Sugar kelp (*Saccharina latissima*)

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

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Buoy line with *Saccharina latissima*.
Photographer: Sue Scott
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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	Nicola White & Charlotte Marshall	**Refereed by**	Dr Joanna Jones
Authority	(Linnaeus) C.E.Lane, C.Mayes, Druehl & G.W.Saunders, 2006		
Other common names	-	**Synonyms**	*Laminaria saccharina* (Linnaeus) C.E.Lane, C.Mayes, Druehl & G.W.Saunders, 2006

Summary

Description

A large brown kelp, which has a long undivided frond, without midrib and with a short stipe. The frond of *Saccharina latissima* has a distinctive frilly undulating margin. It lives for 2 to 4 years and grows quickly from winter to April.

Recorded distribution in Britain and Ireland

All coasts of Britain & Ireland.

Global distribution

Recorded from the Atlantic coasts of Europe as far north as Novaya Zemlya and south to northern Portugal and around Iceland. Also found in Greenland, Eastern coast of America down to New Jersey, Pacific coast of America, Bering Straits and Japan.

Habitat

Saccharina latissima is usually found from the sublittoral fringe down to a depth of 30 m. More rarely it occurs in rock pools. The species usually occurs in sheltered conditions and may attach to unstable substrata such as boulders and cobbles.

Depth range
Less than 30 m

Identifying features

- A long undivided frond with wrinkled surface and wavy margins, rising from a smooth flexible stipe.
- Without midrib.
- Small branching holdfast.
- Yellowish-brown in colour.
- Up to 4 m long.

Additional information

Also known as sugar kelp and sea-belt. The name sugar kelp refers to a whitish, sweet-tasting powder which forms on the dried frond.

Listed by

Further information sources

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Biology review

Taxonomy

Phylum	Ochrophyta	Brown and yellow-green seaweeds
Class	Phaeophyceae	
Order	Laminariales	
Family	Laminariaceae	
Genus	Saccharina	
Authority	(Linnaeus) C.E.Lane, C.Mayes, Druehl & G.W.Saunders, 2006	
Recent Synonyms	Laminaria saccharina (Linnaeus) C.E.Lane, C.Mayes, Druehl & G.W.Saunders, 2006	

Biology

Typical abundance	Moderate density
Male size range	
Male size at maturity	
Female size range	Large(>50cm)
Female size at maturity	
Growth form	Foliose
Growth rate	1.1cm/day
Body flexibility	
Mobility	
Characteristic feeding method	Autotroph
Diet/food source	
Typically feeds on	
Sociability	
Environmental position	Epilithic
Dependency	Independent.
Supports	None
Is the species harmful?	No

Biology information

Growth

Saccharina latissima (studied as *Laminaria saccharina*) grows fastest from late winter to spring at a rate of about 1.1 cm/day although growth rates of up to 4.87 cm/day have been recorded. Growth then declines from June onwards and may cease in late summer. The reduction in summer growth rate is thought to be due to nitrate limitation (Sjøtun, 1993). The length:width ratio of newly grown lamina tissue varies throughout the year and is highest during the periods of fast growth, that is, December to June (Sjøtun, 1993). By shifting effort towards growth in width in late summer, it is possible that the plant can maximize the lamina area for autumn and winter and therefore increase the amount of stored carbon available for plants at this time (Sjøtun, 1993).

The seasonal growth pattern results in annual growth rings or lines in the stipe, which can be used to age the plant. The species may occur as an annual opportunist.

Morphology
The shape of the frond can vary with environmental conditions. Gerard (1987) found that plants subjected to constant longitudinal tension (as would be expected in higher water flow rates) may become morphologically enhanced to a more streamlined shape. In laboratory simulations, he found that plants subjected to longitudinal stress had significantly narrower blades and a significantly higher rate of cell elongation at the end of the six week experiment, compared to those plants that had not experienced the same stress. *Saccharina latissima* (studied as *Laminaria saccharina*) plants from wave exposed sites have short, solid stipes and short, narrow and thick tissued fronds with closely wrinkled blades (Lüning, 1990). In contrast, plants from sheltered sites have a broad thin blade with an undulate surface (Lüning, 1990).

Mobility
The majority of *Saccharina latissima* plants are permanently attached to the substratum. This may include bedrock and large boulders down to pebbles. Even sand grains can provide an attachment sufficient enough to allow the young sporophytes to segment and develop into new plants (Burrows, 1958). However, Burrows (1958) also described large populations of 'loose lying' *Saccharina latissima* (studied as *Laminaria saccharina*) in Port Erin Bay, Isle of Man, which showed no signs of ever having been attached. She concluded that, apart from at the earliest stages of sporophyte development, an attachment to the substratum is not essential for the growth of the plant.

Habitat preferences

Physiographic preferences	
Biological zone preferences	
Substratum / habitat preferences	
Tidal strength preferences	
Wave exposure preferences	
Salinity preferences	
Depth range	Less than 30 m
Other preferences	No text entered
Migration Pattern	

Habitat Information

Saccharina latissima is often found on unstable substrata such as rocks and boulders. The species is adapted to growing on these by having a flexible stipe which reduces leverage on any boulder to which it is attached, reducing the chance of its being turned over by wave movement. The species can even grow unattached and extensive populations can develop on loose-lying sand in calm conditions. In wave-exposed conditions the species may extend into the lower eulittoral.

Life history

Adult characteristics

Reproductive type

Reproductive frequency	Annual episodic
Fecundity (number of eggs)	
Generation time	1-2 years
Age at maturity	15-20 months to maturity
Season	See additional information
Life span	2-5 years

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	
Duration of larval stage	No information
Larval dispersal potential	No information
Larval settlement period	Insufficient information

Life history information

Overview of life history
Saccharina latissima has a typical laminarian life history, in which a macroscopic and structurally complex diploid sporophyte phase alternates with a microscopic haploid gametophyte. The species is a short-lived perennial. Sporophytes (clearly visible adult plants) typically have a lifespan of 2 to 4 years, although plants may occur as annuals. Specimens over four years old have been recorded from a fjord in Greenland (Borum *et al*., 2002).
Timing of reproduction
Saccharina latissima plants usually takes 8 to 15 months to reach fertility at which point the central portion of the blade is covered in unilocular sporangia, that produce zoospores by meiosis. Lüning (1988) reported that sorus (a group of sporangia) formation in *Saccharina latissima* (studied as *Laminaria saccharina*) from Helgoland, in the Southern North Sea, was restricted to autumn conditions whilst Kain (1979) and Parke (1948) reported that, in the British Isles, sorus formation was most frequent in both autumn and winter. It has been suggested that, in the Arctic, *Saccharina latissima* (studied as *Laminaria saccharina*) sporophytes may carry sori throughout the year and can therefore produce gametophytes in all seasons (Makarov & Schoschina, 1998, cited in Sjøtun & Schoschina, 2002). Similarly, Parke (1948) reported that in sheltered habitats on the south Devon coast, reproductive tissue was present in all months, although October to April was the most frequent period of spore production in the British Isles for this species.
Reproduction

- Each sporangium contains 32 zoospores that develop into microscopic dioecious haploid gametophytes.
- The gametophyte goes through a 'dumbbell' stage before enlargement (female) or division (male). This stage is characterized by swelling at the distal end of the germination tube, which is separated by a cell wall from the original spore case from which the tube initially arose (Kain, 1979).
- Lüning (1990) recognized three stages in the development of gametophyte:
  (1) germination of the embryospore to form the gametophyte;
  (2) vegetative growth of the gametophyte to form either a larger single celled female gametophyte or, in the case of male gametophytes, a few small cells, and
  (3) the reproductive phase. If environmental factors do not induce fertility in the

gametophyte (see factors affecting reproduction below), filamentous growth occurs.

- The filaments of female gametophytes are, on average, approximately 10 μm in diameter and those of males are usually half of that (Kain, 1979). Male gametophytes are more branched than the females and have more numerous, smaller and paler cells.
- If the gametophytes become fertile, male gametophytes develop antheridia that produce sperm. The females develop oogonia in which the egg develops (Birkett *et al*., 1998). This egg is subsequently discharged. After the egg has emerged, the cell wall closes behind it and forms a cushion on which the egg is seated (Bisalputra *et al*., 1971).
- The external egg is fertilized by the motile sperm and the resultant zygote eventually develops into the new sporophyte.
- After fertilization, a thick cell wall is formed around the zygote and when the zygote reaches 10-16 μm in diameter, it starts to elongate rapidly (Bisalputra *et al*., 1971).
- Sporophytes first become attached by filamentous rhizoids but later by large branched haptera (Burrows, 1971).
- After rhizoid attachment, an attachment disc is formed from the swollen base of the stipe (Kain, 1979).
- Cell division in the young sporophyte gives rise to a broad flat thallus but eventually a meristem gives rise to a flat blade above it and a cylindrical stipe below (Burrows, 1971). By this stage the plant has taken on the recognizable 'kelp shape'.

Factors controlling reproduction

Light regime

Experimental work using various red and blue light regimes suggest that the onset of fertility in female gametophytes is controlled specifically by blue light above a certain irradiance (Lüning & Dring, 1975). In their experiments, female gametophytes grown in red light for ten days continued to grow vegetatively with no egg production. In contrast, nearly 100% of gametophytes grown in blue light (1.5 nE cm^{-2} sec^{-1} (total irradiation per second)) over the same period became fertile. Equally, plants that had been grown in red light for two weeks became fertile after being irradiated with blue light (1-4 nE cm^{-2} sec^{-1}) for a period of time. After 96 hours of irradiance almost 100% of gametophytes had become fertile. Lüning (1990) also concluded that only blue light induces fertility.

Lüning (1988) cultivated adult sporophytes near Helgoland in the Southern North Sea and cultivated them under various light regimes. Sori were only formed in the 'short day' regime (8:16 hours light:dark respectively). No sori were formed in the 'long day' (16:8) or 'night break' (8:7.5:1:7.5) regimes.

Lüning (1990) found that at 10 °C, the gametophyte could survive at least five months in total darkness.

Temperature

Lee & Brinkhuis (1988) studied the effects of seasonal light and temperature interactions on the development of *Saccharina latissima* (studied as *Laminaria saccharina*) gametophytes and juvenile sporophytes in Long Island Sound and found that, in general:

- germination of zoospores was inhibited at 20 °C;
- gametophyte growth improved with increasing temperature between 4-17 °C;
- fecundity was totally inhibited at 20 °C;
- sporophyte growth was inhibited at 17 and 20 °C, and
- temperature for optimal growth depended on the time of year.

These authors also found that sex ratio was significantly affected by temperature and between

17-20 °C male gametophytes were more prevalent.
Sjøtun & Schoschina (2002) reported 100 % germination of embyospores at 0 °C in this species suggesting a good adaptation to Arctic conditions.
See 'sensitivity' (adult) section on temperature for further information.

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	Moderate

Saccharina latissima is usually permanently attached to the substratum so would be removed upon substratum loss. The species rapidly colonizes cleared areas of the substratum; Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after the substratum was cleared so recovery should be rapid. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

	Intolerance	Recoverability	Sensitivity	Confidence
Smothering	High	High	Moderate	Moderate

The impact of sedimentation on *Saccharina latissima* (studied as *Laminaria saccharina*) was studied by Lyngby & Mortensen (1996). They recorded that deposition of a 1-2 mm thick layer of fine-grained material on the plants caused direct physical damage and rotting and as a result, 25 % of the plants died after 4 weeks. Therefore, smothering by a 5 cm layer of sediment is likely to have a adverse affect on the populations and an intolerance of high has been recorded. On return to normal conditions recovery should be high because the species has been observed to rapidly recruit to cleared areas of the substratum (Kain, 1975). In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

	Intolerance	Recoverability	Sensitivity	Confidence
Increase in suspended sediment	Low	High	Low	Low

An increase in the level of suspended sediment was found to reduce growth rates in *Saccharina latissima* (studied as *Laminaria saccharina*) by 20 % (Lyngby & Mortensen, 1996). Burrow & Pybus (1971) found that the mean breadths of thalli of *Saccharina latissima* (studied as *Laminaria saccharina*) that had grown in the silted waters of Redcar, Souter Point and Robin Hood's Bay (North-East England) were significantly smaller than those grown in the clearer waters of St Abbs (North-East England) and Port Erin (Isle of Man). Adults appear to tolerate silt because they are found in areas of siltation (Birkett *et al.*, 1998) but they cannot tolerate heavy sand scour and the gametophytes and spores are probably even more intolerant. Burrows (1971) found that silt had an adverse effect on zoospore development in this species. In addition, Norton (1978) found that siltation of settled spores inhibited development of gametophytes and spores failed to form an attachment when settling out on silty surfaces. At the benchmark level, the viability of the population may be somewhat reduced but recovery should be high because the species rapidly colonizes cleared areas of the substratum. Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Decrease in suspended sediment

Dessication	High	High	Moderate	Low

Saccharina latissima can tolerate a small level of desiccation because the species can extend into the lower eulittoral in wave exposed conditions. On exposure to air the species suffers desiccation and decreased growth rate because emergence prevents photosynthesis in *Saccharina latissima* (studied as *Laminaria saccharina*) (Kain, 1979). An increase in the level of desiccation would lead to a depression in the upper limit of the species distribution. However, recovery should be high because the species can rapidly colonize cleared areas of the substratum. Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Increase in emergence regime	Intermediate	High	Low	Low

Saccharina latissima can only tolerate short periods of emergence in wave exposed conditions, where the plants are kept moist by spray. On exposure to air the species suffers desiccation and decreased growth rate because emergence prevents photosynthesis in *Saccharina latissima* (studied as *Laminaria saccharina*) (Kain, 1979). An increase in the period of emersion would result in a depression of the species upper limit. However, it is also possible that it an increase in emergence would extend the lower limit of the population through increased irradiances to areas previously too deep for light-saturated photosynthesis. Therefore an intolerance of intermediate has been recorded. Recovery should be high because the species rapidly colonizes cleared areas of the substratum. In Port Erin, Isle of Man, Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Decrease in emergence regime

Increase in water flow rate	Low	High	Low	Low

Saccharina latissima (studied as *Laminaria saccharina*) can tolerate fairly strong water currents (Kain, 1979). An increase in water currents beyond this may cause the plants to be torn off the substratum. Alternatively, the substratum on which the plants are attached may be mobilized. In Port Erin Bay, Isle of Man, evidence was found that suggested some *Saccharina latissima* (studied as *Laminaria saccharina*) plants had been torn away from the rock surface but had grown new hapteron branches which had attached to small stones whilst the fronds were lying on the gravel (Burrows, 1958). Burrows (1958) also suggested that, with the exception of the earliest stages in sporophtye development, attachment to a substratum was not essential for growth in this species.
Gerard (1987) found that plants subjected to constant longitudinal tension may become morphologically enhanced to a more streamlined shape. In laboratory simulations, he found that plants subjected to longitudinal stress had significantly narrower blades and a significantly higher rate of cell elongation, at the end of the six week experiment, compared to those plants that had not experienced the same stress. This plasticity would serve to decrease the risk of thallus damage in areas of greater exposure or in stormier conditions.

A decrease in the level of water flow is unlikely to have a detrimental effect because the species often grows in areas of low water movement where it may form extensive loose-lying populations (Burrows, 1958).
It is unlikely that changes to the water flow rate would adversely affect populations of*Saccharina latissima* and an intolerance of low has been recorded. Recovery should be high

because the species rapidly colonizes cleared areas of the substratum. Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Decrease in water flow rate

Increase in temperature Intermediate High Low Moderate

Temperature can affect reproduction, photosynthesis and growth in Laminariales. As water temperature increases, for instance, the photon fluence rates required to achieve light-saturated photosynthesis have been found to increase concomitantly whilst photosynthetic efficiency decreases (Davison *et al.*, 1991). Similarly, at temperatures above 15 °C, higher photon flux densities were required to induce similar proportions of fertility than at lower temperatures (Lüning, 1990).
Temperature ecotypes are formed in which the temperature tolerance of the species varies with location depending on the local conditions to which the plant is adapted. Consequently, different populations of the species are likely to react in different ways to environmental stresses such as changes in temperature. Furthermore, sporophytes are much more sensitive to temperature change than meiospores and gametophytes (Lee & Brinkhuis, 1988). *Saccharina latissima* (studied as *Laminaria saccharina*) plants from New York, which experience water temperatures in excess of 20 °C each summer, exhibited a much greater tolerance of high temperatures than those from Maine where the plants are rarely exposed to water temperatures exceeding 17 °C (Gerard & Du Bois, 1988). In the field, more than 50% of New York plants survived three weeks in water temperatures exceeding 20 °C whilst the plants from Maine all died (Gerard & Du Bois, 1988). *Saccharina latissima* (studied as *Laminaria saccharina*) from Helgoland in the Southern North Sea experienced disintegration of blade tissue after three months at 15 °C (Lüning, 1988).

In an experiment looking at the effects of growth temperature on respiration and photosynthesis in *Saccharina latissima* (studied as *Laminaria saccharina*) (Davison *et al.*, 1991), sporophytes grown in water with a temperature of 15 °C achieved a net photosynthesis and light-saturated photosynthesis at a lower photon fluence rate at this temperature than plants grown at 5 °C. However, acclimation to growth temperatures compensated for the short term effect of temperature on the compensation point and light-saturated photosynthesis so that plants grown at both 5 and 15 °C were able to achieve similar rates of light-limited photosynthesis, compensation points and light-saturated photosynthesis and their respective growth temperatures (Davison *et al.*, 1991).
Lee & Brinkhuis (1988) studied the interaction of light and water temperature on the development of *Saccharina latissima* gametophytes and juvenile sporophytes in Long Island Sound and found the following.

- Germination of zoospores was generally inhibited at 20 °C but germination in zoospores obtained from field cultures in July, where water temperature was also around 20 °C, exceeded 90 % when photon fluence rates were 5 µE m^{-2} sec^{-1}.
- In general, gametophyte growth improved with increasing water temperature between 4-17 °C.
- Fecundity, determined as the ratio of fertile female gametes to total number of female gametes, was totally inhibited at 20 °C (and 4 °C in those obtained from the field in July and November).
- Fecundity was greatest between 7-14 °C.

- Sporophyte growth was inhibited at 17 and 20 °C whereas the water temperature for optimal growth depended on the time of year (11 °C between November and March and often 14 °C between April and July).

For the gametophytes and young sporophytes of *Saccharina latissima*, the upper temperature tolerance is 22 °C. Lee & Brinkhuis (1988) reported growth of gametophytes in Long Island Sound at 23 °C. This temperature has also been reported as the maximum survival temperature for vegetatively growing *Saccharina latissima* (studied as *Laminaria saccharina*) gametophytes (from three European populations), although after a week all plants had disintegrated (Bolten & Lüning, 1982). Lüning, (1990) reported the upper temperature tolerance of gametophytes as around 20 °C with a suppressed growth below 10 °C.
In the unusually hot summer of 1983, the hottest on meteorological record for seven years, *Saccharina latissima* (studied as *Laminaria saccharina*) showed signs of drought bleaching in Plymouth and off the Isle of Man (Hawkins & Hartnoll, 1985).

In terms of the effects of lower water temperatures on *Saccharina latissima*, 100 % of embryos germinated at 0 °C but the growth of primary cells was limited when compared to cells grown at 10 °C (<10 µm and >16 µm after 16 days respectively). *Saccharina latissima* occurs in a high-arctic Fjord in Greenland where bottom water temperatures are below 0 °C all year (Borum *et al*., 2002).
Therefore, both short term acute changes and longer term, chronic changes may have an adverse effect on populations of *Saccharina latissima* and an intolerance of intermediate has been recorded accordingly. Recovery should be high because the species rapidly colonizes cleared areas of the substratum. Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Decrease in temperature

Increase in turbidity	Low	High	Low	Low

In general, an increase in the level of turbidity would decrease light available for photosynthesis and so reduce growth rates. Light levels often determine the maximum depth for survival of *Saccharina latissima* (studied as *Laminaria saccharina*) at a particular site (Lüning, 1979; Lüning & Dring, 1979; Gerard, 1988) therefore an increase in turbidity may lead to the mortality of some plants towards the deeper end of their depth range. Concomitantly, a decrease in the level of turbidity may allow *Saccharina latissima* to grow at greater depths.
It is likely that a change in turbidity will affect plants from different turbidity regimes in different ways. Gerard (1988), for example, found that population differences in photosynthetic parameters of *Saccharina latissima* (studied as *Laminaria saccharina*) resulted in differences in rates of carbon assimilation and growth rates when plants were grown under different light acclimation levels. The photosynthetic capacity and efficiency was generally highest for plants from turbid waters (5 m depth, New York) than plants from deep or shallow waters (5 and 12 m depth respectively, Maine) which allowed rapid growth under low and variable light conditions. Indeed the plants from turbid sites grew faster under all light conditions. Plants from the deep water saw reduced growth rates when daily irradiances exceeded an average of 20 E (radiant flux) / m^2 / day.
Changes in turbidity and the resulting changes in irradiance may also affect the reproductive cycle of this species. Experimental work using various red and blue light regimes suggest that

the onset of fertility in female gametophytes is controlled specifically by blue light above a certain irradiance (Lüning & Dring, 1975). In their experiments, female gametophytes grown in red light for ten days continued to grow vegetatively with no egg production. In contrast, nearly 100 % of gametophytes grown in blue light (1.5 nE cm^{-2} sec^{-1}) over the same period became fertile. Equally, plants that had been grown in red light for two weeks became fertile after being irradiated with blue light (1-4 nE cm^{-2} sec^{-1}) for a period of time; after 96 hours of irradiance almost 100 % of gametophytes had become fertile. The photon fluence rate (PFR) significantly affected female gametophytic growth with growth rates generally improved at lower PFRs (5-20 μE m^{-2} sec^{-1}. Therefore, an acute change in turbidity, at certain times of the year, may temporarily affect the fertility of the gametophytes and an intolerance of intermediate has been recorded. On return to normal turbidity levels it is likely that the growth rate and percentage fertility would quickly return to normal.

Decrease in turbidity

Increase in wave exposure High High Moderate Low

Saccharina latissima rarely grows in wave exposed conditions. An increase in the level of wave exposure may cause plants to be torn off the substratum. Alternatively, the substratum on which the plants are attached may be mobilized. However, *Saccharina latissima* (studied as *Laminaria saccharina*) may extend their habitat into the lower eulittoral in exposed locations subject to a great deal of wave action (Birkett *et al*., 1998). Recovery should be high because the species can rapidly colonize cleared areas of the substratum. Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Decrease in wave exposure

Noise Tolerant Not relevant Not sensitive Not relevant

Seaweeds have no known mechanism for perception of noise.

Visual Presence Tolerant Not relevant Not sensitive Not relevant

Seaweeds have no known mechanism for visual perception.

Abrasion & physical disturbance Intermediate Very high Low Low

The fronds of *Saccharina latissima* are relatively soft so would be damaged by physical disturbance at the benchmark level. Recovery should be high because the species rapidly colonizes cleared areas of the substratum. Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Displacement Intermediate High Low Low

Saccharina latissima is usually permanently attached to the substratum. However, Burrows (1958) also described large populations of 'loose lying' *Saccharina latissima* (studied as *Laminaria saccharina*) in Port Erin Bay, Isle of Man, which showed no signs of ever having been attached. In addition, evidence was found to suggested that some *Saccharina latissima* plants had been torn away from the rock surface but had grown new hapteron branches, which had attached to small stones whilst the fronds were lying on the gravel. She concluded that, apart from at the earliest stages of sporophyte development, an attachment to the substratum is not essential for the growth of the plant. It is, therefore, possible that a few individuals could survive displacement in suitable conditions. Recovery should be high because the species can rapidly colonize cleared areas of the substratum. Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	Low	High	Low	Low

Adult kelps are generally robust in terms of chemical pollution, although few studies of the effects on *Saccharina latissima* have been carried out. The gametophytes and young sporophytes are likely to be more intolerant (Holt *et al.*, 1995). A mixed laboratory detergent quickly stopped zoospores swimming at 50 mg/l but settling and development was normal at 10 mg/l (Kain, 1979). Increasing concentrations of the detergent Blusyl depressed the growth rate of *Saccharina latissima* (studied as *Laminaria saccharina*); 10 ppm of Blusyl led to only a 60 % increase in surface area compared with a 100 % increase in surface area at 1 ppm and a 200 % increase at 0 ppm. An intolerance of low has been recorded.

Heavy metal contamination	Intermediate	High	Low	High

Sporophytes of *Saccharina latissima* have a low intolerance to heavy metals but the early life stages are more intolerant. The effects of copper, zinc and mercury on *Saccharina latissima* (studied as *Laminaria saccharina*) have been investigated by Thompson & Burrows (1984). They observed that the growth of sporophytes was significantly inhibited at 50 µg Cu /l, 1000 µg Zn/l and 50 µg Hg/l. Zoospores were found to be more intolerant and significant reductions in survival rates were observed at 25 µg Cu/l, 1000 µg Zn/l and 5 µg/l. Therefore an intolerance of intermediate has been recorded.

Hydrocarbon contamination	Low	High	Low	Low

Saccharina latissima (studied as *Laminaria saccharina*) has been observed to show no discernible effects from oil spills, largely due to poor dispersion into the water column and high levels of dilution (Holt et al., 1995).

Radionuclide contamination		Not relevant		Not relevant

Insufficient information

Changes in nutrient levels	Intermediate	High	Low	Moderate

A slight increase in nutrient levels may enhance the growth of *Saccharina latissima* but in excess it may be detrimental. The effects of eutrophication on the species have been studied by Conolly & Drew (1985) on the east coast of Scotland. Plants at most the eutrophicated site, where nutrient levels were 25 percent higher than average, exhibited higher growth rates suggesting that growth is nutrient limited. However, the growth rate of mature plants of *Saccharina latissima* (studied as *Laminaria saccharina*) was lower in water collected near a sewage sludge dumping ground in Liverpool Bay, Irish Sea (Burrows, 1971). Read *et al.* (1983) reported that after removal of a major sewage pollution in the Firth of Forth, *Saccharina latissima* (studied as *Laminaria saccharina*) became abundant on rocky shores from which it was previously absent. Eutrophication could affect turbidity which may also adversely affect the

species (see Turbidity section.)
The importance of nitrogen in high-temperature tolerance of *Saccharina latissima* (studied as *Laminaria saccharina*) was shown by (Gerard, 1997). This author found that *Saccharina latissima* plants from Long Island Sound, New York, (near the southern boundary of its distribution) responded much better to high temperatures than plants from the Atlantic coast of Maine, when nutrients were limited. *Saccharina latissima* plants from Long Island Sound were found to have a consistently higher nitrogen and protein content than the Maine plants. When plants from both areas were grown in nutrient limited water (i.e. no added nutrients) at temperatures of 22 °C for four days, the plants from Long Island Sound maintained daily carbon fixation at similar levels to those of nitrogen-limited plants at the optimum temperature (12 °C). In contrast, the plants from Maine exhibited a negative rate of daily net carbon fixation. Nitrogen therefore plays a key role in the survival of this species over the hot summer months when nitrogen is also limited. However, it is not known what effect a sustained lack of nutrients would have on the temperature tolerance of these plants.

Recovery should be high because the species rapidly colonizes cleared areas of the substratum. Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Increase in salinity	High	High	Moderate	Moderate

It has been observed that *Saccharina latissima* (studied as *Laminaria saccharina*) grows fastest at 31 psu, it is severely retarded at 16 psu and plants do not survive below 8 psu. However, the photosynthetic rate of plants from the White Sea was quickly reduced at 2 psu and less quickly at 6 and 8 psu (Kain, 1979). Recovery should be high because the species rapidly colonizes cleared areas of the substratum. Kain (1975) recorded that *Saccharina latissima* (studied as *Laminaria saccharina*) was abundant six months after substratum was cleared. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long (Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Decrease in salinity				
Changes in oxygenation		Not relevant		Not relevant

Insufficient information

Biological Pressures

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

Saccharina latissima (studied as *Laminaria saccharina*) may be infected by the microscopic brown alga *Streblonema aecidioides*. Infected algae show symptoms of *Streblonema* disease, i.e. alterations of the blade and stipe ranging from dark spots to heavy deformations and completely crippled thalli (Peters & Scaffelke, 1996). Infection can reduce growth rates of host algae.

Introduction of non-native species		Not relevant		Not relevant

Insufficient information

Extraction of this species	Intermediate	High	Low	Moderate

The species has a fast growth rate and has been observed by Kain (1975) to recolonize cleared substrata within 6 months so recovery would be rapid. In the laboratory, under optimal conditions, it took at least eight months to reach the size of fertile plants in the field with blades between 1-2 m long Gerard, unpublished, cited in Gerard & Du Bois, 1988).

Extraction of other species	Not relevant	Not relevant

Insufficient information

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

- *Saccharina latissima* is not harvested at present in Britain and Ireland, but it may be eaten as a sea vegetable. Young stipes are used fresh or the alga is eaten in various forms in coastal western Europe. It has been successfully cultured in Europe and America
- The bryozoan *Celleporella hyalina* is often found in the depressions of the frond.

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