Gut weed (*Ulva intestinalis*)

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

Georgina Budd & Paolo Pizzola

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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/1469]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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Ulva intestinalis **at Bovisand, Devon.**
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	Georgina Budd & Paolo Pizzola	**Refereed by**	This information is not refereed.
Authority	Linnaeus, 1753		
Other common names	-	**Synonyms**	*Enteromorpha intestinalis* Linnaeus, 1753

Summary

Description

Ulva intestinalis is a conspicuous bright grass-green seaweed, consisting of inflated irregularly constricted, tubular fronds that grow from a small discoid base. Fronds are typically unbranched. Fronds may be 10-30 cm or more in length and 6-18 mm in diameter, the tips of which are usually rounded. Like other members of the genus, *Ulva intestinalis* is a summer annual, decaying and forming masses of bleached white fronds towards the end of the season.

Recorded distribution in Britain and Ireland

Common all round the coasts of Britain and Ireland.

Global distribution

More or less world-wide in its distribution.

Habitat

Occurs in a wide range of habitats on all levels of the shore. Where suitable support is available, it will grow on rocks, mud, sand and in rock pools. It is abundant in brackish water areas, where there is appreciable freshwater run-off and in wet areas of the splash zone. It is also a common epiphyte on other algae and shells. The seaweed may become detached from the substratum, and buoyed up by gas, rises to the surface, where it continues to grow in floating masses.

Depth range
Into the sublittoral

Identifying features

Separation of species within the genus is difficult and reliant on cellular features, but

- Simple thalli (fronds) arise from a small discoid base.
- Thalli light to dark grass-green in colour.
- Thallus completely tubular and elongate, increasing in width from base to mid thallus.
- Mature specimens, are 'crisped' and irregularly inflated
- Thalli typically unbranched (see additional information).

Additional information

Origin of species name
Adjective (Latin), relating to or found in the intestines (Guiry & Nic Dhonncha, 2002).

Identification
A recent molecular study suggested that the genus *Enteromorpha* is synonymous with the genus *Ulva* (Hayden *et al*., 2003). Species within the genus *Ulva* are difficult to identify. Identification is heavily reliant on cell detail and cell arrangement, in addition to gross morphology, but complicated by the fact that the morphology of a single species can vary in response to environmental conditions. For instance, *Ulva intestinalis* and *Ulva compressa* (as *Enteromorpha*) are two distinct, genetically divergent and reproductively isolated species (Blomster *et al*., 1998). They are, however, difficult to distinguish. The presence or absence of branching fronds was the most useful gross morphological characteristic distinguishing these two species (*Ulva intestinalis* being unbranched). But ambiguity exists because low salinity or salinity shock can induce branching in *Ulva intestinalis*. However, if environmental factors, such as salinity are taken into account, branching can be used to identify the great majority of thalli correctly (Blomster *et al*., 1998).

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Biology review

Taxonomy

Phylum	Chlorophyta	Green seaweeds
Class	Ulvophyceae	
Order	Ulvales	
Family	Ulvaceae	
Genus	Ulva	
Authority	Linnaeus, 1753	
Recent Synonyms	Enteromorpha intestinalis Linnaeus, 1753	

Biology

Typical abundance	High density
Male size range	
Male size at maturity	
Female size range	Large(>50cm)
Female size at maturity	
Growth form	Straplike / Ribbonlike
Growth rate	0.15-0.25cm/day
Body flexibility	High (greater than 45 degrees)
Mobility	
Characteristic feeding method	Autotroph
Diet/food source	
Typically feeds on	Species is a photoautotroph.
Sociability	
Environmental position	Epifloral
Dependency	Independent.
Supports	None
Is the species harmful?	No

Biology information

Growth rate

Parchevskij & Rabinovich (1991) cultivated *Ulva intestinalis* (as *Enteromorpha intestinalis*) on horizontally and vertically suspended ropes in coastal Black Sea areas polluted with sewage and waste water effluents. Specific growth rate of the seaweed during the spring-summer period was found to be 0.15-0.25 cm/day. A harvest weight of 2600-3000 g/m^2 and 3400-4700 g/m^2 was obtained within two weeks on horizontal and vertical ropes respectively.

Associated fauna

Ulva intestinalis provides shelter for the orange harpacticoid copepod, *Tigriopus brevicornis*, and the chironomid larva, *Halocladius fucicola* (McAllen, 1999). *Ulva intestinalis* is often the only seaweed found in supralittoral rockpools, and the copepod and chironomid species utilize the hollow thallus of *Ulva intestinalis* as a moist refuge from desiccation when the rockpools completely dry out.

Several hundred individuals of *Tigriopus brevicornis* have been observed in a single thallus of *Ulva intestinalis* (McAllen, 1999). Many other intertidal species are often found amongst dense growths of *Ulva* in deep splash zone pools.

Floating masses
Ulva intestinalis may become detached from the substratum, and buoyed up by gas, float to the surface where they continue to grow. Such mats of unattached *Ulva intestinalis* are most frequent in summer. For instance, the occurrence of a summer mass of unattached *Ulva intestinalis* (as *Enteromorpha intestinalis*) was studied by Baeck *et al.* (2000) on the Finnish Baltic Sea west coast. The thalli of the seaweed lost their tubular shape, spread, and formed unattached monostromatic sheets. Mats were between 5-15 cm thick, with a biomass of 97 tonnes in an area of 3.7 km^2 in 1993.

Habitat preferences

Physiographic preferences	Open coast, Strait / sound, Ria / Voe, Enclosed coast / Embayment
Biological zone preferences	Lower littoral fringe, Mid eulittoral, Supralittoral, Upper eulittoral, Upper littoral fringe
Substratum / habitat preferences	Bedrock, Cobbles, Large to very large boulders, Muddy sand, Small boulders
Tidal strength preferences	No information
Wave exposure preferences	Extremely sheltered, Moderately exposed, Sheltered, Ultra sheltered, Very sheltered
Salinity preferences	Full (30-40 psu), Low (<18 psu), Reduced (18-30 psu), See additional Information, Variable (18-40 psu)
Depth range	Into the sublittoral
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

Ulva intestinalis is remarkably euryhaline, in that it can grow in freshwater. However, there is evidence for the existence of genetic strains adapted to high and low salinities (Reed & Russell, 1979).

Life history

Adult characteristics

Reproductive type	Alternation of generations
Reproductive frequency	Annual protracted
Fecundity (number of eggs)	>1,000,000
Generation time	<1 year
Age at maturity	See additional information
Season	See additional information
Life span	<1 year

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	Spores (sexual / asexual)
Duration of larval stage	See additional information
Larval dispersal potential	Greater than 10 km
Larval settlement period	Not relevant

Life history information

Species of the genus *Ulva* are rapidly growing opportunists, favoured by the frequency and speed of their reproduction. The short lived plants reach maturity at a certain stage of development rather than relying on an environmental trigger. *Ulva intestinalis* can be found in reproductive condition at all times of the year, but maximum development and reproduction occur during the summer months especially towards the northern end of the distribution of the species (Burrows, 1991). The life history consists of an isomorphic (indistinguishable except for the type of reproductive bodies produced) alternation between haploid gametophytic and diploid sporophytic generations, but can be modified by environmental conditions (Burrows, 1959; Moss & Marsland, 1976; Reed & Russell, 1978). McArthur & Moss (1979) examined the process of gametogenesis and gamete structure using scanning and transmission electron microscopy.
The haploid gametophytes of *Ulva* produce enormous numbers of biflagellate motile gametes which cluster and fuse to produce a sporophyte (diploid zygote). The sporophyte matures and produces by meiosis large numbers of quadriflagellate zoospores that mature as gametophytes, and the cycle is repeated. Both gametes and spores may be released in such quantities into rock pools or slack water that the water mass is coloured green (Little & Kitching, 1996). Together spores and gametes are termed 'swarmers'. Swarmers are often released in relation to tidal cycles, with the release being triggered by the incoming tide as it wets the thallus. However, the degree of release is usually related to the stage of the spring/neap tidal cycle, so allowing regular periodicity and synchronization of reproduction (Little & Kitching, 1996). Christie & Evans (1962) found that swarmer release of *Ulva intestinalis* (as *Enteromorpha intestinalis*) from the Menai Straits, Wales, peaked just before the highest tides of each neap-spring cycle.
Mobility of swarmers belonging to *Ulva intestinalis* (as *Enteromorpha intestinalis*) can be maintained for as long as 8 days (Jones & Babb, 1968). Algae such as *Ulva intestinalis* tend to have large dispersal shadows, with propagules being found far from the nearest adult plants, e.g. 35 km (Amsler & Searles, 1980).

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	Very high	Low	Moderate

Ulva intestinalis, forms a permanent attachment to a solid substratum (although the species may continue to grow in mats if displaced from the substratum, it requires a substratum for development), so would be intolerant of substratum loss. Intolerance has been assessed to be high and recoverability very high (see additional information below).

	Intolerance	Recoverability	Sensitivity	Confidence
Smothering	High	Very high	Low	Moderate

Ulva intestinalis is a filamentous seaweed without structural support for its thalli, therefore it is likely that entire plants would be smothered by an additional covering of 5 cm of sediment. Smothering would interfere with photosynthesis and over the period of one month the seaweed may begin to rot. Intolerance to smothering has been assessed to be high. However, on return to prior conditions the species is likely to rapidly recolonize the available substratum (see additional information below) and recoverability has been assessed to be very high.

	Intolerance	Recoverability	Sensitivity	Confidence
Increase in suspended sediment	Intermediate	Very high	Low	Low

The effects of increased suspended sediment on adults is likely to be indirect but include smothering (above) as a result of siltation, and increased turbidity and therefore light attenuation (see below). In areas where *Ulva intestinalis* occurs on the shore, current flows are reduced and siltation is likely to be increased. Spores, germlings and juveniles are likely to be highly intolerant of sediment scour and smothering (Vadas *et al.* 1992). However, *Ulva intestinalis* also occurs in estuarine environments where elevated levels of suspended sediment are likely to be experienced, so the species may demonstrate some tolerance. Intolerance has been assessed to be intermediate, as a proportion of the population , especially germlings may be adversely affected by increased suspended sediment. Recoverability has been assessed to be very high (see additional information below).

	Intolerance	Recoverability	Sensitivity	Confidence
Decrease in suspended sediment	Tolerant	Not relevant	Not sensitive	Not relevant

Ulva intestinalis is unlikely to be affected by a decrease in suspended sediment concentrations, and an assessment of tolerant has been made.

	Intolerance	Recoverability	Sensitivity	Confidence
Dessication	Low	Very high	Very Low	Moderate

Ulva intestinalis is often very abundant on the high shore where desiccation stress is the primary factor controlling seaweed distribution, and may even be found above the tidal limits of the shore. *Ulva intestinalis* (studied as *Enteromorpha intestinalis*) can survive several weeks of living in completely dried out rock pools, while becoming completely bleached on the uppermost layers, but remaining moist underneath the bleached fronds. Its ability to survive out of water for so long makes it an ideal refuge for copepods in supralittoral rockpools (McAllen, 1999). Several studies have indicated that stress from aerial exposure can cause high mortality to algal propagules. Baker (1910) found a positive correlation between the vertical distribution of a species and the ability of zygotes to develop in desiccated environments. Hruby & Norton (1979) found that 7-14 day old germlings of *Ulva* (studied as *Enteromorpha*) were more tolerant of desiccation than earlier stages, so an increase in desiccation stress may impact more adversely on newly settled germlings than more mature plants. An intolerance assessment of low has been made to the benchmark change in desiccation and recoverability recorded to be very high (see additional information below).

Increase in emergence regime Tolerant* Not relevant Not sensitive* Low

Ulva intestinalis is often very abundant on the high shore where desiccation stress is the primary factor controlling seaweed distribution, and may even be found above the tidal limits of the shore, so is tolerant of emergence to some extent. Furthermore, above Mean High Water Springs (MHWS) level, *Ulva intestinalis* tends to preferentially inhabit rock pools or is associated with trickles of freshwater that cross the shore, and in such positions the risk of desiccation is reduced. Owing to increased emergence, the species that graze on *Ulva intestinalis* are likely to be less active, owing to risk of desiccation, and the seaweed may benefit from reduced grazing pressure. An assessment of tolerant* has been made.

Decrease in emergence regime Low Very high Very Low Low

Ulva intestinalis is unlikely to be directly affected by a decrease in the emergence regime, as occurs into the subtidal zone. However, it is the preferred food resource of the snail *Littorina littorea* (Lubchenco, 1978) and is grazed by other prosobranchs, all of which will probably be more active grazing during periods of immersion, so that the additional grazing pressure is likely to affect the population. An intolerance assessment of low has been made. A recoverability of very high has been recorded (see additional information, below).

Increase in water flow rate Intermediate Very high Low Very low

Ulva intestinalis is not of a growth form that offers resistance to tidal flow. The fronds would conform to the direction of the flow until drag effects caused tearing of the fronds or dislodgement of the holdfast. Increased scour from sand mobilized by increased tidal streams may cause more damage to the seaweed than increased water flow itself. However, recovery of the species is unlikely to be inhibited by increases water flow. For instance, Houghton *et al.* (1973) observed that swarmers of *Ulva* were able to settle onto surfaces subjected to water speeds of up to 10.7 knots. Intolerance has been assessed to be intermediate, as a proportion of the population may be damaged by increased water flow. Recruitment is not likely to be adversely affected and has been assessed to be very high (see additional information, below).

Decrease in water flow rate Tolerant Not relevant Not sensitive Not relevant

Ulva intestinalis is unlikely to be adversely affected by a decrease in water flow rate, as it occurs in locations, e.g. rockpools, where water flow is negligible. An assessment of tolerant has been made.

Increase in temperature Tolerant* Not relevant Not sensitive* High

Ulva intestinalis occurs to the south of the British Isles, so is likely to be tolerant of a chronic increase in temperature of 2°C. Also, it is characteristic of upper shore rock pools, where water and air temperatures are greatly elevated on hot days. Clarke (1992) reviewed the influence of cooling water effluent on shore communities. Effects are usually restricted to the immediate vicinity of the outfall, but brown seaweeds of the genus, e.g. *Ascophyllum* and *Fucus* were eliminated from a rocky shore heated to 27-30 °C by a power station in Maine, whilst *Ulva intestinalis* (as *Enteromorpha intestinalis*) increased significantly near the outfall (Vadas *et al.*, 1976). The evidence suggests that *Ulva intestinalis* would probably tolerate the benchmark increase in temperature and may benefit indirectly (through loss of competitors) and an assessment of tolerant* has been made.

Decrease in temperature Tolerant | Not relevant | Not sensitive | High

Ulva intestinalis occurs to the north of the British Isles, so is likely to be tolerant of a chronic decrease in temperature of 2°C, and one of the factors contributing to its success as a fouling organism, is its ability to withstand a wide range and variation of temperature *Ulva* sp. (as *Enteromorpha*) were reported to be tolerant of a temperature of -20°C (Kylin, 1917). The evidence suggests that *Ulva intestinalis* would tolerate the benchmark decrease in temperature.

Increase in turbidity Low | Very high | Very Low | Low

The light attenuating effects of increased turbidity are likely to impact on the photosynthetic efficiency of *Ulva intestinalis*, with consequential effects on growth. An intolerance assessment of low has been made to reflect the effect of increased turbidity on the viability of the species. On return to prior conditions recovery is likely to be rapid and growth resume, a recoverability of very high has been recorded.

Decrease in turbidity Tolerant* | Not relevant | Not sensitive* | Low

As a photoautotroph, *Ulva intestinalis*, is likely to benefit from reduced turbidity, as the light attenuating effects of turbid water reduce photosynthesis. An assessment of tolerant* has been made.

Increase in wave exposure Low | Very high | Very Low | Moderate

Wave induced scouring and burial of habitats by sand tends to prevent seaweed growth, except for those that are stress tolerant, robust perennials, or opportunistic ephemeral species such as *Ulva intestinalis*. This species settles when disturbance is at a minimum and rocks are bare, reproduces and disappears when physical disturbance begins again. In wave exposed locations, it is likely that an increase in wave exposure would inhibit settlement of propagules belonging to *Ulva intestinalis* so that a population would become impoverished. An intolerance assessment of low has been made to reflect the probable impact on the species recruitment. On return to prior conditions, recovery is likely to occur within a matter of weeks, and recoverability has been assessed to be very high (see additional information, below).

Decrease in wave exposure Tolerant | Not relevant | Not sensitive | Low

Ulva intestinalis occurs in locations with a variety of wave exposures. It is unlikely that the species would be directly adversely affected by decreased wave exposure. An assessment of tolerant has been made.

Noise Not relevant | Not relevant | Not relevant | Not relevant

Seaweeds have no known mechanism for noise perception.

Visual Presence Not relevant | Not relevant | Not relevant | Not relevant

Seaweeds have no known mechanism for visual perception.

Abrasion & physical disturbance High | Very high | Low | Moderate

Ulva intestinalis is likely to be susceptible to abrasion as it is not of a resilient growth form and would easily be scraped from the substratum by dragging objects. Therefore, intolerance has been assessed as high. However, *Ulva intestinalis* reproduces rapidly to colonize available substrata, and recoverability has been assessed to be very high (see additional information below).

Displacement Tolerant | Not relevant | Not sensitive | Moderate

Ulva intestinalis typically forms a permanent attachment to suitable substrata, suggesting that it would be intolerant of displacement. However, in some circumstances, the algae may becomes detached from the substratum, and buoyed-up by gas, it floats up to the surface and continues to grow in mats (e.g. Baeck *et al*., 2000). The thalli of the seaweed tend to loose their tubular shape, spread, and formed unattached monostromatic sheets. On account of the ability of the algae to continue growing as an unattached mat, following displacement, an assessment of not sensitive has been made.

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	Intermediate	High	Low	High

Ulva intestinalis has been assessed to have an intermediate intolerance to synthetic chemical pollution as available evidence highlights adverse effects upon the species viability and damage leading to death.
For instance, although herbicides tend not to be used directly in the marine environment, they can enter estuarine areas via river discharge and runoff. Paraquat and 3AT were tested for their effects on the settlement, germination and growth of *Ulva* (as *Enteromorpha*) (Moss & Woodhead, 1975). They found that zygotes were able to develop into filaments in the presence of Paraquat at 7 mg/L, but that germination was deferred at higher concentrations. Zygotes demonstrated increased resistance when they settled in clumps on the substratum, and green thalli of *Ulva* were more susceptible than ungerminated zygotes. *Ulva* was more intolerant of 3AT than to Paraquat.
However, synthetic chemicals used as antifouling agents may be directly introduced into the marine environment. Scarlett *et al*. (1997) analyzed water samples taken from the Plymouth Sound locality for the presence of the s-triazine herbicide, Irgarol 1051, which is an ingredient of antifouling paints used on pleasure boats and ships. Irgarol 1051 was detected at all sampling sites within the Sound; the highest levels were found in close proximity to areas of high boat density, especially where water flow was restricted within marinas, although concentrations within the semi-enclosed Sutton Harbour were less than values predicted from leach rate data. The highest detected concentration of over 120 ng/L significantly inhibited the growth of *Ulva intestinalis* (as *Enteromorpha intestinalis*) spores under laboratory conditions; the no effect concentration was 22 ng/L. Photosynthetic efficiency in the adult frond of *Ulva intestinalis* from Sutton Harbour marina was inhibited by Irgarol 1051 in the laboratory with an EC 50 (72 h) of 2.5 µg/L. A small adverse impact on *Ulva intestinalis* reproduction within harbours is therefore likely.
Following the *Torrey Canyon* tanker oil spill, copious amounts of solvent based detergents were sprayed directly on to the shore. Algae on the higher shore was especially affected, and included *Ulva intestinalis* (as *Enteromorpha intestinalis* in high level rock pools where it was killed (Smith, 1968).
Assuming deterioration of contaminants, recoverability has been assessed to be high (see additional information below).

Heavy metal contamination	Low	Very high	Very Low	Moderate

The order of metal toxicity to algae varies, with the algal species and experimental conditions, but generally the order is Hg>Cu>Cd>Ag>Pb>Zn (Rice *et al*., 1973; Rai *et al*., 1981). The effects of copper on macrophytes have been more extensively studied than the effects of any other metal owing to its use in antifouling paints. Lewis *et al*. (1998) investigated the influence of copper exposure and heatshock on the physiology and cellular stress response of *Ulva intestinalis* (as *Enteromorpha intestinalis*). Heat shock proteins (HSPs) are known to be

expressed in response to a variety of stress conditions, including heavy metals (Lewis *et al.*, 1999). *Ulva intestinalis* was exposed to a range of copper concentrations (0-500 µg $^{-1}$ for 5 days, to assess the effect of copper exposure on stress proteins (Stress-70 levels) and physiology of the seaweed. Stress-70 was induced by copper exposure, but was found to be no better an indicator of copper exposure than measurement of growth, which is inhibited by copper.
Species of the genus *Ulva* seem to be especially suitable for monitoring heavy metals in coastal areas and estuaries as it is ubiquitous in both and laboratory experiments have shown that accumulation of Cu, Zn, Cd and Pb by four different species of *Ulva* (as *Enteromorpha*) was sufficiently similar to justify pooling samples of the genus for field monitoring (Say *et al.*, 1990).
The interactions of salinity and temperature with toxicity are not always clear. For instance, Munda (1984) found that the Zn, Mn and Co accumulations in *Ulva intestinalis* (as *Enteromorpha intestinalis*) could be enhanced by decreasing the salinity.
In the absence of evidence to the contrary, an intolerance assessment of low has been made, as available evidence suggests that *Ulva* is relatively tolerant of heavy metal exposure at environmentally realistic concentrations, but experiences reduced growth. On return to prior conditions, and assuming deterioration of the contaminants recovery would probably be rapid.

Hydrocarbon contamination High Very high Low High

Ulva intestinalis is likely to demonstrate intolerance to hydrocarbon contamination. Likely effects include smothering, inhibition of respiration and photosynthesis, bleaching and interference with reproduction, so that affected populations may be destroyed. Intolerance has been assessed to be high. However, the species tends to recover very rapidly from oil pollution incidents. For instance, after the *Torrey Canyon* tanker oil in 1967, grazing species were killed, and a dense flush of ephemeral green algae (*Ulva*, *Blidingia*) appeared on the rocky shore within a few weeks and persisted for up to one year (Smith, 1968). Recoverability has been assessed to be very high (see additional information, below).

Radionuclide contamination Not relevant Not relevant

Ulva sp. are known to be able to acquire large concentrations of substances from surrounding water. In the vicinity of the Sellafield nuclear plant, England, *Ulva* (as *Enteromorpha*) sp. accumulated zirconium, niobium, cerium and plutonium-239, however the species appeared to be unaffected by the radionuclides (Clark, 1997).

Changes in nutrient levels Tolerant* Not relevant Not sensitive* Moderate

Nitrogen enrichment enhances growth of *Ulva intestinalis* (as *Enteromorpha intestinalis*) (Kamer & Fong, 2001), making the species a useful indicator of nutrient enrichment, although it also thrives in 'un-enriched' water. High levels of nutrient enrichment were found to mitigate the negative effects that reduced salinity can have on the growth of the species (Kamer & Fong, 2001). An assessment of tolerant* has been made as *Ulva intestinalis* is likely to increase in abundance as a consequence of nutrient enrichment.
However, excessive growth of green seaweeds in response to nutrients derived from sewage effluent is becoming an increasingly common phenomena in sheltered marine bays (e.g. Soulsby *et al.*, 1985). An overabundance of *Ulva* (as *Enteromorpha*) on the tidal flats of the Wadden Zee during summer was attributed to eutrophication by adjacent sewage effluents (Reise, 1983). Mats were initially composed of *Ulva*, but later joined by *Cladophora*, *Chaetomorpha* and *Porphyra*. The mats became anchored to the feeding tunnels of the abundant *Arenicola marina*, and so avoided displacement by tidal currents. Although the mats lasted little longer than a month, the sediment beneath the algal mats became anoxic, and the species composition was affected.

Increase in salinity Tolerant Not relevant Not sensitive Moderate

Ulva intestinalis has a cosmopolitan distribution throughout coastal areas and estuaries and is considered to be a remarkably euryhaline species, tolerant of extreme salinities ranging from 0 psu to 136 psu.
However, on the basis of evidence available, it is likely that some populations of the algae would be more intolerant of an increase in ambient salinity than others. Reed & Russell (1979) found that the response (ability to regenerate from cut thalli) of individual populations varied according to the salinity conditions of the original habitat, and that the pattern of euryhalinity in parental material and offspring was in broad agreement. This led Reed & Russell (1979) to suggest that salinity tolerances of selected populations have a genetic basis. For example;

- eulittoral zone material showed decreased percentage regeneration in all salinities (dilute: 0, 4.25, 8.5, 17 & 25.5 psu, and concentrated seawater: 51, 68, 95, 102 & 136 psu) except 34 psu, when compared to littoral fringe populations of *Ulva intestinalis* (as *Enteromorpha intestinalis*).
- none of the eulittoral zone material was able to regenerate in freshwater or concentrated seawater, whilst littoral fringe and rock pool material was able to do so.

Increased salinity is most likely to occur in the region of the littoral fringe and supralittoral zone. For instance, during the summer, owing to excessive evaporation brine precipitation may occur in rockpools containing *Ulva intestinalis*and salinity has been reported to rise as high as 180 psu (Reed & Russell, 1979). In follow-up experiments, littoral fringe specimens showed an increased capacity to survive in media of extreme salinity, a significant decrease in regeneration only being recorded after exposure to concentrated seawater (102 psu and 136 psu) for > 7 days.
At the benchmark level an assessment of not sensitive has been made for the average population of the species.

Decrease in salinity Tolerant Not relevant Not sensitive Moderate

Ulva intestinalis has a cosmopolitan distribution throughout coastal areas and estuaries and is considered to be a remarkably euryhaline species, tolerant of extreme salinities ranging from 0 psu to 136 psu. However, on the basis of evidence available, it is likely that some populations of the algae would be more intolerant of reductions in ambient salinity than others. For instance, Reed & Russell (1979) found that the response (ability to regenerate from cut thalli) of individual populations varied according to the salinity conditions of the original habitat, and that the pattern of euryhalinity in parental material and offspring was in broad agreement. This led Reed & Russell (1979) to suggest that salinity tolerances of selected populations have a genetic basis. For example;

- eulittoral zone material showed decreased percentage regeneration in all salinities (dilute: 0, 4.25, 8.5, 17 & 25.5 psu, full: 34 psu and concentrated seawater: 51, 68, 95, 102 & 136 psu) except 34 psu, when compared to littoral fringe populations of *Ulva intestinalis* (as *Enteromorpha intestinalis*).
- none of the eulittoral zone material was able to regenerate in freshwater or concentrated seawater, whilst littoral fringe and rock pool material was able to do so.

Reduced salinity has also been reported to affect the growth rate of *Ulva intestinalis*. Martins *et al.* (1999) observed that in years with high precipitation and significant increase of freshwater runoff to the Mondego estuary (west Portugal), that *Ulva intestinalis* (as *Enteromorpha intestinalis*) failed to bloom. In the laboratory, the growth rate of *Ulva intestinalis* was measured against a range of salinities, from 0 to 32 psu. *Ulva intestinalis* showed the lowest growth rates at extremely low salinity values (less than or equal to 3 psu), and for salinity less than or equal

to 1 psu, the algae died. Growth rates at a salinity lower than 5 psu and higher than 25 psu were also low, in comparison to growth between a salinity of 15 and 20 psu, where *Ulva intestinalis* showed the highest growth rates. Martin *et al.* (1999) concluded that episodes of reduced salinity were an important external parameter in controlling the growth of *Ulva intestinalis*. However, elsewhere *Ulva intestinalis* is known to thrive in areas of the supralittoral zone that receive freshwater runoff.
At the benchmark level an assessment of not sensitive has been made for the average population of the species. Furthermore, Kamer & Fong (2001) found that high nitrogen enrichment mitigated the negative effects that reduced salinity had on *Ulva intestinalis* (as *Enteromorpha intestinalis*) dry biomass, wet : dry biomass, tissue nutrients and ability to remove phosphorus from the water column.

Changes in oxygenation		Not relevant		Not relevant

There is insufficient information available to make an assessment about the effects of reduced oxygen in the water column upon *Ulva intestinalis*.

Biological Pressures

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

No information was found concerning the effects of microbial pathogens on *Ulva intestinalis*.

Introduction of non-native species	Not relevant	Not relevant	Not relevant	Not relevant

Ulva intestinalis is not known to be adversely affected by non-native species.

Extraction of this species	Intermediate	Very high	Low	Moderate

The benchmark for extraction is the removal of 50% of the *Ulva intestinalis* population from the area under consideration. Intolerance has therefore been assessed to be intermediate and recoverability very high as a localized populations of the species will remain from which recruitment can occur (see additional information below).

Extraction of other species	Not relevant	Not relevant	Not relevant	Not relevant

No other species are identified to be host or prey items for *Ulva intestinalis*.

Additional information

Recoverability

Ulva intestinalis is generally considered to be an opportunistic species, with an '*r*-type' strategy for survival. The *r*-strategists have a high growth rate and high reproductive rate. For instance, the thalli of *Ulva intestinalis*, which arise from spores and zygotes, grow within a few weeks into thalli that reproduce again, and the majority of the cell contents are converted into reproductive cells. The species is also capable of dispersal over a considerable distance. For instance, Amsler & Searles (1980) showed that swarmers of a coastal population of *Ulva* (as *Enteromorpha*) reached exposed artificial substrata on a submarine plateau 35 km away.
Ulva intestinalis is amongst the first multicellular algae to appear on substrata that have been cleared following a disturbance, e.g. following the *Torrey Canyon* oil spill in March 1967, species of the genus *Ulva* rapidly recruited to areas where oil had killed the herbivores that usually grazed on them, so that a rapid greening of the rocks (owing to a thick coating of *Ulva*) was apparent by mid-May (Smith, 1968). The rapid recruitment of *Ulva* to areas cleared of herbivorous grazers was also

demonstrated by Kitching & Thain (1983). Following the removal of the urchin *%Paracentrotus lividus%* from areas of Lough Hyne, Ireland, *Ulva* grew over the cleared area and reached a coverage of 100% within one year. Therefore, evidence suggests that *Ulva intestinalis* is likely to have a considerable ability for recovery within a year.

Importance review

Policy/legislation

- no data -

Status

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

Non-native

Native	-		
Origin	-	**Date Arrived**	-

Importance information

- *Ulva intestinalis* is used by the copepod *Tigriopus brevicornis* as a refuge from desiccation (McAllen, 1999)
- Green algae in the form of membranes or flat tubes (e.g. *Ulva* and *Monostroma*) are eaten extensively in Asia (Guiry & Blunden, 1991)
- The potential of *Ulva intestinalis* (as *Enteromorpha intestinalis*) for use in the treatment of secondary municipal sewage and biomass for energy conservation has been investigated (Guiry & Blunden, 1991).

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