within this pressure benchmark. *Demarestia spp. Saccharina latissima* are therefore unlikely to be adversely affected by a decrease in temperature at the benchmark level.

Saccorhiza polyschides sporophyte growth can occur within a range from 3-24°C and gametophyte development within a range of 5-25°C (Norton, 1977). Norton (1977) experimentally observed that at 3-5°C gametophytes failed to develop into viable sporophytes. This temperature range also corresponds with *Saccorhiza polyschides* northern range edge (ca 65° 35'N, mid-Norway), above which the average winter temperature is ≤4°C (U.S. Navy, 1958).

IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, and IR.HIR.KSed.XKScrR are distributed throughout the UK (Connor *et al.*, 2004). Northern to southern Sea Surface Temperature (SST) ranges from 8-16°C in summer and 6-13°C in winter (Beszczynska-Möller &

Dye, 2013)

Sensitivity assessment. Both long-term and acute temperature decrease 2-5°C combined with low winter temperatures could negatively affect *Saccorhiza polyschides* recruitment in biotopes located in the north of the UK. Resistance has been assessed as '**Low**', resilience as '**High**'. Sensitivity has been assessed as '**Low**'.

Salinity increase (local)

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

Lüning (1990) suggest that kelps are stenohaline, their general tolerance to salinity as a phenotypic group covering 16-50 PSU over a 24 hr period. Optimal growth probably occurring between 30-35 PSU (MNCR category-Full Salinity) and growth rates are likely to be affected by periodic salinity stress. Birkett *et al.* (1998) suggested that long-term increases in salinity may affect kelp growth and may result in loss of affected kelp, and, therefore, loss of the biotope.

Karsten (2007) tested the photosynthetic ability of *Saccharina latissima* under acute 2 & 5 day exposure to salinity treatments ranging from 5-60 psu. A control experiment was also carried at 34 PSU (Salinity under normal marine conditions). Between 25-55 PSU *Saccharina latissima* had a high photosynthetic ability at >80% of the control levels.

Sensitivity assessment. The evidence suggests that *Saccharina latissima* can tolerate exposure to hypersaline conditions of ≥40‰ (MNCR full salinity range=30-40‰). Optimal salinities for other kelps are assumed to be 30-35 PSU. Hypersaline tolerances for *Desmarestia spp.* are unknown. Resistance has been assessed as '**Low**', resilience as '**High**'. The sensitivity of this biotope to an increase in salinity has been assessed as '**Low**'.

Salinity decrease (local)

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

Saccorhiza polyschides is affected by low salinities. Norton & South (1969) observed at ≤9‰ zoospores often burst due to internal osmotic pressure and none developed. At ≤25‰, only 25% of gametophytes germinated and at ≤20‰ sporophyte growth was often retarded. At ≤35‰, 76% of gametophytes germinated. These results demonstrate that at ≤25‰ recruitment may be inhibited and sporophyte growth retarded.

Karsten (2007) tested the photosynthetic ability of *Saccharina latissima* under acute 2 & 5 day exposure to salinity treatments ranging from 5-60 psu. A control experiment was also carried at 34 psu (Salinity under normal marine conditions). Between 25-55 psu *Saccharina latissima* had a high photosynthetic ability at >80% of the control levels. Hyposaline treatment of 10-20 psu led to a gradual decline of photosynthetic ability. After 2 days at 5 psu *Saccharina latissima* s photosynthetic ability was ~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 *Saccharina latissima* of the UK may be able to acclimate to salinity changes more effectively and quicker.

Gagnon *et al.* (2013) observed *Desmarestia spp.* sporophytes degraded progressively in low salinity treatments of 26, 23 & 20 psu (<20 psu was not tested). *Desmarestia spp.* accumulate sulphuric acid throughout the growth season which is released when the sporophyte becomes stressed under high temperatures or low salinities. Acid release causes progressive degradation of the sporophyte and mortality. Gagnon *et al.* (2013) exposed *Desmarestia viridis* samples during 30 hour salinity and temperature treatments, observing *Desmarestia spp.* degraded progressively in low salinity treatments of 26, 23 & 20psu (<20psu was not tested).

Sensitivity assessment. A decrease in one MNCR salinity scale from "Full Salinity" (30-40psu) to "Reduced Salinity" (18-30 psu) may result in mortality of *Desmarestia* spp. inhibit *Saccorhiza polyschides* recruitment and inhibit *Saccharina latissima* photosynthesis. Resistance has been assessed as '**Low**' resilience as '**High**'. The sensitivity of this biotope to a decrease in salinity has been assessed as '**Low**'.

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

Peteiro & Freire (2013) measured *Saccharina latissima* growth from 2 sites, the 1st had maximal water velocities of 0.3 m/sec and the 2nd 0.1 m/sec. At site 1 *Saccharina latissima* had significantly larger biomass than at site 2 (16kg /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 is reduced in moderately strong tidal streams (≤1m/sec) when compared to weak tidal streams (<0.5m/sec).

IR.HIR.KSed.SlatSac can be found from very strong (>3m/sec) to very weak tidal streams. IR.HIR.KSed.Sac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR can be found from moderately strong (0.5-1.5m/sec) to weak tidal streams (0.5m/sec). An increase in tidal flow may increase local sediment mobility and scour, potentially increasing dislodgment of kelps (Birket *et al.*, 1998) and *Desmarestia spp.*

Sensitivity assessment. Due to the range of tidal streams which these biotopes can be found a change of 0.1m/s to 0.2m/s, is not likely to dramatically affect biotope structure. Resistance has been assessed as '**High**', resilience as '**High**'. Sensitivity has been assessed as '**Not Sensitive**'.

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

IR.HIR.KSed.Sac and IR.HIR.KSed.XKScr can be found on the sublittoral fringe rock so that the characterizing species would be exposed during low spring tides. IR.HIR.KSed.SlatSac and IR.HIR.KSed.DesFilR are found in the infralittoral and as such would only be exposed on extreme low tides (Connor *et al.*, 2004).

An increase in emergence will result in an increased risk of desiccation and mortality of the dominant seaweeds (*Desmarestia spp.*, *Saccorhiza polyschides*, *Saccharina latissima*). Removal of canopy forming seaweeds has also been shown to increase desiccation and mortality of the understory macroalgae (Hawkins & Harkin, 1985). Providing that suitable substrata are present, the biotope is likely to re-establish further down the shore within a similar emergence regime to that which existed previously. A decrease in emergence could, however, result in the extension of the biotope further up the shore, although its lower limit is still probably controlled by light penetration, competition and grazing so that entire extent of the biotope may move.

Sensitivity assessment. Resistance has been assessed as '**Low**'. Resilience as '**High**'. The sensitivity of this biotope to a change in emergence is considered as '**Low**'.

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

IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR are recorded from extremely exposed to wave sheltered sites and characterized by rapidly colonizing macro-algae (Connor *et al*., 2004). As a result, of rapid recovery, the community is relatively resistant to disturbance when compared to other kelp biotopes (e.g. IR.HIR.Kfar.LhypR). Birkett *et al*., (1998) suggest that *Saccharina latissima* and *Saccorhiza polyschides* are rarely present in areas of wave exposure, where they may be spatially out-competed by *Laminaria hyperborea*. However, the seasonally unstable nature of the substrata or periodic sediment scour within theses biotopes is likely to inhibit the growth of long lived species, such as *Laminaria hyperborea* and allow opportunistic species such as *Demarestia spp*., *Saccharina latissima* and *Saccorhiza polyschides* to proliferate. An increase in local wave height may increase local sediment mobility and scour, potentially increasing dislodgment of kelps (Birket *et al*., 1998) and *Desmarestia spp*.. The biotopes may appear sparse after winter storms but the biotope recovers again due to rapid colonization and growth by the dominant kelps and *Desmarestia spp.*

Sensitivity assessment. The biotope is dominated by rapid colonizing species that tolerate or rapidly recover from scour, siltation and burial. They occur across a broad wave exposure range, and, therefore, a change 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**', 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

Bryan (1984) suggested that the general order for heavy metal toxicity in seaweeds is: Organic Hg > inorganic Hg > Cu > Ag > Zn > Cd > Pb. Cole *et al.* (1999) reported that Hg was very toxic to macrophytes. Similarly, Hopkin & Kain (1978) demonstrated sub-lethal effects of heavy metals on kelp gametophytes and sporophytes, including reduced growth and respiration. Sheppard *et al.* (1980) noted that increasing levels of heavy metal contamination along the west coast of Britain reduced species number and richness in holdfast fauna, except for suspension feeders which became increasingly dominant. Gastropods may be relatively tolerant of heavy metal pollution (Bryan, 1984). Although macroalgae species may not be killed, except by high levels of contamination, reduced growth rates may impair the ability of the biotope to recover from other environmental disturbances. Thompson & Burrows (1984) observed the growth of *Saccharina latissima* sporophyte growth was significantly inhibited at 50 µg Cu /l, 1000 µg Zn/l and 50 µg Hg/l. Zoospores were found to be more intolerant and significant reductions in survival rates were observed at 25 µg Cu/l, 1000 µg Zn/l and 5 µg/l.

However, this pressure is **Not assessed**.

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

IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR, are predominantly recorded in the sub-tidal (<0 m). These habitats are therefore not likely to come into contact with freshly released oil but only to sinking emulsified oil and oil adsorbed onto particles (Birket *et al*., 1998). The mucilaginous slime layer coating of laminarians may protect them from smothering by oil. Hydrocarbons in solution reduce photosynthesis and may be algicidal. However, Holt *et al.* (1995) reported that oil spills in the USA and from the *Torrey Canyon* had little effect on kelp forests. Similarly, surveys of subtidal communities at a number sites between 1-22.5m below chart datum showed no noticeable impacts of the *Sea Empress* oil spill and clean up (Rostron & Bunker, 1997). Laboratory studies of the effects of oil and dispersants on several red algae species, including *Delesseria sanguinea* (Grandy 1984; cited in Holt *et al*., 1995) concluded that they were all sensitive to oil/ dispersant mixtures, with little differences between adults, sporelings, diploid or haploid life stages.

However, this pressure is **Not assessed**.

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.

O'Brian & Dixon (1976) suggested that red algae were the most sensitive group of macrophytes to oil and dispersant contamination (see Smith, 1968). *Saccharina latissima* has also been found to be sensitive to antifouling compounds. Johansson (2009) exposed samples of *Saccharina latissima* to several antifouing compounds, observing chlorothalonil, DCOIT, dichlofluanid and tolylfluanid inhibited photosynthesis. Exposure to Chlorothalonil and tolylfluanid, was also found to continue inhibiting oxygen evolution after exposure had finished, and may cause irreversible damage.

Smith (1968) observed that epiphytic and benthic red algae were intolerant of dispersant or oil contamination during the Torrey Canyon oil spill; only the epiphytes *Crytopleura ramosa* and *Spermothamnion repens* and some tufts of *Jania rubens* survived together with *Osmundea pinnatifida*, *Gigartina pistillata* and *Phyllophora crispa* from the sublittoral fringe. *Delesseria sanguinea* was probably the most intolerant since it was damaged at depths of 6m (Smith, 1968). Holt *et al.*(1995) suggested that *Delesseria sanguinea* is probably generally sensitive of chemical contamination.

Radionuclide contamination	Not relevant (NR) 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: Medium A: High C: High	High Q: Medium A: High C: High	Not sensitive Q: Medium A: High C: High

Reduced oxygen concentrations can 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). However, in wave exposed, highly mixed, areas, the hypoxic conditions are likely to be transient.

Sensitivity Assessment. Reduced oxygen levels are likely to inhibit photosynthesis and respiration but not cause a loss of the macroalgae population directly. Resistance has been assessed as '**High**', Resilience as '**High**'. Sensitivity has been assessed as '**Not sensitive**' at the benchmark level.

Nutrient enrichment	Medium Q: Medium A: High C: High	High Q: High A: Medium C: High	Low Q: Medium A: Medium C: High

Conolly & Drew (1985) found that *Saccharina latissima* sporophytes plants at the most eutrophic site in a study on the east coast of Scotland where nutrient levels were 25% higher than ambient levels exhibited a high growth rate. However, Read *et al*. (1983) reported after removal of a major sewage pollution 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. Within 3 years of the experiment no significant effect was observed in the communities, however, 4-5 years into the experiment a shift occurred from perennials to ephemeral algae occurred. 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, and explain the disparity between the findings of Conolly & Drew (1985) & Read *et al*. (1983).

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) however also highlighted that macroalgal communities are relatively 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). Nutrient enrichment may also result in phytoplankton blooms that increase turbidity and, therefore, may negatively impact photosynthesis.

Sensitivity assessment. However, the biotope is assessed as '**Not sensitive**' at the pressure benchmark that assumes compliance with good status as defined by the WFD.

Organic enrichment	Medium Q: Medium A: High C: High	High Q: High A: Medium C: High	Low Q: Medium A: Medium C: High

Conolly & Drew (1985) found *Saccharina latissima* sporophytes had relatively higher growth rates close to a sewage outlet in St Andrews, UK when compared to other sites along the east coast of

Scotland. At St Andrews, nitrate levels were 20.22µM, which represents an approx 25% increase when compared to other comparable sites (approx 15.87 µM). Handå *et al.* (2013) also reported *Saccharina latissima* sporophytes grew approx 1% faster per day when in close proximity to Norwegian Salmon farms, where elevated ammonium can be readily absorbed. Read *et al.* (1983) reported after the installation of 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. Within 3 years of the experiment no significant effect was observed in the communities, however, 4-5 years into the experiment a shift occurred from perennials to ephemeral algae occurred. 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. Differences between the findings of the aforementioned studies are likely to be related to the level of organic enrichment, however, could also be time dependent.

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) however also highlighted that macroalgal communities are relatively 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). Organic enrichment may also result in phytoplankton blooms that increase turbidity and, therefore, may negatively impact photosynthesis.

Sensitivity assessment. Although short-term exposure (<4 years) to organic enrichment may not affect seaweeds directly, indirect effects such as turbidity may significantly affect photosynthesis. Therefore, resistance has been assessed as '**Medium**', resilience as '**High**' and sensitivity as '**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 rock substrata were replaced with sedimentary substrata this would represent a fundamental change in habitat type, which *Saccharina latissima*, *Saccorhiza polyschides* and *Desmarestia spp.* would not be able to tolerate. The biotope would be lost.

Sensitivity assessment. Resistance to the pressure is considered '**None**', and resilience '**Very Low**'.

The sensitivity of this biotope to change from sedimentary or soft rock substrata to hard rock or artificial substrata or vice-versa is assessed as '**High**'.

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

Not relevant

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

Not relevant on hard rock substrata.

Abrasion/disturbance of the surface of the substratum or seabed	None Q: Low A: NR C: NR	High Q: High A: High C: High	Medium Q: Low A: NR C: NR

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 rock substrata and cause high mortality in the resident community.

However, the characteristic species within IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR have rapid growth rates and are distinctive of 'disturbed' areas. Information on from experimental clearances is summarised under resilience above.

Sensitivity assessment. Resistance has been assessed as '**None**', Resilience as '**High**'. Sensitivity has been assessed as '**Medium**'.

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

Not relevant, please refer to pressure "Abrasion/disturbance of the substratum on the surface of the seabed".

Changes in suspended solids (water clarity)	Low Q: Medium A: Medium C: Medium	High Q: High A: High C: High	Low Q: Medium A: Medium C: Medium

Suspended Particle Matter (SPM) concentration has a linear relationship with subsurface light attenuation (Kd) (Devlin *et al.*, 1998). Light penetration influences the maximum depth at which kelp species 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 6-7m 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*., 1998b). Limited information is available on which to assess the effect of a decrease in water clarity on Laminariales 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). *Demarestia* spp. recruitment has also been found highly affected by light attenuation and frequency, typically rare (ca <10% coverage (Edwards, 1998) beneath kelp canopies where light levels can be 1-5% of surface irradiance (Kitching, 1941).

A decrease in water clarity as a result of mobilised sediments may also increase sediment scour of biotopes within close proximity. However, the characterizing species within IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR have rapid growth and colonisation rates are as such relatively resilient to sediment scouring.

Sensitivity assessment. An increase in water clarity from clear to intermediate (10-100 mg/l) represent a change in light attenuation of ca 0.67-6.7 Kd/m and is likely to result in a greater than 50% reduction in photosynthesis of *Laminaria* spp. Resistance to this pressure is defined as '**Low**' as the biotope is typical of sediment affected habitats. Resilience to this pressure is defined as '**High**' and this biotope is regarded as having a sensitivity of '**Low**'.

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

Smothering by sediment e.g. 5 cm material during a discrete event is unlikely to damage *Saccharina latissima*, *Saccorhiza polyschides*, and *Desmarestia spp*. sporophytes but may provide a physical barrier to zoospore settlement and, therefore, 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 and would probably survive smothering by a discrete event and once returned to normal conditions gametophytes resumed growth or maturation within 1 month (Dieck, 1993). *Saccorhiza polyschides* zoospores successfully developed after 180 days of darkness (Norton, 1977). Intolerance to this factor is likely to be higher during the peak periods of sporulation and/or spore settlement.

IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR are found from extreme wave exposed-sheltered sites (Connor *et al*., 2004). In wave 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 and the effects of deposition could be longer lasting.

Sensitivity assessment. Resistance has been assessed as '**High**', resilience as '**High**' and sensitivity as '**Not Sensitive**'.

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

Smothering by sediment e.g. 30 cm material during a discrete event is unlikely to damage *Saccharina latissima*, *Saccorhiza polyschides*, and *Desmarestia spp*. sporophytes but may provide a physical barrier to zoospore settlement and therefore negatively impact on recruitment processes (Moy & Christie, 2012). The volume of sediment may also inundate juvenile sporophytes. Given the short life expectancy of *Saccharina latissima* (2-4 years; Parke, 1948), self-sustaining populations are likely to be dependent on annual recruitment (Moy & Christie, 2012). Given the microscopic size of the gametophyte, 30 cm of sediment could be expected to significantly inhibit growth. Laboratory studies showed that kelp and gametophytes can survive in darkness for between 6-16 months at 8°C and would probably survive smothering by a discrete event and once returned to normal conditions gametophytes resumed growth or maturation within 1 month (Dieck, 1993). *Saccorhiza polyschides* zoospores, specifically, successfully developed after 180 days of darkness (Norton, 1977). Intolerance to this factor is likely to be higher during the peak periods of sporulation and/or spore settlement.

IR.HIR.KSed.XKScrR is subject to periodic burial from surrounding sediments, however, IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR are recorded from extreme wave exposed-sheltered sites (Connor *et al*., 2004) and, therefore, the effects of burial are likely to be mediated. In highly wave 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, the high volume of deposited sediment could remain and the effects could be longer lasting. However, these biotopes are periodically disturbed by winter storms or sediment scour therefore deposited sediments are unlikely to remain for a full season.

Sensitivity assessment. Resistance has been assessed as '**Medium**', resilience as '**High**'. Sensitivity has been assessed as '**Low**'.

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

Not assessed.

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

Not relevant

Introduction of light or shading	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR

There is no evidence to suggest that anthropogenic light sources would affect *Saccharina latissima*, *Saccorhiza polyschides*, and *Desmarestia spp*. Shading of the biotope (e.g. by the construction of a pontoon, pier etc) could adversely affect the biotope in areas where the water clarity is also low, and tip the balance to shade tolerant species, resulting in the loss of the biotope directly within the shaded area, or a reduction in seaweed abundance.

Sensitivity assessment. Resistance is probably '**Low**', with a '**Medium**' resilience and a sensitivity of '**Medium**', albeit with 'low' confidence due to the lack of direct 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 the dispersal of spores. But spore 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. Collision from grounding vessels is addressed under abrasion above.

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

No evidence regarding the genetic modification or effects of translocation of native kelp populations was found.

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

Undaria pinnatifida has received a large amount of research attention as a major Invasive Non-Indigenous Species (INIS) which could out-compete native UK kelp habitats (see Farrell & Fletcher, 2006; Thompson & Schiel, 2012, Brodie *et al.*, 2014; Hieser *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 1.65m (Birket *et al.*, 1998). Farrell & Fletcher (2006) suggested that native short lived species that occupy similar ecological niches to *Undaria pinnatifida*, such as *Saccharina latissima*, *Saccorhiza polyschides* or *Desmarestia spp.*, are likely to be worst affected and out-competed by *Undaria pinnatifida*. Where present, an abundance of *Undaria pinnatifida* corresponded to a decline in *Saccharina latissima* (Farrel & Fletcher, 2006) and *Laminaria hyperborea* (Hieser *et al.*, 2014). Furthermore, disturbance has been found a significant pathway for the establishment of *Undaria pinnatifida* (Valentine & Johnson, 2003). Therefore, periodic disturbance within this biotope could facilitate the establishment of *Undaria pinnatifida*.

In New Zealand, Thompson & Schiel (2012) observed that native fucoids could out-compete

U.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 at 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. Resistance to the pressure is considered '**Low**', and resilience '**Very low**'. The sensitivity of this biotope to the introduction of microbial pathogens is assessed as '**High**'.

Introduction of microbial pathogens	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

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 and *Desmarestia viridis*, however, the effects of infection are unknown (Müller *et al*., 1999).

Sensitivity assessment. Due to a lack of conclusive evidence the sensitivity of this biotope cannot be assessed against this pressure.

Removal of target species	None Q: Low A: NR C: NR	High Q: High A: High C: High	Medium Q: Low A: NR C: NR

There has been recent commercial interest in *Saccharina latissima* as a consumable called "sea vegetables" (Birkett *et al*., 1998b). However, *Saccharina latissima* 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). No evidence has been found for commercial extraction of *Saccorhiza polyschides* or *Desmarestia spp*. However, if the biotopes were subject to harvest, then a large proportion of the resident kelp population could be removed. Thus evidence to assess the resistance of IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR to direct harvesting is limited. It has been assumed that if targeted harvesting were in operation it would remove >75% of sporophytes.

Sensitivity assessment. Resistance has been assessed as '**None**', Resilience as '**High**'. Sensitivity has been assessed as '**Medium**'.

Removal of non-target species	None Q: Low A: NR C: NR	High Q: High A: High C: High	Medium Q: Low A: NR C: NR

IR.HIR.KSed.Sac, IR.HIR.KSed.SlatSac, IR.HIR.KSed.DesFilR, IR.HIR.KSed.XKScrR Are characterised by a canopy of *Saccorhiza polyschides*, *Saccharina latissima* and *Desmarestia spp*. If the canopy were removed the red seaweeds understory community may become bleached, and/or perish (Hawkins & Harkin, 1985), leading to further reductions in biodiversity. The biotope is however naturally periodically disturbed and as such would recover rapidly.

Sensitivity assessment. Resistance has been assessed as ‘**None**’, Resilience as ‘**High**’. Sensitivity has been assessed as ‘**Medium**’.

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