A green seaweed (*Cladophora rupestris*)

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

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

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Dense stand of *Cladophora rupestris* on a gently sloping granite shore.
Photographer: Keith Hiscock
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See online review for distribution map

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

Researched by	Georgina Budd	**Refereed by**	Dr Fabio Rindi
Authority	(Linnaeus) Kützing, 1843		
Other common names	-	**Synonyms**	-

Summary

Description

Cladophora rupestris is a densely tufted plant, that grows up to 20 cm in height, with dark green or bluish coloured dull fronds. Typical specimens branch profusely upwards from the base, in an irregular, whorled or opposite pattern. The stoutness, density and arrangement of branches gives the seaweed a coarse feel.

Recorded distribution in Britain and Ireland

Found all round the coast of Britain and Ireland on suitable substrata.

Global distribution

See additional information.

Habitat

Cladophora rupestris grows in rock pools, on the surface of rocks, hanging in 'ropes' in crevices or forming undergrowth to macroalgae at all levels on the shore.

Depth range

See additional information

Identifying features

- Plants grow up to 15-20 cm in height.
- Dark green or bluish in colour.
- Coarse texture, rather like rope.
- Basal plate of rhizoids give rise to numerous erect fronds.
- Fronds (thalli) straight or slightly curved outwards.
- Thallus is a uniseriate (constructed of cells in a single row) usually highly branched filament of cells, whose cells decrease in size from base to apex.

Additional information

The morphology of the species is fairly constant over a wide range of habitat conditions and over a wide geographical area. Its morphology is affected by physical damage due to grazing by animals and loss of the apical region on reproduction, both instances are followed by regeneration and proliferation of branches. *Cladophora rupestris* sometimes forms an almost complete cover of stunted growth at high tide level and occasionally in the splash zone where pools are brackish. Filaments are short and branching dense in the most wave exposed locations (Burrows, 1991).

Listed by

Further information sources

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Biology review

Taxonomy

Phylum	Chlorophyta	Green seaweeds
Class	Ulvophyceae	
Order	Cladophorales	
Family	Cladophoraceae	
Genus	Cladophora	
Authority	(Linnaeus) Kützing, 1843	
Recent Synonyms	-	

Biology

Typical abundance	
Male size range	
Male size at maturity	
Female size range	Medium(11-20 cm)
Female size at maturity	
Growth form	Shrub
Growth rate	
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	No text entered.
Supports	See additional information
Is the species harmful?	No

Biology information

Species of the genus *Cladophora* are colonized by a wide variety of epiphytes and motile animals because they can offer protection from predation, provide food (either in the form of epiphytes, or itself), or a substratum that is anchored against water flow turbulence (Dodds & Gudder, 1992). *Cladophora rupestris* is only very rarely epiphytic (F. Rindi, pers. comm.).

Habitat preferences

Physiographic preferences	Open coast, Offshore seabed, Strait / sound, Sea loch / Sea lough, Ria / Voe, Enclosed coast / Embayment

Biological zone preferences	Lower eulittoral, Lower infralittoral, Lower littoral fringe, Mid eulittoral, Sublittoral fringe, Supralittoral, Upper eulittoral, Upper infralittoral, Upper littoral fringe
Substratum / habitat preferences	Macroalgae, Bedrock, Cobbles, Large to very large boulders, Small boulders
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.)
Wave exposure preferences	Exposed, Moderately exposed, Sheltered, Very exposed
Salinity preferences	Full (30-40 psu), Low (<18 psu), Reduced (18-30 psu), Variable (18-40 psu)
Depth range	See additional information
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

The species occurs throughout the year but attains maximum development in summer near low tide level (Burrows, 1991). It is mostly an intertidal species although it may also extend into the sublittoral but only by a few metres (F. Rindi, pers. comm.).

Global distribution

European Atlantic coast from Scandinavia to the Mediterranean, Adriatic, Baltic Sea, Murman Sea and White Sea. Atlantic coasts of North America from Canadian Arctic, south to Massachusetts, Greenland, Iceland and Faeroes. Also found in Morocco, Brazil, Japan, Lord Howe Island (Australia) and in the Antarctic (Guiry & Nic Dhonncha, 2002).

Life history

Adult characteristics

Reproductive type	Alternation of generations
Reproductive frequency	Annual protracted
Fecundity (number of eggs)	No information
Generation time	<1 year
Age at maturity	Insufficient information
Season	
Life span	Insufficient information

Larval characteristics

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

Life history information

Information on the ecology of reproduction and propagation of the genus *Cladophora* is limited. Reproduction is achieved by the release of quadriflagellate zoospores and biflagellate isogametes formed in the terminal cells of fronds. The life history consists of an isomorphic (indistinguishable except for the type of reproductive bodies produced) alternation of gametophyte and sporophyte generations, the plants are dioecious (Burrows, 1991). Both zoospores and gametes can be found at most times of the year. Archer (1963, cited in Burrows, 1991) was unable to find any correlation between the time of reproduction, the state of tide or environmental conditions. Most species of *Cladophora* attach to the substratum by multicellular, branching rhizoids (van den Hoek, 1982); these basal holdfasts may serve as resistant structures from which new growths can arise.

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	High

Cladophora rupestris forms a permanent attachment to substrata, so would be intolerant of substratum loss. Intolerance has been assessed to be high. Recoverability has been assessed to be very high (see additional information below).

	Intolerance	Recoverability	Sensitivity	Confidence
Smothering	Intermediate	Very high	Low	Moderate

Cladophora rupestris is a stout shrub-like seaweed, whose fronds may grow up to 20 cm in height. A covering of sediment to a depth of 5 cm is likely to partially cover the seaweed, and at low tide the whole plant may be covered whilst lying limply on the rock. Unless the sediment is removed by the incoming tide, photosynthesis would be inhibited and fronds begin to decay over the duration of one month. Spores, germlings and juveniles are likely to be highly intolerant of smothering by sediment (Vadas *et al.* 1992). An intolerance assessment of intermediate has been made to reflect the probable impact of smothering on germlings, thereby preventing recruitment for that period, and the inhibitory effects upon more mature specimens. On return to prior conditions, the species is likely to recover, either new growth will arise from the resistant multicellular branching rhizoids (van den Hoek, 1982) that may remain *in situ*, or the species is likely to recruit to cleared substrata via its 'swarmers' (reproductive propagules). Recoverability has been assessed to be very high. For instance, after the *Torrey Canyon* tanker oil spill in mid March 1967, recolonization by sporelings of *Ulva* and *Cladophora* had occurred by the end of April.

	Intolerance	Recoverability	Sensitivity	Confidence
Increase in suspended sediment	Tolerant	Not relevant	Not sensitive	Low

The filamentous branching morphology of *Cladophora rupestris* would probably enable it to effectively accumulate sediment from suspension. For instance, Boney & Venn (1982) observed *Cladophora rupestris* to accumulate deposits of ferric oxide from suspension, derived from iron ore spillage and wind-winnowed dust from stockyards on the British Steel Hunsteston Peninsula, Firth of Clyde, Scotland. However, the specimens were apparently healthy with green chloroplasts and starch filled pyrenoids, despite incrustations of ferric oxide. The probable indirect effects of increased suspended sediment are addressed elsewhere, and include smothering (above) as a result of siltation, and increased turbidity and therefore light attenuation (see below). Available evidence suggests that *Cladophora rupestris* is tolerant of elevated levels of suspended sediment and an assessment of tolerant has been made, but at low confidence.

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

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

	Intolerance	Recoverability	Sensitivity	Confidence
Dessication	Intermediate	Very high	Low	Low

Cladophora rupestris is a bushy filamentous algae, Norton *et al.* (1982) supposed that the numerous filaments retained large quantities of water when the plant became exposed on the shore, which might be a vital function in the prevention of desiccation. However, as soon as the seaweed is removed from water its photosynthetic rate drops sharply, owing to the restriction of inorganic carbon (Lobban & Harrison, 1997). Those individuals living at the highest level on the shore are living at the top of their physiological tolerance limits and so would not be likely to tolerate a further increase in emersion levels. This would probably result in the upper extent of the species being depressed. An intolerance assessment of intermediate has been made. On return to prior conditions, the species is likely to recover, and recoverability has been assessed to be very high (see additional information below).

Increase in emergence regime	Intermediate	Very high	Low	Low

An increase in the period of emersion involves exposure to desiccation, chilling or heating, removal of most nutrients required for growth, and, frequently, changes in the salinity of the water in the surface film on the seaweed and in the free space between cells (Lobban & Harrison, 1997). Although *Cladophora rupestris* is tolerant of a range of salinity, it is likely to be intolerant of desiccation stress resulting from an increase in the emergence regime, and an intolerance assessment of intermediate has been made. Should the abundance of the species be affected, e.g. decline in the upper distribution, on return to prior conditions, recovery is likely to be rapid (see additional information, below).

Decrease in emergence regime	Low	Very high	Very Low	Moderate

Cladophora rupestris is found in the shallow sublittoral and therefore could potentially benefit from a decrease in the emergence regime. *Cladophora rupestris* is considered to be relatively palatable to invertebrates (Dodds & Gudder, 1992), all of which will probably be more active grazing during periods of immersion, so that the additional grazing pressure may affect the abundance of the species. 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	Low	Immediate	Not sensitive	Moderate

Lewis (1964) named *Cladophora rupestris* to be amongst the understorey algae of tidal rapids at Lough Ine. Part of the success of species of the genus *Cladophora* is probably related to its ability to withstand the shear stress experienced in rocky intertidal habitats. The thallus of the seaweed is tough, but flexible, and allows water to flow through and around it (Dodds, 1991). At low current velocities the thallus spreads out, but becomes more streamlined as the current velocity increases. As tufts of *Cladophora* become more compact with higher current, transport of materials to and from the plant may be inhibited or self shading may increase, leading to an overall decrease in photosynthesis (Pfeifer & McDiffett, 1975). An intolerance assessment of low has been made to reflect the possible effects of increased water flow on photosynthesis by the seaweed. Following a reduction in water flow, recovery is likely to be immediate, as the fronds splay out and photosynthesis increases.

Decrease in water flow rate	Low	Immediate	Not sensitive	Low

Water flow is important to macroalgae as the processes of photosynthesis, respiration and growth is dependent on a flux of substrates (CO_2, O_2 & nutrients) and to remove waste products. Therefore a reduction in the water flow below a certain level may have an adverse effect on the species. An intolerance assessment of low has been made as the viability of the species may be affected. On return to prior conditions, recovery is likely to be immediate.

Increase in temperature	Tolerant	Not relevant	Not sensitive	Moderate

Cladophora rupestris occurs to the south of the British Isles, so is likely to be tolerant of a chronic increase in temperature of 2 °C. Fortes & Lüning (1980) and Lüning (1984) reported that *Cladophora rupetrsis* from Helgoland were able to survive at temperatures between 0 - 28°C (for a period of a week), so the species is likely to tolerate the benchmark acute increase in temperature, the species is also characteristic of upper shore rock pools, where water and air temperatures are greatly elevated on hot days. An assessment of tolerant has been made.

Decrease in temperature	Tolerant	Not relevant	Not sensitive	Moderate

Growth measurements of *Cladophora rupestris* from Roscoff, France, led Cambridge *et al.* (1984) to conclude that the species was tolerant of temperatures of below -5°C and at the benchmark level the species has been assessed to be tolerant of a decrease in temperature.

Increase in turbidity	Low	Very high	Very Low	Low

Although *Cladophora rupestris* is common on shaded overhangs (Lewis, 1964) the light attenuating effects of increased turbidity are likely to impact on the photosynthetic efficiency of the species, 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*	Not relevant

As a photoautotroph, *Cladophora rupestris* 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	Low

Cladophora biomass in rock pools is affected by wave action. Loosely attached mats slough off with wave action as they become thick (Dethier, 1982) and cause a localized decline in abundance. Morphology of *Cladophora* has also been linked to hydrodynamic factors. Branching of marine species of *Cladophora* may become more pronounced with increased wave energy (Van den Hoek, 1964; 1982). Increased wave action may therefore cause distortion of morphology. Furthermore, wave action is likely to be effective in the dislodgement/breaking off of fronds of *Cladophora rupestris*. Either new growth will arise from the resistant multicellular branching rhizoids (van den Hoek, 1982) that may remain in situ, or the species is likely to recruit to cleared substrata via its 'swarmers' (reproductive propagules). Recoverability has been assessed to be very high. For instance, after the *Torrey Canyon* tanker oil spill in mid March 1967, recolonization by sporelings of *Ulva* and *Cladophora* had occurred by the end of April. Intolerance has been assessed to be low. Recovery has been assessed to be very high.

Decrease in wave exposure	Tolerant	Not relevant	Not sensitive	Low

Cladophora rupestris is unlikely to be adversely affected by reduced wave action, as it also thrives in wave sheltered locations. 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	Tolerant	Not relevant	Not sensitive	Low

As *Cladophora rupestris* may grow in the form of a thick turf over the rock, and amongst other algae it may be more resistant to abrasion in the form of trampling and dragging of chain for example, owing to the cushion effect of the fronds overlying the holdfast. Individual fronds may incur damage, but the factor is unlikely to cause a substantial decline in the species abundance. At the benchmark level an assessment of tolerant has been made, but with low confidence. A more severe abrasive impact such as the grounding of a vessel would be likely to cause damage and intolerance expected to be higher.

Displacement	High	Very high	Low	High

Cladophora rupestris forms a permanent attachment to solid substrata. It is likely to be intolerant of displacement as, once removed, mature plants are unable to reattach. Intolerance has been assessed to be high. The species has a considerable ability for recovery. For instance, after the *Torrey Canyon* tanker oil spill in mid March 1967, recolonization by sporelings of *Ulva* and *Cladophora* had occurred by the end of April. Recoverability has been assessed to be very high.

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	Intermediate	Very high	Low	Moderate

Following the *Torrey Canyon* tanker oil spill in 1967, copious amounts of non-ionic detergents were employed to disperse the oil. The detergents used contained a surfactant, an organic solvent and a stabilizer; the solvents all contained a proportion of aromatic compounds which made the detergent more effective but more toxic. Porthleven Reef, Cornwall, was badly polluted, an estimated total of 35 000 gallons of detergent was used in an eight day period. The algae most seriously damaged occurred at the higher levels of the shore. Smith (1968) reported *Cladophora rupestris* to be amongst the algae of very unhealthy appearance, with bleached fronds and dead specimens, although apparently healthy specimens were still found lower on the shore. In follow-up toxicity experiments, *Cladophora rupestris* was found to be the most intolerant of the intertidal species tested. Severe damage was noted at the apical cells of the filaments, which are the growing points, after six hours immersed in 6% solutions of all detergents (except BP1002, which was apparently harmless at that concentration). Less severe, but irreversible damage was noted down to about 1% concentration. Intolerance has been assessed to be intermediate. The species has a high capacity for recovery. On return to prior conditions, the species is likely to recover, either new growth will arise from the resistant multicellular branching rhizoids (van den Hoek, 1982) that may remain in situ, or the species is likely to recruit to cleared substrata via its swarmers. Recoverability has been assessed to be very high. For instance, after the *Torrey Canyon* tanker oil spill in mid March 1967, recolonization by sporelings of *Ulva* and *Cladophora* had occurred by the end of April.

Heavy metal contamination		Not relevant		Not relevant

The order of metal toxicity to algae varies, with the algal species and environmental conditions, (Rice *et al*., 1973; Rai *et al*., 1981) but Bryan (1984) suggested that the general order for heavy metal toxicity in seaweeds is: Organic Hg > inorganic Hg > Cu > Ag > Zn > Cd > Pb. No information was found concerning the specific effects of heavy metals on *Cladophora rupestris*.

Hydrocarbon contamination	Intermediate	Very high	Low	Moderate

The toxic effects of oil on algae may be categorized as those associated with the coating of the fronds, e.g. coating by oil is likely to reduce CO_2 diffusion and light penetration to the plant, and those attributable to the uptake of hydrocarbons and subsequent disruption of cellular metabolism (Lobban & Harrison, 1997).

Cullinane *et al.* (1975) summarized the damage caused to *Cladophora rupestris* following the crude oil spill in 1974 in Bantry Bay, Ireland. No damage was immediately apparent to *Cladophora rupestris*, but microscopic examination of material from rock pools at League Point showed complete bleaching of the terminal cells (only). Burrows (1991) indicated that following damage to the apical cells of fronds, that regeneration was possible.
Bokn *et al.* (1993) examined the long term effects of the water-accommodated fraction (WAF) of diesel oil on rocky shore populations. Two doses (average hydrocarbon concentration in diesel oil equivalents; High: = 129.4 µmg l-1, and Low = 30.1µmg l-1) of WAF of diesel oil were delivered via sea water to established rocky shore mesocosms over a two year period, however there were no demonstrable effects in the abundance patterns of *Cladophora rupestris*, *Ulva* spp. or *Ulva lactuca* in the oil contaminated compared with the control mesocosms at the end of that period. Intolerance has been assessed to be intermediate. On return to prior conditions, the species is likely to recover, either new growth will arise from the resistant multicellular branching rhizoids (van den Hoek, 1982) that may remain in situ, or the species is likely to recruit to cleared substrata via its swarmers. Recoverability has been assessed to be very high. For instance, after the *Torrey Canyon* tanker oil spill in mid March 1967, recolonization by sporelings of *Ulva* and *Cladophora* had occurred by the end of April.

Radionuclide contamination		Not relevant		Not relevant

Insufficient information.

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

Nutrient enrichment of the water column, e.g. resulting from sewage discharge, can stimulate blooms of opportunistic benthic macroalgae, especially *Cladophora* and *Ulva* (Knox, 1986). An assessment of tolerant* has been made, as the species may increase in abundance as a result of nutrient enrichment.

Increase in salinity	Tolerant	Not relevant	Not sensitive	Low

Cladophora rupestris found in intertidal rock pools can withstand 5-30 psu (Jansson, 1974) and as the species is successful in the high intertidal zone it is likely that the species has a broad salinity tolerance (Dodds & Gudder, 1992). At the benchmark level an assessment of not sensitive has been made.

Decrease in salinity	Tolerant	Not relevant	Not sensitive	Low

Cladophora rupestris can tolerate salinities as low as 5 psu (Burrows, 1991) and as the species is successful in the high intertidal zone it is likely that the species has a broad salinity tolerance (Dodds & Gudder, 1992). At the benchmark level an assessment of not sensitive has been made. However, Thomas *et al.* (1988) found that, at extreme temperatures, *Cladophora rupestris* had a reduced salinity tolerance range, e.g. the most marked inhibition of photosynthesis occurred in conditions of low salinity (0 psu) and high temperatures (25 - 30°C).

Changes in oxygenation		Not relevant		Not relevant

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

Biological Pressures

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

No information was found concerning the effects of microbial pathogens on *Cladophora rupestris*.

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

No non-native species are known to adversely impact upon *Cladophora rupestris*.

Extraction of this species Intermediate Very high Low Moderate

The benchmark for extraction is the removal of 50% of the *Cladophora rupestris* population from the area under consideration. Intolerance has therefore been assessed to be intermediate and recovery very high as a local population of the species will remain from which recruitment can occur.

Extraction of other species Low Very high Very Low Moderate

No other species are identified to be host or prey items for *Cladophora rupestris*. During experiments to investigate intertidal and subtidal canopy interactions, Hawkins & Harkin (1985) removed the overlying canopy of both *Fucus serratus* and *Laminaria digitata* on shores of differing wave exposure, and results led them to conclude that in the region that spans the boundary between the intertidal and subtidal on N.W. European shores, canopy effects are the dominant biological factors structuring the community. It was noted that, following removal of *Fucus serratus*, the more permanent understorey algae (*Cladophora rupestris* and *Corallina officinalis*) became covered to some extent by *Ulva intestinalis*, *Palmaria palmata* and *Fucus serratus*, and decreased in cover but still survived. *Ulva intestinalis* grew on and amongst the understorey, whereas *Palmaria palmata* and *Fucus serratus* shaded the plants by growth from gaps in the understorey turf. An intolerance assessment of low has been made to reflect the fact that the understorey alga *Cladophora rupestris* may decline in abundance following removal of key structuring macroalgae, owing to overgrowth, but still survive.

Additional information

Recoverability

It is likely that *Cladophora rupestris* will have a considerable capacity for recovery. The species is widespread around the British Isles and Ireland, and may be found in reproductive condition all year round. Numerous motile 'swarmers' (reproductive propagules) are released and in the water column they can be dispersed over considerable distances. In addition to recruitment by swarmers, new growth may arise from the resistant multicellular branching rhizoids (van den Hoek, 1982) that may remain in situ. Recoverability has been assessed to be very high. For instance, after the *Torrey Canyon* tanker oil spill in mid March 1967, recolonization by sporelings of *Ulva* and *Cladophora* had occurred by the end of April (Smith, 1968).

Importance review

Policy/legislation

- no data -

Status

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

Non-native

Native	-		
Origin	-	**Date Arrived**	-

Importance information

Cladophora rupestris forms an important habitat and food resource for juvenile isopods and amphipods that are a major component of fish diets (Jansson, 1967).

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