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Mixed *Laminaria hyperborea* and *Laminaria ochroleuca* forest on moderately exposed or sheltered infralittoral rock

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

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2015-10-12

This review can be cited as:
Stamp, T.E., 2015. Mixed [Laminaria hyperborea] and [Laminaria ochroleuca] forest on moderately exposed or sheltered infralittoral rock. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. DOI https://dx.doi.org/10.17031/marlinhab.1039.1

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Mixed *Laminaria hyperborea* and *Laminaria ochroleuca* forest on moderately exposed or sheltered infralittoral rock
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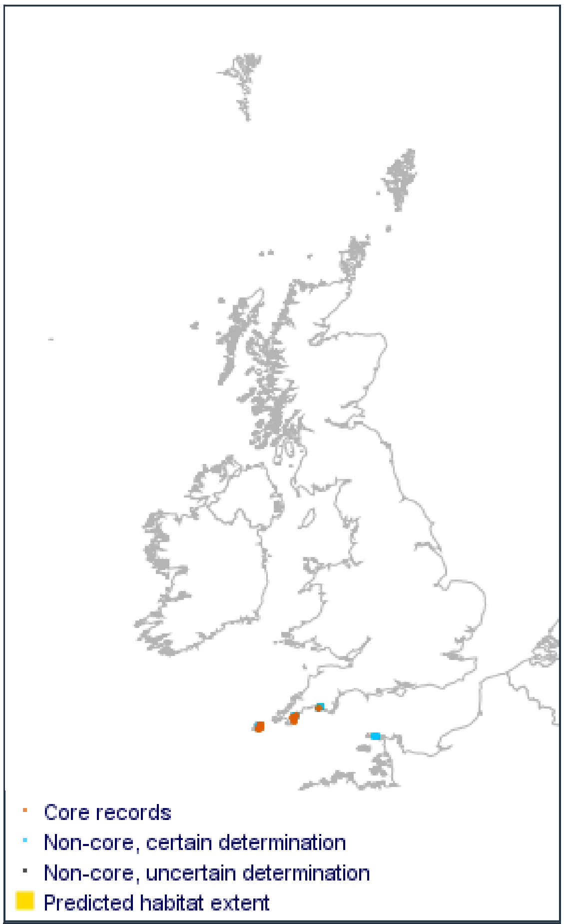

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Thomas Stamp **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A3.311	Mixed *Laminaria hyperborea* and *Laminaria ochroleuca* forest on moderately exposed or sheltered infralittoral rock
JNCC 2015	IR.LIR.K.LhypLoch	Mixed *Laminaria hyperborea* and *Laminaria ochroleuca* forest on moderately exposed or sheltered infralittoral rock
JNCC 2004	IR.LIR.K.LhypLoch	Mixed *Laminaria hyperborea* and *Laminaria ochroleuca* forest on moderately exposed or sheltered infralittoral rock
1997 Biotope	IR.MIR.KR.Lhyp.Loch	Mixed *Laminaria hyperborea* and *Laminaria ochroleuca* forest on moderately exposed or sheltered infralittoral rock

Description

Mixed *Laminaria hyperborea* and *Laminaria ochroleuca* forest on upper infralittoral moderately exposed or sheltered rock is restricted to the coast of Cornwall and the Isles of Scilly. Unlike *L.*

hyperborea, however, *L. ochroleuca* has a smooth stipe and it lacks the epiphytic growth of seaweeds. The bryozoan *Membranipora membranacea* may encrust the very lower part of the stipe but the rest of the stipe is characteristically bare. The fronds too are generally free of encrusting hydroids, bryozoans and grazing gastropods as compared to *L. hyperborea*. *L. ochroleuca* holdfasts, however, are often encrusted with sponges and colonial ascidians. A large variety of foliose and filamentous red seaweeds are often present underneath the canopy. These include *Callophyllis laciniata*, *Plocamium cartilagineum*, *Cryptopleura ramosa*, *Delesseria sanguinea*, *Dilsea carnosa* *Bonnemaisonia asparagoides*, *Erythroglossum laciniatum*, *Sphaerococcus coronopifolius*, *Polyneura bonnemaisonii* and *Corallina officinalis*. The foliose brown seaweed *Dictyota dichotoma* is frequently found in this biotope along with the occasional kelp such as *Saccorhiza polyschides* and *Saccharina latissima*. The faunal composition of the biotope as a whole is often sparse. The anthozoans *Corynactis viridis* and *Caryophyllia smithii* are common on vertical surfaces with scattered bryozoan turf species such as Crisiidae. Grazers such as the gastropod *Gibbula cineraria* and the urchin *Echinus esculentus* are often present. *L. ochroleuca* occurs across a wide range of wave exposures (in common with *L. hyperborea*) and consequently it occurs at low abundance in other kelp biotopes (sheltered through to exposed) that occur in the South-West between Dorset to Lundy. In such cases, records should be considered as regional variations of the usual kelp biotopes. Records should only be assigned to this biotope when the canopy is dominated by *L. ochroleuca* alone, or by a mixture of both *L. hyperborea* and *L. ochroleuca* (though the latter is usually at greater abundance). *L. ochroleuca* commonly occurs on the Brittany and Normandy coasts.

Depth range

-

Additional information

-

Listed By

- none -

Further information sources

Search on:

JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

IR.LIR.K.LhypLoch is characterized by mixed canopies of *Laminaria hyperborea* and *Laminaria ochroleuca*, where *Laminaria ochroleuca* is the dominant or most abundant kelp. IR.LIR.K.LhypLoch is limited to the south west coast of England and recorded in moderate to sheltered wave exposed environments (Connor *et al*., 2004). Beneath the kelp canopy is an understory dominated by red seaweeds which include *Plocamium cartilagineum*, *Cryptopleura ramosa* and *Callophyllis laciniata*.

Laminaria ochroleuca is a traditionally Lusitanian kelp species which was first recorded in the UK in the Hamble Estuary in 1948 (Parke, 1948), however, has since spread east to the Isle of Wight and North to Lundy Island (Blight & Thompson, 2008; Brodie *et al*., 2009). *Laminaria ochroleuca* is morphologically similar to *Laminaria hyperborea* but lacks the epiphytic stipe growth (Smale *et al*., 2014). At the time of writing relatively little is known on the ecological effects or growth of *Laminaria ochroleuca* in the UK (Smale *et al*., 2014). In general however, kelp beds increase the three-dimensional complexity of unvegetated rock (Birkett *et al*., 1998b; Norderhaug, 2004; Norderhaug *et al*., 2007; Norderhaug & Christie, 2011; Gorman *et al*., 2012 ; Moy & Christie 2012; Smale *et al*., 2013), and support high local diversity, abundance and biomass of epibenthic species (Smale *et al*., 2013), and serve as nursery grounds for a number of commercial important species, e.g. Cod and Pollack (Rinde *et al*., 1992).

In undertaking this assessment of sensitivity, an account is taken of knowledge of the biology of important characterizing species in the biotope. There is an abundance of literature for regeneration of mono-specific *Laminaria hyperborea* beds, however at the time of writing, there is limited research for the recovery of mixed kelp canopies and specifically *Laminaria ochroleuca* growth and recovery within the UK. For this sensitivity assessment *Laminaria hyperborea* and, in particular, *Laminaria ochroleuca* are the primary foci of research. The abundance of *Laminaria ochroleuca* is important for to the recognition of this biotope (important characterizing) and a decrease in its abundance will probably result in loss of the biotope and its replacement by another kelp biotope. The understory red seaweed communities also characterize the biotope but are present in other *Laminaria* biotopes, and are therefore not a primary focus of research. Examples of important species groups are mentioned where appropriate.

Resilience and recovery rates of habitat

Laminaria ochroleuca is a Lusitanian kelp species which has a geographic range from the Messina strait in the Mediterranean to its northern limit in the south west of the UK (Smale *et al*., 2014). *Laminaria ochroleuca* is most abundant in wave sheltered locations (John, 1971; Yesson *et al*., 2015), however, surveys in 2013-14 found *Laminaria ochroleuca* to be common in moderately exposed locations of Plymouth Sound, UK. In Portugal *Laminaria ochroleuca*'s reproductive season lasts from April-May to November-December (when sori become visible, Pereira *et al*. (2011). Laminaria spp. recruitment has been shown to be highly seasonally specific, and the survival of various growth phases to be temperature dependent (Birkett *et al*., 1998), therefore *Laminaria ochroleuca* reproduction times could differ across its distribution range, specifically in the UK. At the time of writing there is limited information on the reproduction and life history of *Laminaria ochroleuca* (Barradas *et al*., 2011). However, *Laminaria ochroleuca* is very similar to *Laminaria hyperborea* and therefore (barring temperature related differences mentioned below), reproduction and recruitment processes are assumed to be similar across the two species (Birkett *et al*., 1998; Smale *et al*., 2014). *Laminaria ochroleuca* has a reported temperature optimum for spore development of between 12 and 18°C (Izquierdo *et al.*, 2002). *Laminaria ochroleuca* spores have a maximum development temperature of 23-24°C and Pereira *et al.* (2011) suggested temperatures above 25°C would likely cause high mortality. When compared to other kelp species (e.g. *Saccorhiza polyschides*) *Laminaria ochroleuca* has a relatively low fecundity at 10°C. This evidence plus recent modelling (Yesson *et al.*, 2015) suggests that *Laminaria ochroleuca*' northern spread may be limited by winter temperatures and that the species may be maladapted to the environmental conditions in the UK.

In Portugal *Laminaria ochroleuca* has been shown to re-establish rapidly following physical removal. Barradas *et al.* (2011) scraped all macroalgae from intertidal rock pools, including the dominant canopy forming *Laminaria ochroleuca* and understory algae. *Laminaria ochroleuca* recruits appeared one month following removal small (mean length 2.02cm) at a mean density of 40 recruits per m^2. Sporophytes had an average length of 14.91cm four months after removal and average densities of 82 recruits per m^2. Barradas *et al.* (2011) noted a lack of recruitment in natural adjacent *Laminaria ochroleuca* populations and theorised that the rapid colonization of *Laminaria ochroleuca* was caused by latent microscopic spores on the underlying rock which grew rapidly when the *Laminaria ochroleuca* canopy was removed. Barradas *et al.* (2011) did not comment on the length of time for *Laminaria ochroleuca* to reach a similar size and density to that of pre-treatment nor the likely environmental conditions that spores could tolerate and for how long, however, the results in Barradas *et al.* (2011) demonstrate *Laminaria ochroleuca* can recover from disturbance rapidly.

If environmental conditions are favourable *Laminaria hyperborea* can recover following disturbance events reaching comparable plant densities and size to pristine *Laminaria hyperborea* beds within 2-6 years (Kain, 1979; Birkett *et al.*, 1998; Christie *et al.*, 1998). Holdfast communities may recover in 6 years (Birkett *et al.*, 1998). Full epiphytic community and stipe habitat complexity regeneration requires over 6 years to recover (possibly 10 years) (Svendsen, 1972). These recovery rates were based on discrete kelp harvesting events and recurrent disturbance occurring frequently within 2-6 years of the initial disturbance is likely to lengthen recovery time (Birkett *et al.*, 1998, Burrows *et al.*, 2014). 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 within 2 years of clearance the blocks were dominated by *Laminaria hyperborea*.

Laminaria hyperborea has a heteromorphic life strategy. A vast number of zoospores (mobile asexual spores) are released into the water column between October-April (Kain & Jones, 1964). Zoospores settle onto rock substrata and develop into dioecious gametophytes (Kain, 1979) which, following fertilization, develop into sporophytes and mature within 1-6 years (Kain, 1979; Fredriksen *et al.*, 1995; Christie *et al.*, 1998). Laminaria hyperborea zoospores have a recorded dispersal range of approx. 200 m (Fredriksen *et al.*, 1995). However zoospore dispersal is greatly influenced by water movements, plus 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 nature of kelp biotopes is partially reliant on low (or no) populations of sea urchins, primarily the species; *Echinus esculentus*, *Paracentrotus lividus* and *Strongylocentrotus droebachiensis*, which graze directly on macroalgae, epiphytes and the understory community. Multiple authors (Steneck et al., 2002; Steneck et al., 2004; Rinde & Sjøtun, 2005; Norderhaug & Christie, 2009; Smale *et al.*, 2013) have reported dense aggregations of sea urchins to be a principal threat to kelp biotopes of the North Atlantic. In northern Norway intense urchin grazing create expansive areas known as “urchin barrens”, in which a shift can occur from kelp dominated biotopes to those characterized by coralline encrusting algae, with a resultant reduction in biodiversity (Lienaas & Christie, 1996; Steneck *et al*., 2002, Norderhaug & Christie, 2009). Lienaas & Christie (1996) removed *Strongylocentrotus droebachiensis* from “Urchin Barrens” and observed a succession effect. Initially, the substratum was colonized by filamentous algae, after a couple of weeks, these were out-competed by *Saccharina latissima*. However after 2-4 years *Laminaria hyperborea* dominated the community.

Reports of large scale urchin barrens within the North East Atlantic are generally limited to regions of the North Norwegian and Russian Coast (Rinde & Sjøtun, 2005, Nourderhaug & Christie, 2009). Within the UK, urchin grazed biotopes (IR.MIR.KR.Lhyp.GzFt/Pk, IR.HIR.KFaR.LhypPar, IR.LIR.K.LhypSlat.Gz & IR.LIR.K.Slat.Gz) are generally localised to a few regions in North Scotland and Ireland (Smale *et al*., 2013; Stenneck *et al*., 2002; Norderhaug & Christie 2009; Connor *et al*., 2004). IR.MIR.KR.Lhyp.GzFt/Pk, IR.HIR.KFaR.LhypPar, IR.LIR.K.LhypSlat.Gz & IR.LIR.K.Slat.Gz are characterized by a canopy-forming kelp however urchin grazing decreases the abundance and diversity of understory species. In the isle of Man Jones & Kain (1967) observed low *Echinus esculentus* grazing pressure can control the lower limit of *Laminaria hyperborea* in the and remove *Laminaria hyperborea* sporelings and juveniles. Urchin abundances in “Urchin Barrens” have been reported as high as 100 individuals/m^2 (Lang & Mann, 1976), Kain (1967) reported urchin abundances of 1-4/m^2 within experimental plots of the Isle of Man. Therefore, while “Urchin Barrens” are not presently a large scale issue within the UK, relatively low urchin grazing has been found to control the depth distribution of *Laminaria hyperborea*, negatively impact on *Laminaria hyperborea* recruitment and reduce the understory community abundance and diversity.

Other factors that are likely to influence the recovery of kelp biotopes is competitive interactions with Invasive Non-Indigenous Species (INIS) *Undaria pinnatifida* (Smale *et al*., 2013; Brodie *et al*., 2014; Heiser 2014). *et alet alet alet alet alet al*Fletcher & Farrell (1999) noted that, once established, *Undaria pinnatifida* resists most attempts of long-term removal. Kelp biotopes are unlikely to fully recover until *Undaria pinnatifida* is fully removed from the habitat, which as stated above is unlikely to occur.

Resilience assessment. Little is known on the recovery of *Laminaria ochroleuca* in the UK. Due to the similarity between *Laminaria ochroleuca* & *Laminaria hyperborea* it is assumed that the two species would have similar recovery rates. The evidence suggests that *Laminaria hyperborea* beds can regenerate from disturbance within a period of 1-6 years, and the associated community within 7-10 years. Therefore, resilience has been assessed as **Medium** from either a loss of abundance (e.g. ‘Low’ resistance) or removal of the canopy (e.g. resistance is ‘None’).

Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

Of the two kelp species which define IR.LIR.K.LhypLoch, *Laminaria hyperborea* has a northern distribution (Birkett *et al*., 1998b). *Laminaria ochroleuca* has a southern distribution. Hence, increases in temperature above a threshold will cause an increase in the dominance of *Laminaria ochroleuca*.

Kain (1964) stated that *Laminaria hyperborea* sporophyte growth and reproduction could occur within a temperature range of 0-20°C. Upper and lower lethal temperatures have been estimated at between 1-2 °C above or below the extremes of this range (Birkett *et al.*, 1988). Above 17°C gamete survival is reduced (Kain, 1964 & 1971) and gametogenesis is inhibited at 21°C (Dieck, 1992). It is therefore likely that *Laminaria hyperborea* recruitment will be impaired at a sustained temperature increase of above 17°C. Sporophytes can tolerate temperatures of 20°C (Kain, 1964). Temperature tolerances for *Laminaria hyperborea* are also seasonally variable and temperature changes are less tolerated in winter months than summer months (Birkett *et al.*, 1998b).

Laminaria ochroleuca is distributed from Messina, Mediterranean to the south of the UK, and has a thermal optimum for spore development between 12-18°C (Izquierdo *et al.*, 2002). *Laminaria ochroleuca* spores have a maximum development temperature of 23-24°C and temperatures above 25°C will likely cause high mortality (Pereira *et al.*, 2011).

Subtidal red algae are less tolerant of temperature extremes than intertidal red algae, surviving between -2°C and 18-23 °C (Lüning 1990; Kain & Norton, 1990). Temperature increase may affect growth, recruitment or interfere with reproduction processes. For example, there is some evidence to suggest that blade growth in *Delesseria sanguinea* is delayed until ambient sea temperatures fall below 13°C. Blade growth is also likely to be intrinsically linked to gametangia development (Kain, 1987), maintenance of sea temperatures above 13°C may affect recruitment success.

IR.LIR.K.LhypLoch is recorded exclusively in the UK south west, where summer Sea Temperature (ST) range from 12-16°C, and winter 8-13°C (Plymouth: 1981-2010, Beszczynska-Möller & Dye, 2013). Little evidence is available for acute heat shock in the both *Laminaria ochroleuca* and *Laminaria hyperborea*, however, any increases in sea temperature are likely to favour *Laminaria ochroleuca* which has higher temperatures optimums. All temperature effects would be seasonally variable, and more affective in winter. However, an increase in 5°C in the UK south west would likely affect *Laminaria hyperborea* recruitment processes and limit *Laminaria hyperborea* sporophyte growth (Plymouth: 1981-2010, Beszczynska-Möller & Dye, 2013).

Sensitivity assessment. A long-term increase in temperature may benefit the biotope and cause a localised increase in the abundance of *Laminaria ochroleuca*. However, beneficial effects of pressures are not assessed. *Laminaria hyperborean* may decrease in abundance however IR.LIR.K.LhypLoch would still be the recognised biotope. Therefore resistance is assessed a '**High**', so that resilience is therefore '**High** 'and the biotope is regarded as '**Not sensitive**' to this pressure.

Temperature decrease (local)	None Q: High A: High C: High	Medium Q: High A: Medium C: High	Medium Q: High A: Medium C: High

Of the two kelp species which define IR.LIR.K.LhypLoch, *Laminaria hyperborea* has a northern distribution (Birkett *et al.*, 1998b). *Laminaria ochroleuca* has a southern distribution. Hence, decreases in temperature will likely benefit *Laminaria hyperborea*.

Laminaria hyperborea is a boreal northern species with a geographic range from mid-Portugal to Northern Norway (Birket *et al.*, 1998). Kain (1964) stated that *Laminaria hyperborea* sporophyte growth and reproduction could occur within a temperature range of 0-20°C. Upper and lower lethal temperatures have been estimated at between 1-2°C above or below the extremes of this range (Birkett *et al.*, 1988).

Laminaria ochroleuca has a reported temperature optimum for spore development between 12-18°C (Izquierdo *et al.*, 2002), *Laminaria ochroleuca* gametophyte development can occur in temperatures as low 5°C (Lüning, 1990). Recent modelling has also predicted winter temperature in the UK to strongly influence the distribution, and hence spread, of *Laminaria ochroleuca* in the UK (Yesson *et al.*, 2015). Pereira *et al.* (2011) examined the development of early *Laminaria ochroleuca* life stages and found that *Laminaria ochroleuca* had relatively low fecundity at 10°C and may be maladapted to environmental conditions within the UK and vulnerable to local extinctions.

Subtidal red algae are less tolerant of temperature extremes than intertidal red algae, surviving between -2°C and 18-23 °C (Lüning 1990; Kain & Norton, 1990). Temperature increase may affect growth, recruitment or interfere with reproduction processes. For example, there is some evidence to suggest that blade growth in *Delesseria sanguinea* is delayed until ambient sea temperatures fall below 13 °C. Blade growth is also likely to be intrinsically linked to gametangia development (Kain, 1987), maintenance of sea temperatures above 13 °C may affect recruitment success.

IR.LIR.K.LhypLoch is recorded exclusively in the UK south west, where the average Sea Temperature (ST) range from 12-16°C, and winter 8-13°C (Plymouth: 1981-2010, Beszczynska-Möller & Dye, 2013). Little evidence is available for an acute cold shock in the both *Laminaria ochroleuca* and *Laminaria hyperborea*. A decrease of 5°C for 1 month during winter could negatively affect *Laminaria ochroleuca* fecundity, spore and gametophyte development and hence recruitment success. A decrease of 2°C for 1 year could negatively affect fecundity and spore development. A decrease in temperature may cause local extinctions of *Laminaria ochroleuca* and/or increase the dominance of either monospecific *Laminaria hyperborea* (as in IR.MIR.KR.Lhyp) or mixed *Saccharina latissima* canopies (IR.LIR.K.LhypSlat), dependant on the wave exposure.

Sensitivity assessment. Resistance to the pressure is considered '**None**', and resilience '**Medium**'. The sensitivity of this biotope to a decrease in temperature has been assessed as '**Medium**'.

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

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 occurs 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 *Laminaria hyperborea* growth and may result in loss of affected kelp, and, therefore, loss of the biotope.

Laminaria ochroleuca grows in the Messina strait, Mediterranean where ambient salinity has been measured at 38.5‰ (Sheppard *et al.*, 1978). *Laminaria ochroleuca* has also been found growing in Portuguese intertidal rock pools (Barradas *et al.*, 2011). As a result of high evaporation rates, rainfall and land run-off, rock pools and the organisms that reside within them are likely to experience short-term high variability in salinity (Reed & Russell, 1978). The effects of long-term (e.g. ≥ 1 year) salinity changes on *Laminaria ochroleuca* are unknown.

Sensitivity assessment. Resistance has been assessed as '**Low**', resilience as '**Medium**'. The sensitivity of this biotope to an increase in salinity has been assessed as '**Medium**'.

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

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 occurs 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 *Laminaria hyperborea* growth and may result in loss of affected kelp, and, therefore, loss of the biotope.

Hopkin & Kain (1978) tested *Laminaria hyperborea* sporophyte growth at various low salinity treatments. The results showed that *Laminaria hyperborea* sporophytes grew normally at 19 psu, was reduced at 16 psu and did not occur at 7 psu. *Laminaria ochroleuca*A decrease in one MNCR salinity scale from Full Salinity (30-40 psu) to Reduced Salinity (18-30 psu) may result in a decrease of *Laminaria hyperborea* sporophyte growth. *Laminaria hyperborea* may also be out-competed by low salinity tolerant species e.g. *Saccharina latissima* (Karsten, 2007).

Sensitivity assessment. Resistance has been assessed as ‘**Low**’ resilience as ‘**Medium**’. The sensitivity of this biotope to a decrease in salinity has been assessed as ‘**Medium**’.

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

IR.LIR.K.LhypLoch is recorded from moderately strong (0.5-1.5 m/sec) to weak tidal streams (<0.5m/sec) (Connor *et al.*, 2004). In northern France and the Messina strait, Mediterranean *Laminaria ochroleuca* is subject to strong tidal streams. Searles & Schneider (1978) observed *Laminaria ochroleuca* has proportionally greater biomass and stipe lengths in areas of strong tidal streams. In Port Levi, Northern France, which is subject to strong to very strong tidal streams (approximately 2.5 m/sec), when compared to other sites in northern Spain and England that experience “minimal” tidal streams. Seven year old *Laminaria ochroleuca* from Port Levi had stipe lengths of 110 (±12) cm whereas those from England and Spain were 86 & 69 cm respectively. Searles & Schneider (1978) also found that *Laminaria ochroleuca* growth was similarly large in deep populations (approximately 55 m) of Messina, Mediterranean, where environmental conditions were starkly different but experienced strong tidal streams of approximately 2.2 m/sec.

Tide swept *Laminaria hyperborea* biotopes (IR.MIR.KR.LhypT/X) are recorded from very strong (>3 m/sec) to very weak (Negligible) tidal streams. Pederson *et al.* (2012) observed *Laminaria hyperborea* biomass, productivity and density increased with an increase in wave exposure. At low wave exposure, *Laminaria hyperborea* canopy forming plants were smaller, had lower densities and had higher mortality rates than at exposed sites. At low wave exposure Pederson *et al.* (2012) suggested that high epiphytic loading on *Laminaria hyperborea* impaired light conditions, nutrient uptake, and increased the drag on the host *Laminaria hyperborea* during extreme storm events.

Sensitivity assessment. The evidence suggests that both *Laminaria ochroleuca and Laminaria hyperborea* would be highly resistant to a change in peak mean spring bed velocity of 0.1-0.2 m/sec. Resistance to the pressure is considered ‘**High**’, and resilience ‘**High**’. The sensitivity has been assessed as ‘**Not sensitive**’.

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

IR.LIR.K.LhypLoch is recorded from the sublittoral fringe to the lower infralittoral. An increase in emergence will result in an increased risk of desiccation and mortality of the dominant kelp species (*Laminaria ochroleuca* & *Laminaria hyperborea*). Removal of canopy-forming kelps has also been shown to increase desiccation and mortality of the understory macroalgae (Hawkins & Harkin, 1985). Several mobile species such as sea urchins, brittle stars and feather stars are likely to move away. However, providing that suitable substrata are present, the biotope could re-establish further down the shore within a similar emergence regime to that which existed previously. Similarly, a decrease in emergence may allow the biotope to extend its extent up the shore, however, completion from other species would probably erode its lower extent.

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

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

In the UK *Laminaria ochroleuca*, and IR.LIR.K.LhypLoch, are limited to moderate exposed to wave sheltered sites (John, 1969; Connor *et al*., 2004; Smale *et al*., 2014). However in other parts of *Laminaria ochroleuca* geographic range (e.g. Mouro Island, Spain) it can be found abundant in high wave exposure (Arroyo *et al*., 2004). In the UK Open/wave exposed locations *Laminaria hyperborea* forms monospecific canopies (as in IR.MIR.KR.Lhyp or IR.HIR.KFaR.LhypR) (Connor *et al*., 2004; Smale *et al*., 2014). Little evidence was found to assess the effect of wave exposure on *Laminaria ochroleuca* in the UK. However, Smale *et al.* (2014) suggest that *Laminaria ochroleuca* is becoming established at moderately exposed sites of Plymouth sound, UK, and is likely spatially competing with *Laminaria hyperborea*.

Kregting *et al.* (2013) measured *Laminaria hyperborea* blade growth and stipe elongation from an exposed and a sheltered site in Strangford Lough, Ireland from March 2009-April 2010. Wave exposure was found to be between 1.1 and 1.6 times greater between the exposed and sheltered sites. Maximal significant wave height (Hm0) was 3.67 & 2 m at the exposed and sheltered sites. Maximal water velocity (Velrms) was 0.6 & 0.3 m/s at the exposed and sheltered sites. Despite the differences in wave exposure and water velocity, there was no significant difference in *Laminaria hyperborea* growth between the exposed and sheltered site.

Biotope structure is, however, different between wave exposed and sheltered sites. Pederson *et al*., (2012) observed *Laminaria hyperborea* biomass, productivity and density increased with an increase in wave exposure. At low wave exposure, *Laminaria hyperborea* canopy forming plants were smaller, had lower densities and had higher mortality rates than at exposed sites. At low wave exposure high epiphytic loading on *Laminaria hyperborea* was theorised to impair light conditions, nutrient uptake, and increase the drag of the host *Laminaria hyperborea* during extreme storm events.

Sensitivity assessment. While wave exposure is a defining feature of IR.LIR.K.LhypLoch, the benchmark level of change is unlikely to have a significant effect in areas already subject to wave exposure, even where sheltered. Resistance has been assessed as '**High**', resilience as '**High**'. Sensitivity has been assessed as '**Not Sensitive**'.

Chemical Pressures

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

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

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 *Laminaria hyperborea* 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). *Echinus esculentus* recruitment is likely to be impaired by heavy metal contamination due to the intolerance of its larvae. *Echinus esculentus* are long-lived and poor recruitment may not reduce grazing pressure in the short-term. 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.

	Resistance	Resilience	Sensitivity
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.

Laminaria hyperborea and *Laminaria ochroleaca* fronds, being almost exclusively subtidal, would not 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 1-22.5 m below chart datum, including *Laminaria hyperbora* communities, showed no noticeable impacts of the Sea Empress oil spill and clean up (Rostron & Bunker, 1997). An assessment of holdfast fauna in *Laminaria* showed that although species richness and diversity decreased with increasing proximity to the *Sea Empress* oil spill, overall the holdfasts contained a reasonably rich and diverse fauna, even though oil was present in most samples (Somerfield & Warwick, 1999). 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. Holt *et al.* (1995) concluded that *Delesseria sanguinea* is probably generally sensitive of chemical contamination. Overall the red algae are likely to be highly intolerant to hydrocarbon contamination. Loss of red algae is likely to reduce the species richness and diversity of the biotope and the understorey may become dominated by encrusting corallines; however, red algae are likely to recover relatively quickly.

	Resistance	Resilience	Sensitivity
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). Although *Laminaria hyperborea* sporelings and gametophytes are intolerant of atrazine (and probably other herbicides) overall they may be relatively tolerant of synthetic chemicals (Holt *et al.*, 1995). *Laminaria hyperborea* survived within >55 m from the acidified halogenated effluent discharge polluting Amlwch Bay, Anglesey, albeit at low density. These specimens were greater than 5 years of age, suggesting that spores and/or early stages were more intolerant (Hoare & Hiscock, 1974). *Patella pellucida* was excluded from Amlwch Bay by the pollution and the species richness of the holdfast fauna decreased with proximity to the effluent discharge; amphipods were particularly intolerant although polychaetes were the least affected (Hoare & Hiscock, 1974). The richness of epifauna/flora decreased near the source of the effluent and epiphytes were absent from *Laminaria hyperborea* stipes within Amlwch Bay. The red alga *Phyllophora membranifolia* was also tolerant of the effluent in Amlwch Bay. Smith (1968) also noted that epiphytic and benthic red algae were intolerant of dispersant or oil contamination due to 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 to 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. Although *Laminaria hyperborea* may be relatively insensitive to synthetic chemical pollution, evidence suggests that grazing gastropods, amphipods and red algae are sensitive. Loss of red algae is likely to reduce the species richness and diversity of the biotope and the understorey may become dominated by encrusting corallines; however, red algae are likely to recover relatively quickly.

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

Reduced oxygen concentrations have been shown to inhibit both photosynthesis and respiration in macroalgae (Kinne, 1977). Despite this, macroalgae are thought to buffer the environmental conditions of low oxygen, thereby acting as a refuge for organisms in oxygen depleted regions especially if the oxygen depletion is short-term (Frieder *et al.*, 2012). A rapid recovery from a state of low oxygen is expected if the environmental conditions are transient. If levels do drop below 4 mg/l negative effects on these organisms can be expected with adverse effects occurring below 2 mg/l (Cole *et al.*, 1999).

Sensitivity Assessment. Reduced oxygen levels are likely to inhibit photosynthesis and respiration but not cause a loss of the macroalgae population directly. However, small invertebrate epifauna may be lost, causing a reduction in species richness. Therefore a resistance of '**High**' is recorded. Resilience is likely to be '**High**', and the biotopes '**Not sensitive**' at the benchmark level.

Nutrient enrichment	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not sensitive Q: NR A: NR C: NR

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).

Holt *et al.* (1995) suggest that *Laminaria hyperborea* may be tolerant of nutrient enrichment since healthy populations are found at ends of sublittoral untreated sewage outfalls in the Isle of Man. Increased nutrient levels e.g. from sewage outfalls, has been associated with increases in abundance, primary biomass and *Laminaria hyperborea* stipe production but with concomitant decreases in species numbers and diversity (Fletcher, 1996).

Increased nutrients may result in phytoplankton blooms that increase turbidity. Increased nutrients may favour sea urchins, e.g. *Echinus esculentus*, due their ability to absorb dissolved organics, and result in increased grazing pressure leading to loss of understorey epiflora/fauna, decreased kelp recruitment and possibly 'urchin barrens'. Therefore, although nutrients may not affect kelps directly, indirect effects such as turbidity, siltation and competition may significantly affect the structure of the biotope.

However, this biotope is considered to be '**Not sensitive**' at the pressure benchmark, that assumes compliance with good status as defined by the WFD.

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

Organic enrichment is associated with eutrophication, increased siltation and turbidity (Fletcher 1996). Eutrophication is associated with loss of perennial algae and replacement by mussels or opportunistic algae (Fletcher 1996). 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 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).

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Sensitivity assessment. Resistance to the pressure is considered '**Low**', and resilience '**Medium**'. The sensitivity of this biotope to organic enrichment is assessed as '**Medium**'.

Physical Pressures

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

All marine habitats and benthic species are considered to have a resistance of 'None' to this pressure and to be unable to recover from a permanent loss of habitat (resilience is '**Very Low**'). Sensitivity within the direct spatial footprint of this pressure is, 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 *Laminaria hyperborea* would not be able to tolerate (Birket *et al*., 1998). The biotope would be lost.

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

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

Not relevant to bedrock biotopes.

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

Barradas *et al.* (2011) scraped all macro-algae from intertidal Portuguese rock pools, including the dominant canopy forming *Laminaria ochroleuca* and understory algae. I small (mean length 2.02cm) *Laminaria ochroleuca* recruits appeared 1 month following removal at a mean density of 40 recruits per m^2. Four months after removal sporophytes had an average length of 14.91cm and an average density of 82 recruits per m^2. Barradas *et al.* (2011) noted a lack of recruitment in natural adjacent *Laminaria ochroleuca* populations and theorized the rapid colonization of *Laminaria ochroleuca* was caused by latent microscopic spores on the underlying rock which grew rapidly when the *Laminaria ochroleuca* canopy was removed. Barradas *et al.* (2011) did not comment on the length of time for *Laminaria ochroleuca* to reach similar size and density to that of pre-treatment nor the likely environmental conditions which spores could tolerate and for how long, however, the results in Barradas *et al.* (2011) demonstrate *Laminaria ochroleuca* can recover from disturbance rapidly.

Christie *et al.* (1998) observed *Laminaria hyperborea* habitat regeneration following commercial *Laminaria hyperborea* trawling in south Norway. Within the study area, trawling removed all large canopy-forming adult *Laminaria hyperborea*. In 2-6 years of harvesting, a new canopy had formed 1m off the seabed. The associated holdfast communities recovered in 6 years, however, the epiphytic stipe community did not fully recover and may take up to 10 years to recover (Svendsen, 1972). Christie *et al.* (1998) suggested that kelp habitats were relatively resistant to direct disturbance/removal of *Laminaria hyperborea* canopy.

Recurrent disturbance occurring at a smaller time scale than the recovery period of 2-6 years (stated above) could extend recovery time. 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 within 2 years of clearance the blocks were dominated by *Laminaria hyperborea* (Fletcher *et al.*, 2006). Lienaas & Christie (1996) also observed *Laminaria hyperborea* re-colonization of “urchin barrens”, following removal of urchins. The substratum was initially colonized by filamentous macroalgae and *Saccharina latissima* however after 2-4 years *Laminaria hyperborea* dominated the community.

Sensitivity assessment. Abrasion due to passing bottom gear has the potential to remove a significant proportion of the standing kelp population, similar to direct harvesting. The resident red algal turf may also be affected by direct abrasion while fauna on vertical surfaces may avoid direct impact. Therefore, resistance in probably ‘**Low**’. *Laminaria ochroleuca* has been shown to recovery rapidly (within 1-2 years) following complete kelp canopy removal. *Laminaria hyperborea* has been shown can recover within 2-6 and the associated community 7->10 years (Birkett *et al.*, 1998). The full community is, therefore, likely to completely recover in >2 years. Resilience is therefore probably ‘**Medium**’ and 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 or seabed'

Changes in suspended solids (water clarity)	None Q: High A: High C: High	Medium Q: High A: Medium C: High	Medium Q: High A: Medium C: High

Suspended Particle Matter (SPM) concentration has a linear relationship with sub-surface light attenuation (Kd) (Devlin *et al.*, 2008). An increase in SPM results in a decrease in sub-surface light attenuation. Light availability and water turbidity are principal factors in determining kelp depth range (Birkett *et al*., 1998). Light penetration influences the maximum depth at which kelp species can grow and it has been reported that laminarians grow down to 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 *Laminaria hyperborea* 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 (Birkett *et al*. 1998b; Lüning, 1990).

Laminaria spp. 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). An increase in water turbidity will likely affect the photosynthetic ability of *Laminaria hyperborea* and *Laminaria ochroleuca* and decrease *Laminaria hyperborea* abundance and density (see sub-biotope-IR.MIR.KR.Lhyp.Pk). Kain (1964) suggested that early *Laminaria hyperborea* gametophyte development could occur in the absence of light. Furthermore, observations from south Norway found that a pool of *Laminaria hyperborea* recruits could persist growing beneath *Laminaria hyperborea* canopies for several years, indicating that sporophyte growth can occur in light-limited environments (Christe *et al*., 1998). However in habitats exposed to high levels of suspended silts *Laminaria hyperborea* is out-competed by *Saccharina latissima*, a silt tolerant species, and thus, a decrease in water clarity is likely to decrease the abundance of *Laminaria hyperborea* in the affected area (Norton, 1978).

Díez *et al*., (2003) studied subtidal vegetation distribution patterns in relation to environmental conditions (pollution, wave exposure, sedimentation, substratum slope and depth) in northern Spain. The results showed that *Laminaria ochroleuca* only occurred at sites without sedimentation loading. In contrast to this evidence, IR.LIR.K.LhypLoch is found in low energy environments (Connor *et al*., 2004) which are inherently subject to a degree of siltation.

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. Therefore, the dominant kelp species will probably suffer a significant decline and resistance to this pressure is assessed as '**Low**'. Resilience to this pressure is probably '**Medium**' at the benchmark. Hence, this biotope is assessed as having a sensitivity of '**Medium** 'to this pressure.

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

Smothering by sediment (e.g. 5 cm of material) during a discrete event is unlikely to damage *Laminaria hyperborea* or *Laminaria ochroleuca* sporophytes but is likely to affect gametophyte survival as well as holdfast fauna, and interfere with zoospore settlement (Moy & Christie, 2012). Given the microscopic size of the gametophyte, 5 cm of sediment could be expected to significantly inhibit growth. However, laboratory studies showed that kelp gametophytes can survive in darkness for between 6-16 months at 8 °C and would probably survive smothering by a discrete event. Once returned to normal conditions the gametophytes resumed growth or maturation within one month (Dieck, 1993). Intolerance to this factor is likely to be higher during the peak periods of sporulation and/or spore settlement.

Díez *et al*., (2003) studied subtidal vegetation distribution patterns in relation to environmental conditions (pollution, wave exposure, sedimentation, substratum slope and depth) in northern Spain. The results showed that *Laminaria ochroleuca* only occurred at sites without sedimentation loading and may, therefore, be sensitive to light sedimentation. In contrast to this evidence IR.LIR.K.LhypLoch is found in low energy environments which are inherently subject to a degree of siltation.

If inundation is long lasting then the understory flora may be adversely affected. If clearance of deposited sediment occurs rapidly then understory communities are expected to recover quickly. In moderately exposed examples of IR.LIR.K.LhypLoch deposited sediment is unlikely to remain for more than a few tidal cycles (due to water flow or wave action). In wave sheltered examples of IR.LIR.K.LhypLoch sediment could remain and recovery rate would be related to sediment retention.

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

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

Smothering by sediment (e.g. 30 cm of fine material) in a discrete event is unlikely to damage *Laminaria hyperborea* or *Laminaria ochroleuca* plants but is likely to affect gametophyte survival as well as holdfast fauna, and interfere with zoospore settlement. Given the microscopic size of the gametophyte, 30 cm of sediment could be expected to significantly inhibit growth. However, laboratory studies showed that gametophytes can survive in darkness for between 6-16 months at 8°C and would probably survive smothering by a discrete event. Once returned to normal conditions the gametophytes resumed growth or maturation within 1 month (Dieck, 1993). Intolerance to this factor is likely to be higher during the peak periods of sporulation and/or spore settlement.

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If inundation is long lasting then the understory flora may be adversely affected, which is likely in wave sheltered environments. If clearance of deposited sediment occurs rapidly then understory communities are expected to recover quickly. In moderately exposed examples of IR.LIR.K.LhypLoch deposited sediments are unlikely to remain for more than a few tidal cycles (due to water flow or wave action). In wave sheltered examples of IR.LIR.K.LhypLoch sediment could remain and recovery rate would be related to sediment retention.

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

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

Not assessed

Electromagnetic changes	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

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

Shading of the biotope (e.g. by 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 laminarian abundance from forest to park type biotopes.

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" pressure.

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 in 1994 attached to a boat in the Hamble estuary (Fletcher & Manfredi, 1995) and has since spread to sheltered, typically man-made, habitats around the UK e.g. marinas (Farrell & Fletcher, 2006).

Undaria pinnatifida was first recorded in Plymouth Sound, UK in 2003 (NBN, 2015) subsequent surveys in 2011 have reported that *Undaria pinnatifida* is widespread throughout Plymouth Sound, colonizing rocky reef habitats. Where *Undaria pinnatifida* is present Heiser *et al.* (2014) observed a significant decline in the abundance of other *Laminaria* species, including *Laminaria hyperborea*.

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 of the substratum was partially due to an annual *Undaria pinnatifida* die back, which as noted by Heiser *et al*. (2014) did 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 (see 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 recover until *Undaria pinnatifida* is fully removed from the habitat, which as stated above is unlikely to occur. Furthermore as observed by Farrell & Fletcher (2006) the wave sheltered environment which can define IR.LIR.K.LhypLoch may facilitate the establishment of *Undaria pinnatifida*.

Sensitivity assessment. Resistance to the pressure is considered '**None**', and resilience '**Very Low**'. The sensitivity of this biotope to the introduction of microbial pathogens is assessed as '**High**'.

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

Galls on the blade of *Laminaria hyperborea* and spot disease are associated with the endophyte *Streblonema* sp. although the causal agent is unknown (bacteria, virus or endophyte). The resultant damage to the blade and stipe may increase losses in storms. The endophyte inhibits spore production and, therefore, recruitment and recoverability. However, no other evidence was found.

Sensitivity assessment. Resistance to the pressure is considered '**Medium**', and resilience '**High**'. The sensitivity of this biotope to the introduction of microbial pathogens is assessed as '**Low**'.

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

Kelp trawling and abrasion have been found to cause 75% mortality of kelp beds (See abrasion pressure). Therefore, incidental removal of the kelp species within this biotope is likely to fundamentally change the character of this biotope.

Kelp species are key/characterizing species within this biotope. Removal of canopy-forming kelps has been shown to increase desiccation and mortality of the understory macroalgae community (Hawkins & Harkin, 1985). *Laminaria hyperborea* stipes also host a large array of epiphytic species (Birkett *et al*., 1998). This epiphytic community would also be lost from the biotope if a large proportion of the kelp biomass were removed.

Sensitivity assessment. Resistance to the pressure is considered '**None**', and resilience '**Medium**'. The sensitivity of this biotope to damage to seabed surface features is assessed as '**Medium**'.

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

Kelp trawling and abrasion have been found to cause 75% mortality of kelp beds (See abrasion pressure). Therefore, incidental removal of the kelp species within this biotope is likely to fundamentally change the character of this biotope.

Kelp species are a key characterizing species within this biotope. Removal of canopy-forming kelps has been shown to increase desiccation and mortality of the understory macro-algae community (Hawkins & Harkin, 1985). *Laminaria hyperborea* stipes also host a large array of epiphytic species (Birkett *et al*., 1998). This epiphytic community would also be lost from the biotope if a large proportion of the kelp biomass were removed.

Sensitivity assessment. Resistance to the pressure is considered '**None**', and resilience '**Medium**'. The sensitivity of this biotope to damage to seabed surface features is assessed as '**Medium**'.

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