MarLIN

Marine Information Network

Information on the species and habitats around the coasts and sea of the British Isles

Hornwrack (*Flustra foliacea*)

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

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Flustra foliacea.
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	Dr Harvey Tyler-Walters & Susie Ballerstedt	**Refereed by**	Dr Joanne Porter
Authority	(Linnaeus, 1758)		
Other common names	-	**Synonyms**	-

Summary

Description

Flustra foliacea forms a stiff but flexible bushy clump 6 -10 cm high, occasionally up to 20cm high. *Flustra foliacea* is much divided into fronds that are usually broadly lobed, occasionally strap-like, and made up of zooids (individuals) on both sides (bilaminar). Fronds are light grey to brown in colour. Zooids are tongue shaped, 0.4 mm long and 0.2 - 0.28 mm wide. They bear 4 to 5 marginal club-like spines at the broad (distal) end of each zooid. The fronds have a distinct smell of lemons when freshly collected. Hornwrack is sometimes found washed ashore after storms.

Recorded distribution in Britain and Ireland

Common on all rocky coasts of Britain and Ireland.

Global distribution

Flustra foliacea occurs in the Kara Sea, White Sea and Barents Sea in the Arctic circle, the North Sea, and extends south as far as Bay of Biscay. Also found on the east coast of Greenland.

Habitat

Found on coarse sediment and rocky substrate in the shallow sublittoral, where it favours current-swept rocky grounds.

Depth range

Sublittoral 1 -200m

Identifying features

- Bushy clumps of palmate, flattened fronds, 6 -10 cm but occasionally 20 cm high.
- Distinct smell of lemons when fresh.
- Zooids are tongue shaped and bear 4 to 5 marginal club-like spines on their broad, distal margin and lacks an ascus (anascan).
- Fronds composed of a double layered (bilaminar) sheet of zooids.
- Zooids arranged in a quincunx pattern, i.e. four zooids surrounding a central one.
- The polypide of each zooid bears 13-14 tentacles.
- Avicularia about half the size of the autozooids (feeding zooids) and arise at the bifurcation between rows of autozooids.
- Ovicell immersed, endozooidal, embedded in the base of the distal zooid.

Additional information

Flustra foliacea forms only a flat incrustation during its first year of growth, erect growth occurs in subsequent years. Fronds can often be encrusted by other bryozoans, hydroids and sedentary polychaetes.

Listed by

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Biology review

Taxonomy

Phylum	Bryozoa	Sea mats, horn wrack & lace corals
Class	Gymnolaemata	
Order	Cheilostomatida	
Family	Flustridae	
Genus	Flustra	
Authority	(Linnaeus, 1758)	
Recent Synonyms	-	

Biology

Typical abundance	Moderate density
Male size range	
Male size at maturity	
Female size range	Medium(11-20 cm)
Female size at maturity	
Growth form	Modular, Turf
Growth rate	1.6-3cm/year
Body flexibility	High (greater than 45 degrees)
Mobility	Sessile
Characteristic feeding method	Active suspension feeder
Diet/food source	Omnivore
Typically feeds on	Phytoplankton, detritus and dissolved organic matter.
Sociability	Solitary
Environmental position	Epibenthic
Dependency	Independent.
Supports	Substratum Small green algae, bryozoans, hydroids, sessile polychaetes, barnacles, lamellibranchs and tunicates (see additional information below)
Is the species harmful?	See additional information

Biology information

Detailed diagrams of the autozooid and avicularium of *Flustra foliacea* are provide by Silén (1977).

Growth form
The newly metamorphosed coronate larvae develops into the first zooid of the new colony, the 'ancestrula'. In its first year of growth, *Flustra foliacea* forms a flat incrustation on the substratum and commences erect growth during the second year. This is achieved simply by the opposition of actively growing lobes of a colony; on contact two growing edges are deflected vertically (J. Porter, pers. comm.).
The two layers of zooids grow, synchronously 'back to back' forming a bilaminar, erect frond at 90 °

to the original encrusting mat. Branching of the erect fronds varies between branches and colonies (Stebbing, 1971a; Silén, 1981).
Ryland (1976) suggested that erect growth avoids the spatial constraints (availability of substratum and competition) suffered by encrusting forms. Repair of grazing damage, i.e. removal of one bilaminar layer, may result in generation of an new bilateral branch (Stebbing, 1971a).

Growth rates
Stebbing (1971a) reported that growth began in late February/early March but stopped in November in specimens off the Gower Peninsula , with a slight check in growth in August, and no growth occurred over winter. Growth stopped in October in Isle of Man specimens (Eggleston, 1963; cited in Stebbing, 1971a). The winter growth check results in visible annual growth lines, which have been used to age colonies (Stebbing, 1971a; Eggleston, 1972; Menon, 1978). Stebbing (1971a) suggested that the growth line formed a line of weakness, which gave the frond flexibility.

Stebbing (1971a) stated that the length of time spent as an encrusting form was unclear but assumed the first growth line at the base of the frond represented the first winter, 1 years growth. *Flustra foliacea* colonies regularly reached 6 years of age, although 12 year old specimens were reported off the Gower Peninsula (Stebbing, 1971a; Ryland, 1976). Furthermore, O'Dea & Okamura (2000) demonstrated seasonal fluctuations in zooid size synchronous with temperature regimes, the largest zooid zooids occurring with the lowest temperatures.

Stebbing (1971a) reported that growth rates were reasonably consistent between samples, age classes and years. Stebbing (1971a) reported a mean increment in frond height of 16.8mm/yr, whereas Eggleston (1972) reported that annual lines were usually between 2-3cm apart in Isle of Man specimens, and Menon (1978) reported that Helgoland specimens reached an average of 21.2 mm in height at 2 years old and an average of 79.3 mm after 8 years. Silén (1981) reported that erect fronds grew in zooid number about 10-20 times that of the encrusting base. Menon (1978) reported that growth rates varied in specimens over 5 years old.

At the base of fronds, in the holdfast area, the zooids give rise to layers of non-feeding frontal buds after 3 years of age, which strengthen the base of the frond. The number of layers increases with frond height up to 145mm in height, and up to 20 layers deep (Stebbing, 1971a).

Growth rates probably vary between locations. O'Dea & Okumara (2000) noted that colonies of *Flustra foliacea* from the Bay of Fundy showed reduced growth compared to colonies in the Menai Straits and the Skagerrak. Low primary productivity, genetic variation and parasitism were cited as possible explanations for the difference.

Regeneration and repair
Silén (1981) reported that experimental removal of a notch in the frond was repaired within 5 -10 days. The newly formed margin grew at normal rates (4-5 zooid lengths per month). Removal of one layer of the bilaminar frond, experimentally (Silén, 1981) or by predators (Stebbing, 1971a) was repaired with similar rapidity, the un-damaged layer, halting growth while the damaged area was repaired (Silén, 1981).

Epiphytes
The epizoic fauna of *Flustra foliacea* was described by Stebbing (1971b) and consisted of 25 species of bryozoan, 5 hydroid species, some sessile polychaetes, barnacles, lamellibranchs and tunicates. The bryozoans *Bugulina flabellata*, *Crisia* spp. and *Scrupocellaria* spp. were major epizoites. The stolons of *Bugulina flabellata* penetrate the zooids of *Flustra foliacea*. *Scrupocellaria* spp. settled

preferentially on the youngest, distal, portions of the frond, possibly to elevate their branches into faster flowing water (Stebbing, 1971b). A small green alga *Epicladia flustrae* was reported to be a specific epiphyte (Nielsen, 1984). Stebbing (1971a) reported that the growth rates of *Flustra foliacea* were reduced by ca 50% when encrusted by epizoites. Peters *et al*, (2003) reported the presence of chemical compounds in *Flustra foliacea* that demonstrated antagonistic effects against the growth of some associated bacterial species, and electron microscopic examination of the distal end of the zooid revealed no microbial settlement. Dyrynda (1985, cited in Peters *et al.*, 1985) reported the toxicity of extracts of *Flustra foliacea* on larvae of other modular invertebrates, fish and bacteria.

Toxicity

Some people can react to *Flustra* sp. and some fishermen have reported allergic reactions to it although this is anecdotal information (J. Porter, pers. comm.). Research into biomedical compounds from marine organisms has revealed that a sample of *Flustra foliacea* from the southern North Sea yielded deformylflustrabromine, which was moderately cytotoxic to the human colon cancer cell-line HCT-116 (Lysek *et al.*, 2002; Jha & Zi-rong, 2004).

Habitat preferences

Physiographic preferences	Open coast, Offshore seabed, Strait / sound, Sea loch / Sea lough, Ria / Voe
Biological zone preferences	Lower circalittoral, Lower infralittoral, Upper circalittoral, Upper infralittoral
Substratum / habitat preferences	Bedrock, Cobbles, Large to very large boulders, Mixed, Small boulders
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Strong 3 to 6 knots (1.5-3 m/sec.), Very Strong > 6 knots (>3 m/sec.), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Exposed, Moderately exposed, Sheltered, Very exposed
Salinity preferences	Full (30-40 psu)
Depth range	Sublittoral 1 -200m
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

Flustra foliacea may colonize any hard substratum, such as shells, stones, or cobbles but forms dense aggregations particularly in otherwise barren, current swept rocky bottoms. Although present in a wide range of tidal streams and wave exposure, *Flustra foliacea* is abundant in moderately strong to strong tidal streams (Hiscock, 1983). Dyer *et al.* (1982) reported between <10 to >200 colonies per m^2 in trawls in the North Sea. *Flustra foliacea* is associated with strong currents and areas subject to sediment abrasion (Stebbing, 1971a; Knight-Jones & Nelson-Smith, 1977; Hartnoll, 1983; Holme & Wilson, 1985) and requires stable hard substrata (Eggleston, 1972b; Ryland, 1976; Dyrynda, 1994). The abundance of bryozoans is positively correlated with supply of stable hard substrata and hence with current strength (Eggleston, 1972b; Ryland, 1976).

Life history

Adult characteristics

Reproductive type	Permanent (synchronous) hermaphrodite
Reproductive frequency	Annual episodic
Fecundity (number of eggs)	100,000-1,000,000
Generation time	1-2 years
Age at maturity	See additional text
Season	August - April
Life span	5-10 years

Larval characteristics

Larval/propagule type	Cyphonautes
Larval/juvenile development	Lecithotrophic
Duration of larval stage	< 1 day
Larval dispersal potential	See additional information
Larval settlement period	Insufficient information

Life history information

Reproduction

Bryozoan colonies are hermaphrodite, however, zooids may be monoecious, dioecious, protandrous or protogynous, depending on species (Hayward & Ryland, 1998). *Flustra foliacea* bears both male and female zooids and is presumably hermaphrodite.

- Male zooids of *Flustra foliacea* in the Isle of Man were reported to be full of sperm in September, giving the entire colony a white appearance. Sperm were absent by October. Orange eggs were visible in August and the yellow coloured embryos had entered the ooecia (ovicells) by October (Eggleston, 1970; 1972a). Sperm are shed from pores in the polypide tentacles of male zooids.
- Fertilization in brooding species such as *Flustra foliacea* is probably internal (Hayward & Ryland, 1998). In bryozoans, released sperm are entrained by the tentacles of feeding polypides and may not disperse far, resulting in self-fertilization. However, genetic cross-fertilization is assumed in oviparous and brooding bryozoans, although there is evidence of self fertilization (Hayward & Ryland, 1998).
- Eggleston (1972a) reported that about one third of zooids produced a single embryo in their first and second years, but that older zooids were infertile. Embryos were brooded overwinter and larvae released between February and April.

Fecundity

Dalyell (cited in Hincks, 1880) stated that ca 10,000 larvae were released from a specimen of *Flustra foliacea* within 3 hrs. Eggleston (1972a) reported that each zooid produced a single embryo, so that fecundity is probably related to the number of sexual zooids and hence size of the colony.

Longevity

Flustra foliacea colonies regularly reached 6 years of age, although 12 year old specimens were reported off the Gower Peninsula (Stebbing, 1971a; Ryland, 1976).

Recruitment

- Larvae are positively phototactic on release, and swim for only short periods, although in species in which light stimulus is un-important, larvae may delay metamorphosis for 12 hrs of more (Hayward & Ryland, 1998). Daylength is an important cue for larval release in some species of bryozoa, and *Flustra foliacea* releases larvae in spring (February- April) (Eggleston, 1972a; Hayward & Ryland, 1998), however, at the depths *Flustra foliacea* can occur light may not be important.
- Larvae are probably sensitive to surface contour, chemistry and the proximity of conspecific colonies. However, Hayward & Ryland (1998) suggested that larval behaviour at settlement is only of prime importance to species occupying ephemeral habitats. Eggleston (1972b) demonstrated that the number and abundance of species of bryozoan increased with increased current strength, primarily due to a resultant increase in the availability of stable, hard substrata (Eggleston, 1972b; Ryland, 1976). Dyrynda (1994) noted that the abundance of *Flustra foliacea* was greatest in the deepest, and most current scoured, mouth of Poole Harbour due to the presence of circalittoral boulders not commonly found in other parts of the harbour, although reduced salinity probably also restricted its distribution within the harbour. Therefore, recruitment is probably dependant on the availability of suitable substratum.
- The short larval life probably results in good local but poor long-range dispersal. Ryland (1976) reported that significant settlement in bryozoans was only found near a reservoir of breeding colonies. However, the hydrographic regime probably strongly influences potential dispersal, and in the strong currents tolerated by *Flustra foliacea*, larvae may be transported some distance in a short time, unless constrained within eddies between faunal turf forming species. The sand abrasion tolerated by *Flustra foliacea* may remove other species, providing *Flustra foliacea* with space to colonize.

Sensitivity review

This MarLIN sensitivity assessment has been superseded by the MarESA approach to sensitivity assessment. MarLIN assessments used an approach that has now been modified to reflect the most recent conservation imperatives and terminology and are due to be updated by 2016/17.

Physical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Substratum Loss	High	High	Moderate	Moderate

Removal of the substratum would result in the removal of the *Flustra foliacea* population and its associated fauna. Recovery will depend on recruitment from other populations and is assessed as high (see additional information below).

	Intolerance	Recoverability	Sensitivity	Confidence
Smothering	Tolerant	Not relevant	Not sensitive	High

Holme & Wilson (1985) examined the bottom fauna in a tide-swept region of the central English Channel. *Flustra foliacea* dominated communities were reported to form in, and hence tolerate, areas subject to sediment transport (mainly sand) and periodic, temporary, submergence by thin layers of sand (ca <5 cm). In some cases, *Flustra foliacea* was seen to be partially buried by sand. It is likely that *Flustra foliacea* would withstand smothering by 5cm of sediment for a month. Large colonies are likely to be >6cm in height and exposed autozooids, will be able to feed, providing food for the rest of the colony. Therefore, not sensitive has been recorded. However, smothering for protracted periods or by impermeable materials may have a greater impact.

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

Suspended sediment is likely to cause abrasion and effect suspension feeding physically. But *Flustra foliacea* dominated communities have been reported from areas subject to sediment abrasion due to strong tidal streams, either by mainly sand (Holme & Wilson, 1985) or by gravel (Knight-Jones & Nelson-Smith, 1977; Hartnoll, 1983). Their toughness and erect form, coupled with their flexibility probably confers tolerance (Knight-Jones & Nelson-Smith, 1977; Holme & Wilson, 1985). Hyman (1959) noted that erect forms were more calcified than encrusting forms, e.g. *Flustra foliacea* was reported to have a calcareous content of 97-99%. In addition, *Flustra foliacea* was reported to be abundant in turbid, fast flowing waters of the Menai Straits (Moore, 1977). Therefore, together with evidence of periodic partial burial by sediment (see smothering above) *Flustra foliacea* is likely to tolerate increased suspended sediment. Bryozoan larvae are reported to avoid areas affected by siltation (Eggleston, 1972b; Ryland, 1976), however, the abundance of *Flustra foliacea* in areas subject to sediment abrasion and suspended sediment loads subjects that the some of its larvae are also able to settle and survive. An increase in siltation and associated scour may remove competitors and provide additional space for colonization, therefore, 'tolerant*' has been recorded.

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

A significant reduction in suspended sediment load for a month (see benchmark) is unlikely to adversely affect *Flustra foliacea*. Therefore, a rank of tolerant has been recorded. However, the longer term reduction may allow other species to colonize available substratum and increase competition for space with *Flustra foliacea*.

	Intolerance	Recoverability	Sensitivity	Confidence
Dessication	Not relevant	Not relevant	Not relevant	Not relevant

Flustra foliacea is probably highly intolerant of desiccation, and specimens washed ashore are usually dead. However, it is a subtidal species unlikely to be exposed to the air.

Increase in emergence regime Not relevant Not relevant Not relevant Not relevant

Flustra foliacea is a subtidal species, and unlikely to be affected by a change in emergence regime at the benchmark level.

Decrease in emergence regime Not relevant Not relevant Not relevant Not relevant

Flustra foliacea is a subtidal species, and unlikely to be affected by a change in emergence regime at the benchmark level.

Increase in water flow rate Tolerant High Not sensitive High

Flustra foliacea colonies are flexible, robust and reach high abundances in areas subject to strong currents and tidal streams (see distribution; Stebbing, 1971; Eggleston, 1972b; Knight-Jones & Nelson-Smith, 1977; Hiscock, 1983, 1985; Holme & Wilson, 1985). Dyrynda (1994) suggested that mature fronded colonies do not occur on unstable substratum due to the drag caused by their fronds, resulting in rafting of colonies on shells or the rolling of pebbles and cobbles, resulting in destruction of the colony. Dyrynda (1994) reported that the distribution of *Flustra foliacea* in the current swept entrance to Poole Harbour was restricted to circalittoral boulders, on which it dominated as nearly mono-specific stands. Therefore, an increase in water flow from moderately strong to very strong may not adversely affect colonies on stable substrata. However, colonies, especially if large, on coarse grounds, shells, cobble and pebbles are likely to be more intolerant of increase in water flow, and a proportion of the population may be displaced, although the colony may survive as long as it is not crushed in the process. Therefore, tolerant has been recorded.

Decrease in water flow rate Intermediate High Low Low

Flustra foliacea reaches high abundances in strong currents (see above) but decreases in abundance in weak currents. Decreased water flow may result in increased siltation and accumulation of fine sediments, increased competition from other space occupying species such as sponges, hydroids and other bryozoans, and a decrease in food availability. While, the pumping activity of the lophophores provide the greatest proportion of the colonies food requirements (Hayward & Ryland, 1998), the current generated is probably very localized and the colonies are dependant on water currents to carry food particles to them. Therefore, a decrease in water flow from, e.g. moderately strong to weak, is likely to result in a decrease in the abundance of *Flustra foliacea* and an intolerance of intermediate has been recorded.

Increase in temperature Tolerant Not relevant Not sensitive Low

No information concerning temperature tolerance was found. However, *Flustra foliacea* is an amphiboreal species found in the Arctic Circle and south to the Bay of Biscay, and from the shallow sublittoral to deep circalittoral. Therefore, it is unlikely to be adversely affected by long term changes in temperature within British waters, and a rank of tolerant has been recorded.

Decrease in temperature Tolerant Not relevant Not sensitive Low

No information concerning temperature tolerance was found. However, *Flustra foliacea* is an amphiboreal species found in the Arctic Circle and south to the Bay of Biscay, and from the shallow sublittoral to deep circalittoral. Therefore, it is unlikely to be adversely affected by long term changes in temperature within British waters, and a rank of tolerant has been recorded.

Increase in turbidity Tolerant Not relevant Not sensitive Low

Increased turbidity will reduce light penetration and hence phytoplankton productivity. Small phytoplankton are probably an important food source in the shallow subtidal, although, *Flustra foliacea* is also found at greater depths, where organic particulates (detritus) are probably more important. Therefore, an increase in turbidity is unlikely to adversely affect *Flustra foliacea*.

Decrease in turbidity	Tolerant*	Not relevant	Not sensitive*	Low

Decreased turbidity is likely to result in increased primary productivity, and therefore indirectly increase the availability of food (phytoplankton or detritus) for *Flustra foliacea*, which may, therefore, benefit. Therefore, a rank of tolerant* has been recorded.

Increase in wave exposure	Intermediate	High	Low	Moderate

Flustra foliacea occurs from very wave exposed to sheltered waters, although probably limited to deeper waters in very wave exposed conditions. The oscillatory water flow generated by wave action may be more damaging than constant strong currents, e.g. strong wave action may generate an oscillatory flow of 2m/sec at 20m (Hiscock, 1983, 1985). *Flustra foliacea* is a common member of the flotsam, having been removed from its substratum by storms. Colonies on unstable substrata or subject to extreme wave exposure and storms are likely to be more intolerant. An increase in wave action from exposed to extremely exposed, or storms (especially in more wave sheltered environments or shallow water populations) are likely to remove a proportion of the population. Therefore, *Flustra foliacea* is probably of intermediate intolerance to increases in wave action. Recoverability is likely to be high (see additional information below).

Decrease in wave exposure	Intermediate	High	Low	Low

Flustra foliacea occurs from very wave exposed to sheltered waters. In wave sheltered habitats water flow rates are probably more important than wave action in determining the occurrence and abundance of *Flustra foliacea*. Water movement (wave or water flow induced) is important for suspension feeding invertebrates such as Flustra foliacea, to prevent siltation and provide adequate food supplies, oxygenation, nutrients and remove waste products. A decrease in wave action to very sheltered or ultra sheltered, in the absence of adequate water flow, may decrease water movement, leading to an increase in fine sediments, loss of suitable substratum and a reduction in food supply and oxygenation. Predation and competition from space occupying species such as hydroids, and macroalgae are likely to increase.
In very wave exposed sites, however, a decrease in wave exposure may be beneficial by reducing the populations vulnerability to storm damage (see above).

Overall, *Flustra foliacea* populations are most abundant in areas of high water movement (e.g. Menai Straits), and a decrease in wave action, in the absence of tidal flow or currents, is likely to result in a reduction of the abundance of *Flustra foliacea*. Therefore, an intolerance of intermediate has been recorded. Recoverability has been assessed as high (see additional information below).

Noise	Tolerant	Not relevant	Not sensitive	High

Bryozoa probably react to local vibrations, that may herald the attach of predators, interrupting feeding. But they are unlikely to be aware of noise at the benchmark level.

Visual Presence	Tolerant	Not relevant	Not sensitive	High

Bryozoa probably react to very local shading effects, interrupting feeding. But their visual acuity is probably extremely poor, and they are unlikely to be affected by visual disturbance.

Abrasion & physical disturbance	Intermediate	High	Low	Moderate

Flustra foliacea is tolerant of sediment abrasion (see smothering and suspended sediment above) but physical disturbance by fishing gear has been shown to adversely affect emergent epifaunal communities. For example, emergent epifauna were indicative of scallop dredge damage on *Modiolus modiolus* beds (see species review), and hydroid and bryozoan matrices were reported to be greatly reduced in fished areas (Jennings & Kaiser, 1998 and references therein). Mobile gears also result in modification of the substratum, including removal of shell debris, cobbles and rocks, and the movement of boulders (Bullimore, 1985; Jennings & Kaiser, 1998).
Although, *Flustra foliacea* is flexible physical disturbance by a passing scallop dredge (see benchmark) is likely to damage fronds and remove some colonies, suggesting an intolerance of intermediate. Colonies on hard substrata are probably less vulnerable to fishing activity but would probably be damaged or partially removed. Colonies growing on rocks, cobbles and shells on coarse grounds, may be removed by a scallop dredge (see substratum loss above) and therefore, be highly intolerant. Recovery will depend on local recruitment from surviving colonies (depending on where the nearest undamaged colonies are situated) and a recoverability of high has been recorded (see additional information below).

Displacement	High	High	Moderate	Moderate

Colonies of *Flustra foliacea* that are displaced while attached to their substratum, e.g. shell debris or rocks will probably survive if moved to a suitable habitat and not crushed in the process. But if removed from its substratum, *Flustra foliacea* colonies cannot reattach and will probably be washed to deep water or be deposited on the strand line and die. Therefore, an intolerance of high has been recorded, with a recoverability of high (see additional information below).

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	High	High	Moderate	Very low

Bryozoans are common members of the fouling community, and amongst those organisms most resistant to antifouling measures, such as copper containing anti-fouling paints (Soule & Soule, 1979; Holt *et al.*, 1995). Bryan & Gibbs (1991) reported that there was little evidence regarding TBT toxicity in bryozoa with the exception of the encrusting *Schizoporella errata*, which suffered 50% mortality when exposed for 63 days to 100ng/l TBT. Rees *et al.* (2001) reported that the abundance of epifauna (including bryozoans) had increased in the Crouch estuary in the five years since TBT was banned from use on small vessels. This last report suggests that bryozoans may be at least inhibited by the presence of TBT. Hoare & Hiscock (1974) suggested that polyzoa (bryozoa) were amongst the most intolerant species to acidified halogenated effluents in Amlwch Bay, Anglesey and reported that *Flustra foliacea* did not occur less than 165m from the effluent source.
Therefore, an intolerance of high has been recorded. A recoverability of high has been recorded (see additional information).

Heavy metal contamination	Low	Very high	Very Low	Very low

Bryozoans are common members of the fouling community, and amongst those organisms most resistant to antifouling measures, such as copper containing anti-fouling paints (Soule & Soule, 1977; Holt *et al.*, 1995). Bryozoans were shown to bioaccumulate heavy metals to a certain extent (Holt *et al.*, 1995). For example, *Bowerbankia gracialis* and *Nolella pusilla* accumulated Cd, exhibiting sublethal effects (reduced sexual reproduction and inhibited resting spore formation) between 10-100 µg Cd /l and fatality above 500 µg Cd/l (Kayser, 1990). However, given the tolerance of bryozoans to copper based anti-fouling treatments, as assuming similar physiology between species, an intolerance of low has been recorded albeit with very low confidence.

	Intolerance	Recoverability	Sensitivity	Confidence
Hydrocarbon contamination		Not relevant		Not relevant

Little information on the effects of hydrocarbons on bryozoans was found. *Flustra foliacea* is likely to be protected from the direct effects of oil spills by its subtidal habit but may be exposed to water soluble fractions of oils, PAHs or oil adsorbed onto particulates. In addition, Ryland & Putron (1998) did not detect adverse effects of oil contamination on the bryozoan *Alcyonidium* spp. in Milford Haven or St. Catherine's Island, south Pembrokeshire although it did alter the breeding period. However, it is difficult to extrapolate between species, and no assessment has been made.

	Intolerance	Recoverability	Sensitivity	Confidence
Radionuclide contamination		Not relevant		Not relevant

Insufficient information

	Intolerance	Recoverability	Sensitivity	Confidence
Changes in nutrient levels		Not relevant		Not relevant

A moderate increase in nutrient levels may increase the food available to *Flustra foliacea*, either in the form of phytoplankton or detritus. However, no effects of nutrients enrichment on bryozoans were found.

	Intolerance	Recoverability	Sensitivity	Confidence
Increase in salinity	Not relevant	Not relevant	Not relevant	Not relevant

Flustra foliacea is unlikely to encounter hypersaline conditions in current swept, subtidal habitats.

	Intolerance	Recoverability	Sensitivity	Confidence
Decrease in salinity	High	High	Moderate	Low

Ryland (1970) stated that, with a few exceptions, the Gymnolaemata were fairly stenohaline and restricted to full salinity (ca 35 psu) and noted that reduced salinities result in an impoverished bryozoan fauna. Similarly, Dyrynda (1994) noted that *Flustra foliacea* and *Alcyonidium diaphanum* were probably restricted to the vicinity of the Poole Harbour entrance by their intolerance to reduced salinity. Although, protected from extreme changes in salinity due to their subtidal habitat, the introduction of freshwater, or hyposaline effluents may adversely affect *Flustra foliacea* colonies. Therefore, an intolerance of high has been recorded, and recoverability assessed as high (see additional information below).

	Intolerance	Recoverability	Sensitivity	Confidence
Changes in oxygenation		Not relevant		Not relevant

No information on the tolerance of *Flustra foliacea* to changes in oxygenation was found.

Biological Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of microbial pathogens/parasites	Low	Immediate	Not sensitive	High

No information on diseases was found. Stebbing (1971a) reported that encrusting epizoites reduced the growth rate of *Flustra foliacea* by ca 50% and Stebbing (1971b) described the epizoic fauna of hornwrack in detail. The bryozoan *Bugulina flabellata* produces stolons that grow in and through the zooids of *Flustra foliacea*, causing "irreversible degeneration of the enclosed polypide" (Stebbing, 1971b). Therefore, given the reduction in growth caused by epizoic infestation an intolerance of low has been recorded. Recovery and repair would probably be rapid (see additional information below).

Introduction of non-native species		Not relevant		Not relevant

No information found.

Extraction of this species	Not relevant	Not relevant	Not relevant	Not relevant

Flustra foliacea is not presently known to be subject to extraction. However, many bryozoans have been recently found to contain pharmacologically active substances (Hayward & Ryland, 1998; Lysek *et al*., 2002; Peters *et al*., 2003). Therefore, *Flustra foliacea* may be subject to harvesting in the future.

Extraction of other species	High	High	Moderate	Low

Flustra foliacea may occur on coarse grounds used for fishing of other marine species, e.g. scallops. Mobile fishing gear, such as scallop dredges and beam trawls result in physical disturbance to the sediment surface. Emergent epifauna have been shown to be particularly intolerant of physical disturbance, depending on intensity (see abrasion) and emergent fauna, together with shells, and rocks form part of by-catch. Therefore, an intolerance of high and a recoverably of high have been recorded (see additional information below).

Additional information

Recoverability
Silén (1981) reported that *Flustra foliacea* could repair physical damage to its fronds with 5-10 days. Presumably, as long as the holdfast remains intact, *Flustra foliacea* will survive and grow back. The brooded, lecithotrophic larvae of bryozoans have a short pelagic life time of several hours to about 12 hours (Ryland, 1976). Recruitment is dependant on the supply of suitable, stable, hard substrata (Eggleston, 1972b; Ryland, 1976; Dyrynda, 1994). Even in the presence of available substratum, Ryland (1976) noted that significant recruitment in bryozoans only occurred in the proximity of breeding colonies. For example, Keough & Chernoff (1987) reported that population of *Bugula nerita* demonstrated spatial variation over very small scales, and populations were sometimes absent even when substantial populations were <100m away.
Flustra foliacea colonies are perennial, and potentially highly fecund when large. In the strong currents occupied by *Flustra foliacea* populations many larvae are probably swept away, either to colonize other substrata or lost. Recruitment may be enhanced in areas subject to sediment abrasion, where less tolerant species are removed, making more substratum available for colonization, especially if larvae release in spring coincides with the end of winter storms. Once settled, new colonies take at least 1 year to develop erect growth and 1-2 years to reach maturity , depending on environmental conditions. Four years after sinking, the wreck of a small coaster, the M.V. *Robert*, off Lundy was found to be colonized by erect bryozoans and hydroids, including occasional *Flustra foliacea* (Hiscock, 1981). The wreck was several hundreds of metres from any significant hard substrata, and hence a considerable distance from potentially parent colonies (Hiscock, 1981 and pers comm.)
Overall, local recruitment is probably good and a damaged or reduced population may recover its numbers and percentage cover in less than 5 years. Where the population was removed, recruitment would depend on the proximity of other populations or individuals and the hydrographic regime, and is likely to be more protracted, taking up to 5 years. In areas isolated by either by distance or hydrographic regime, *Flustra foliacea* may take longer to recolonize.

Importance review

Policy/legislation

- no data -

Status

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

Non-native

Native	-		
Origin	-	**Date Arrived**	-

Importance information

Aggregations of *Flustra foliacea* provide a habitat for various species of sponges, hydroids, caprellid amphipods and the suspension feeding crab *Pisidia longicornis* (as *Porcellana*), as well as a number of epizoic species (see MCR.Flu and Stebbing, 1971b)

Flustra foliacea is the preferred prey of the pycnogonid *Achelia echinata*, whose feeding behaviour is described by Wyer & King, 1973 and Ryland, 1976. In addition, *Flustra foliacea* is preyed on by sea urchins such as *Echinus esculentus* and *Psammechinus miliaris* (Ryland, 1976) and nudibranchs, especially the dorid *Crimora papillata* (Picton & Morrow, 1994).

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