Tangle or cuvie (*Laminaria hyperborea*)

MarLIN – Marine Life Information Network
Biology and Sensitivity Key Information Review

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The Marine Life Information Network, Marine Biological Association of the United Kingdom.

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***Laminaria hyperborea*.**
Photographer: Keith Hiscock
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See online review for distribution map

Distribution data supplied by the Ocean Biogeographic Information System (OBIS). To interrogate UK data visit the NBN Atlas.

Researched by	Dr Harvey Tyler-Walters	**Refereed by**	Dr Joanna Jones
Authority	(Gunnerus) Foslie, 1884		
Other common names	-	**Synonyms**	-

Summary

Description

A large conspicuous kelp which can grow up to 3.5 m in length in suitable conditions although this length is rarely attained (J. Jones, pers. comm.). The blade is broad, large, tough, flat and divided into 5 - 20 straps or fingers (digitate). The blade is glossy, golden brown to very dark brown in colour. The holdfast is large, conical and branched with conspicuous haptera. The stipe is stiff, rough textured, thick at the base and tapers towards the frond. The stipe stands erect when out of water. The stipe is often covered with numerous epifauna and epiflora. The amount of energy allocated to growth of the stipe, and consequently maximum length of stipe, varies with season, the age of plant and location. This species is often confused with *Laminaria digitata*, especially when young.

Recorded distribution in Britain and Ireland

Found on most coasts of Britain and Ireland. Scarce along the south east coast of Britain due to a lack of suitable substrata.

Global distribution

Restricted to the north east Atlantic from the northern coast of Iceland, north to the Russian coast near Murmansk and south to Cape Mondego, mid-Portugal including Norway, Faroes, northern

France and northern Spain but absent from the Bay of Biscay.

Habitat

Found on bedrock or other stable substrata from extreme low water to depths dependant on light penetration and sea urchin grazing (typically about 8 m depth in coastal waters to 30 m in clear coastal waters). It grows as dense forests under suitable conditions. Found at depths of up to 47 m around St Kilda.

Depth range

1-36m

Identifying features

- Large frond up to 1 m in length lacking midrib.
- Frond is smooth, wide and digitate.
- Stipe stiff, rough in texture and often covered by red seaweeds.
- Stipe is circular in cross section and snaps when bent if already nicked.
- May be confused with *Laminaria digitata* when young. However, the stipe of *Laminaria digitata* is usually oval in cross section, not thicker at the base and does not snap easily.

Additional information

Other common names include, redware, cuvy, sea rod, mayweed or Slat mara. The new blade grows below the older from November onwards. The old blade is shed in spring and early summer. Blade and stipe vary with exposure and current. In sheltered conditions the blade has few or no digits and the stipe becomes thin but in exposed conditions the blade is deeply digitate and the stipe becomes thick. The stipe is usually up to 1m long but stipes up to 3m long have been recorded (Parke unpublished, cited in Kain, 1971a).

Listed by

Further information sources

Search on:

NBN WoRMS

Biology review

Taxonomy

Phylum	Ochrophyta	Brown and yellow-green seaweeds
Class	Phaeophyceae	
Order	Laminariales	
Family	Laminariaceae	
Genus	Laminaria	
Authority	(Gunnerus) Foslie, 1884	
Recent Synonyms	-	

Biology

Typical abundance	High density
Male size range	Gametophyte ca 0.01 mm
Male size at maturity	
Female size range	Gametophyte ca 0.01 mm
Female size at maturity	
Growth form	Arborescent / Arbuscular
Growth rate	0.94cm/day
Body flexibility	
Mobility	
Characteristic feeding method	Autotroph
Diet/food source	Autotroph
Typically feeds on	Not relevant
Sociability	
Environmental position	Epilithic
Dependency	Independent.
Supports	None
Is the species harmful?	No Edible

Biology information

The adult plant exhibits no gender but the gametophytes are dioecious. The approximate size of male and female gametophytes are given.

Growth
The growth rate during maximal growth is reported. Adults grow rapidly until about 5 years old. Peak growth occurs during winter (November to June) and stops in summer initiated by a photoperiodic response to day length. The total carbon content of canopy lamina is reported to vary with season reflecting a change in carbohydrate storage (Sjøtun, 1996). Carbon content is high in the summer and autumn and starts to decrease in winter with the onset of growth. The old blade is replaced by a new blade formed between the meristem (top of stripe) and the old blade. Nutrients from the old blade contribute to growth. The old blade is shed in spring to early summer.

In *Laminaria hyperborea*, the proportion of growth allocated to various regions of the plant is reported to vary with both the age of the plant and its habitat (Sjøtun & Fredriksen, 1995). The proportion of growth allocated to the stipe and hapteron, for instance, increases with exposure, the latter probably helping the plant to remain attached and help it to survive in exposed localities (Sjøtun & Fredriksen, 1995). In one year old plants however, growth mainly occurred in the lamina in order to maximize the area for photosynthesis in the light limited understory.

Habitat preferences

Physiographic preferences	Open coast, Strait / sound, Ria / Voe, Enclosed coast / Embayment
Biological zone preferences	Lower infralittoral, Upper infralittoral
Substratum / habitat preferences	Artificial (man-made), Bedrock, Cobbles, Large to very large boulders, Pebbles
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Exposed, Moderately exposed, Very exposed
Salinity preferences	Full (30-40 psu)
Depth range	1-36m
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

Laminaria hyperborea is not found in areas influenced by sediment (e.g. sand) scour. *Laminaria hyperborea* is absent is areas of extreme wave action or currents (e.g. surge gullies) since the stiff stipe is likely to snap or holdfasts tear off. It is also absent from sheltered areas. The upper limit of its distribution may be depressed by wave action, e.g. in St Kilda its upper limit is several metres below MLWS (Birkett *et al.*, 1998b). High irradiances (comparable to direct sunlight) reduce photosynthesis in *Laminaria hyperborea*, which may explain its absence from intertidal rock pools, where it is replaced by *Laminaria digitata* (Kain *et al.*, 1975). The lower limit of *Laminaria hyperborea* is determined by light penetration except in the presence of grazing e.g. by *Echinus* in the Isle of Man (Jones & Kain, 1967; Kain *et al.* 1974). The lower limit for Laminarians is generally considered to be about 1 percent of surface irradiance (Luning, 1990; Birkett *et al.*, 1998b).

Life history

Adult characteristics

Reproductive type	Gonochoristic (dioecious)
Reproductive frequency	Annual episodic
Fecundity (number of eggs)	>1,000,000
Generation time	2-5 years
Age at maturity	2 -6 years
Season	September - April
Life span	11-20 years

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	Spores (sexual / asexual)
Duration of larval stage	See additional information
Larval dispersal potential	0 - 10 km
Larval settlement period	Can be all year round (see additional information)

Life history information

Laminaria hyperborea is a perennial and lives for up to 20 years. Longevity is thought to be higher in its northern distribution (Sjøtun *et al*., 1993). Spores are produced from sori over most of the blade surface (except most distal or proximal areas) over 6-7 weeks in winter (September - April) (Kain, 1975). Most young sporophytes (germlings) appear in spring but can appear all year round depending on conditions (Birkett *et al*., 1998b).

Laminarians exhibit alternation of generations and morphologically distinct reproductive phases. The obvious plant is the sporophyte (diploid) producing vast numbers of meiotic haploid zoospores from 'sori'. The flagellated zoospores are about 5 microns in diameter (Sauvageau, 1918; cited in Kain, 1979) and may be transported at least 5 km from the parent (Jónsson, 1972, cited in Norton, 1992). They lose their flagella after 24 hrs (Kain, 1964) and settle on the available substrata. However, settling rate is dependant on the local currents, therefore larval settling time is probably longer than 1 day (Fredriksen *et al*., 1995). The zoospores develop into microscopic dioecious gametophytes. These become fertile in 10 days in optimal conditions.

Male gametophytes release motile sperm that fertilize eggs of female gametophytes and the resultant zygote develops into the new sporophyte. Mass and rapid sperm release was initiated by adding a drop of sea water, into which female *Laminaria hyperborea* gametophytes had released eggs, to the male gametophyte culture medium, suggesting the eggs produce pheromones which induce the release of and attract the sperm (Lüning & Müller, 1978).

Maturation of the gametophytes can be delayed under less optimal conditions and development remains vegetative. For example, Lüning (1980) reported that fertility, the induction of fertilization in male and female gametophytes, depended on a critical quantum dose of blue light. Fragments of damaged vegetative gametophytes may develop into separate gametophytes (only a few cells are required) hence reproductive potential may be increased. If optimal conditions return the gametophyte may become fertile and produce gametes. Spore production may be inhibited by epifauna such as *Membranipora membranacea* (sea mat) and endophytes such as *Streblonema* sp. (Kain, 1975b).

Sensitivity review

This MarLIN sensitivity assessment has been superseded by the MarESA approach to sensitivity assessment. MarLIN assessments used an approach that has now been modified to reflect the most recent conservation imperatives and terminology and are due to be updated by 2016/17.

Physical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Substratum Loss	High	Moderate	Moderate	Moderate

Removal of the substratum would entail removal of the plants themselves, juvenile sporophytes (germlings) and gametophytes. They can not re-attach once removed and would be swept away. Experimental clearance experiments (Kain, 1979) in the Isle of Man showed that *Laminaria hyperborea* out-competed opportunistic species (e.g. *Alaria esculenta*, *Saccorhiza polyschides* and *Desmarestia* spp.) and returned to near control levels of biomass within 3 years at 0.8 m but that recovery was slower at 4.4m. However, Kain (1979) noted that grazing would slow recovery since, even though they did not prevent spore settlement, few sporophytes survived after 1 year in the presence of *Echinus esculentus*. These experiments did not remove the gametophyte 'seed' bank. Research on harvested populations of *Laminaria hyperborea* in Norway suggests that kelp forest biomass returned to pre-harvesting levels after 1-2 years, but that the plants were mainly small (1m) and that the age structure of the population was shifted towards younger plants. Sivertsen (1991, cited in Birkett *et al*., 1998b) showed that kelp populations stabilize after about 4-5 year post-harvesting. Re-growth was due primarily to growth of viable juveniles after harvesting. Current advice in Norway suggest that kelp forest should be left for 7-10 years after harvesting for the kelp biomass and non-kelp species to recover (Birkett *et al*., 1998b). Therefore, recovery is dependant on the depth (light availability) and grazing. However, given the potentially large number of spores and gametophytes it is likely that recolonization would occur rapidly and sporophytes may grow up to 0.94 cm /day under optimal conditions.

Smothering	Low	Immediate	Not sensitive	Low

Although smothering of the adult sporophyte may reduce photosynthetic activity it is unlikely to cause damage. However, juvenile sporophytes may be smothered and their growth inhibited. The germlings, zoospores and gametophytes are likely to be intolerant of smothering.

Increase in suspended sediment	Low	Immediate	Not sensitive	Low

Increased sedimentation may result in smothering of adults (sporophytes), germlings and gametophytes (see above). It may also prevent spore attachment (J. Jones, pers. comm.). Increased sediment deposition may increase sediment scour. However, the most likely effect of increased siltation will be increased light attenuation and turbidity (see below).

Decrease in suspended sediment

Dessication	High	Moderate	Moderate	Low

Laminaria hyperborea is primarily a subtidal species and is unlikely to experience desiccation except during extreme low waters events. It is likely to be highly intolerant of desiccation, and should the single meristem (growth region) be destroyed the plant will die. Although individuals at the top of the shore may be lost the majority of population is found subtidally and is unlikely to be affected.

Increase in emergence regime High Moderate Moderate Low

Laminaria hyperborea is primarily a subtidal species and is likely to be highly intolerant of increases in emergence. Its upper limit on the shore is in part dependant on the emergence regime as well as competition from more tolerant species such as *Laminaria digitata*. An increase in emergence time is likely to depress its upper limit on the shore.

Decrease in emergence regime

Increase in water flow rate High Moderate Moderate Moderate

The morphology of the stipe and blade vary with water flow rate. In wave exposed areas, for example, *Laminaria hyperborea* develops a long and flexible stipe and this is probably a functional adaptation to strong water movement (Sjøtun, 1998). In addition, the lamina becomes narrower and thinner in strong currents (Sjøtun & Fredriksen, 1995). However, the stipe of *Laminaria hyperborea* is relatively stiff and can snap in strong currents. It is usually absent from areas of high wave action or strong currents although in Norway it can do well in rapids (J. Jones, pers. comm.).

Decrease in water flow rate

Increase in temperature High Moderate Moderate Moderate

Birkett *et al.* (1998) suggest that kelp are stenothermal (intolerant of temperature change) and that upper and lower lethal limits for kelp would be between 1-2 °C above or below the normal temperature tolerances. The optimum temperature for the development of *Laminaria hyperborea* gametophytes and young sporophytes is between 10-17 °C (Kain, 1971). Above 17 °C, gamete survival is reduced (Kain, 1971) and gametogenesis is inhibited at 21 °C in this species (tom Dieck, 1992). Given its distribution in the North Atlantic this species is likely to be tolerant of low temperatures. This species is likely to be intolerant of change in temperature equivalent to either benchmark outside its normal range. The temperature tolerances of the gametophyte stages are different to those of the adult. Gametophytic development has been observed at 0 °C although development is slow and suggests that 0 °C is close to the lowest temperature allowing vegetative development of the primary cells (Sjøtun & Schoschina, 2002).

Decrease in temperature

Increase in turbidity Intermediate Moderate Moderate Moderate

The light penetration influences the maximum depth at which kelps species can grow. Dring (1982) reported that laminarians grow at depths at which the light levels are reduced to 1 percent of incident light at the surface. This varies with the turbidity of the sea water from 100 m in the Mediterranean to only 6-7 m in the silt laden German Bight to a maximum of about 35 m in Atlantic European waters. In very turbid waters the depth limit for kelp may be limited to 2 m or it may be absent completely, e.g. Severn Estuary) (Birkett *et al.*, 1998b; Lüning, 1990). Increased turbidity due to coastal engineering, dredging, cooling water plumes have been reported to result in the loss of local kelp forest. Suspended material in vicinity of sewage outfalls have been reported to result in reduced the depth range and the fewer new plants under the canopy. The quality or wavelength of light also affects kelps. Red light favours the accumulation of carbohydrates and blue light enhances protein synthesis, enzyme activity, respiration and is important for the formation of oogonia (eggs) in gametophytes (Dring, 1988). Dissolved organic materials (yellow substance or gelbstoff) absorbs blue light strongly, therefore changes in riverine input or other land based runoff are likely to influence kelp density and distribution. *Laminaria hyperborea* is likely to be intolerant of a increase of light attenuation of 30 percent of incident surface illumination but would probably not be destroyed within 5 weeks. However, it is likely to be highly intolerant of an increase in turbidity for longer periods especially in deeper waters.

Decrease in turbidity

Increase in wave exposure	High	Moderate	Moderate	Moderate

Laminaria hyperborea is unable to survive where wave action is extreme because of its large frond area attached to a stiff stipe which is liable to snap. Wave action depresses the upper limit of populations to several metres below low water. In Norway, for example, the upper and lower limits of *Laminaria hyperborea* are raised from 5 to 0 m and 32 to 26 m from exposed to sheltered sites respectively (Kain, 1971b). It is absent from Rockall possibly due to extreme exposure and strong currents or geographical isolation. Older and larger plants, especially if the holdfasts are weakened by feeding by *Helcion pellucidum*, are most intolerant of wave action and populations affected by wave action have a reduced age range. As wave exposure increases *Laminaria hyperborea* is out-competed by *Laminaria digitata* or *Alaria esculenta*. In a study in Norway (Sjøtun *et al.*, 1993) *Laminaria hyperborea* from the most wave exposed site (in Finnmark) exhibited the lowest annual biological productivity per plant. Furthermore, of the four most exposed sites, three of them corresponded with the lowest mean standing crops (fresh weights). Therefore, *Laminaria hyperborea* is probably highly intolerant of increases in exposure at the benchmark level. It could benefit from decreases in wave exposure, possibly extending its upper limit up the shore, however this would only happen if its upper limit was depressed below the lowest astronomical tide (LAT) as it is highly intolerant of emergence (J. Jones, pers. comm.).

Decrease in wave exposure

Noise	Tolerant	Not relevant	Not sensitive	Not relevant

Plants have no known sound or vibration receptors

Visual Presence	Tolerant	Not relevant	Not sensitive	Not relevant

Macroalgae are not known to react to the rapid changes in light and shade that would be associated with movement and have no known visual receptors.

Abrasion & physical disturbance	Intermediate	Moderate	Moderate	Very low

Physical disturbance caused by a scallop dredge or equivalent impact is likely to have similar effects to that of harvesting, although not so severe (see below). Plants are likely to be removed or damaged by a passing dredge. Therefore, an intolerance of intermediate has been recorded.. Recovery is likely to moderate.

Displacement	High	Moderate	Moderate	High

Laminaria hyperborea cannot re-attach once removed and would be swept away. Experimental clearance experiments (Kain, 1979) in Isle of Man showed that *Laminaria hyperborea* out competed other opportunistic species (e.g. *Alaria esculenta*, *Saccorhiza polyschides* and *Desmarestia* spp.) and returned to near control levels of biomass within 3 years at 0.8m but that recovery was slower at 4.4m. However, Kain (1979) noted that grazing would slow recovery since, even though they did not prevent spore settlement, few sporophytes survived after 1 year in the presence of *Echinus esculentus*. These experiments did not remove the gametophyte 'seed' bank. Research on harvested populations of *Laminaria hyperborea* in

Norway suggests that kelp forest biomass returned to pre-harvesting levels after 1-2 years, but that the plants were mainly small (1m) and that the age structure of the population was shifted towards younger plants. Sivertsen (1991, cited in Birkett *et al*., 1998) showed that kelp populations stabilize after about 4-5 year post-harvesting. After 4 years post harvesting, kelps had only two thirds of their pre-harvesting canopy height. Re-growth was due primarily to growth of viable juveniles after harvesting. Current advice in Norway suggest that kelp forest should be left for 7-10 years after harvesting for the kelp biomass and non-kelp species to recover (Birkett *et al*., 1998b). Therefore, recovery is dependant on the depth (light availability) and grazing. However, given the potentially large number of spores and gametophytes it is likely that recolonization would occur rapidly and sporophytes may grow up to 0.94 cm /day under optimal conditions.

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	Low	Immediate	Not sensitive	Moderate

- Atrazine was lethal to young sporophytes of *Laminaria hyperborea* at 1mg/l and caused growth suppression at 10 µg/l in short term experiments (Hopkin & Kain, 1978). Mixed detergents, herbicides (dalapon and 2,4-D) were not toxic at the levels tested (Hopkin & Kain, 1978). Cole *et al* (1999) report the following as very toxic to macrophytes: atrazine; simazine; diuron; and linuron (herbicides). It is likely therefore that Laminariales such as *Laminaria hyperborea* have an intermediate intolerance to atrazine and some other herbicides as levels equivalent to the short term benchmark (20 µg /l).
- PCBs inhibited growth, gametogenesis and sporophyte recruitment in *Macrocystis pyrifera* at 5 µg/litre and, therefore, may have similar sub-lethal effects on *Laminaria hyperborea*.
- Hoare & Hiscock (1974) noted that *Laminaria hyperborea* and the red algae *Phyllophora membranifolia* were the most tolerant algae of acidified, halogenated effluent, occurring within 55 m of the effluent outfall in Amlwch Bay, Anglesey. However, they also reported that the surviving *Laminaria hyperborea* plants were at least 5 years of age and that no new sporelings occurred closer to the outfall than 8 m from the closest adults. Hoare & Hiscock (1974) also noted that several species were excluded from Amlwch Bay by the effluent, notably *Antedon bifida* and *Helcion pellucidum* (as *Patina pellucida*) and the epiphytic red algae together with Echinodermata, Polyzoa and Amphipoda were particularly intolerant.
- However, Holt *et al.* 1995 state that mature *Laminaria hyperborea* may be relatively tolerant of chemical pollution probably due to the presence of alginates. Although alginates sequester heavy metals and some radionuclides from seawater it probably binds them in an inert form. This species is likely to exhibit a low intolerance at the level of the benchmark.

	Intolerance	Recoverability	Sensitivity	Confidence
Heavy metal contamination	Intermediate	Immediate	Very Low	Moderate

Hopkin & Kain (1978) examined the effect of Cu, Zn, Hg and Cd on *Laminaria hyperborea* gametophytes and sporophytes. Sublethal effects on sporophyte development, growth and respiration were shown at concentrations higher than the short term benchmark for Hg, Zn and Cd. Hg was found to be lethal at 0.05 mg/l. However, Cu affected sporophyte development at 0.01mg/l, lower than the benchmark level but was lethal at 0.1 mg/l. However, this report did not examine other heavy metals or their synergistic effects.

Hydrocarbon contamination Low Immediate Not sensitive Moderate

Mucilaginous slime coating kelp fronds is thought to protect them from coatings of oil. Hydrocarbons in solution reduce photosynthesis and may be algicidal. Reduction in photosynthesis depends on the type of oil, its concentration, length of exposure, method used to prepare oil-water mixture and irradiance in experimental trials (Lobban & Harrison, 1994). The sublittoral fringe populations of *Laminaria hyperborea* would be most vulnerable to oiling. Subtidal populations being only exposed to dispersed oil or oil adsorbed to particles. Kelps are relatively insensitive to dispersants (Birkett *et al.*, 1998). Three days exposure to 1 percent diesel emulsion reduced photosynthesis completely in young *Macrocytsis* plants. *Laminaria digitata* exposed to diesel oil at 130 microgrammes per litre reduced growth by 50 percent in a two year experiment. No growth inhibition was noted at 30 microgrammes per litre and the plants recovered completed in oil-free conditions. Holt *et al.* (1995) report that oil spills in the USA and the *Torry Canyon* spillage had little effect on kelp forest. Respiration in *Laminaria hyperborea* was inhibited by phenol at 100 mg/l (100 ppm).

Radionuclide contamination Not relevant

Insufficient information

Changes in nutrient levels Intermediate Moderate Moderate Moderate

All kelp species are efficient absorbers of nutrients (nitrates and phosphates) and can take up and store excess nutrients. Dring (1982) reports that storage of nitrates in winter (when nutrients are plentiful) allows Laminarians to continue growth for 2-3 months after the spring decrease in sea nutrients levels. Although growth is negligible in summer, photosynthesis remains high and reserves of carbohydrates are built up. These carbohydrate reserves peak in autumn, are translocated to the meristem in winter and allow rapid growth in winter when nutrient levels are high. Holt *et al.* (1995) suggest that *Laminaria hyperborea* may be tolerant of eutrophication since healthy populations are found at ends of sublittoral untreated sewage outfalls in the Isle of Man. Nutrients may be added to macrophyte cultures to increase productivity. However, eutrophication is associated with loss of perennial macrophytes, a reduction in the depth range and replacement by mussels or opportunistic algae species (Fletcher, 1996; Birkett *et al.*, 1998b) presumably due to indirect effects such as increased turbidity. Increased nutrients may increase growth of epiphytes and plankton, resulting in reduced light penetration for photosynthesis and a subsequent reduction in the depth at which kelp could grow and possibly competition with juvenile sporophytes. Therefore, a rank of intermediate intolerance has been given to represent the likely indirect effects on turbidity and competition.

Increase in salinity Intermediate Moderate Moderate Moderate

Lüning (1990) suggests that kelps are stenohaline and that their tolerance to salinity covers a range between 16 - 50 psu. Optimal growth probably occurs between 30 -35 psu and grow rates are likely to be affected by periodic salinity stress. Hopkin & Kain (1978) stated that early sporophytes of *Laminaria hyperborea* grew optimally between 20 -35 psu but did not survive at 6 psu. Birkett *et al.* (1998) suggest that long term changes in salinity may result in loss of affected kelp beds.

Decrease in salinity

Changes in oxygenation Not relevant Not relevant

Little information on the effects of oxygen depletion on macroalgae was found. Kinne (1972) reports that reduced oxygen concentrations inhibit both photosynthesis and respiration. The effects of decreased oxygen concentration equivalent of the benchmark would be greatest during dark when the kelps are dependant on respiration.

Biological Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of microbial pathogens/parasites	Low	Immediate	Not sensitive	Moderate

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). Resultant damage to the blade and stipe may increase losses in storms. The endophyte inhibits spore production and therefore recruitment and recoverability.

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of non-native species		Not relevant		Not relevant

The Japanese kelp *Undaria pinnatifida* (wakame) has recently spread to the south coast of England from Brittany where it was introduced for aquaculture. It is presently restricted to man made structures but could spread in ballast water of commercial or recreational boats and shipping. Its potential competition with other kelps in the UK, including *Laminaria hyperborea* requires further study (Birkett*et al.*, 1998).

	Intolerance	Recoverability	Sensitivity	Confidence
Extraction of this species	Intermediate	Moderate	Moderate	High

Research on harvested populations of *Laminaria hyperborea* in Norway suggests that kelp forest biomass returned to pre-harvesting levels after 1-2 years, but that the plants were mainly small (1m) and that the age structure of the population was shifted towards younger plants. Sivertsen (1991; cited in Birkett *et al.*, 1998) showed that kelp populations stabilize after about 4-5 year post-harvesting. Re-growth was due primarily to growth of viable juveniles after harvesting. Current advice in Norway suggest that kelp forest should be left for 7-10 years after harvesting for the kelp biomass and non-kelp species to recover (Birkett *et al.*, 1998). Therefore recovery is dependant on the depth (light availability) and grazing. However, given the potentially large number of spores and gametophytes it is likely that recolonization would occur rapidly and sporophytes may grow up to 0.94 cm /day under optimal conditions. Evidence from storm damage indicates that kelp forest can regrow within 14 months. Experimental clearance experiments (Kain, 1979) in Isle of Man showed that *Laminaria hyperborea* out competed other opportunistic species (e.g. *Alaria esculenta*, *Saccorhiza polyschides* and *Desmarestia* spp.) and returned to near control levels of biomass within 3 years at 0.8 m but that recovery was slower at 4.4 m. However, Kain (1979) noted that grazing would slow recovery since, even though it did not prevent spore settlement, few sporophytes survived after 1 year in the presence of by *Echinus esculentus*. These experiments did not remove the gametophyte 'seed' bank.

	Intolerance	Recoverability	Sensitivity	Confidence
Extraction of other species	Intermediate	Moderate	Moderate	Moderate

Removal of urchin predators such as lobsters or crawfish has been implicated in increases in urchin populations and therefore the creation of 'urchin barrens' and the loss of kelp beds (Birkett *et al.*, 1998b). Similarly, removal of grazing abalone by fishing is thought to have resulted in the loss of kelp beds as sea urchins populations benefited from reduced competition for food. However, the evidence is equivocal as sea urchin barrens occur in areas where lobsters are not found (Birkett *et al.*, 1998; Hawkins & Raffaelli, 1999). It is likely that there is a complex interaction between sea urchin recruitment and predation. However, removal of predators or other grazers may perturb the ecosystem making it more intolerant of natural fluctuations in sea urchin numbers or other perturbations.

Additional information

Importance review

Policy/legislation

- no data -

Status

National (GB) importance	-	**Global red list (IUCN) category**	-

Non-native

Native	-		
Origin	-	**Date Arrived**	Not relevant

Importance information

Drift kelp has long been collected as an agricultural fertilizer and soil conditioner. Recently kelps have been harvested for the alginate industry which produces valuable emulsifiers and gelling agents for cosmetic, pharmaceutical and food industry. *Laminaria hyperborea* is harvested commercially in Norway, Brittany, Scotland and Ireland (for reviews see Guiry & Blunden, 1991; Wilkinson, 1995 and Birkett *et al.*, 1998b).

Kelps provide a unique habitat and substratum for many organisms and kelp forests are species rich habitats (Birkett *et al.*, 1998b). *Laminaria hyperborea* provide three separate habitats, the blade (or frond), the stipe and the holdfast. The blades support *Patella pellucida*, the bryozoan *Membranipora membranacea* and the hydroid *Obelia geniculata* (Erwin *et al.*, 1990; Birkett *et al.*, 1998b) as well as endophytes and epiphytes, e.g. *Myrionema corunnae* (only found on *Laminaria* blades), and *Pogotrichum filiforme* and *Chilionema* sp., which are mainly restricted to kelp blades (Birkett *et al.*, 1998b).

The stipes support a diverse flora and fauna, especially foliose algae, depending on the age of the stipe, density of the kelp plants, and depth (Norton *et al.*, 1977; Birkett *et al.* 1998b,). Hiscock & Mitchell (1980) list 15 species of algae associated with kelp stipes including, *Palmaria palmata*, *Membranoptera alata*, and *Phycodrys rubens* which are found mainly or solely on kelp stipes in the sublittoral.

Kelp holdfasts support a diverse fauna that represents a sample of the surrounding mobile fauna and crevice dwelling organisms, e.g. cnidaria, polychaetes, nematodes, gastropods, bivalves, cirripedes, amphipods, isopods, copepods (mainly harpacticoids), and small crabs (Hoare & Hiscock, 1974; Jones, 1971; Moore, 1973a & b; Sheppard *et al.*, 1980). Moore (1973a) lists 389 species from holdfasts collected from the north east coast of Britain. A useful account of holdfast fauna is given by Hayward (1988).

Kelp holdfasts form a convenient sampling unit, and holdfast fauna has been used to investigate the effects of pollution (e.g. Moore, 1973a, b; Sheppard *et al.*, 1980) and were recently used (amongst other studies) to examine the effects of the Sea Empress Oil spill (Somerfield & Warwick, 1999). Further information of the community associated with *Laminaria hyperborea* and its importance is detailed under the biotope EIR.LhypR.

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