A red seaweed (*Furcellaria lumbricalis*)

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.

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/1616]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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The seaweed *Furcellaria lumbricalis*, plant with fertile branches.
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	Will Rayment	**Refereed by**	Dr Stefan Kraan
Authority	(Hudson) J.V.Lamouroux, 1813		
Other common names	-	**Synonyms**	*Furcellaria fastigiata* (Hudson) J.V.Lamouroux, 1813, *Fucus fastigiata*

Summary

Description

A reddish brown to brownish black seaweed with glossy, cartilaginous, cylindrical fronds, branching dichotomously 6 to 11 times. The fronds rise from a much branched holdfast up to 25 mm in diameter. The reproductive bodies occur as pod-like structures at the ends of the branches. The seaweed grows up to about 30 cm in length.

Recorded distribution in Britain and Ireland

Occurs around all coasts of Britain and Ireland. There is a paucity of records from eastern England and the east coast of Ireland which may reflect a lack of suitable substrata.

Global distribution

See additional information

Habitat

Furcellaria lumbricalis typically grows on rock and stones in the shallow subtidal to a depth of 20 m on sheltered to moderately exposed coasts. Although *Furcellaria lumbricalis* has been recorded in depths up to 30 m or more in clear water it is rarely found that deeply, especially around the UK, and one would expect to find it to depths of around 10 m. It also occurs in rockpools in the eulittoral. The holdfast is often covered by coarse, sandy deposits. Tolerates sand cover.

Depth range

In pools in eulittoral to 30m

Identifying features

- Erect, cylindrical, dichotomously branching fronds.
- Holdfast is a mass of rhizoids.
- Reddish brown to brownish black in colour, brown in transmitted light and sometimes bleached green by sunlight.
- Tetrasporangial plants larger than gametangial, with branches terminating in spindle shaped pod-like structures.
- Female thalli with fructifications similar to tetrasporangia but with attenuate sterile tip, often forked and 8-18mm long.
- Male thalli distinctive as fertile tips of branches are ovoid, *ca* 5mm long, slimy and yellowish in colour tinged with pink.

Additional information

-none-

Listed by

Further information sources

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Biology review

Taxonomy

Phylum	Rhodophyta	Red seaweeds
Class	Florideophyceae	
Order	Gigartinales	
Family	Furcellariaceae	
Genus	Furcellaria	
Authority	(Hudson) J.V.Lamouroux, 1813	
Recent Synonyms	Furcellaria fastigiata (Hudson) J.V.Lamouroux, 1813Fucus fastigiata	

Biology

Typical abundance	Moderate density
Male size range	up to 300mm
Male size at maturity	90-300mm
Female size range	90-300mm
Female size at maturity	
Growth form	Arborescent / Arbuscular
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	None
Is the species harmful?	No

Biology information

Size at maturity
Plants become fertile when they achieve their full size of 90-300mm according to habitat, during the 4th to 6th year (Austin 1960a,b).
Growth rate
Bird *et al.* (1979) reported growth rates of *Furcellaria lumbricalis* in the laboratory as a doubling in weight in 25-50 days or a 3.3% increase in fresh weight per day. For comparison, the corresponding rates for *Chondrus crispus* are 10 days and 7.3%, and for *Fucus serratus* are 12.5 days and 6.2%. These figures suggest that *Furcellaria lumbricalis* grows slowly in comparison to other red and brown seaweeds. The reported growth rates from the field are even slower. Blinova (1975) (cited in Bird *et al.*, 1979) recorded a doubling in fresh weight every 167 days and Taylor (1975) (cited in Bird *et al.*, 1979) recorded a 1.3% increase in fresh weight per day. From a site in Wales, Austin (1960b) reported annual length increments of 29-37mm in fronds initially ranging from

10-60mm in length.

Environmental position

As well as the common epilithic form, a free floating variant *Furcellaria lumbricalis* forma *aegagropila* has been reported forming rafts several metres thick on the Danish coast and may occur in Scottish and Irish sea lochs (Levring *et al.*, 1969). The free floating form has a globose thallus of radiating fronds and is smaller in stature and frond diameter, with denser and less regular branching than the attached form (Bird *et al.*, 1991).

Habitat preferences

Physiographic preferences	Strait / sound, Sea loch / Sea lough, Enclosed coast / Embayment
Biological zone preferences	Lower eulittoral, Lower infralittoral, Mid eulittoral, Sublittoral fringe, Upper circalittoral, Upper eulittoral, Upper infralittoral
Substratum / habitat preferences	Macroalgae, Bedrock, Cobbles, Large to very large boulders, Pebbles, Rockpools, Small boulders
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Very Weak (negligible), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Exposed, Extremely sheltered, Moderately exposed, Sheltered, Very sheltered
Salinity preferences	Low (<18 psu), Reduced (18-30 psu), Variable (18-40 psu)
Depth range	In pools in eulittoral to 30m
Other preferences	
Migration Pattern	Non-migratory / resident

Habitat Information

Global distribution

In Europe, from northern Norway to the Bay of Biscay, including the Faroe Islands and the Baltic Sea. Also found in Italy and Sardinia. Possibly occurs in Greenland and Iceland. In North America, occurs in Newfoundland and the Gulf of St Lawrence and its outer coasts. In Asia, it occurs in Pakistan and India. See Guiry (2006) for further details.

Around Prince Edward Island, Canada, *Furcellaria lumbricalis* is sometimes found growing epiphytically on *Phyllophora* sp. (Sharp *et al.*, 1993).

Life history

Adult characteristics

Reproductive type	See additional information
Reproductive frequency	Annual episodic
Fecundity (number of eggs)	>1,000,000
Generation time	5-10 years
Age at maturity	4-6 years
Season	December - April
Life span	Insufficient information

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	Spores (sexual / asexual)
Duration of larval stage	Not relevant
Larval dispersal potential	No information
Larval settlement period	Insufficient information

Life history information

Reproductive Type
The typical attached form of *Furcellaria lumbricalis* reproduces asexually through tetrasporangial plants and sexually through dioecious gametangial plants (Dixon & Irvine, 1977). The male and female plants are usually in equal proportions but are outnumbered by the tetrasporophytes. The free floating form *Furcellaria lumbricalis* forma *aegagropila* reproduces only vegetatively through fragmentation, regeneration and proliferation (Bird *et al*., 1991). Proliferation, where propagules develop on the parent plant and then detach, is probably the most important mechanism.
Reproduction and seasonality
The mode and timing of reproduction in *Furcellaria lumbricalis* was reviewed by Dixon & Irvine (1977) and Bird *et al.* (1991). On the male plants, spermatangial ramuli begin development in late October, developing superficially in the much swollen apical regions and are conspicuous until late April or early May. Discharge of the spermatia occurs from December to April with a peak in February and March. On the female plants, the carpogonial branches are initiated in late December, with carpogonia developing internally in the apical regions. Fertilization probably only occurs over a short period commencing in mid January. The zygote is retained on the female plant but the carposporophyte is not obvious until mid summer. Maturation of the carposporophytes does not occur until a year after fertilization, with a massive discharge of carpospores occurring over a 2-4 week period from late December. 1 million 35-50µm diameter carpospores may be released from an average sized plant when a tract of cells disintegrates forming an ill defined pore to the exterior.
On diploid plants, tetrasporangia are initiated in early April and develop in markedly thickened apical regions. They mature in December and 1-2 million tetraspores are liberated per plant over 2 weeks following disintegration of the thallus surface.
The fruiting pods of all plants fall when they are past maturity and new shoots arise from the resulting truncated tips.

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	High

Removal of the substratum would also remove the entire population of *Furcellaria lumbricalis* growing on it. A small proportion of the population may grow epiphytically on other algal species, e.g. *Phyllophora* sp. (Sharp *et al.*, 1993), and these would also be removed by substratum loss. Intolerance is therefore assessed as high. Recovery is recorded as moderate (see additional information below). The free living *Furcellaria lumbricalis* forma *aegagropila* is not attached to the substratum and therefore would not be affected by substratum loss. However, the free living form is not widely distributed (Levring *et al.*, 1969) and so is not considered to represent the typical intolerance of the species.

Smothering	Intermediate	Moderate	Moderate	Low

Furcellaria lumbricalis is an erect species which grows up to 300mm in length and is often found with the holdfast buried in coarse sediment (Dixon & Irvine, 1977). Furthermore, Johansson *et al.* (1998) reported that *Furcellaria lumbricalis* persisted in areas of the Baltic Sea where eutrophication resulted in high sediment loads. It is likely therefore that mature individuals would be tolerant of smothering with 5cm of sediment. However, recently settled propagules and small developing plants would be buried by 5cm of sediment and be unable to photosynthesize. For example, Vadas *et al.* (1992) stated that algal spores and propagules are adversely affected by a layer of sediment, which can exclude up to 98% of light. There is therefore likely to be mortality of some portion of the population and so intolerance is assessed as intermediate. Recoverability is recorded as moderate (see additional information below).

Increase in suspended sediment	Intermediate	Moderate	Moderate	Low

Furcellaria lumbricalis is not likely to be affected directly by an increase in suspended sediment. However, increased suspended sediment will have knock on effects in terms of light attenuation (considered in 'turbidity') and siltation. As discussed above in 'smothering', increased rate of siltation may inhibit development of algal spores and propagules resulting in some mortality. Intolerance is therefore assessed as intermediate. Recoverability is recorded as moderate (see additional information below).

Decrease in suspended sediment	Tolerant	Not relevant	Not sensitive	High

Furcellaria lumbricalis is not likely to be affected directly by a decrease in suspended sediment and the consequent decrease in siltation. However, the species is tolerant of a certain amount of siltation as demonstrated by the fact that it is often found with its holdfast buried in coarse sediment. If siltation decreased, *Furcellaria lumbricalis* may become open to competition from algal species which are less sediment tolerant and would otherwise be excluded.

Dessication	High	Moderate	Moderate	Moderate

Like many sublittoral algae, *Furcellaria lumbricalis* is very intolerant of desiccation. Gessner &

Schramm (1971) (reviewed by Bird *et al.*, 1991) recorded that at 18-20°C, the critical saturation deficit for the species was 60-70% of total water content, as contrasted with 10% for the intertidal species *Fucus vesiculosus*. On desiccation to 65% total water content, photosynthetic rate was depressed to 60% of the norm and recovery following re-immersion took 7 hours. Desiccation to 42% resulted in only 50% recovery in 7 hours and there was no recovery of photosynthesis in thalli dried to 7% of their original water content. Growth experiments by Indergaard *et al.* (1986) revealed that growth in a continuous spray regime was over 3 times faster (227µm/day vs. 61µm/day) than growth in an intermittent spray regime. The benchmark level of desiccation is exposure to air and sun for one hour. It is difficult to determine how this level relates to the recorded reactions, but it is likely that desiccation would cause mass mortality and so an intolerance of high is recorded. Recovery is recorded as moderate (see additional information below).

Increase in emergence regime	Intermediate	Moderate	Moderate	Moderate

Furcellaria lumbricalis is essentially a subtidal algae, but also occurs in rockpools in the intertidal (Dixon & Irvine, 1977) and occasionally at the extreme low water springs level on exposed shores (Austin, 1960b). An increase in emergence of 1 hour every tidal cycle for a year would place the portion of the population furthest up the shore in a zone where it would be vulnerable to desiccation. The effects of desiccation are detailed in the relevant section. Mortality of this portion of the population would be likely so intolerance is assessed as intermediate. Recoverability is recorded as moderate (see additional information below).

Decrease in emergence regime	Tolerant	Not relevant	Not sensitive	High

Furcellaria lumbricalis is a subtidal species (Dixon & Irvine, 1977) and so would not be affected by a decrease in emergence regime.

Increase in water flow rate	Intermediate	Moderate	Moderate	Very low

Furcellaria lumbricalis appears to be able to tolerate a wide range of water flow rates. It occurs from extremely sheltered areas with "very weak" tidal streams (Connor *et al.*, 1997a) to exposed coasts (Austin, 1960b) where presumably it experiences much greater water flow rates. Moderate water movement is beneficial to seaweeds as it carries a supply of nutrients and gases to the plants, removes waste products, and prevents settling of silt. However, if flow becomes too strong, plants may be damaged and growth stunted. For example, Austin (1960b) recorded loss of fronds and restricted growth in *Furcellaria lumbricalis* specimens from an exposed shore in Wales. Additionally, an increase to very strong flows may inhibit settlement of spores and may remove adults or germlings. It is likely therefore that an increase in water flow rate would place the populations originally at the limit of their tolerance into a zone of intolerance and some mortality would result. Intolerance is therefore assessed as intermediate. Recoverability is recorded as moderate.

Decrease in water flow rate	Tolerant	Not relevant	Not sensitive	High

Furcellaria lumbricalis occurs in areas of "very weak" water flow (Connor *et al.*, 1997a) and therefore is likely to be tolerant of decreases in water flow. Gessner (1955) (cited in Schwenke, 1971) stated that deeper growing species of the benthos near Helgoland, including *Furcellaria lumbricalis*, had a smaller stagnation-caused respiratory inhibition than surface living species, which enabled them to thrive in low flow conditions. Furthermore, Austin (1960b) noted that *Furcellaria lumbricalis* in areas of low water flow lived longer and grew larger than specimens from areas with high flow. The species is therefore assessed as being tolerant.

Increase in temperature	Low	Very high	Very Low	Moderate

Furcellaria lumbricalis has a wide geographic range, occurring in Europe from northern Norway to the Bay of Biscay. Novaczek & Breeman (1990) recorded that specimens of *Furcellaria lumbricalis* grew well in the laboratory from 0-25°C with optimal growth between 10 and 15°C. Growth ceased at 25°C and 100% mortality resulted after 3 months exposure to 27°C. Similarly, Bird *et al.* (1979) recorded optimum growth at 15°C and cessation of growth at 25°C with associated necrosis of apical segments. Considering that maximum sea surface temperatures around the British Isles rarely exceed 20°C (Hiscock, 1998), it is unlikely that *Furcellaria lumbricalis* would suffer mortality due to the benchmark increase in temperature. However, elevated temperatures would probably result in inhibition of growth and hence intolerance is recorded as low. Growth should quickly return to normal when temperatures return to their original levels so recoverability is assessed as very high.

Decrease in temperature	Tolerant	Not relevant	Not sensitive	High

Furcellaria lumbricalis has a wide geographic range, occurring in Europe from northern Norway to the Bay of Biscay. Novaczek & Breeman (1990) recorded that specimens of *Furcellaria lumbricalis* grew well in the laboratory from 0-25°C with optimal growth between 10 and 15°C. The species tolerated -5°C for 3 months with no mortality. Bird *et al.* (1979) extrapolated from a growth curve they calculated for *Furcellaria lumbricalis* and concluded that growth would not be inhibited at 0°C. Minimum surface seawater temperatures rarely fall below 5°C around the British Isles so *Furcellaria lumbricalis* is likely to tolerate the benchmark decrease in temperature.

Increase in turbidity	Tolerant	Not relevant	Not sensitive	Moderate

Furcellaria lumbricalis often occurs in relatively turbid waters. Laboratory experiments by Bird *et al.* (1979) revealed that *Furcellaria lumbricalis* was growth saturated at very low light levels (*ca* 20µE/m□/s) compared to other algae such as *Chondrus crispus* (50-60µE/m□/s) and *Fucus serratus* (100µE/m□/s). They suggest that this may be an explanation why *Furcellaria lumbricalis* is able to proliferate in relatively deep and turbid waters. Similarly, in their review, Bird *et al.* (1999) comment that in all studies, saturation and inhibition radiances were low for *Furcellaria lumbricalis* compared to other macroalgae indicating good competitive ability in the attenuated light of deeper or more turbid waters. In light of its tolerance of turbid conditions it is expected that the majority of the *Furcellaria lumbricalis* population would be unaffected by increases in turbidity, indeed, such changes may even provide the species with a competitive advantage over other macroalgae.

Decrease in turbidity	Tolerant	Not relevant	Not sensitive	Low

Furcellaria lumbricalis is unlikely to be affected by a decrease in turbidity as it is growth saturated at very low light levels compared to other macroalgae (Bird *et al.*, 1979; Bird *et al.*, 1991).

Increase in wave exposure	Intermediate	Moderate	Moderate	Low

Furcellaria lumbricalis typically occurs in a wide range of exposure categories, from "extremely sheltered" (Connor *et al.*, 1997a) to exposed (Austin, 1960b). Increases in wave exposure may result in compromised growth and damage to or removal of the plants due to physical abrasion by sediments mobilized by wave action. Austin (1960b) noted that *Furcellaria lumbricalis* from extremely exposed sites have smaller dimensions than individuals from semi-exposed sites and that fronds may be lost due to storm action. Furthermore, Sharp *et al.* (1993) reported *Furcellaria lumbricalis* found cast ashore following storms. It is likely therefore that some mortality would occur due to increases in wave action and so intolerance is assessed as intermediate. Recoverability is recorded as moderate (see additional information below). It should be noted that the free living form *Furcellaria lumbricalis* forma *aegagropila* only occurs in sheltered habitats (Levring *et al.*, 1969) and is likely to be more susceptible to being cast ashore by increased wave action.

Decrease in wave exposure Tolerant Not relevant Not sensitive High

Furcellaria lumbricalis occurs in "extremely sheltered" habitats (Connor *et al.*, 1997a) and is likely to tolerate decreases in wave exposure. Gessner (1955) (cited in Schwenke, 1971) noted that deep living species such as *Furcellaria lumbricalis* had a relatively high tolerance of stagnation. However, Austin (1960b) commented that *Furcellaria lumbricalis* from extremely sheltered habitats achieved smaller dimensions than individuals from moderately exposed habitats.

Noise Tolerant Not relevant Not sensitive High

Algae have no mechanisms for detection of sound and therefore would not be sensitive to disturbance by noise.

Visual Presence Tolerant Not relevant Not sensitive High

Algae have no visual acuity and therefore would not be affected by visual disturbance.

Abrasion & physical disturbance Intermediate Moderate Moderate Low

The fronds of *Furcellaria lumbricalis* are cartilaginous and flexible and are therefore likely to be reasonably resistant to physical abrasion. However, Austin (1960b) noted that fronds are detached by storm action. The plant's point of attachment to the substratum, the holdfast, is a potential point of weakness. For example, Taylor (1970) (cited in Sharp *et al.*, 1993) stated that clumps of fronds were easily removed from the substratum by drag-raking, but only where the plant had a sufficient number of dichotomies (usually more than 3) to snag in the rake. It is likely therefore that the benchmark level of abrasion, for instance the impact of an anchor and dragging of a chain, would cause some detachment and/or damage. It is unlikely that detached plants would find suitable substrata for reattachment and so mortality is likely to result. Intolerance is therefore assessed as intermediate. Recoverability is recorded as moderate (see additional information below). The free living *Furcellaria lumbricalis* forma *aegagropila* would prevent no mechanical resistance to abrasion and so would be unlikely to be damaged.

Displacement Low Very high Very Low Low

Sharp *et al.* (1993) noted that, following detachment, *Furcellaria lumbricalis* plants were capable of reattachment. During this process, growth may be compromised as energy would need to be diverted to the reattachment process. Intolerance is therefore assessed as low. Growth should quickly return to normal once the holdfast has become re-established so recoverability is recorded as very high. It should be noted that reattachment would only be possible if the plant was displaced to a suitable substratum.

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	High	Moderate	Moderate	Low

No evidence was found specifically relating to the intolerance of *Furcellaria lumbricalis* to synthetic chemicals. However, inferences may be drawn from the sensitivities of red algal species generally. O'Brien & Dixon (1976) suggested that red algae were the most sensitive group of algae to oil or dispersant contamination, possibly due to the susceptibility of phycoerythrins to destruction. They also report that red algae are effective indicators of detergent damage since they undergo colour changes when exposed to relatively low concentration of detergent. Smith (1968) reported that 10 ppm of the detergent BP 1002 killed the majority of specimens in 24hrs in toxicity tests. Laboratory studies of the effects of oil and dispersants on several red algal species, including *Plocamium cartilagineum* (order Gigartinales), concluded that they were all sensitive to oil/ dispersant mixtures, with little difference between adults, sporelings, diploid or haploid life stages (Grandy, 1984) (cited in Holt *et al.*, 1995). Cole *et al.* (1999) suggested that herbicides , such as simazina and atrazine were very toxic to macrophytes. Hoare & Hiscock (1974) noted that all red algae except *Phyllophora* sp. were excluded from Amlwch Bay, Anglesey, by acidified halogenated effluent discharge. The evidence suggests that in general red algae are very sensitive to synthetic chemicals. Intolerance of *Furcellaria lumbricalis* is therefore recorded as high. Recoverability is recorded as moderate (see additional information below).

Heavy metal contamination		Not relevant		Not relevant

Bryan (1984) suggested that the general order for heavy metal toxicity in seaweeds is: Organic Hg > inorganic Hg > Cu > Ag > Zn > Cd > Pb. Cole *et al.* (1999) reported that Hg was very toxic to macrophytes. The sub-lethal effects of Hg (organic and inorganic) on the sporelings of another intertidal red algae, *Plumaria elegans*, were reported by Boney (1971). 100% growth inhibition was caused by 1 ppm Hg. No information was found concerning the effects of heavy metals on *Furcellaria lumbricalis* specifically, and therefore an intolerance assessment has not been attempted.

Hydrocarbon contamination	High	Moderate	Moderate	Low

No evidence was found specifically relating to the intolerance of *Furcellaria lumbricalis* to hydrocarbon contamination. However, inferences may be drawn from the sensitivities of red algal species generally. O'Brien & Dixon (1976) suggested that red algae were the most sensitive group of algae to oil or dispersant contamination, possibly due to the susceptibility of phycoerythrins to destruction. Laboratory studies of the effects of oil and dispersants on several red algal species, including *Plocamium cartilagineum* (order Gigartinales), concluded that they were all sensitive to oil/ dispersant mixtures, with little difference between adults, sporelings, diploid or haploid life stages (Grandy, 1984) (cited in Holt *et al.*, 1995). Intolerance is therefore assessed as high. Recoverability is recorded as moderate (see additional information below).

Radionuclide contamination		Not relevant		Not relevant

No information was found concerning the intolerance of *Furcellaria lumbricalis* to radionuclides.

Changes in nutrient levels	Intermediate	Moderate	Moderate	Low

Bird *et al.* (1991) commented that productivity by *Furcellaria lumbricalis* was low, uptake of nutrients was slow and the species was not nutrient limited under normal conditions. This suggests that the species would not be greatly affected by an increase in nutrient concentration. However, eutrophication may have other knock-on effects. Johansson *et al.* (1998) suggested that one of the symptoms of large scale eutrophication is the deterioration of benthic algal vegetation in areas not directly affected by land-runoff or a point source of nutrient discharge. Altered depth distributions of algal species caused by decreased light penetration and/or increased sedimentation through higher pelagic production have been reported in the Baltic Sea (Kautsky *et al.*, 1986; Vogt & Schramm, 1991). Johansson *et al.* (1998) studied changes in the benthic algal community of the Skagerrak coast in the Baltic Sea, an area heavily affected by eutrophication, between 1960 and 1997. They noted the disappearance of the red alga, *Polyides rotundus*, but commented that problems existed in their sampling method. They also noted the increase of delicate red algae with foliaceous thalli, e.g. *Delesseria sanguinea* and *Phycodrys rubens*, and tougher red algae with foliaceous thalli, e.g.

Phyllophora sp. Increases in the delicate algae were most pronounced at the more wave exposed sites, while increases in the tougher algae occurred at the more sheltered sites with high sedimentation. They commented that these results suggest that the increase of delicate species with large growth potential may have been caused by eutrophication, but that the effect is counteracted when eutrophication results in high sedimentation, in which case the tougher *Phyllophora* sp. thrive. Additionally, *Chondrus crispus* and *Furcellaria lumbricalis*, both species with tough thalli, decreased at the wave exposed sites, possibly due to competition from the more vigorous *Phycodrys rubens* and *Delesseria sanguinea*, but persisted at the sites with high sedimentation. This study suggests that, although *Furcellaria lumbricalis* may be tolerant of eutrophication *per se*, populations may suffer as result of the reactions of other algal species. Intolerance is therefore recorded as intermediate, and recoverability as moderate (see additional information below).

Increase in salinity	Low	Very high	Very Low	High

Furcellaria lumbricalis is a euryhaline species which occurs in a wide range of salinity conditions down to 6-8 psu (Bird *et al*., 1991). In the Kattegat and the Gulf of St Lawrence, it is reported to compete well with other species at salinities ranging from 25-32 psu (see review by Bird *et al*., 1991). Growth experiments in the laboratory revealed that optimum growth occurred at 20 psu, the species grew well at 10 psu and 30 psu, but that growth declined above 30 psu to negligible levels at 50 psu (Bird *et al*., 1979). It is expected that an increase in salinity may cause reduced growth and fecundity, but that mortality is unlikely. Intolerance is therefore assessed as low. Once salinities return to original levels, growth should quickly return to normal so recoverability is recorded as very high. The reason for the alga's euryhalinity may lie in its betaine content. Although these substances are present in insufficient quantity to act as osmotic solutes, they may have a complimentary osmoregulatory function in modifying membrane behaviour or in transporting ions (Blunden *et al*., 1989).

Decrease in salinity	Tolerant	Not relevant	Not sensitive	High

Furcellaria lumbricalis occurs in the lowest category on the salinity scale (Connor *et al*., 1997a) and therefore probably relatively tolerant of decreases in salinity. The species forms extensive populations in the main basin of the Baltic Sea where salinity is 6-8 psu in the upper 60-70 m and its extension into the Gulfs of Bothnia and Finland is limited by the 4 psu isohaline (see review by Bird *et al*., 1991). The reason for the alga's euryhalinity may lie in its betaine content. Although these substances are present in insufficient quantity to act as osmotic solutes, they may have a complimentary osmoregulatory function in modifying membrane behaviour or in transporting ions (Blunden *et al*., 1989).

Changes in oxygenation		Not relevant		Not relevant

The effects of reduced oxygenation on algae are not well studied. Plants require oxygen for respiration, but this may be provided by production of oxygen during periods of photosynthesis. Lack of oxygen may impair both respiration and photosynthesis (see review by Vidaver, 1972). A study of the effects of anoxia on another red alga, *Delesseria sanguinea*, revealed that specimens died after 24 hours at 15°C but that some survived at 5°C (Hammer, 1972). Insufficient information is available to make an intolerance assessment for *Furcellaria lumbricalis*.

Biological Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of microbial pathogens/parasites		Not relevant		Not relevant

Little evidence exists concerning the infection of red algae by microbial pathogens. Barton (1901) noted that *Furcellaria lumbricalis* may become infested with nematode worms and reacts by gall formation. Insufficient information exists to make an intolerance assessment.

Introduction of non-native species		Not relevant		Not relevant

Johansson *et al.* (1998) identified a number of algal species introduced to the Baltic Sea which could potentially compete with the native flora. Of these, only *Bonnemaissonia hamifera* and *Sargassum muticum* were observed to proliferate. The habitat preferences of *Sargassum muticum* and *Furcellaria lumbricalis* are likely to overlap and competition could potentially occur, with the vigorous *Sargassum muticum* likely to proliferate.

Extraction of this species	High	Moderate	Moderate	Low

Commercial utilization of *Furcellaria lumbricalis* is based on the gelling properties of its extracted structural polysaccharide, furcellaran (Bird *et al*., 1991). Extraction of *Furcellaria lumbricalis* was reviewed by Guiry & Blunden (1991). Commercial beds of *Furcellaria lumbricalis* occur in Denmark where the algae are harvested with purpose built trawl nets, whereas in the rest of Europe, the biomass is not sufficient for harvesting. In Denmark, harvesting reached its highest level of 31,000 t p.a. in 1962, but over-exploitation has led to a fall in production and the current harvest is about 10,000 t p.a. Christensen (1971) (cited in Bird *et al*., 1991) and Plinski & Florczyk (1984) noted that over-exploitation of *Furcellaria lumbricalis* has resulted in severe depletion of stocks. A sustainable harvest of *Furcellaria lumbricalis* occurs in Canada on the shores of the Gulf of St Lawrence where the harvest is sustainable as dredging and raking are prohibited and only storm cast plants may be gathered. In view of the potential impact that harvesting may have on the population, intolerance is assessed as high, however, no commercial harvest as yet occurs in Britain or Ireland. Recoverability is recorded as moderate (see additional information below).

Extraction of other species	Intermediate	Moderate	Moderate	Low

Around Prince Edward Island, Canada, *Furcellaria lumbricalis* is gathered as bycatch along with the target species, *Chondrus crispus*. Intolerance is therefore assessed as intermediate and recoverability is recorded as high (see additional information below). However, *Furcellaria lumbricalis* is unwanted and areas with high proportions of the species are abandoned. *Furcellaria lumbricalis* may therefore potentially proliferate due to selective exploitation of *Chondrus crispus* (Sharp *et al*., 1993).

Additional information

Furcellaria lubricalis is highly fecund, an average sized gametophyte being able to produce approximately 1 million carpospores, or a tetrasporophyte, up to 2 million tetraspores (Austin, 1960a). However, the species grows very slowly compared to other red algae (Bird *et al*., 1979) and takes a long time to reach maturity. For example, Austin (1960b) reported that in Wales, *Furcellaria lumbricalis* typically takes 5 years to attain fertility. This would mean that, following perturbation, recovery to a mature reproductive community would take at least 5 years. Norton (1992) reviewed dispersal by macroalgae and concluded that dispersal potential is highly variable. Spores of *Ulva* sp. have been reported to travel 35km, *Phycodrys rubens* 5km and *Sargassum muticum* up to 1km. However, the point is made that reach of the furthest propagule and useful dispersal range are not the same thing and recruitment usually occurs on a much more local scale, typically within 10m of the parent plant. Hence, it is expected that *Furcellaria lumbricalis* would normally only recruit from local populations and hence recovery would be even more protracted in isolated areas. Dispersal could feasibly occur via the free floating *Furcellaria lumbricalis* forma *aegagropila* but, as this form only occurs in sheltered areas (Levring *et al.*, 1969) and only reproduces vegetatively (Bird *et al.*, 1991), the establishment of allopatric viable populations is unlikely. Christensen (1971) (cited in Bird *et al.*, 1991) noted that following harvesting of *Furcellaria lumbricalis* forma *aegagropila* in the Baltic Sea, harvestable biomass had not been regained 5 years after the suspension of harvesting. In view of its slow growth, time to maturity and limited dispersal, recoverability of *Furcellaria lumbricalis* is assessed as moderate.

Importance review

Policy/legislation

- no data -

Status

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

Non-native

Native	-		
Origin	-	**Date Arrived**	-

Importance information

Commercial utilization of *Furcellaria lumbricalis* is based on the gelling properties of its extracted structural polysaccharide, furcellaran (Bird *et al.*, 1991). Currently, Denmark is the chief producer of furcellaran, mostly processing *Furcellaria lumbricalis* extracted from Danish waters, although in the past a mixture of *Furcellaria lumbricalis* and *Chondrus crispus* was harvested from the Gulf of St Lawrence, Canada (Sharp *et al.*, 1993). Present utilization of furcellaran centres on the food industry, with other applications in pharmaceuticals, wherever water or milk based gels or stabilizers are required (see review by Bird *et al.*, 1991).

Bibliography

Austin, A.P., 1960a. Life history and reproduction of *Furcellaria fastigiata* (L.) Lamouroux. *Annals of Botany, New Series*, **24**, 257-274.

Austin, A.P., 1960b. Observations on the growth, fruiting and longevity of *Furcellaria fastigiata* (L.) Lamouroux. *Hydrobiologia*, **15**, 193-207.

Barton, E.S., 1901. On certain galls in *Furcellaria* and *Chondrus*. *Journal of Botany*, **39**, 49-51.

Bird, C.J., Saunders, G.W. & McLachlan, J., 1991. Biology of *Furcellaria lumbricalis* (Hudson) Lamouroux (Rhodophyta: Gigartinales), a commercial carrageenophyte. *Journal of Applied Phycology*, **3**, 61-82.

Bird, N.L., Chen, L.C.-M. & McLachlan, J., 1979. Effects of temperature, light and salinity of growth in culture of *Chondrus crispus*, *Furcellaria lumbricalis*, *Gracilaria tikvahiae* (Gigartinales, Rhodophyta), and *Fucus serratus* (Fucales, Phaeophyta). *Botanica Marina*, **22**, 521-527.

Blunden, G., Smith, B.E. & Cary, P.D., 1989. *Trans*-4-hydroxy-beta-prolinebetaine, a new betaine from *Furcellaria lumbricalis*. *Journal of Applied Phycology*, **1**, 1-4.

Boney, A.D., 1971. Sub-lethal effects of mercury on marine algae. *Marine Pollution Bulletin*, **2**, 69-71.

Bryan, G.W., 1984. Pollution due to heavy metals and their compounds. In *Marine Ecology: A Comprehensive, Integrated Treatise on Life in the Oceans and Coastal Waters*, vol. 5. *Ocean Management*, part 3, (ed. O. Kinne), pp.1289-1431. New York: John Wiley & Sons.

Cole, S., Codling, I.D., Parr, W. & Zabel, T., 1999. Guidelines for managing water quality impacts within UK European Marine sites. *Natura 2000 report prepared for the UK Marine SACs Project.* 441 pp., Swindon: Water Research Council on behalf of EN, SNH, CCW, JNCC, SAMS and EHS. [UK Marine SACs Project.], http://www.ukmarinesac.org.uk/

Connor, D.W., Dalkin, M.J., Hill, T.O., Holt, R.H.F. & Sanderson, W.G., 1997a. Marine biotope classification for Britain and Ireland. Vol. 2. Sublittoral biotopes. *Joint Nature Conservation Committee, Peterborough, JNCC Report* no. 230, Version 97.06., *Joint Nature Conservation Committee, Peterborough, JNCC* Report no. 230, Version 97.06.

Dickinson, C.I., 1963. *British seaweeds*. London & Frome: Butler & Tanner Ltd.

Dixon, P.S. & Irvine, L.M., 1977. *Seaweeds of the British Isles. Volume 1 Rhodophyta. Part 1 Introduction, Nemaliales, Gigartinales.* London: British Museum (Natural History) London.

Fish, J.D. & Fish, S., 1996. *A student's guide to the seashore.* Cambridge: Cambridge University Press.

Guiry, M.D. & Blunden, G., 1991. *Seaweed Resources in Europe: Uses and Potential.* Chicester: John Wiley & Sons.

Hammer, L., 1972. Anaerobiosis in marine algae and marine phanerograms. In *Proceedings of the Seventh International Seaweed Symposium, Sapporo, Japan, August 8-12, 1971* (ed. K. Nisizawa, S. Arasaki, Chihara, M., Hirose, H., Nakamura V., Tsuchiya, Y.), pp. 414-419. Tokyo: Tokyo University Press.

Hardy, F.G. & Guiry, M.D., 2003. *A check-list and atlas of the seaweeds of Britain and Ireland.* London: British Phycological Society

Hiscock, K., ed. 1998. *Marine Nature Conservation Review. Benthic marine ecosystems of Great Britain and the north-east Atlantic.* Peterborough, Joint Nature Conservation Committee.

Hoare, R. & Hiscock, K., 1974. An ecological survey of the rocky coast adjacent to the effluent of a bromine extraction plant. *Estuarine and Coastal Marine Science*, **2** (4), 329-348.

Holt, T.J., Jones, D.R., Hawkins, S.J. & Hartnoll, R.G., 1995. The sensitivity of marine communities to man induced change - a scoping report. *Countryside Council for Wales, Bangor, Contract Science Report*, no. 65.

Indergaard, M., Oestgaard, K., Jensen, A. & Stoeren, O., 1986. Growth studies of macroalgae in a microcomputer-assisted spray cultivation system. *Journal of Experimental Marine Biology and Ecology*, **98**, 199-213.

Johansson ,G., Eriksson, B.K., Pedersen, M. & Snoeijs, P., 1998. Long term changes of macroalgal vegetation in the Skagerrak area. *Hydrobiologia*, **385**, 121-138.

Kautsky, N., Kautsky, H., Kautsky, U. & Waern, M., 1986. Decreased depth penetration of *Fucus vesiculosus* (L.) since the 1940s indicates eutrophication of the Baltic Sea. *Marine Ecology Progress Series*, **28**, 1-8.

Levring, T., Hoppe, H.A. & Schmid, O.J., 1969. *Marine Algae: a survey of research and utilization.* Hamburg: Cram, de Gruyter & Co. [Botanica Marina Handbooks, Vol. 1.]

Norton, T.A. (ed.), 1985. *Provisional Atlas of the Marine Algae of Britain and Ireland*. Huntingdon: Biological Records Centre, Institute of Terrestrial Ecology.

Norton, T.A., 1992. Dispersal by macroalgae. *British Phycological Journal*, **27**, 293-301.

Novaczek, I. & Breeman, A.M., 1990. Thermal ecotypes of amphi-Atlantic algae. 2. Cold-temperate species (*Furcellaria lumbricalis* and *Polyides rotundus*). *Helgolander Meeresuntersuchungen*, **44**, 475-485.

O'Brien, P.J. & Dixon, P.S., 1976. Effects of oils and oil components on algae: a review. *British Phycological Journal*, **11**, 115-142.

Schwenke, H., 1971. Water movement: 2. Plants. In *Marine Ecology. Volume 1. Environmental Factors (2)*, 705-820 (ed. O. Kinne). Wiley-Interscience, London.

Sharp, G.J., Tetu, C., Semple, R. & Jones, D., 1993. Recent changes in the seaweed community of western Prince Edward Island:

implications for the seaweed industry. *Hydrobiologia*, **260-261**, 291-296.

Smith, J.E. (ed.), 1968. 'Torrey Canyon'. *Pollution and marine life.* Cambridge: Cambridge University Press.

Vadas, R.L., Johnson, S. & Norton, T.A., 1992. Recruitment and mortality of early post-settlement stages of benthic algae. *British Phycological Journal*, **27**, 331-351.

Vidaver, W., 1972. Dissolved gases - plants. In *Marine Ecology. Volume 1. Environmental factors (3)*, (ed. O. Kinne), 1471-1490. Wiley-Interscience, London.

Vogt, H. & Schramm, W., 1991. Conspicuous decline of *Fucus* in Kiel Bay (Western Baltic): what are the causes ? *Marine Ecology Progress Series*, **69**, 189-194.

Datasets

Centre for Environmental Data and Recording, 2018. Ulster Museum Marine Surveys of Northern Ireland Coastal Waters. Occurrence dataset https://www.nmni.com/CEDaR/CEDaR-Centre-for-Environmental-Data-and-Recording.aspx accessed via NBNAtlas.org on 2018-09-25.

Cofnod – North Wales Environmental Information Service, 2018. Miscellaneous records held on the Cofnod database. Occurrence dataset: https://doi.org/10.15468/hcgqsi accessed via GBIF.org on 2018-09-25.

Fenwick, 2018. Aphotomarine. Occurrence dataset http://www.aphotomarine.com/index.html Accessed via NBNAtlas.org on 2018-10-01

Fife Nature Records Centre, 2018. St Andrews BioBlitz 2014. Occurrence dataset: https://doi.org/10.15468/erweal accessed via GBIF.org on 2018-09-27.

Fife Nature Records Centre, 2018. St Andrews BioBlitz 2015. Occurrence dataset: https://doi.org/10.15468/xtrbvy accessed via GBIF.org on 2018-09-27.

Kent Wildlife Trust, 2018. Biological survey of the intertidal chalk reefs between Folkestone Warren and Kingsdown, Kent 2009-2011. Occurrence dataset: https://www.kentwildlifetrust.org.uk/ accessed via NBNAtlas.org on 2018-10-01.

Kent Wildlife Trust, 2018. Kent Wildlife Trust Shoresearch Intertidal Survey 2004 onwards. Occurrence dataset: https://www.kentwildlifetrust.org.uk/ accessed via NBNAtlas.org on 2018-10-01.

Manx Biological Recording Partnership, 2017. Isle of Man wildlife records from 01/01/2000 to 13/02/2017. Occurrence dataset: https://doi.org/10.15468/mopwow accessed via GBIF.org on 2018-10-01.

Manx Biological Recording Partnership, 2018. Isle of Man historical wildlife records 1995 to 1999. Occurrence dataset: https://doi.org/10.15468/lo2tge accessed via GBIF.org on 2018-10-01.

Merseyside BioBank., 2018. Merseyside BioBank (unverified). Occurrence dataset: https://doi.org/10.15468/iou2ld accessed via GBIF.org on 2018-10-01.

National Trust, 2017. National Trust Species Records. Occurrence dataset: https://doi.org/10.15468/opc6g1 accessed via GBIF.org on 2018-10-01.

NBN (National Biodiversity Network) Atlas. Available from: https://www.nbnatlas.org.

OBIS (Ocean Biogeographic Information System), 2019. Global map of species distribution using gridded data. Available from: Ocean Biogeographic Information System. www.iobis.org. Accessed: 2019-03-21

Outer Hebrides Biological Recording, 2018. Non-vascular Plants, Outer Hebrides. Occurrence dataset: https://doi.org/10.15468/goidos accessed via GBIF.org on 2018-10-01.

Royal Botanic Garden Edinburgh, 2018. Royal Botanic Garden Edinburgh Herbarium (E). Occurrence dataset: https://doi.org/10.15468/ypoair accessed via GBIF.org on 2018-10-02.

South East Wales Biodiversity Records Centre, 2018. SEWBReC Algae and allied species (South East Wales). Occurrence dataset: https://doi.org/10.15468/55albd accessed via GBIF.org on 2018-10-02.

Yorkshire Wildlife Trust, 2018. Yorkshire Wildlife Trust Shoresearch. Occurrence dataset: https://doi.org/10.15468/1nw3ch accessed via GBIF.org on 2018-10-02.