Oarweed (*Laminaria digitata*)

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

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A report from:
The Marine Life Information Network, Marine Biological Association of the United Kingdom.

Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/species/detail/1386]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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Laminaria digitata **(foreground) and** ***Laminaria ochroleuca*** **(background) at West Hoe, Plymouth.**
Photographer: Keith Hiscock

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	Jacqueline Hill	**Refereed by**	Dr Stefan Kraan
Authority	(Hudson) J.V.Lamouroux, 1813		
Other common names	-	**Synonyms**	*Laminaria cucullata* (Hudson) J.V.Lamouroux, 1813, *Laminaria cucullata* (Hudson) J.V.Lamouroux, 1813

Summary

Description

A large conspicuous kelp growing up to 2 m in length commonly found at low water during spring tides on rocky shores. The frond is broad and digitate, glossy and dark brown in colour and lacks a midrib. The stipe is oval in cross section, smooth and flexible and is usually free of epiphytes, although old stipes which have become slightly roughened may support a few epiphytes, notably *Palmaria palmata*. The kelp is attached by freely branched haptera, which spread out to form a shallow dome-shaped holdfast. *Laminaria digitata* may be confused with young *Laminaria hyperborea* plants. However, the stipe of *Laminaria hyperborea* is circular in cross section, is stiff and snaps easily when bent (although you won't see that in younger plants).

Recorded distribution in Britain and Ireland

Most coasts of Britain and Ireland, including Rockall. Scarce along east coast of England, particularly between Ouse and Thames estuaries, due to turbidity and lack of hard substrata. (Information continued in additional information).

Global distribution

Recorded from the Atlantic coasts of Europe as far north as Novaya Zemlya and south to the Canary Islands including the Baltic and Black Sea. It has also been recorded in Romania. (Information continued in additional information).

Habitat

Found attached to bedrock or other suitable hard substrata in the lower intertidal and sublittoral fringe, down to a maximum depth of 20 m in clear waters. *Laminaria digitata* flourishes in moderately exposed areas or at sites with strong water currents. In exposed locations with strong wave action the species may extend upwards into the lower eulittoral. Occurs in rockpools up to mid-tide level and higher on wave-exposed coasts.

Depth range

+1-20m

Identifying features

- Frond is broad, leathery and digitate.
- Lacks a midrib.
- Stipe is flexible and smooth, oval in cross section and free of epiphytes except maybe *Palmaria palmata* in older kelps.
- Holdfast of freely branched haptera which spread out to form a shallow dome.
- May be confused with young *Laminaria hyperborea* plants. However, the stipe of *Laminaria hyperborea* is circular in cross section and stiff.

Additional information

Common names in England also include Tangle, Red ware and Sea girdle. In Ireland common names include Leath and Learach. The length of the frond varies with season, age of plant and location, reaching over 1 m in suitable conditions. The number of frond digits vary with amount of exposure. In shelter these are few and short, but with increasing exposure, they are more numerous (up to 10 or 12) and extend almost to the base of the frond. Reported to store sodium glutamate and thus tasty when dried.

Listed by

Further information sources

Search on:

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Biology review

Taxonomy

Phylum	Ochrophyta	Brown and yellow-green seaweeds
Class	Phaeophyceae	
Order	Laminariales	
Family	Laminariaceae	
Genus	Laminaria	
Authority	(Hudson) J.V.Lamouroux, 1813	
Recent Synonyms	Laminaria cucullata (Hudson) J.V.Lamouroux, 1813Laminaria cucullata (Hudson) J.V.Lamouroux, 1813	

Biology

Typical abundance	High density
Male size range	
Male size at maturity	Gametophyte size circa 0.005mm
Female size range	Gametophyte size circa 0.01mm
Female size at maturity	
Growth form	Digitate
Growth rate	See additional information
Body flexibility	High (greater than 45 degrees)
Mobility	
Characteristic feeding method	Autotroph
Diet/food source	
Typically feeds on	Not relevant
Sociability	
Environmental position	Epilithic
Dependency	Independent.
Supports	No information
Is the species harmful?	No Edible

Biology information

Kelps of the family *Laminariaceae* exhibit an alternation of generations, which involves dissimilar (heteromorphic) phases; an asexual diploid phase (the sporophyte) is usually of considerable size and a haploid dioecious phase (the gametophyte) that is microscopic. Sporophytes of *Laminaria digitata* can grow to a length of 2-4 m. In the sporophyte, new growth takes place at the base of the lamina (blade) (Dickinson, 1963).

Growth rate
Growth rate is seasonally controlled with a period of rapid growth from February to July and one of slower growth from August to January. A mean growth rate of 1.3 cm / day has been reported during the season of maximal growth (Pérez, 1971; cited in Kain, 1979).

Habitat preferences

Physiographic preferences	Enclosed coast / Embayment, Open coast, Ria / Voe, Strait / sound
Biological zone preferences	Lower eulittoral, Sublittoral fringe, Upper infralittoral
Substratum / habitat preferences	Artificial (man-made), Bedrock, Cobbles, Large to very large boulders, Pebbles, Small boulders
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Strong 3 to 6 knots (1.5-3 m/sec.), Very Strong > 6 knots (>3 m/sec.), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Exposed, Moderately exposed, Sheltered, Very exposed
Salinity preferences	Full (30-40 psu), See additional Information
Depth range	+1-20m
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

There is a marked difference in the lower depth limit of *Laminaria digitata* between the various parts of its geographical range. The lower depth limit for growth and survival is determined by water clarity, competition and grazers. In the Isle of Man the lower limit is at 1-2 m below the lowest astronomical tide and at Milford Haven it has been recorded at 5 m. At the northern distribution limit *Laminaria digitata* extends to depths of 15-20 m (Birkett *et al*., 1998b). Where *Laminaria hyperborea* thrives it out-competes *Laminaria digitata* limiting the lower limit of *Laminaria digitata* (Kain, 1975). The salinity optimum for *Laminaria digitata* is full salinity. However, on the Norwegian coast, which is subjected to seasonal fluctuations in salinity, healthy *Laminaria digitata* plants were found growing at 15-25 psu (Sundene, 1964).

Recorded distribution in Britain and Ireland continued
Absent from Liverpool Bay and Severn estuary due to turbidity. Also scarce on the south-east coast of Ireland, in particular Counties Wicklow and Wexford, due to lack of hard substrata.

Global distribution continued
Also found in southern Greenland and east coast Canada, Quebec and North America from Hudson Straits to New York.

Life history

Adult characteristics

Reproductive type	Gonochoristic (dioecious)
Reproductive frequency	Annual protracted
Fecundity (number of eggs)	>1,000,000
Generation time	1-2 years
Age at maturity	18-20 months
Season	See additional text
Life span	6-10 years

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	Spores (sexual / asexual)
Duration of larval stage	1 day
Larval dispersal potential	100 -1000 m
Larval settlement period	All year (see additional information)

Life history information

- *Laminaria digitata* is a perennial and lives for 4 to 6 years (Gatral & Cosson, 1973; cited in Birkett *et al*., 1998b).
- *Laminarians* exhibit alternation of generations with morphologically dissimilar (heteromorphic) reproductive phases. The diploid phase (the sporophyte) is usually of considerable size and a haploid dioecious phase (the gametophyte) is microscopic.
- The sporophyte produces vast numbers of haploid zoospores from sporangia which develop in small patches on the lamina called sori.
- The flagellated zoospores are about five microns in diameter and may be transported at least 200 m from the parent (Birkett *et al*., 1998b). They loose their flagella after 24 hrs and settle on any available substrata.
- The zoospores develop into microscopic dioecious haploid gametophytes, male plants producing spermatozoid and female plants developing oogonia. The gametophytes become fertile in under 10 days in optimal conditions i.e. low temperatures and blue light.
- Maturation of the gametophytes can be delayed under less optimal conditions, for example in red light development remains vegetative. 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 (Hoek van den *et al*., 1995).
- Male and female gametes must settle at a high density (within 1 mm of each other) if the maturing gametangial egg is to be fertilized (Reed, 1990; cited in Birkett *et al*., 1998b). On fertilization of the extruded egg, young sporophytes start to grow *in-situ*.
- Sori are produced over most of the blade surface (except most distal or proximal areas) all year round with maxima in July - August and November - December.
- Young sporophytes (germlings) appear all year with maxima in spring and autumn.
- Chapman (1981) demonstrated that substantial recruitment of *Laminaria digitata* plants to areas barren of kelp plants was possible up to 600 m away from reproductive plants.

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	High	Moderate	High

Laminaria digitata is permanently attached to hard substrata and so would be completely removed by any substratum loss. They cannot re-attach once removed and would be swept away. Plants are able to rapidly re-colonize gaps in the upper infralittoral which result from storm damage (Birkett *et al*., 1998b) and after plant cutting the standing crop of *Laminaria digitata* was re-established within 18-20 months (Kain, 1979). In macroalgae clearance experiments at Port Erin, Isle of Man (Kain, 1975) recolonization of *Laminaria digitata* on concrete blocks had taken place within 2 years. In France, Ciam (le Comité interprofessionel des algues marines) proposed that , regardless of collection method, the restoration of stands of Laminariales took up to 18 months after harvesting (from Arzel, 1998). Recovery of cleared plots in Helgoland to original density took longer, 25 months, probably because plots were burned to ensure all spores and germlings were also removed (Markham & Munda, 1980). However, although the density of algal cover had returned to pre-clearance levels the *Laminaria digitata* plants were smaller than those on undisturbed plots. This suggests full population recovery is longer than 25 months.

Smothering	Intermediate	High	Low	Low

Smothering of mature sporophytes by a 5 cm layer of sediment on the substratum is unlikely to have an impact on photosynthetic activity because only the holdfast of the plant is likely to be covered. Germlings, spores and gametophytes are intolerant of smothering inhibiting development and so intolerance has been assessed as intermediate. Recoverability should be high as *Laminaria digitata* can rapidly re-colonize suitable substrata.

Increase in suspended sediment	Intermediate	High	Low	Moderate

Increased siltation can increase turbidity of the water and reduce available light for photosynthesis. Lyngby & Mortensen (1996) found that an increase in the level of suspended sediment may significantly reduce growth of *Laminaria* plants. Germlings, gametophytes and spores are probably more intolerant of siltation. Combined with water movements sediments can abrasively scour surfaces of settled spores. Development of *Saccharina latissima* (studied as *Laminaria saccharina*) gametophytes, for example, was inhibited by silt and failed to form an attachment when settling out on silty surfaces (Norton, 1978). However *Laminaria saccharina* is more tolerant of siltation and may out-compete *Laminaria digitata* in high silt environments. Heavy siltation may also result in smothering of plants (see Smothering).

Decrease in suspended sediment	Tolerant*	Not relevant	Not sensitive*	Moderate

Laminaria digitata may well benefit from a reduction in levels of suspended sediment as a result of potential decreased light attenuation and, therefore, increased light for photosynthesis. Tolerant* has been suggested.

Dessication	Intermediate	High	Low	High

Laminaria digitata regularly becomes exposed to air during very low water events and so is moderately tolerant of desiccation. Dring & Brown (1982) found that plants that lost up 40-50 % of their initial water content were still able to return to their original photosynthetic rate on re-immersion.

Increase in emergence regime Intermediate High Low High

At the sublittoral fringe *Laminaria digitata* regularly becomes exposed to air at very low water events and so is moderately tolerant of emergence. The rate of photosynthesis during emersion does not decline over a period of several hours if the thallus does not dry out, indicating that emersion is not, in itself, detrimental for photosynthesis (Dring & Brown, 1982). *Laminaria digitata* has also been shown to extend upshore when the algae immediately above it is removed (Hawkins & Hartnol, 1985) although plants at the upper extreme of the range may be killed when periods of emersion coincide with high temperatures. An increase in the period of emersion over the period of the benchmark (a 1 hour change in the time covered or not covered by the sea for a period of 1 year) would probably result in a depression of the upper limit of *Laminaria digitata*.

Decrease in emergence regime Tolerant* Not relevant Not sensitive* Moderate

An decrease in the period of emersion over the period of the benchmark would probably result in an extension of the upper limit of *Laminaria digitata*. Therefore, tolerant* has been suggested.

Increase in water flow rate Low High Low Low

With a flexible stipe and low profile holdfast *Laminaria digitata* flourishes in areas with strong water currents. In Lough Ine in Ireland, for example, *Laminaria digitata* forms dense forests in the fast flowing water of the Rapids where water speeds vary from 4-6 knots (Bassingdale *et al.*, 1948). However, *Laminaria digitata* is also found in very strong flows (> 6 knots) although it is often out-competed by *Alaria esculenta*.
The morphology of the blade varies with flow rate, becoming narrower and more digitate as water flow rate increases (Sundene, 1964).

Decrease in water flow rate Intermediate High Low Low

With a flexible stipe and low profile holdfast *Laminaria digitata* flourishes in areas with strong water currents. However, it can also be found in slower currents although it is likely to be out competed by *Laminaria hyperborea* and therefore an intolerance of intermediate has been suggested.

Increase in temperature Intermediate High Low Moderate

Laminaria digitata is a eurythermal species with sporophytes growing over a wide temperature range. Atlantic species showed only slightly sub-optimal growth over a range of temperatures, from 0-20 °C, with optimum growth at 10 °C (Bolton & Lüning, 1982). *Laminaria digitata* is likely to tolerate a long term, chronic change in temperature within this range, e.g. a 2 °C change in temperature for a year. Lüning (1984) detected a seasonal shift in heat tolerance of *Laminaria digitata* plants in Helgoland of 2 °C between spring and summer. However, *Laminaria digitata* may be intolerant of rapid changes in temperature outside its tolerance range. During an exceptionally warm summer in Norway, Sundene (1964) reported the destruction of plants exposed to temperatures of 22-23 °C. Therefore *Laminaria digitata* is likely to be of intermediate intolerance to short term acute temperature change.

Decrease in temperature Intermediate High Low Moderate

Laminaria digitata is a eurythermal species with sporophytes growing over a wide temperature range. Atlantic species showed only slightly sub-optimal growth over a range of temperatures, from 0-20 °C, with optimum growth at 10 °C (Bolton & Lüning, 1982). *Laminaria digitata* is likely to tolerate a long term, chronic change in temperature within this range, e.g. a 2 °C change in temperature for a year. Lüning (1984) detected a seasonal shift in heat tolerance of *Laminaria digitata* plants in Helgoland of 2 °C between spring and summer. However, *Laminaria digitata* may be intolerant of rapid changes in temperature outside its tolerance range. In Scotland, when spring low tides coincided with night time extreme air frosts on several consecutive days mortality of all but the lowest shore adult *Laminaria digitata* plants occurred (Todd & Lewis, 1984). Therefore *Laminaria digitata* is likely to be of intermediate intolerance to short term acute temperature change.

Increase in turbidity	Intermediate	High	Low	Moderate

In very turbid waters the depth at which *Laminaria digitata* is found will be reduced because of light attenuation. In the silt-laden waters around Helgoland, Germany the depth limit for *Laminaria digitata* growth may be reduced to between 0 m and 1.5 m (Birkett *et al.*, 1998b). Increased turbidity around a sewage treatment plant was thought to be responsible for the absence of *Laminaria digitata* plants in the Firth of Forth (Read *et al.*, 1983). An increase in turbidity will reduce photosynthesis and growth of plants. In Narragansett Bay, Rhode Island growth rates of *Laminaria digitata* fell during a summer bloom of microalgae that dramatically reduced irradiance. Quality of light is also important with blue light necessary for gametogenesis and development of gametophytes. 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.

Decrease in turbidity	Tolerant*	Not relevant	Not sensitive*	Moderate

A decrease in turbidity is concurrent with a decrease in light attenuation. Reduced turbidity will increase photosynthesis and the growth of the plants. Quality of light is also important with blue light necessary for gametogenesis and development of gametophytes. A decrease in turbidity is likely benefit the plants and therefore tolerant* has been suggested.

Increase in wave exposure	Low	High	Low	High

Laminaria digitata flourishes in moderately to strongly exposed areas due to a flexible stipe and low profile holdfast. The species may extend its upper limit upwards into the lower eulittoral in exposed areas with strong wave action. *Laminaria digitata* is found at very exposed locations such as Rockall. In extreme wave exposure it is replaced by *Alaria esculenta*. The level of wave exposure is known to effect the morphology of the blade, becoming narrower and more digitate as wave exposure increases (Sundene, 1964).

Decrease in wave exposure

Laminaria digitata flourishes in moderately to strongly exposed areas due to a flexible stipe and low profile holdfast. As wave exposure decreases, *Laminaria digitata* combines with, and is then replaced by, *Saccharina latissima* (studied as *Laminaria saccharina*) (Birkett *et al.*, 1998b). It is possible that the extent of the *Laminaria digitata* stand will decrease over the year and therefore an intermediate intolerance has been suggested.

Noise	Tolerant	Not relevant	Not sensitive	Not relevant

Macroalgae have no known receptors for noise or vibration.

Visual Presence	Tolerant	Not relevant	Not sensitive	Not relevant

Macroalgae have no known mechanism for visual perception.

Abrasion & physical disturbance	Intermediate	High	Low	Moderate

Abrasion is a part of the normal growth cycle of the frond where growth at the base of the frond is almost balanced by erosion at the tips. Fronds of the plant are leathery and the whole plant is very flexible so physical disturbance equivalent to a standard boat anchor landing on or being dragged across the organism, is unlikely to cause significant damage to the plant. However, a passing dredge is likely to catch and damage or remove individual plants. Therefore, an intolerance of intermediate has been recorded. Recoverability is likely to be high.

Displacement	High	High	Moderate	Low

Laminaria digitata cannot re-attach once displaced from the substratum and it will be swept away. Individual plants are unable to recover but populations have good recoverability because recolonization of cleared areas can take place within about two years (see Substratum loss).

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	Intermediate	High	Low	Moderate

Intolerance to some chemicals has been observed. *Laminaria digitata* was found absent from sites close to acidified, halogenated effluent from a bromide extraction plant (Hoare & Hiscock, 1974). Axelsson & Axelsson (1987) investigated the effect on *Laminaria digitata* of exposure to various chemicals for 24 hours by measuring ion leakage as an indication of plasma membrane damage. The pesticide Lindane had no effect on ion loss when compared to the control at concentrations ranging from 0.03 to 0.3mg/L. Only limited ion loss was seen on exposure to two detergents, nonylphenol ethoxylate (NP-10) and linear alkylbenzene sulfonate (LAS).

Heavy metal contamination	Intermediate	High	Low	Moderate

Zinc was found to inhibit growth in *Laminaria digitata* at a concentration of 100µg/L and at 515µg/L growth had almost completely ceased (Bryan, 1969). Axelsson & Axelsson (1987) investigated the effect of exposure to mercury (Hg), lead (Pb) and nickel (Ni) for 24 hours by measuring ion leakage to indicate plasma membrane damage. Inorganic and organic Hg concentrations of 1mg/L resulted in the loss of ions equivalent to ion loss in seaweed that had been boiled for 5 minutes. *Laminaria digitata* was unaffected when subjected to Pb and Ni at concentrations up to 10mg/L. The results also indicate that the species is intolerant of the tin compounds butyl-Sn and phenyl-Sn.

Hydrocarbon contamination	Low	High	Low	High

The toxic effects of oil on algae fall into two categories: those associated with coating of the plant and those due to uptake of hydrocarbons resulting in disruption of cellular metabolism. Reductions in photosynthesis rates are correlated with the thickness of the oil layer. *Laminaria digitata* is less susceptible to coating than some other seaweeds because of its preference for exposed locations where wave action will rapidly dissipate oil. The brown algae are thought to be largely protected from oil penetration damage by the presence of a mucilaginous coating (O'Brian & Dixon, 1976). In addition effects of oil accumulation on the thalli are mitigated by the perennial growth of kelps. No significant effects of the *Amoco Cadiz* spill were observed for *Laminaria* populations and the *World Prodigy* spill of 922 tons of oil in Narragansett Bay had no discernible effects on *Laminaria digitata* (Peckol *et al.*, 1990). The upper limit of distribution for *Laminaria digitata* moved up wave exposed shores by as much as 2m during the first few years after the *Torrey Canyon* oil spill due to the death of animals that graze the plants (Southward &

Southward, 1978). Mesocosm studies in Norwegian waters showed that chronic low level oil pollution (25µg/L) reduced growth rates in *Laminaria digitata* but only in the second and third years of growth (Bokn, 1985).

Radionuclide contamination Not relevant

Brown algae readily accumulate radionuclides and have been routinely used in temperate latitudes as biomonitors of radionuclide pollution (van der Ben & Bonotto, 1991). Any contaminants bioaccumulated in the alga can enter the food chain through, for example, grazers such as sea urchins. However, the actual effects of radionuclide accumulation in the alga are not well documented and accordingly, insufficient information has been suggested for this section.

Changes in nutrient levels Low High Low High

The growth of macroalgae in temperate coastal waters is generally expected to be limited by nitrogen in the summer period. A comparison of *Laminaria digitata* growth rates in Arbroath, Scotland with a more oligotrophic and a more eutrophic site appears to support this hypothesis (Davison *et al.*, 1984). In Helgoland, where ambient nutrient concentrations are double those of the Scotland site *Laminaria digitata* grows in the summer months. *Laminaria digitata* does not accumulate the significant internal reserves seen in some other kelps. Higher growth rates have also been associated with plants situated close to sewage outfalls. However, after removal of sewage pollution in the Firth of Forth, *Laminaria digitata* became abundant on rocky shores from which they had previously been absent. Therefore, although nutrient enrichment may benefit *Laminaria digitata*, the indirect effects of eutrophication, such as increased light attenuation from suspended solids in the water column and interference with the settlement and growth of germlings, may be detrimental.

Increase in salinity Not relevant None Not relevant Moderate

Laminaria digitata is commonly found in areas of full salinity on the open coast and an increase in salinity is therefore unlikely.

Decrease in salinity Intermediate Very high Low Moderate

Birkett *et al.* (1998b) suggest that kelps are stenohaline seaweeds, in that they do not tolerate wide fluctuations in salinity. Growth rate may be adversely affected if the kelp plant is subjected to periodic salinity stress. The lower salinity limit for *Laminaria digitata* lies between 10 and 15psu. On the Norwegian coast Sundene (1964) found healthy *Laminaria digitata* plants growing between 15 and 25psu. Axelsson & Axelsson (1987) investigations indicated damage of plants plasma membranes occurs when salinity is below 20 or above 50psu. Localized, long term reductions in salinity, to below 20psu, may result in the loss of kelp beds in affected areas.

Changes in oxygenation Not relevant

Insufficient information

Biological Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of microbial pathogens/parasites	Low	High	Low	Moderate

The occurrence of hyperplasia or gall growths, seen as dark spots, on *Laminaria digitata* is well known and may be associated with the presence of endophytic brown filamentous algae. *Ectocarpus deformans*, for example, was considered the cause of galls in *Laminaria digitata* by

Apt (1988). In Helgoland, Ellertsdottir and Peters (1997) found 86 % of *Laminaria digitata* thalli infected with endophytic brown algae and all those that exhibited weak to moderate but visible thallus alterations such as dark spots on the lamina or small warts on the stipe were infected. No cases of the severe morphological deformities as seen in *Saccharina latissima* were observed.

Introduction of non-native species Low Moderate Very low

The Northwest Pacific kelp *Undaria pinnatifida* has been introduced into Europe in recent years both deliberately for aquaculture purposes in northern Brittany and accidentally probably through movement of shellfish for aquaculture. Introduction into Britain (primarily in the south-west) is thought to have been on ships' hulls due to its propensity for colonizing floating objects. It may cause displacement of native kelp species including *Laminaria digitata* although in Brittany *Undaria pinnatifida* was seen to colonize areas normally inhabited by *Saccorhiza polyschides* rather than *Laminaria digitata* or *Laminaria hyperborea*.

Sargassum muticum, first found in the UK in the 1970s, is also a potential threat. Cosson (1999) reported a progressive disappearance of *Laminaria digitata* from the coasts of Calvados (France) together with a huge growth of *Sargassum muticum* in the same area.

Extraction of this species Intermediate High Low High

Laminaria digitata plants are able to rapidly re-colonize any gaps in the upper infralittoral which result from storm damage (Birkett *et al.* 1998b). After plant cutting (harvesting) the standing crop was re-established within 18-20 months (Kain, 1979). In macroalgae clearance experiments at Port Erin, Isle of Man (Kain, 1975) recolonization of *Laminaria digitata* on concrete blocks took place within 2 years. In France, Ciam (le Comité interprofessionel des algues marines) proposed that , regardless of collection method, the restoration of stands of Laminariales took up to 18 months after harvesting (from Arzel, 1998). In Helgoland, recovery of cleared and burned plots to original density took 25 months, but plants were smaller than those on undisturbed plots (Markham & Munda, 1980). This suggests that when all spores and germlings are removed, full population recovery takes longer than 25 months.

Extraction of other species Intermediate High Low Moderate

Removal of kelp grazing animals has been observed to have an impact on the density and distribution of kelps. *Laminaria digitata* was able to extend 2m upshore after the death of limpets and other grazers caused by the *Torrey Canyon* oil spill (Southward & Southward, 1978). In Newfoundland removal of sea urchins resulted in the growth of kelps including *Laminaria digitata* that had previously been absent (Keats *et al.*, 1990).

Additional information

Importance review

Policy/legislation

- no data -

Status

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

Non-native

Native	-		
Origin	-	**Date Arrived**	-

Importance information

Kelp species around the world have been exploited over the years as a source of chemicals for industry. Kelp cast up on the shore has long been collected for use as an agricultural fertilizer. More recently *Laminaria digitata* is commercially harvested in Brittany for alginate production and in Ireland and France for sea-vegetable production.

Kelp beds and forests form important habitats for many other plants and animals. The structure of kelp beds is complex with many different habitats i.e. bedrock, crevices, sediment pockets, the holdfast, stipe and blade of the plants themselves.

Primary production of kelp plants is impressive and large kelps often produce annually well in excess of a kilogram of carbon per square metre of shore. Only about 10 % of this productivity is directly grazed. Kelps contribute 2-3 times their standing biomass each year as particulate detritus and dissolved organic matter that provides the energy supply for filter feeders and detritivores in and around the kelp bed.

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